State of Utah

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ADDENDUM #1

Date: July 16, 2008

To: Consultants

From: Dave McKay, Project Manager, DFCM

Reference: Life Sciences Research Center
Utah State University Innovation Campus – North Logan, Utah
DFCM Project No. 06292770

Subject: **Addendum No. 1**

Pages			
	Addendum	1	page
	Architects Drawings	199	pages
	Total	200	pages

Note: This Addendum shall be included as part of the Contract Documents. Items in this Addendum apply to all drawings and specification sections whether referenced or not involving the portion of the work added, deleted, modified, or otherwise addressed in the Addendum. Acknowledge receipt of this Addendum in the space provided on the Bid Form. Failure to do so may subject the Bidder to Disqualification.

While we contend that SB220 should only be potentially applicable to a contract issued after the effective date of said bill, this is to clarify that for purposes of this contract, regardless of the execution or effective dates of this contract, the status of Utah Law and remedies available to the State of Utah and DFCM, as it relates to any matter referred to or affected by said SB220, shall be the Utah law in effect at the time of the issuance of this Addendum.

1.1 **SCHEDULE CHANGES – There are no changes to the project schedule.**

1.2 **GENERAL ITEMS** – AJC Architects – Drawings.

Utah!
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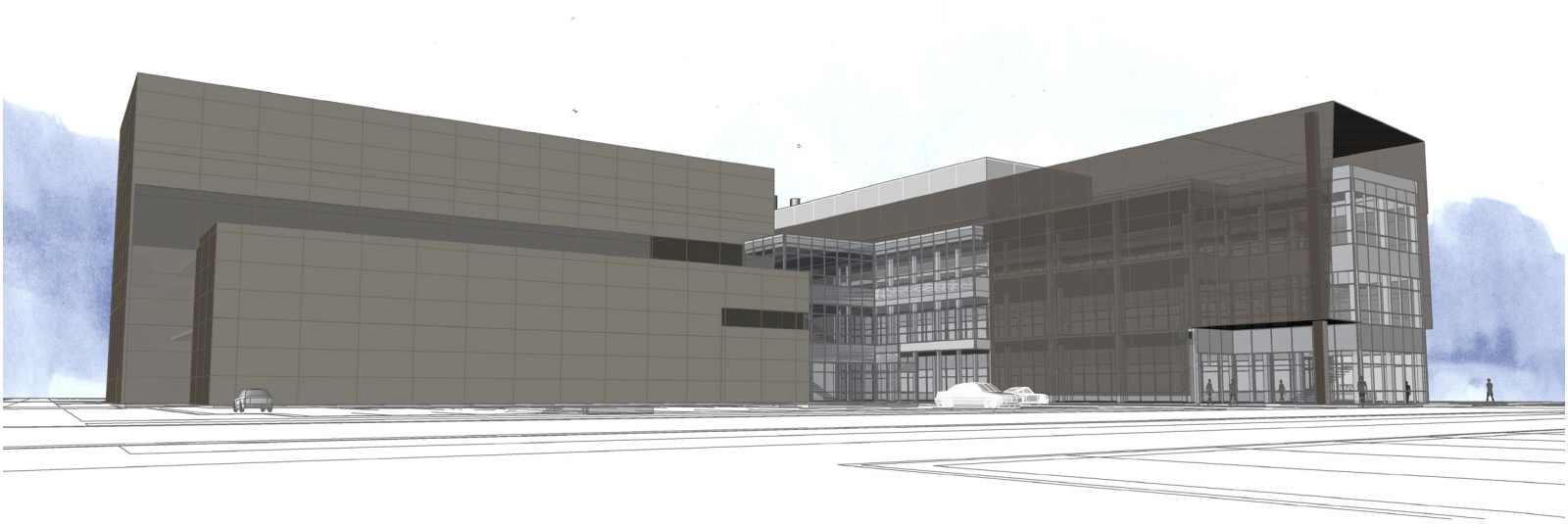
Schematic Design Submittal



Basis of Design

Utah State University

USTAR Building #2

Life Sciences Research Center

ajc architects

PAYETTE

DFCM Project #06292770 July 10, 2008

Review Signatures

USTAR Building #2 - Life Sciences Research Center
Utah State University

DFCM Project #06292770

We have reviewed the Schematic Design Submittal, including the Basis of Design for USTAR Building #2 at Utah State University and warrant that it adequately represents our request for a facility to fulfill our mission, programmatic and building needs. All appropriate parties representing the University have reviewed it for approval.

Ted McAleer — Date
Executive Director, USTAR Governing Authority

Ned Weinshenker Ph.D. — Date
Vice President for Strategic Ventures & Economic Development

Jeff R. Broadbent — Date
USU Associate Vice President for Research

Dave McKay — Date
Program Director, DFCM

Darrell E. Hart — Date
Associate Vice President, Facilities / Business & Finance

Participants

The following is a list of individuals and groups that have participated through Schematic Design for USTAR Building #2 at Utah State University:

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State of Utah, Division of Facilities Construction Management

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Ken Engstrom	Stantec Consulting Engineers (Civil)
Dave Barrett	Stantec Consulting Engineers (Civil)
Jan Streiffel	Landmark Design (Landscape)
Ric Jedrziewski	Miller & Jedrziewski Associates (Kitchen Consultant)

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Basis of Design 01

Schematic Design Summary

Project History and Justification

In order to solidify Utah's role in world-wide high-tech economic growth, the State Legislature introduced the Utah Science, Technology, and Research Economic Development Initiative (USTAR). USTAR aims to expand the State's high-tech industry through an increase in its universities' research capacity. USTAR includes two key areas of development: programmatic investment in research; and new facilities.

USTAR Development at Utah State University

Utah State University (USU) has an extensive history of successful research in the natural sciences, attracting more than $168 million in contracts and grants in 2004. USU is among the top 25 most innovative colleges in the nation. USU's recent success in hiring promising researchers and research teams that accent the University's strengths, and meet USTAR criteria, is evidence that USU is striving toward the Legislature's goals. Furthermore, USU is equipped with a powerful research infrastructure, including a Microscopy Facility, a Nuclear Magnetic Resonance Facility, and the Center for Integrated Biosystems, a multi-faceted core facility which currently serves University investigators as well as off-campus academic and industrial collaborators. Yet previous investigations conducted by USU have concluded that many of the existing research laboratory facilities on USU's main campus are at capacity, or are obsolete. It is clear that more state-of-the-art research laboratory space will be required to fully implement the USTAR initiative, accommodate additional research teams, and expand USU's research capacity.

In January 2007, the State Legislature earmarked $60 million (total project costs) for the initial USTAR facility development at USU. In January of 2008, DFCM commenced the Design Phase for the Proposed USTAR development at USU. DFCM contracted with Gramoll Construction, as well as ajc architects and Payette to lead the Design Team. Based on the Program Document (ajc architects and Payette December 2007), the Design Team worked with the Steering Committee and potential building users to refine the program of spaces, needs and requirements.

Building Vision and Planning

The goal of the project is to optimize the opportunity of the USTAR funding in order to advance research in sciences and engineering at USU. To support this goal, the new USTAR Building will be a state-of the art research facility for life sciences on the Innovation Campus of Utah State University in Logan, Utah. It will provide USU with much-needed office spaces, meeting and gathering spaces, research laboratory and support spaces, as well as Vivarium and ABSL3 Bio-Containment spaces.

The long term vision for the building is to become the foundation for establishing the Innovation Campus at USU as a research center at the forefront of high technology transfer. As such, the project will have a long term effect on the development of the sciences on the Innovation Campus and at USU in general. The Steering Committee and the Design Team expended significant time and effort during Programming to ensure that the decisions on the project will encourage rather than inhibit future growth in research at USU.

The following vision statements and principles, generated during Programming, have guided and directed the Steering Committee the Design Team: Research programs in the USTAR Building will...

...Promote interdisciplinary research and support collaboration between research and industry.
...Lead to commercial applications and economic development opportunities.
...Accent the strengths of Utah State University and the Governor's Office of Economic Development clusters.

The USTAR Building will...

...Support the development of technology transfer oriented research at USU, by providing state-of-the-art labs and equipment, high level security and protocol for equipment and ideas, technology and commercialization outreach, and strategic planning/meeting rooms.
...Increase links between the Main Campus and the Innovation Campus.
...Seek efficiencies and avoid redundancies with existing core facilities.

The architecture of the USTAR Building will...
...Express the state-of-the-art research it houses.
...Embody environmentally friendly design by embracing the USTAR Governing Board's mandate to aim for USGBC LEED Gold level of certification.

As suggested in Programming, the USTAR Building's will be located on Innovation Campus's Grand Avenue. This location will provide opportunities for convenient access to USU's main campus, the existing research community, as well as local commercial and industry.

In order to be flexible and adaptable for future modifications, the USTAR building is being designed for generic life sciences. However, at the Schematic Design phase, the USTAR Building will initially house research programs for the Center for Advanced Nutrition (CAN) and the Institute for Antiviral Research (IAR). New research programs will be integrated as they come on-line.

In order to provide the University and the State with an efficient facility, and to reduce the project's overall impact on the environment, the USTAR Building is being designed to meet or exceed the State's High Performance Building Requirements and is planned for Gold Level LEED Certification.

Project Update

This document records the Basis of Design for Schematic Design, including technical and functional criteria of all building systems, and is intended to be supplemental to the Schematic Design drawings. The drawings illustrate the USTAR Building design progress to a schematic level, and will serve as the foundation for subsequent design phases.

As shown on the drawings, the USTAR Building is currently at 101,430 Gross Square-Feet (GSF), with an additional 11,030 GSF of interstitial space and 16,797 GSF for the mechanical penthouses, for a total of 129,257 GSF. While the building plans generally meet the programmatic needs at this early design phase, the total GSF is above the programmed square-footage number.

The State has allocated $42,519,616 for total construction costs (including site work). Soft costs are not included in this budget. Similarly, inflation is not included in this budget, and will be managed by the State.

A current construction cost estimate is not available at this time. Gramoll is currently working with the Schematic Design Drawings to develop an accurate cost model for Design Development. As the building is well-above the Program GSF estimate, area reductions may be necessary as the project progresses into Design Development.

To date, the project is scheduled for completion in November of 2010. Ground-breaking is currently being planned for Fall of 2009. In order to meet this challenging design/construction schedule, the Design Team will be working with the CM/GC to prepare early bid packages as necessary.

Architectural Design Narrative

Architectural Planning Principles

The building site provides convenient access to USU's Main Campus, the existing research community at Innovation Campus, and commercial and industry businesses. It is anticipated, with the planned completion of Grand Avenue connecting to 800 East, that the main vehicular entrance to Innovation Campus will be from the East. Additionally, Innovation Campus plans to create a vehicular path at 700 east, on the east side of the USTAR site. In order to align the building with these recent developments and the intent of the Innovation Campus Master Plan, the building orientation has been modified accordingly since programming. The USTAR Building will have building frontage on both Grand Avenue and 700 East. The main entrance will be highly visible to those travelling to the site from the east. The building entrance will provide convenient access from the planned parking lots to the south and east of the building, as well as encourage pedestrian traffic from other existing and future facilities on the campus. A bus stop is planned within 500 feet of the main entrance.

The building has been oriented to share zones of the overall site with existing USTAR Building 1 (Building 620). The loading dock, service entrance, mechanical rooms, and utility enclosures for the new USTAR Building are planned to be located on the west side of the building, adjacent to the existing transformer as well as Building 620's existing generator enclosure.

Building Mass and Form

The new USTAR Building is composed of two primary volumes - the Lab / Office Volume, and the Vivarium Volume. The programmatic differences in each building are significant - the Lab/Office Volume is open and relatively public with a need for maximum daylight. In contrast, the Vivarium Volume has maximum security requirements, and has a majority of spaces that require limited natural light (animal holding rooms). This general contrast of more open space (Lab/Office) and less-open space (Vivarium) is the basis for the architectural concept, guiding both massing and materiality.

The Lab/Office volume is oriented east/west to maximize natural daylight and views from the spaces. The Vivarium Volume is oriented north/south, and is pushed to the western edge of the site, affording most of the lab/office spaces with views of the mountains and agricultural farm land to the north, east, and south.

The two volumes are separated by a connector space, which houses virtical circulation, restrooms, and electrical and tele/data rooms. While the building is generally 3 levels above existing grade, the need for tall floor-to-floor heights, mechanical penthouses, as well as an interstitial mechanical space for the Bio-Containment Suites, results in an overall building height of approximately 75 feet (nearly double that of a common three-story building).

Approach to Materials and Finishes

The proposed material palette consists of metal panel at the Vivarium Volume and perforated metal panel and glazing at the Lab/Office Volume. The perforated metal panels will provide a layer of solar control, by diffusing the natural daylight, yet will allow for expansive views of the valley from virtually every location at in the Lab/Office wing. Along with the desire for an innovative, efficient, and sustainable building, the proposed materials for the new USTAR building draw on the rich context of Cache Valley, with an intrisic character of simplicity and economy, and continues USU's legacy in architectural diversity.

Function

Generally, the building is planned as an open environment where maximum interaction among its users is encouraged and accommodated. However, certain program functions have specific privacy and security needs: The more public areas and non-wet research are located on the Level One. Wet lab spaces will be located above the Level Two and Three. The Vivarium has to be as separate from all areas as possible; yet it needs to have access to the labs on every floor, and requires a dedicated loading facility.

A reception desk in the main lobby welcomes researches and visitors, with an adjacent security office.

The clinical area is accessible to the public only through the receptionist area.

The access to the lab floor areas will be regulated by function and all applicable guidelines. To that end, some control is required at the entrance to the lab floors, which is provided by locating the office support areas near the elevators.

The building's main entrance and other public areas are separated from the Vivarium, both physically and visually. The Bio-Containment Research Suite ABSL3, where work with select agents will take place, has been designed as an isolated zone from the Vivarium and the rest of the building. This area is intended to function as a "box within a box", and should have strictly controlled access and special security measures. See Electrical, Lab, Vivarium, and Bio-Containment Design Criteria for detailed security system information.

The USTAR Building is a two-wing, three-level facility. The building is separated into a Public / Lab wing and an Vivarium wing. The wings are composed of the following programmatic components:

Level One:

Main Lobby / Public Entrance / Security
50 person Conference Room
Human Nutrition clinical offices and exam rooms
Human Nutrition Food Service componet,
including commercial kitchen
and dining room
Vivarium Quarantine Areas
Vivarium Cage Wash facilities
Vivarium Support Spaces
Vivarium Storage Rooms
Vivarium Loading Dock
Building Loading Dock
Hazardous Waste Storage Rooms
Main Mechanical and Electrical Rooms

Level Two

Research Offices
Open Office area for Research
Office Support Spaces
Meeting and informal Gathering Spaces
Open-plan labs
Lab Support Spaces
Access to Vivarium and Bio-Containment Suites
Animal Holding Rooms
Operating Suite

Level Three

Research Offices
Open Office area for Research
Office Support Spaces
Meeting and informal Gathering Spaces
Open-plan labs
Lab Support Spaces
Bio-Containment Suites

See the Design Criteria for Labs, Bio-Containment, and Vivarium Spaces for detailed information.

Circulation

External circulation is orients researches and the public from the parking lots, to the south and east of the building, to the main building entrance on the east side of the building. The path is planned to accommodate safe and accessible (ADA) travel. The system of pedestrian pathways will be further developed in subsequent desing phases to encourage the use of outdoor spaces and will be part of the larger network of pedestrian circulation planned in the master plan. This includes outdoor seating areas, shade trees, water and other natural features

Internal circulation flow is generally open, with control points at the entry, human subjects' area and lab access. A main path aligns the primary stairway with the "public" spaces / meeting spaces on each level. This path connects the offices to the labs and lab support spaces. The private offices are easily accessible, but located on a secondary path to maximize privacy.

While a secondary secure entrance will be provided at the main level, and at each floor in the connection between the two building wings, the Vivarium is accessed only from Level Two.

Two internal service docks are provided, one for the Vivarium, and one for building services. The two docks share a common exterior area, but their internal facilities are separate and dedicated.

Natural Light and Views

While the site affords spectacular views of the Cache Valley in virtually any direction, the main view is of the mountains to the northeast/southeast. The building orientation and floor plan maximize this view for both private offices and meeting / informal gathering spaces, as well as the primary stair way.

Consistent with sustainable guidelines, the building makes use of natural light to the greatest extent possible. This will help to conserve energy and provide a healthy environment for the users.
Workspaces that are continuously occupied are placed at or near a window, generally on the north side of the building.

Where this is not possible, “borrowed” daylight will be allowing to penetrate as deep as possible through the offices and other perimeter spaces through translucent wall materials and careful planning of objects / furniture that may obstruct daylight.

Operable windows at the non-lab areas are still being considered, as they contribute to the quality of the environment.

The building generally adheres to the guidelines in-USU’s document “Optimizing the Learning Environment”, issued by Facilities Planning, Design & Construction. The guidelines state that daylight should be used as the “primary lighting system for at least 74% of the space, excluding copy rooms, storage areas, mechanical... and other low occupancy support areas.” The building orientation maximizes solar conditions to optimize daylight harvesting and minimize glare and thermal gain.

Open labs with larger windows are oriented to the north to minimize thermal gain.

Offices and other controlled environments can be oriented to the northand the south (with solar control devices integrated into the building envelop.

Openings is oriented to the west have been minimized, with mechanical and lab support functions occupying those zones of the floor plates.

Life Safety and Code Summary

A Life Safety and Building Code Summary is provided on the Schematic Design Drawings.

Civil Design Criteria

Summary of Proposed Utilities

Culinary Water

Building fire flows are expected to be approximately 3300 gpm. In order to provide water capacity to the project site, the existing 6" water line in 600 East will need to be replaced with a larger 12" size pipe. This pipe replacement would need to extend from the existing 12" water line in 1800 North Street south approximately 1350 feet to the site. An existing 8" water line will also need to be replaced with a new 12" water line from 600 East to the new building site. From this new replaced water line, new building laterals for a 6" fire line and a 3" culinary water line will most likely be needed. Two fire hydrants will be installed around the building. The existing water lines will be abandoned.

Sanitary Sewer

A new 8" sewer main will be installed along the new access off of 600 East. A 6" lateral will run north from this main to the building. We do not anticipate the need for a grease trap since the new building has no food preparation. A Vivarium is planned for the building which will require a Vivarium waste line. This Vivarium waste will need to enter some form of grinder/digester before entering the city's main line. The existing sanitary sewer lines crossing the site are no longer in use and will be removed.

Storm Drain

Storm water runoff will be stored in several ponds. The existing pond south of Building 620 will be enlarged to provide some storage for the USTAR building as well as Building 620. An additional pond will be installed west of this pond between the proposed building and the Building 620 parking lot. These ponds will incorporate both retention as required by LEED certification requirements as well as detention to meet the city requirements.

Detention storage facilities will need to accommodate the shallow ground water. This limits the depth of the ponds. Storm water detention should at a minimum restrict the rate and volume of runoff to the pre-development rate and volume for LEED design requirements. The on-site storm drainage

system consists of inlets and pipes connected to the storm water detention storage. The discharge from the detention storage can then connected to the existing storm drain pipes around the existing adjacent building #162 (Bio-Molecular Building). Minimum pipe size should be 12" for ease of maintenance.

Secondary Water

New irrigation lateral for the building will connected to the existing secondary water line in 600 East Street.

Gas

New gas service for the building will come from the existing gas line on the west side of 600 East Street and a new gas meter will be required.

Sustainable Design

The goal of this project is to obtain USGBC Gold Level Certification. There are two storm drain related credits which can be earned for Gold Level Certification.
Credit 6.1 requires that the post-developed storm water rate and quantity not exceed that of the pre-developed site. Examples of this would be using a vegetated roof and pervious pavement to minimize the amount of impervious area. Detention ponds and percolating the water into the ground are also acceptable methods however the high water table may make these difficult. Capturing and storing storm runoff for irrigation purposes can help earn this credit.

Credit 6.2 calls for improving the quality of the storm water before it leaves the site. Removing the total suspended solids (TSS) can be performed using acceptable best management practices (BMPs). These include vegetated roofs, vegetated swales, wetlands as well as mechanical treatment systems.

Landscape Design Criteria

Landscape Design

The primary focus for the landscape shall be to provide a design that is appropriate to conditions at the Innovation Campus and to achieve LEED Gold Certification. In order to accomplish these goals, it is critical that the landscape architect work closely with the civil engineer to jointly develop storm drainage and water harvesting systems. The landscape design will adhere to the Innovation Campus Site Development and Landscape Guidelines and the DFCM Guidelines for Landscape and Irrigation.

Appropriate Plant Materials: Throughout the site development, plants appropriate to site conditions will be utilized. Where areas are dry, native and adapted water conserving plant materials will be utilized. Where areas are wet due to high water table conditions or detention/retention basins, appropriate water-tolerant plants will be utilized. Limited locations will be installed with sod to providing streetscape consistency where needed. Whenever possible, locally grown plant materials will be specified.

Restoration of Habitat: The landscape design will restore habitat in the storm water detention basins by landscaping with native vegetation. To accomplish this we will work closely with the civil engineer to capture storm water run-off and utilize it in an acceptable and sustainable manner.

Heat Island Effect Mitigation: The landscape design will mitigate the heat island effect by providing shading to paved surfaces including parking lots and walkways with the use of selected trees.

Irrigation Design: It is the intent to reduce or eliminate the use of potable water in the landscape, and use efficient irrigation systems including drip methods. Planters along the Grand Avenue will be serviced with secondary water already plumbed to the site. If secondary irrigation water is available for use on the remainder of the site, it will be used. If not, every effort will be made to utilized harvested water combined with low water use landscape treatments, and drip irrigation to reduce culinary water use.

Topsoil: Topsoil will be stripped, stockpiled, and re-used for site landscape purposes.

Specifications

02900 Landscape
02810 Irrigation Systems

Structural Design Criteria

Foundation System

A geotechnical report for the building has been completed by AMEC Earth & Environmental Inc., dated February 1, 2008. The report indicates that existing soils at the building site consist of a surface layer of lean clay up to 5 feet thick. The clay layer is underlain by silty sand with gravel and layered silts and clays. Groundwater was measured at depths of 7.7 to 9.5 feet below the existing ground surface approximately one week after the borings were completed.

The geotechnical report includes information on various acceptable foundation systems depending foundation loads and foundation performance parameters. Based primarily on the calculated column loads for the building, a reinforced concrete mat foundation system has been selected for the building. The calculated column loads are higher than the maximum recommended load for spread footing systems, but are within acceptable limits for a mat foundation system. Mat foundations will be designed to not exceed an average net allowable bearing pressure of 650 psf. Based on the planned column spacing, it is anticipated that the thickness of the mat footing will be in the range of 30” to 36” thick. This approximate thickness of the mat foundation will be verified as the design progresses. The mat foundation will be placed on a minimum of 6” of free draining granular material such as 1” to ¾” crushed rock as recommended in the geotechnical report.

It is anticipated that overturning and sliding forces in the braced frame that make up the lateral force resisting system will be resisted by the reinforced concrete mat footing. The mat footing will most likely require additional reinforcing steel and increased thickness in the area of the braced frames to keep soil bearing pressures within the geotechnical design limits of the final soils report.

The top of the mat foundation will likely be placed approximately 2 to 3 feet below the slab on grade at the ground level to allow for pipes, conduits, and other utilities to be placed below the floor slab without being embedded into the concrete mat founda-

tion. The actual required dimension between the floor slab and the top of the mat foundation will be coordinated with the mechanical and electrical engineers as the design progresses. It is anticipated that the space between the floor slab and the mat foundation will be filled with clean gravel or compacted structural fill. The top of the mat footing will most likely need to be stepped down to a lower elevation at the area of the boiler room where the ground floor will be stepped down. The mat footing may also need to be depressed at elevator pits. At areas where the mat foundation is depressed to a significant degree, the mat may reach the elevation of the groundwater and de-watering measures will be required.

The geotechnical report states that there is potential for liquefaction in the native soils at the site when they are subjected to earthquake ground motion. The estimated settlement from liquefaction is in the range of 2 to 3 inches according to the report. The continuity of the reinforced concrete mat footing will help to reduce the effects of differential settlement that occurs as part of the overall settlement associated with liquefaction of the soils. The concrete mat foundation has the ability to span across, and even out, areas of differential settlement to a higher degree than isolated spread footing systems. While the potential effects of differential settlement are not eliminated with the mat foundation system, they are reduced below that which would be experienced for a spread footing system. It should be understood that if the soils liquefy and settle during an earthquake, the building may experience some degree of damage due to differential settlement in the soil.

Deep foundation systems such as piles would reduce the effects of liquefaction related settlement to a higher degree than the mat foundation, but at a significantly higher cost. The mat foundation system has been selected considering its performance characteristics and lower cost relative to deep foundation systems.

Floor and Roof Structure

The proposed structural system at the suspended floors, the lower roof, and the upper roof at the penthouse floor level is a steel beam and girder system with normal weight concrete on 3” deep steel floor

deck. The steel beams in vibration sensitive areas of the suspended floor structures will be stiffened to meet the required vibration performance criteria in these areas. They will be considerably stiffer and stronger than would be required if gravity load were the only design consideration on the floor framing. The proposed concrete floor slab is a total of 7 ½" thick to aid in controlling vibration in the floor structure acting in conjunction with the stiffer floor beams. As an added side benefit, the 7 ½" thick floor slab will provide a two hour rating without fireproofing the deck. Sprayed fireproofing may be required on some limited portions the structural steel frame to achieve the required fire rating. Roof areas created by plan step-backs will remain concrete slabs on metal deck due to the anticipated demands on the diaphragms from plan offsets of braced frames.

The suspended floor structures will be designed for the following vibration performance criteria:

Support space	8,000 micro-inches per second
Laboratory space	4,000 micro-inches per second
Vivarium space	2,000 micro-inches per second
Operating rooms	1,000 micro-inches per second
Imaging rooms	500 micro-inches per second

The ground level floor will consist of a 4" thick reinforced concrete slab on grade. The floor slab will be thickened where required to support the loads of heavier equipment. A 5" to 6" thick slab on grade is anticipated in the mechanical rooms at ground level. A vapor retarder membrane is anticipated below the slab on grade due to the fairly high water table at the site.

Columns supporting the suspended floor and roof structures will be steel wide flange sections. Presently, the plan dimensions of the gravity columns are anticipated to be approximately 12 inches square. Columns at braced frames are wide flange section with anticipated plan dimensions in the range of 14 to 16 inches square.

Penthouse Roof Structure

The proposed roof framing system at the penthouse roof is anticipated to be 1½" deep galvanized steel deck supported by open web steel joists and steel wide flange girders. The steel wide flange girders will reduce the depth of the roof structure compared to steel open web joist girders. If heavier mechanical equipment is hung from the penthouse roof structure, some of the open web steel joists may be replaced with wide flange steel beams to increase the load capacity of the roof structure. It is anticipated that the roof structure will be constructed as a basically flat structure, but sloped to drain, and will be supported by steel wide flange columns.

Limited areas of the joists and girders in the penthouse roof structure may need to be fireproofed to achieve the fire rating required by the code analysis.

Walls

Based on discussion with the architect, cladding at the exterior walls will most likely be either a brick veneer system or a lightweight metal panel system. The anticipated back-up structure for both cladding systems is light gauge metal studs. The depth of the metal studs is anticipated to be 6" to 8" due to the higher floor to floor heights of the building. Deeper studs may be required at some locations where walls are higher than normal, such as a lobby area. Exterior walls below grade will be reinforced concrete foundation walls.

Lateral Force Resisting System

A special concentric steel braced frame or buckling restrained braced frame system is anticipated for the lateral force resisting system of the new structure. Further study will be performed as the design development phase progresses to evaluate the relative cost different types of braced frame systems and determine which type of braced frame system will be best for the project.

The braced frame system will experience a lower magnitude of horizontal drift under earthquake loads compared to the drift that would be experienced if more flexible moment resistant frames

were incorporated into the building. This is advantageous in reducing non-structural damage during an earthquake and meeting the drift limits that the building code requires.

Braced frames will be located to meet code requirements such that they are distributed evenly across the footprint of the building but minimize impact on the floor plan of the building. The locations of the braced frames are shown on the drawings and will continue to be coordinated with the architect as the design of the building progresses.

It is anticipated that overturning and sliding forces in the braced frames will be resisted by the reinforced concrete mat footing. The mat footing will most likely require additional reinforcing steel and increased thickness in the area of the braced frames to keep soil bearing pressures within the geotechnical design limits of the final soils report.

Future Expansion

No vertical expansion is anticipated in the future. Horizontal expansion adjacent to the building may be a possibility. The structure of the building will not be designed to support loads from the future expansions. It has been assumed that the structures for the future additions will be self-supporting and separated from this building.

Structural Design Criteria and Material Strengths

The structural design criteria and material strengths listed below are according to our best estimate at this time based on the information above. The criteria and strengths will continue to be evaluated as the design progresses, and may change. The structural design will be according to the 2006 International Building Code and the DFCM Design Manual. Preliminary design criteria are shown on the following page:

Governing Building Code	2006 International Building Code (IBC)
Occupancy Category	II – standard occupancy
Base Roof Snow Load	35 psf plus snow drift per IBC
Ground Snow Load	50 psf
Snow Importance Factor	IS = 1.0
Suspended Floor Live Loads	
Office space	80 psf live load plus 20 psf partition load
Lab and Vivarium space	125 psf live load
Corridors, stairs, assembly areas	100 psf live load
Mechanical equipment rooms	125 psf or as required by mechanical equip.
Lateral Loads	
Seismic Loads:	
Short Period Spectral Acceleration	SS = 0.90
One Second Spectral Acceleration	S1 = 0.317
Importance Factor	I = 1.00
Site Class	D
Seismic Design Category	D
Response Modification Factor	As specified by code for the selected lateral system
Wind Loads:	
Basic Wind Velocity	90 M.P.H.
Exposure Type	B
Importance Factor	I = 1.00

Preliminary Working Stresses for Materials are as follows:

Concrete (28 day strengths):	
Concrete Mat Footing	f ‘c = 4000 p.s.i.
Interior Slab on Grade	f ‘c = 3000 p.s.i.
Concrete on Steel Floor Deck	f ‘c = 3000 p.s.i.
Exterior Slab on Grade	f ‘c = 4000 p.s.i
Concrete Foundation Walls	f ‘c = 4000 p.s.i.
Reinforcing Steel	ASTM 615 Grade 60 fy = 60 ksi
Structural Steel:	
Steel Beams	ASTM A992 fy = 50 ksi
Misc. Steel	ASTM A-36 fy = 36 ksi
Steel Tube	ASTM A50 Grade B fy = 46 ksi
Steel to Steel Bolts	ASTM A325 or A490
Anchor Rods	ASTM 307 or ASTM F1554

Mechanical and Plumbing Design Criteria

Owners Project Requirements

Codes

International Building Code, 2006
International Mechanical Code, 2006
International Plumbing Code, 2006
International Fire Code, 2006
International Energy Conservation Code, 2006
NFPA 13
Utah State Boiler Code

Standards

Utah Division Of Facilities And Construction Management Design Criteria
Utah State University Architect & Engineer Manual
Utah State University Planning & Design For High Performance Facilities
American Industrial Hygiene Association (AIHA). ANSI/AIHA Z9.5 National Standard For Laboratory Ventilation.
American Society Of Heating, Refrigerating And Air Conditioning Engineers, Inc. (ASHRAE). Laboratory Design Guide
ASHRAE Fundamentals Handbook, HVAC Applications Handbook, Systems And Equipment Handbook.
Centers For Disease Control (CDC) And National Institute Of Health (NIH). Biosafety In Microbiological And Biomedical Laboratories.
National Fire Protection Association (NFPA). NFPA 15 Fire Protection For Laboratories Using Chemicals.

Environmental And Sustainability Goals

DFCM High Performance Building Requirements

This facility will conform with the dfcm high performance building rating system.

Basic Requirements:

Fundamental building systems commissioning. Dfcm will engage a commissioning agent that is not an individual directly responsible for project design or employed by one of the designers. Commission-

ing agent shall ensure that fundamental l building components are installed and calibrated to operate as intended.

Life cycle cost analysis. Designers shall use life-cycle cost analysis in making decisions about their investments in products, services, construction, and other projects to lower the state government's costs and to reduce energy and water consumption.

CFC reduction in HVAC and refrigeration equipment. Designer shall select HVAC and refrigeration equipment without chlorofluorocarbons (cfc) based refrigerants.

Ventilation systems. Designer shall provide mechanical ventilation system according to ASHRAE standard 62. Mechanical ventilation system shall have the capability to operate continuously during occupancy and designed not to be easily shutdown or otherwise defeated, such as blocked registers.

Drainage systems. Designer shall design surface grades, storm drainage system, HVAC system, and other systems to avoid accumulation of standing water around and in the building.

Mold prevention during construction. Contractor shall ensure porous type building materials, insulation, and fabric, is kept dry to prevent the growth of mold and bacteria. Materials that have been affected by mold shall be abated or replaced. Building insulation that is damp or wet for 72 hours shall be replaced.

Filtration media replacement before occupancy. Contractor shall ensure that filtration media is replaced before occupancy.

Thermal comfort. Designer shall ensure that thermal comfort requirements are according to ASHRAE standard 55. Exceptions:

Winter humidification is not (normally) required;
Summer dehumidification is not (normally) required;
and upper temperature limit in natural ventilated buildings is not required.

Energy Efficiency Requirements:

Energy performance. Provide an integrated system of components to reduce source energy use from what is required by ASHRAE standard 90.1.

Sustainability Credits:

Provide a minimum of 20 sustainability credits. These items include daylighting, energy, renewable energy, indoor air quality, commissioning and training, acoustics, sustainable materials, waste reduction, water reduction, performance measurement and verification and innovation in design.

Leed Requirements

The project will achieve usgbc LEED Gold certification.

Equipment and system expectations

General: mechanical systems incorporating centralized equipment are preferred over unitary type equipment. The majority of the maintenance can be performed in the mechanical equipment rooms. Central maintenance personnel would prefer not to have to enter animal rooms, containment rooms or special labs to perform maintenances. Central systems provide more flexibility to accommodate future changes.

Flexibility for future changes: the building mechanical systems must be able to accommodate future changes. Lab facilities of this type experience dramatic changes over the life of the building.

Design Parameters

1. Temperature:

	Winter	Summer
Outdoor Temperature	-20° F	94° DB/65° WB
Indoor Temperature – Typical Labs		
	72° F	72° F
Indoor Temperature – Animal Rooms		
	64° F Min	85° F Max (winter & Summer)

2. Chemical Fume Hood Exhaust

Occupied mode face velocity - 100 feet/minute

Unoccupied mode face velocity - 60 feet/minute

Use of proximity sensors to reduce air flow when hood is not in use.

3. Minimum Air Change Rates

Typical Lab Space, Occupied Mode
- 4 ACH (air changes per hour)

Vivarium - 10 ACH

Typical Lab Space, Unoccupied Mode – none

4. Air Handler Pressure Drop/
   Velocity - 4" W.G..400 ft/min

5. Duct Pressure Drop/
   Velocity - 2.2" W.G./2500 ft/min

6. Heat Recovery:
Provide heat recovery from general exhaust.
Provide heat recovery from fume hood exhaust.

7. Laboratory plug load design
For preliminary design purposes use -
10 watts/square foot
Final loads to be determined during design process.

8. Means to reduce cooling air flow in rooms with high plug loads will be fan coil units

9. Humidification Requirements

Typical laboratories

Summer	50% RH max.
Winter	NA

Vivarium

Summer	50% RH max.
Winter	30% RH min.

10. Acoustic design: the HVAC-related background noise shall comply with ASHRAE handbook HVAC applications 2007:

	Rc(n)
Laboratories (with fume hoods) Testing/research with telephone use and Speech communication	40 to 50
Group Teaching	35 to 45
Offices	25 to 35
Conference Rooms	25 to 35

Heat Source

The heat source will be gas fired hot water boilers. There will be a minimum of two boilers for redundancy. Each boiler will be sized for 50% of the load. The boilers will have capacity to heat the building if the heat recovery system fails. Provide a small summer boiler, the high efficiency condensing type. Consideration shall be given to a low temperature (130ºf) hot water system with all high efficiency condensing boilers.

A central heat pump system should also be considered, in lieu of gas fired boilers. This would include a minimum of two heat recovery chillers and a ground-coupled well water system.

Cooling Source

The cooling source will be a minimum of two water cooled chillers for redundancy. Each chiller will be sized for 50% of the load. The chillers will have capacity to cool the building if the heat recovery system fails. At least one chiller shall be the variable flow type for improved efficiency. There will be a cooling tower for each chiller.

Heat recovery chillers should also be considered, in lieu of the standard chillers. This system would include a ground-coupled well water system.

Ventilation

Ventilation will be provided in compliance with the 2006 IMC.

Classrooms – 15 CFM/person
Office space - 20 CFM/person
Typical lab – 100% outside air
Vivarium – 100% outside air

Steam System

A central high pressure (80 psi) steam system will be provided to serve sterilizers, cage washers, animal room washdown and the Vivarium humidification. Provide two gas fired boilers for redundancy.

A clean steam system is required for the autoclaves and the humidifiers. Normal (dirty) steam damages the animal cages and is not recommended for humidification. A primary and standby dirty steam-to-clean steam generator will be requires.

Heating Hot Water Piping System

Primary standby pumps each sized at 100% flow. Variable flow, VFD's on each pump.

Chilled Water Piping System

Chilled water supply temperature - 42º F
Chilled water return temperature - 55º F
Primary – standby pumps, each sized at 100% flow. VFD's on each pump.

HVAC Systems

Typical laboratories: general - the design of the HVAC system for a laboratory should maintain a safe working environment for the users. All laboratory areas shall be served by 100% outside air systems.

Rooms should be maintained at a negative pressure with respect to adjacent areas. High air discharge velocities should be avoided (not more than 50 feet per minute) in the immediate vicinity

of the fume hood. Fume hood face velocity should be maintained at 100 FPM all sash positions in the occupied mode. The system design shall be based on 100 feet per minute hood face velocity when the fume hood sash is opened to a height of 18 inches. Fume hood shall be equipped with a motion sensor which will reduce face velocity to 60 FPM when the area around the hood is unoccupied.

The HVAC system should have features that enable control of supply and exhaust air flow, laboratory pressurization control, hood face velocity and hood air flow, energy consumption, and room temperature.

Laboratories will be provided with variable volume fume hoods, variable volume supply air and variable volume general exhaust air. Room supply and exhaust air will be controlled through linear or non-linear air terminal devices utilizing either a volumetric control.

Vivarium:
General - the design of the HVAC system will maintain a stable environment for the animals and safety and comfort for animals and personnel.

The HVAC system for the Vivarium will be similar to the typical laboratories. The Vivarium systems will be 100% outside air. Rooms will be designed such that they can be positive pressure or negative pressure.

The HVAC system will have features that enable control of supply and exhaust air flow, room pressurization control (positive or negative), energy consumption, room temperature, and room humidity.

The ventilated cage racks will require individual supply air and exhaust air control with filters.

HVAC redundancy is required. The HVAC system will have redundant supply fans and exhaust fans which will provide operation of the facility at a reduced level in the event of a fan failure. HVAC equipment serving the Vivarium will be on emergency power. This includes chiller, boiler, pumps, supply fans, exhaust fans and controls.

Animal Biosafety Level 3 Labs

The ventilation system shall be 100% outside air. The ABSL3 and ABSL3 enhanced lab shall be negative pressure in relationship to adjacent spaces. There will be audible and visual alarms to notify personnel on loss of pressure control. Gastight dampers will be provided in the supply and exhaust ductwork to allow for decontamination of the ABSL3 lab and ABSL3 enhanced lab. The ductwork up to the gastight dampers will be gastight stainless steel.

Air Handlers

The supply air handlers will be located indoors to accommodate servicing and piping and to avoid freezing problems. The exhaust air handlers may be located outdoors. The air handlers will have multiple fans for redundancy.

Outside Air Intakes And Exhaust Air Discharge

Air intakes shall be positioned to avoid short-circuiting of exhaust air back into the building. Exhaust from laboratories must be discharged to the atmosphere through stacks at the top of the building with a minimum velocity of 3000 FPM. If variable volume systems are employed for supply and exhaust, then design provision must be made to assure that the 3000 FPM exhaust velocity is maintained at all times at all conditions.

Exhaust Air System

There will be several sources of exhaust air: (1) general lab exhaust (typical labs and Vivarium) (2) chemical fume hood exhaust (3) biological safety cabinet exhaust (4) general building exhaust (toilet rooms, photocopy areas, janitor's closets, etc.). (5) Special chemical fume hood exhaust (radioisotope hoods, digester hoods).

The general lab exhaust, chemical fume hood exhaust and biological safety cabinet exhaust should commit to a central manifolded variable air volume (VAV) system. A central system provides redundancy, flexibility to add future hoods, diversity and heat recovery capability. Another advantage is that central exhaust systems reduce the noxious and hazardous substance levels through dilution. Mani-

folded exhaust system provide a higher plume due to the momentum associated with a higher mass flow.

General building exhaust will be ducted to separate exhaust fans to preclude contamination. Special chemical fume hood exhaust hoods (radioisotope, digester) will be ducted to independent exhaust fans. The exhaust air from the tunnel washers is saturated with moisture and needs to be independently ducted.

Automatic Temperature Control System

The ATC system will be a direct digital control (DDC) type. The system will be compatible with the USU campus control system. The approved atc manufacturers/installers are Johnson controls/Johnson controls and TAC/Utah controls.

Plumbing

General

Properly designed plumbing systems are critical to the operation of the lab facility. Due to the large number of piped utilities, the piping must be carefully organized and properly labeled. Safety of the personnel and the animals is a primary concern. Care must be taken to protect the water supplies to the building and the public sewer system which serves the building. Care must be taken to prevent the domestic water systems within the building from contamination. The plumbing system must be flexible to allow for future changes as the needs change.

Reagent Grade Water System

Two central reagent grade systems will be provided, one for the general labs and an independent system for the Vivarium. Pure water will be piped throughout the building. The pure water system will be capable of generating 18 megohm purity water.

Pure water will be recirculated through a storage tank with ultraviolet light to keep the system free of bacteria. Point-of-use water stations will be provided where ultra pure water is required.

Water Softener

A duplex water softener will be provided. The domestic hot water, pure water, and steam make-up water will be softened.

Acid Waste And Vent System

Provide a dedicated acid waste and vent system with automatic wastewater pH control systems with acid and caustic injection.

Biological Effluent Waste System (ABSL3 and ABSL3 Enhanced Spaces)

Provide a dedicated biological waste system. System will be piped to a steam heated decontamination unit.

Laboratory Vacuum System

Provide a central system with two vacuum pumps for redundancy.

Laboratory Air System

Provide a central system with two compressors for redundancy.

Medical Gases

Central medical gas system will be provided for use in surgery, pre-op and post-op rooms. Medical gases include oxygen, vacuum and air.

Domestic Hot And Cold Water Systems

There will be two separate hot and cold water systems: (1) potable hot and cold water (2) industrial (non-potable) hot and cold water, the industrial hot and cold water will be piped to lab spaces. The industrial water will be served by parallel reduced pressure backflow preventers.

Water Heaters

There will be separate industrial and potable water heaters. There will be two industrial water heaters and two potable water heaters, for redundancy in each system.

Fire Sprinkling

Automatic wet-pipe sprinkler system with a Class I standpipe in two stairways. Piping will be standard weight black steel with mechanical couplings, threaded joints or welded joints. Comply with NFPA 13.

Future Expansion

There are no immediate plans for a future expansion of this building.

Heating/cooling source alternatives

Two heating/cooling source alternatives are being considered: (1) proposed design (as shown on the drawings) (2) central ground coupled heat pump system.

The proposed design includes gas fired high efficiency condensing boilers as the primary heat source. It includes indirect evaporative cooling, direct evaporative cooling and water cooled chillers for the primary cooling source. A glycol run-around heat recovery system is incorporated in both alternatives. Both alternatives would have central air handlers for supply and exhaust.

The central ground coupled heat pump system consists of a well field of approximately 200 wells, 300 foot deep, multiple water-to-water heat pumps (or heat recovery chillers), a hot water building loop and a chilled water building loop.

A thermal conductivity test is currently being con-

ducted at two test wells drilled on the site. The results will be available in about two weeks. A Utah geological and mineral survey done in 1982 shows some potential for "low temperature geothermal" water. A well approximately ¼ mile from the site showed 70º F water. The normal "deep earth" water temperature in cache valley is about 55 º F.

A schematic design phase DOE II energy simulation model was performed. It was based on an assumed deep earth temperature of 55 º F. This will be adjusted when the thermal conductivity test is completed. The results of the DOE II energy model are included in the schematic design package. The baseline energy costs are $471,474.00 Per year. The proposed design energy costs are $361,540.00 Per year. The heat pump alternative energy costs are $472,488.00.

The heat pump alternative will have a higher initial installed cost than the proposed design. The additional installed cost for the heat pump alternative is about $500,000.00, Roughly the cost of the well field.

Based on the current schematic design phase DOE II energy model, the proposed design is the recommended heating/cooling source alternative.

Heat Source

The heat source is multiple gas-fired high efficiency condensing boilers. The efficiency will be about 95%. In order to achieve this efficiency, the hot water supply/return temperatures will be 130º F/90º F. The glycol run-around heat recovery loop will recover about 50% of the heating energy from the exhaust air stream. With the heat recovery loop operating, the high efficiency boilers will have capacity to do the space heating. If the heat recovery system fails one of the two high pressure steam gas/oil fired boilers will act as a standby heat source. If the natural gas service fails, one of the gas/oil steam boilers will provide space heating. If one or more of the high efficiency boilers fail, one of the gas/oil steam boilers will act as a standby heat source.

Cooling Source

The cooling source is two water cooled chillers, in conjunction with indirect evaporative cooling and direct evaporative cooling. Outdoor air economizer cooling will also be used.

Each chiller will be sized for 50% of the cooling load. The Vivarium wing requires 100% cooling redundancy. The chillers will be sized for the total cooling load assuming that both the indirect evaporative cooling and the direct evaporative cooling are not operational. Each chiller will be served by a cooling tower. The cooling towers will also provide cooling for the indirect cooling system.

Process Steam System

Steam is required for the autoclaves, the tunnel washers, the rack washers, the tissue digester, the effluent decontamination unit and the steam humidifiers. The steam will be provided by two high pressure (125 psi) gas/oil fired steam boilers. Each boiler is sized for 100% of the steam loads for redundancy. Redundancy is required in the Vivarium wing, in order to keep it operational. If the gas service is lost, the boilers can fire on oil, as a standby fuel system.

Clean steam (using pure water for make-up) is required in the autoclaves, where direct steam comes in contact with cages, “dirty” (treated make-up water) steam damages the cages. Clean steam will also be used for humidification, since it does not contain chemicals which may be harmful to the personnel and the animals. The Vivarium requires a redundant clean steam source to remain operational at all times. There will be two dirty steam-to-clean steam generators, each sized for 100% of the load.

The steam condensate that is contained in heat exchangers, such as the rack washers and tunnel washers, will be returned to the boiler. Steam condensate that is exposed to bedding etc., Such as the autoclaves, will be cooled and dumped to the waste water.

A boiler stack economizer coil will be provided on each steam boiler to preheat the makeup water.

Supply Air Handlers

The supply air for the entire building will be 100% outside air. Air cannot be recirculated from the laboratory spaces or from the Vivarium spaces. The office spaces will be supplied with 100% outside air. The return air from the office spaces will be used for makeup air to the building to keep the entire building from going to negative pressure. The supply air handlers will be sized for reduced air tunnel face velocity to reduce pressure losses and the associated energy. Units with 50% redundancy will have a face velocity of 400 feet per minute in lieu of 500 feet per minute. Units with 100% redundancy will be selected at 500 FPM, but will be at 250 FPM during normal operation.

The Lab/Office wing air handler will have two supply air fans, each sized at 50% of the load, for redundancy.

The Biocontaminant Space (level 3 of the Vivarium wing) will be served by two independent air handlers, to prevent contamination of other areas. The Biocontaminant Space includes ABSL3 and ABSL3 Enhanced spaces. These spaces require 100% air handler redundancy. Each air handler will have 100% capacity. In normal operation, both air handlers will run at 50%, in order to reduce the air velocity and pressure drop there the air handlers.

The general Vivarium spaces (levels one and two) of the Vivarium wing will be served by two separate air handlers. Since animal spaces are involved, 100% air handler redundancy is required. Each air handler will have 100% redundancy, same as the biocontaminant air handler.

Exhaust air handlers

The building is 100% exhaust air.

The Lab/Office wing will be served by two exhaust air handlers, each sized at 50% of the load, for redundancy.

The Biocontaminant Space will be served by two independent exhaust air handlers, to prevent con-

tamination of other spaces. Each air handler will be sized for 100% capacity. In normal operation, both units will operate in order to reduce the pressure drop.

The general Vivarium space will be served by two separate air handlers. Each air handler will be sized for 100% redundancy, as required for animal spaces. In normal operation, both air handlers will operate at 50%.

The tunnel washer and rack washer will be served by an independent exhaust air system, since this air stream is saturated with moisture.

The kitchen hoods will be served by an independent exhaust air system, since this air stream is laden with grease.

HVAC Systems

The supply air system will be variable air volume (VAV) with hot water reheat coils. Vav reheat systems are common at USU and familiar to the maintenance personnel. Centralized air handlers allow for easy access and maintenance. Vav systems are energy efficient. These systems allow for flexibility to accommodate future changes. Vav reheat systems provide excellent zoning; each space can be independently zoned.

The exhaust air system will be a VAV manifolded system. Manifolded exhaust systems are very flexible; exhaust VAV boxes can be added in the future. Manifolded exhaust systems provide a safer system due to the dilution from general exhaust air and from hoods which may not e in use. Manifolded exhaust systems provide higher terminal exhaust plumes due to smaller fans. VAV manifolded exhaust systems are energy efficient.

Room Pressure Control

Room pressure control will be accomplished by measuring and controlling the supply air entering each room and the exhaust air leaving each room. This will be done with phoenix (or equal) controls and pressure independent VAV boxes. Phoenix

VAV boxes will be provided on the room supply air, general exhaust air, chemical fume hoods, animal cage rack exhaust air and biological safety cabinets (with ducted connections). Rooms can be positive or negative pressure as required. Room pressure control will be accomplished by using the volumetric offset method, which can be related to a differential pressure; i.e. For a negative room, the exhaust air flow will be 50 cfm more than the supply air flow.

Room pressure will be monitored and alarmed by an edstrom or equal monitoring system.

Outside Air Intakes And Exhaust Air Discharge

The exhaust air is discharged vertically at the roof through stacks which are 10 feet minimum above the penthouse roof. The discharge velocity will be 3000 FPM minimum. The most prevalent wind is the east canyon drainage winds. The next most common wind is from the southwest, ahead of the storm fronts. The next is the northwest winds associated with storm fronts and high pressure systems. The least common wind is from the west.
With the prevalent winds in mind, the outside air intakes are located on the east side of the building. The exhaust air stacks are located west of the outside air intakes. Outside air is brought in through wall louvers at the penthouse level.

During the design development stage, a wind study will be performed by an independent engineering from to validate the current design approach.

LEED Mechanical Credit

The project goal is LEED Gold. The proposed LEED Mechanical Credits are as listed below:

WE 3.1 Water Use Reduction 20%

Use dual flush toilets, 1/8 gallon flush or waterless urinals, low flow showers, sinks and lavatories (non-lab sinks) to reduce the building water usage.

WE 3.2 Water Reduction 30%

Use dual flush toilets, 1/8 gallon flush or waterless urinals, low flow showers, sinks and lavatories (non-lab sinks) to reduce the building water usage.

EA 1 Optimize Energy Performance

Improve building envelope construction to achieve a building envelope that is significantly better than code minimum by better insulating walls and roof and by using high performance glass reducing the size of mechanical equipment needed to heat and cool the building.

Improve building lighting beyond the code minimum and employ lighting control strategies to reduce energy use associated with lighting.

Use variable air volume fume hoods and variable air volume supply air and general exhaust to reduce fan energy and reduce energy associated with tempering makeup air.

Use heat recovery on biosafety cabinets, fume hoods, and general exhaust air.

Use three stage cooling minimizing the requirement for mechanical cooling, the fist two staged will be indirect and direct evaporative cooling with the third stage being mechanical cooling.

Fume hood exhaust and associated makeup air will be reduced during unoccupied hours and non-use time.

Zone temperatures will be capable of being reset to minimize energy use during unoccupied hours.

High efficiency steam boilers will be used for process steam needs.

Boiler stack economizers will be used on the high pressure steam to reheat makeup water or to preheat combustion air.

High pressure steam boiler burners will be variable speed.

Feedwater pumps serving the high pressure steam boilers will be variable speed.

High efficiency condensing type gas fired boilers will be utilized for heating needs. This style boiler is more efficient at part load than at full load. The building is almost always in a part load condition.

Reduce the static pressure drop through the supply air handlers and exhaust air handlers by reducing the air velocity in the air handlers.

High efficiency water cooled chillers variable frequency drive control will be used to maintain high efficiency during part load conditions.

A plate type heat exchanger will be utilized for a water side economizer to provide cooling needs through out the winter for process cooling and other year round cooling needs where outside air economizers are not used.

Low pressure drop HEPA filters will be used in animal rooms.

Premium efficiency motors will be used.

Air-side bypass around heat recovery coils will be analyzed.

Variable frequency drives will be provided on cooling tower fans.

A central ground coupled heat pumps system will be analyzed/

A high delta t will be used for heating hot water and chilled water to reduce pumping energy.

High efficiency domestic water heater will be used.

The steam condensate will be returned from the jacket of autoclaves and washers in lieu of dumping to waste.

EA 4 Enhanced Refrigerant Management

All HVAC equipment will use non-cfc and non-hcfc refrigerants with zero ozone depletion potential and to minimize contributions to global warming. Building chillers will be r134a; smaller equipment will use r410a or r407c.

EQ 1 Outdoors Air Delivery Monitoring

Airflow measurement stations with feedback will be

used for outdoor air intakes and will be controlled and monitored by the building DDC control system to provide required outside air ventilation. If the system fails to provide the required level of fresh air, a visible and audible alarm will be generated by the DDC system.

Conference rooms and other high density occupancy spaces (higher than 25 people per 1000 square feet) will have individual room CO2 sensors with feedback that are continually monitored by the DDC system, higher than desired CO2 levels will trigger increased ventilation by the variable air volume system. If system does not respond to maintain desired CO2 levels, an alarm will be generated by the DDC system.

EQ 2 Increased Ventilation

Ventilation (per person) will be increased 30%.

EQ 3.1 Construction IAQ Management Plan

Filters will be provided on the return air grille to keep ductwork clean while system is operated during construction.

EQ 5 Indoor Chemical & Pollutant Source Control

The architectural design will provide for permanent entry way systems in the primary direction of travel to capture dirt and particulates.

Exhaust will be provided from the building general exhaust system to keep areas of pollutants sufficiently negative with respect to adjacent spaces.

Air handlers will have MERV 13 high efficiency filters which filters outside air and return air.

EQ 6.2 Controllability of Systems

The building mechanical system design will provide individual VAV boxes to almost all rooms, each VAV box will have its own thermostat allowing individual control or adjustment. Small offices and other non-lab spaces will have operable windows. Individual labs will each have an adjustable VAV box and thermostat.

EQ 7.1 Thermal Comfort Design

Each space will be designed to provide comfort levels as established by ASHRAE 55-2004 thermal comfort for human occupancy.

EQ 7.2 Thermal Comfort Verification

An assessment of the building thermal comfort satisfaction will performed within 6 to 18 months after occupancy, if it is determine that mire than 20% of occupants are dissatisfied with thermal comfort, a plan for corrective action will be established and implemented.

Electrical Design Criteria

Codes & Standards

International Building Code (IBC) 2006
International Fire Code (IFC) 2006
National Electrical Code 2008
International Energy Conservation Code (IECC) 2006
Utah State Fire Marshall's Regulations
IESNA, Illuminating Engineering Society of North America
NFPA, National Fire Protection Association
Division of Facilities Construction and Management Design Criteria
Utah State University Design Standards for Electrical Engineering
CDC/NIH BMBL 5th Edition (Best Practices)

Site Electrical

Power Utilities

Rocky mountain power (RMP) will provide two (2) transformers, one at 120/208 volt and the other at 277/480 volt, to feed electrical power to the new USU USTAR life sciences building. At this time, negotiations are in progress with RMP on the number of transformers that they will allow. While there is some early indication that RMP is only going to approve one transformer for this project, the sd design is based, at this time, on the two (2) transformers that the USU USTAR program documents require. There is an existing RMP ground sleeve on the west side of the site that will provide medium voltage service to the two (2) transformers, which will be located within a screened enclosure situated at the far west side of the project site, adjacent to the enclosure that is currently part of the existing 620 building. Locating the RMP transformers inside the new building was considered, but it was determined that space was not available and the need to provide separation from sensitive electronic lab equipment required that the transformers be

placed outside the building. The transformers will feed the two (2) building services, 'MS1' (277/480 volt) and 'MS2' (120/208 volt). The building services (ct cabinet/main disconnect) cabinets will be located within the same screened enclosure as the transformers. The estimated sizes of the transformers are as follows:

277/480 Volt service	1500 KVA
120/208 Volt service	500 KVA

The main building disconnects (breakers) shall be electronic, as required in the program. This will allow for easier breaker coordination, which is important in a facility of this nature, as reliability of the electrical distribution system is NECessary for proper operations. The 277/480 volt service will have ground fault protection for the 277/480 volt service, as required by the national electrical code (NEC).

Communication Utilities

The new USTAR life sciences building will be connected to the USU campus distribution network. A total of four (4) 4" conduits will extend from a manhole on the north side of grand avenue (proposed new distribution network by USU) and extend south to a new 7' wide x 9' long x 7' deep communications manhole that will be set at the southeast corner of the lab wing. Two (2) 4" conduits will extend out of the new communication manhole and run west into the new USTAR life sciences building; two (2) additional 4" conduits will extend out of the vault and span to the east to provide communication/data conveyance to a future USTAR building. This design varies from the program, which had the new USU campus distribution network located along 1550 south. Telecommunications work shall comply with USU's telecommunications design standards and all work will be coordinated with campus it department, which will be installing the cables to the building.

Site Lighting

Full cut-off, pulse-start metal halide luminaries on 25' poles and 2'-0" round concrete pole bases will be used to provide illumination to the parking lot areas. Poles will be placed in landscape areas to the

greatest extent possible to minimize obstructions in parking lot areas, thus facilitating snow removal. The illumination levels for parking lot areas shall be a minimum 1.0 Foot candle with a uniformity ratio of 20:1. Poles will be located to ensure that light trespass onto adjacent properties is zero. All exterior site light fixtures will conform to USU standards. Additional light poles will be used for street lighting as required by USU standards. All pole fixtures will be supplied with break-away fuse holders at the pole base.

Secure Parking Lot Access System

120 Volt power and data will be provided to two (2) entry/exit gates for the secure parking. These gates will be an integral part of the card access security system that is used in the building. Detection loops (two per lane) will be placed in the asphalt as part of the system.

Building Lighting

Interior Lighting

In order to keep energy usage to an absolute minimum, several strategies will be applied to the interior lighting of the life sciences building. These strategies include:

1. Selecting, throughout the building, that the lamp type used for the majority of fixtures will be 4' super T8 with a 28 watt energy consumption. The lamps will be specified as TCLP-compliant.

2. The use of high efficient fixtures, which will tend to get the majority of the light out of the fixture. We will utilize fixtures that have the highest efficiencies.

3. The use of ballasts with a low power factor in order to ensure that energy consumption is kept to a minimum. This is required for the RMP energy efficiency programs.

4. Using ballast that have a THD <10%.

For comfort levels, the fluorescent lamp color will be specified as 3500K unless there are other requirements for specific spaces. The uniformity of the light shall be no higher than 4:1 maximum-to-minimum illuminance levels.

The illumination levels that will be used for each of the defined spaces are as follows:

Defined space	Illumination level
Offices	50 fc
Laboratories	75 fc
General Circulation Corridors	15 fc
Vivarium Wing Corridors	30 fc
Locker/Restrooms	30 fc
Conference Rooms	Variable 30 fc – 70 fc.
Animal Holding Rooms	Variable 30 fc – 70 fc.
Bio-Level 3 Labs	70 fc
Lobbies	30 fc
Kitchen	50 fc
Operating suites	100 fc

Lighting for both open and enclosed offices will consist of indirect/direct linear fluorescent steel pendant lights, mounted at 8' from finished floor, with a 70% up light and 30% down light distribution. For those office areas that are adjacent to exterior windows, light fixtures with dimming ballasts and integral light level sensors will be used for daylight harvesting. Additionally, lights shall be oriented perpendicular to the exterior windows to minimize light trespass from the building, thus satisfying LEED requirements.

Lighting in general lab areas will consist of indirect/direct linear fluorescent steel pendant lights, mounted at 8' above the finished floor, with a 70% up light and 30% down light distribution. Lights will be centered between lab benches. For lab support areas, fluorescent acrylic lens recessed fixtures will be used. For those labs that are adjacent to exterior windows, light fixtures with dimming ballasts and integral light level sensors will be used for daylight harvesting. For the large lab areas, the general lighting control system will turn the fixtures on and off. There will be local switches in the spaces

to allow for individual occupant control. Individual lab support areas will employ an occupancy sensor and switch for control of the lights.

Large conference rooms will have linear fluorescent pendant fixtures with supplemental fluorescent recessed down lights. Control for this type of space shall be a crestron-type lighting control system, which will control lights (on/off and dimming) and motorized shades, in addition to interfacing with a ceiling-mounted audio/video system. Smaller conference rooms will use occupancy sensors and local dimming switches.

In Vivarium support areas (first floor Vivarium wing), including dirty cage wash, clean cage wash, NECroscopy, quarantine space, corridors, and associated support spaces, fluorescent recessed 1'x4' 2-lamp waterproof sealed fixtures will be used. In most individual rooms, both an occupancy sensor and switch will be used to control the lights. Corridor lighting and larger open areas will be tied to the lighting control system, with local switches for control.

In Vivarium areas (second floor Vivarium wing), including animal holding rooms, support spaces, surgery spaces, associated corridors, feed storage rooms, and other associated spaces, fluorescent recessed 1'x4' 2-lamp waterproof sealed fixtures will be used. For animal holdrooms and breeding areas, the lights shall have a high- and low-level illumination with associated controls that switch from low to high. The controls shall interface with either the building management system or a local control system for precise control of the lights. Lights within animal holding room located in the Vivarium shall be connected to emergency power.

Mechanical and control spaces will have 4' channel, fluorescent strip lights with wire guards.

Lobby areas specifically in the north lab wing will employ more decorative fluorescent lighting such as recess can lights, cove lighting, and decorative wall mounted fixtures.

Vapor-tight, surface-mounted fluorescent fixtures will be used in all walk-in coolers and freezers.

Exterior Lighting

All exterior lighting will be designed to meet IESNA RP-33-99 guide lines. A full cut-off metal halide wall mounted light fixture will be used at all entrances and exits in the building. These fixtures will be controlled by a lighting control system to run during the night and to be shut off during daytime hours. These fixtures will be specified with a quartz re-strike component and tied to the emergency system to allow the fixture to used for the emergency egress lighting that is required at all entrances and exits. No up-lighting will be used on the building in order to meet LEED requirements.

Electrical Service and Distribution (Normal Power)

277/480 Volt Electrical Service and Distribution

The main service disconnect for the 277/480 volt service will be located in the screened enclosure that will be located west of the building, as described in the power utilities section of this narrative. This service will be used to provide power primarily to building lighting, mechanical systems, and some of the larger lab equipment. The size of the main service disconnect will be 2,500 amps based on the following calculation:

Lighting Load	1.7 Watts/square foot
Mechanical Load	15.0 Watts/square foot
Large Lab Equipment	2.0 Watts/square foot
Total Load	18.7 Watts/square

18.7 watts/square foot x 100,000 square feet = 1,870,000 watts which equals 2,251 amps.

A 2,500 amp branch feeder will extend from the CT/MS1 cabinet in the west enclosure to the 277/480 volt, free standing main distribution panel 'HMDP' located in the main electrical room on level 1 of the building. A power multi-meter that meets USU requirements will be provided with this switchgear. There will be one (1) 225 amp lighting panel on each level of the building. There may be total of four (4) motor control centers (MCC). Two (2) will be located on the main level (in each of the mechanical rooms), and one will be placed in each

of the two penthouses. These will provide power to chillers, boilers, pumps, air handlers, and other similar pieces of equipment. The four (4) elevators found in the building will also receive power from 'HMDP'. A busman-type elevator switch will be used for the disconnecting means at each elevator equipment room. The tunnel washers and large autoclaves will also be fed from this service.

120/208 Volt Electrical Service and Distribution

The main service disconnect for the 120/208 volt service will also be located in the screened enclosure that will be located west of the building, as described in the power utilities section of this narrative. This service will be used to provide power to general convenience outlets, in addition to the lab and office equipment. The size of the main service disconnect will be 2,000 amps based on the following calculation:

Convenience Outlet Load	1.0 Watt/square foot
Lab Equipment Load	6.0 Watts/square foot
Total Load	7.0 Watts/square foot

7.0 Watts/square foot x 100,000 square feet = 700,000 watts which equals 1,945 amps.

A 2,000 amp branch feeder will extend from the CT/MS2 cabinet in the west screened enclosure to the 120/208 volt, free standing main distribution panel 'LMPD' located in the main electrical room on level 1 of the building. A power multi-meter that meets USU requirements will be provided with this switchgear. This main distribution panel will provide power to individual lighting and appliance panelboards on level one and distribution panels on the other two (2) levels of the building which then feed lighting and appliance panelboards. The branch panels will be located at various locations mainly in corridors of the building. There will be a total of six (6) electrical panels per each level and wing. Every two (2) panels will cover 1/3 of the wing. Isolated grounding will be provided for some of these panelboards to feed computers and other electronic equipment.

Transient voltage surge suppressors will be provided for all 120/208 volt, 277/480 volt main distri-

bution switchboards, and for computer equipment branch panelboards.

Electrical Service and Distribution (Emergency Power)

An emergency generator with an under-skid mounted fuel tank will be provided and located in the screened enclosure at the west of the site as described earlier. The sizing of the generator is currently based on taking one half of the total building load. As more details are forthcoming, generator sizing will probably change. The generator will be sized to include 25% spare capacity. The fuel tank will be sized for 48 hours of back-up at full load.

Total Building Load:	2,570 KVA
½ Building Load:	1,285 KVA
Preliminary Generator Size:	1500 KW

The generator will feed a free standing, 2500 amp, emergency distribution panel 'emdp' which will be located in the enclosure with the generator. The 'emdp' will be provided with four (4) fused switches that will feed the following branches:

1. Life Safety
2. Legally Required Standby
3. Optional Standby (277/480 volt)
4. Optional Standby (120/208 volt)

Based on the branches described above, there will be a total of four (4) automatic transfer switches located in the main electrical room that will feed emergency and standby electrical distribution throughout the building. On each level of the building, there will be six (6) electrical panelboards tied to the optional standby (120/208 volt) branch to feed lab equipment. There will be three (3) electrical panelboards, one per level that will be tied to the optional standby (277/480 volt) branch. This will be used to feed mostly lighting for the Vivarium areas and other support areas. Additionally, the emergency distribution system will be designed to allow for a portable generator to be temporarily connected to the system in the event that the primary generator is not functioning. Approved generator manufacturer's:

Kohler
Caterpiller
Onan

Building Power

All conductors will be copper. Conductors will be sized to prevent voltage drop exceeding 3% at the farthest point with 80% of circuit breaker demand load (duplex outlets, equipment, etc.) The total voltage drop on both feeders and branch circuits will not exceed 5%.

All conductors will be installed in conduit. The minimum size that will be used is ¾". Mc cable will not be used; manufactured flex whips will be used for lighting, instead. Normal power and emergency power will be run in separate conduit systems as required by the NEC.

There are a total of three (3) electrical rooms that are located central to the building (knuckle). Electrical rooms have been stacked on top of each other (floor to floor) to reduce the length of feeder runs and to allow for easy accessibility and conveyance.

Mechanical equipment requiring variable frequency drives (VFDs) will comply with dfcm and USU standards. The following manufactures are approved:

Energy Management Corporation (Mitsubishi)
Long Building Environments (Yaskawa)
Midgley-Huber (ABB)
TMS (Danfoss)

Starters for fans and pumps shall have hand-off auto switches.

UPS power will consist of small stand-alone units rather than a central system with distribution. This varies from the program but was what was requested by USU.

A grounding system will be provided for the building. Ground bars will be located in all electrical and communication rooms. In addition, the building will be provided with a lightning protection system that will also be connected to the building grounding system. The two (2) services in the building will be physically tied to the same grounding system to ensure they are at the same potential.

Power Quality

A fault current and breaker coordination study shall be performed to indicate the available fault current at all points in the distribution system. New switchboards, panelboards, etc. Will be adequately rated for the available fault current. Fuses and circuit breakers will be selected to ensure minimum system power outages due to overloads and faults. Circuit breakers with adjustable long time, short time, instantaneous and/or ground fault setting will be set at levels for optimum system coordination.

Fluorescent light fixtures and electronic equipment (such as computers, electronic lab equipment, and VFDs) produce harmonic currents that may have an influence on system operation. In order to mitigate these currents, fluorescent ballasts will be specified with a thd <10%. Distribution equipment that feeds computer equipment will be supplied with 200% neutrals. Vfds will be specified with input filters to ensure that harmonic currents will not get back into the system.

Receptacle Requirements

The location and number of outlets will be coordinated for each space, with the needs of the users in mind. The following is a guide to the type of outlets that will be provided:

Offices: for all individual offices, two (2) outlets will be installed for computer use, with additional outlets installed for every 6' of wall space. For open office areas, power will be provided for systems furniture.

Countertops (in general): one outlet for every 4' of counter space.

Conference rooms: one outlet for every 6' of wall space. A dedicated outlet will be provided for computer terminal. A floor box or poke-through device will be provided under table.

Large wet labs: for fixed lab benches, wiremold raceway, with outlets spaced 2' O.C., Will be provided for movable lab benches, power connec-

tions, in the ceiling, that can connect to the movable, prewired lab benches that will be prewired will be provided.

Lab Support Spaces: outlets to meet the users' needs and surface wiremold, where required.

Corridors/Hallways/Stairs/Lobbies: one outlet every 25' along corridors. One duplex at each stairway landing, and one duplex outlet every 6' on alternating sides of the lobby.

Electrical/Mechanical: one outlet on normal power and one outlet on emergency power for all electrical rooms and mechanical spaces. Additional outlets will be installed in large mechanical areas.

Communication Room: one outlet on normal power. Multiple outlets on emergency power, as needed, to support the required equipment located in the communications room.

Bio-Containment Suites: outlets will be provided as required by the user. All outlets shall be installed with wash-down, weather-proof in-use covers.

Fire Alarm System

A building-wide addressable fire alarm system will be supplied. The manufacture of the system will be notifier, which is USU's campus standard. This system will be networked to the campus system to allow for remote monitoring. The main fire alarm panel will be located in the main electrical room, with a remote annunciator panel located near the main entrance to the building. A minimum of two (2) notification appliance circuit panelboards (NACs) will be located on each level in the electrical rooms to provide power for horn/strobes on those levels. Style d initiating circuits, style z notification circuits, and style 6 and 7 signaling line circuits shall be used. All conduits used for the system shall be colored red.

Horn/strobes will be provided for all public spaces, including corridors, meeting rooms, break rooms, restrooms, large open office areas, large lab spaces, large mechanical spaces, and library spaces. Weatherproof horns will also be provided at all entrances into the building.

Smoke detectors will be provided in all egress corridors, elevator lobbies for capture and recall, elevator machine rooms, and control spaces. Heat detectors will be located in all mechanical spaces, elevator shaft, elevator machine room, kitchens and break rooms.

Pull stations will be provided at all exits from the building and all stair exits on upper floors. Pull stations shall also be provide at exits from mechanical spaces.

Communication/Data System

Each level of the building has one (1) communication room (MDF & IDFrooms). The rooms are stacked and located central to the building. Four (4) 4" conduit sleeves are provided between levels for conveyance of communication/data cabling. On each level, a 12" wide x 4" deep aluminum, ladder-style cable tray is provided down the main corridors for conveyance of communication/data cables from the work station. In each communication room, data racks with copper and fiber patch panels will be provided. On the main level, a central computer server room has been provided and will contain the equipment need to tie into the campus network (this head-end equipment will be supplied by the users/USU). A fiber optic cable back bone will be provided to tie the three (3) communication/data rooms to the central computer server room.
Cabling from work station outlets will be run in conduit from the work station to the cable tray. The conduit will be physically secured to the cable tray. The length of the communication/data cables, based on the location of the communication rooms, will be 300 feet or less in length. Two (2) cat 6 communication/data cables will be run from each work station to the rack in the communication room.
Communication outlets will be provided at various locations throughout the building to allow for a wireless network.

Access Control System

An access control system will be provided for the building to limit access both to the main entrance, and locations within, the building. Doors requiring

card access will be closely coordinated with the users and USU. The manufacturer of the access control system will be tac, which is USU's standard. The head end equipment for this system will be located in the computer server room and will be rack-mounted. Remote door controllers will be scattered around the building to pick up the required doors. This system will use the fiber optic distribution system to connect all doors to the head-end equipment.

For access into the Vivarium wing, a biometric reader will be used. Once inside the Vivarium wing, card readers with key pads will be used.

One option that may be considered is a standalone system (watchdog) which the user is interested in. Additional research is required to determine the feasibility of using this type of system.

CCTV System

A closed circuit television system will be provided for the building for enhanced security. Location of cameras will be closely coordinated with the users and USU. The manufacturer of the system may be pelco or equivalent. The head end equipment for this system will be located in the computer server room and will be rack mounted. Remote camera power supplies will be located around the building to feed the required camera. As a minimum, cameras will be provided at all entrances/exits to the building, lobbies, entrance and exits from the Vivarium wing, docks, bio-containment suites and entrance and exits from the bio-containment suite. Cameras will also be located outside the building to watch the building site and surrounding areas. Control and viewing equipment will be supplied in the security office in the main building lobby.

LEED

Sustainable Sites - Credit 8. Light Pollution (1 point available):

Under this strategy, interior lighting shall be located so that the maximum candela from each fixture does not exit through the windows. Furthermore,

all non-emergency interior light fixtures shall turn off during non-business hours, with manual override. As part of this strategy, the long axis of the light fixture shall be oriented perpendicular to the window. This point is achievable.

Exterior area, landscaping, and building lighting should be selected and employed so as not to exceed 80% of the lighting power densities for the exterior area and 50% for the building facades and landscaping features, as defined in ASHRAE/IES-NA standard 90.1-2004.

Energy & Atmosphere - Prereq. 1. Fundamental Building System Commissioning (Requirement):

The electrical systems of the building shall be commissioned to ensure that the systems are operating and performing as designed. This will be done by the commissioning agent.

Energy & Atmosphere - Prereq. 2. Minimum Energy Performance (Requirement):

The electrical systems shall comply with the minimum requirements of ASHRAE 90.1-2004. The electrical systems will be designed to meet the minimum energy performance.

Energy & Atmosphere - Credit 1. Optimize Energy Performance (1 to 10 points are available):

By using lighting control systems, occupancy sensors, dimming, the amount of electrical energy usage can be reduced. Dimming of light fixtures can also help reduce the overall heating load into the building so that energy used by the mechanical systems will also be reduced. A lighting control system will be used to help decrease to building energy usage. Coordination will take place with the mechanical engineer to determine what the total energy reduction is for the building.

Energy & Atmosphere - Credit 2. On-site Renewable Energy (1 to 3 points are available):

Under this strategy, the use of alternative energy sources should be explored. There are several technologies available, including wind, photovoltaic, hydro, wave, tidal, and bio-fuel based electrical

production systems. Although these systems can be cost prohibitive, they should be considered, as one or more may be required in order to achieve the goal of LEED Gold certification. The use of one or more of these technologies may, in fact, enhance the acceptance and use of this facility. The use of photovoltaic cells integrated into the building glazing system is becoming more and more popular and can really enhances and define a building.

Energy & Atmosphere - Credit 5. Measurement & Verification (1 point available):

This credit provided for ongoing accountability and optimization of building energy and water consumption performance over time. Caution should be taken when pursuing this credit. If the measured energy and water consumptions fall short of the expected goad, changes to building system may be required to bring those system into compliance. Lighting control systems are available with provisions to allow for energy measurements. If this credit is pursued, systems of that type should be considered.

Energy & Atmosphere - Credit 6. Green Power (1 point available):

Encourage the development and use of grid-source energy technologies on a net-zero pollution basis, 35% of the building's "regulated" electricity for utwo yearsu. Rocky mountain power's blue sky program offers wind power at a relatively low cost of $.0195/Kwh above the standard rate. Although this is related to the electrical systems of the building, the owner dfcm/USU will need to determine whether this is something they want to pursue.

Indoor Environmental Quality - Credit 6.1. Controllability of Systems (1 point available):

Provide lighting controls for 90% of occupants and controllability for all shared spaces that meets group needs or preferences both for perimeter spaces as well as non-perimeter spaces. This point is achievable.

DFCM – High Performance Building Standard (Relevant to the electrical design)

1. Design and technology charrette – shielded or reduced parking and façade lighting to reduce night sky pollution will be discussed. This is a requirement that will be done.

3. Life-cycle cost analysis – under this requirement, photovotaics may be considered and the life cycle cost for that system would be calculated.

8. Fundamental lighting design – the lighting systems of the project will be design based on the IESNA lighting handbook.

12. Energy performance – energy efficiency measures will be described and calculations made. Energy efficiency measures as they pertain to electrical would include lighting control system, lighting products such as high efficient fixtures, lamp and ballast combinations, etc.

28. System performance monitoring – measurement equipment will be specified to allow measurement and verification of lighting control systems, variable speed drive operation, motor loads >20 hp, process loads.

Lab Design Criteria

Architectural Criteria

General

The architectural design for the lab and lab support areas shall be developed to meet the requirements of 2006 IBC, NFPA 45 standard on fire protection for laboratories using chemicals, and ANSI Z358.1 Standard for emergency eyewash and shower equipment.

Typical Planning Module

A typical laboratory planning module is the smallest practical laboratory environment and is the basis for all other laboratory sizes. Laboratory planning modules can be combined and/or subdivided to create the appropriate sized laboratory based on head count and/or function. The planning module for this project is dimensioned as follows:

Module Type	Width	Depth
A. Laboratory	11'-0" O.C.	32'-0" + 8'6" (including column line)
B. Laboratory Support	11'-0" O.C.	Varies (large, medium & small)

Ceiling Height

Minimum clear hung ceiling height shall be:

10'-0"	In "open" lab bench bays
9'- 0"	In laboratory support rooms
9'-0"	In private lab offices
10'-0"	In lab floor meeting rooms and "open" office area
8'-6"	In corridors

Floor Loading

The recommended live load capacity for the laboratory portion of the building is 100 psf. Laboratory support modules shall be 100 psf. (Local codes shall govern the design live load selection for the building).

Clearances

For purposes of safe passage of occupants past people and equipment in aisles, the minimum recommended clearance between benches, or between a bench and a designated equipment area, is 5'-0" in the laboratories.

Personnel/Equipment Access

Provide a 48” wide door opening between corridor, laboratory support and laboratory consisting of one 36” wide active door with a 12” inactive leaf to facilitate personnel and equipment access. All laboratories will have at least two (2) means of egress unless the functional laboratory unit is sufficiently small (e.g.: Cold Room; Dark Room, Single Module Lab, etc.).

ADA Requirements (Access and Workstation)

Access to and within all laboratory areas shall meet ada requirements. Provide the ability to modify the workstation in all laboratory modules to meet ada requirements as needed in the future. To meet the disabled workstation requirements, we recommend the following:

A. Counter top at standard low bench height of 31” A.F.F.

B. Knee space at least 32” wide with a clear height of at least 29” to underside of nearest obstruction (typically front apron). Provide 6” wide and 10” high toe space on at least one side of workstation.

C. Service fixtures located maximum 18” from front edge of counter top. Fixtures can be either standard or remote control type.

D. Sink drops shall occur at least 8” from front edge of counter top and trap shall be minimum 9” A.F.F.

E. Fume hoods modified to meet the above requirements.

F. Confirm additional conformance requirements for sink stations and fume hoods.

Noise

Ambient noise level in the laboratories and support rooms shall meet nc 35-40. In vicinity of fume hoods and BSC’s it shall be higher. Prevent acoustic levels due to intermittent activity occurring outside the laboratory from exceeding ambient noise level by more than 5 dB.

Architectural Finishes

The following is a list of recommended architectural finishes for typical laboratory floor spaces:

A. Private Office, Office, Shared Office, Office Cube, Admin Space, Library/Journal room, File Storage, 15 person Break-out Meeting room, 10 person Break-out Meeting Room, Break Room / Lounge:

Floor:	Carpet
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” natural fissure acoustic lay-in tile.
Casework:	none

B. Printer/Copy/Fax Area, Kitchenette/Coffee/Break Area:

Floor:	Tile / Rubber
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” natural fissure acoustic lay-in tile.
Casework:	Wood base cabinets with a plastic laminate counter top and wood wall cabinets.

C. Supply Closet, Coat Closet

Floor:	Concrete / Sealed
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” natural fissure acoustic lay-in tile.
Casework:	none

D. Wet Lab Bay, Lab Desk

Floor:	Tile / Rubber
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” vinyl coated acoustic lay-in tile.
Casework:	Wood base cabinets with a gray epoxy resin counter top, epoxy under mounted sink and wood shelving plus metal table frame with gray epoxy resin counter top “flexible benches”.

E. Bioinformatics, Electrophysiology Rm., Flow Cytometer Rm., Fume Hood Alcove , Imaging / Microscopy Room, Instrument / Equipment Room, Lab Supplies Storage Room, Microbiology Rm., Other Lab Support Room, Radioisotope Room, Solution Prep Room, Confocal Microscope Rm.:

Floor:	Tile / rubber
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” vinyl coated acoustic lay-in tile.
Casework:	Wood with a gray epoxy resin counter top, epoxy under mounted sink and wood shelving.

F. Cell Culture Room, Tissue Processing Room:

Floor:	Sheet (welded seam) / rubber w/integral base
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” natural fissure acoustic lay-in tile.
Casework:	Wood with a gray epoxy resin counter top, epoxy under mounted sink and wood shelving.

G. Controlled temperature room:

Floor:	Sheet (welded seam) / Rubber w/integral base*
Wall:	Prefabricated 4” thick metal clad insulated panels with baked-on white polyester finish on galvanized steel.
Ceiling:	Prefabricated 4” thick metal clad insulated panels with baked-on white polyester finish on galvanized steel.
Casework:	Stainless steel counter and integral SS sink on SS legs w/fixed shelf and SS wall shelves

* For thermal insulation the underside of the slab below the controlled temperature room shall have spray on insulation- over spray by 48” the width & length of the room

H. Autoclave Room:

Floor:	Sheet (welded seam) / rubber w/integral base
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” gypsum wallboard (GWB) with paint.
Casework:	none

I. Freezer Farm:

Floor:	Concrete /Sealed
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” natural fissure acoustic lay-in tile.
Casework:	none

J. Dark Room:

Floor:	Sheet (welded seam) / Rubber w/integral base
Wall:	5/8” gypsum wallboard (GWB) with paint.
Ceiling:	5/8” gypsum wallboard (GWB) with paint.
Casework:	wood w/plastic laminate cabinet with fiberglass developer style sink

Natural Light

Laboratories shall have access to natural light. Window treatment (shades or blinds) shall be provided where appropriate to vary the amount of natural light entering the laboratory or office. Darkrooms, tissue culture rooms, cold rooms and warm rooms shall avoid access to natural light.

Laboratory Hazard Classification

Laboratories will be Class C: low hazard as per NFPA 45 and quantities of flammable or liquid Class I, II and IIA combustible liquids shall not exceed 8 gallons per 100 square feet of laboratory unit or 400 gallons in a sprinklered laboratory unit. A typical 24” wide flammable storage cabinet located under fume hoods can hold up to 12 gallons or 48” wide flammable storage cabinet can hold up to 27 gallons. According to NFPA 45, Class C laboratory doors do not have to swing in the direction of egress and laboratory partitions do not have to be fire rated.

Vibration Criteria

Limit center bay vibration velocity to:

8,000 Microinches/second in the office and meeting rooms area

4,000 Microinches/second in the lab bench/lab desk area

2,000 Microinches/second in the support rooms area

500 Microinches/second in designated lab support zone (electrophysiology/microscopy suite)

Further, the limit in the lab bench/labdesk area of 2,000 microinches/second due to building resonances and footfall induced vibration including slow walking speed within labs and moderate walking speeds in adjacent corridors. Regions within 5' of columns shall be restricted to a vibration velocity of 600 microinches/second with inducer located at center of bay. This will provide a laboratory environment where approximately 45% of the lab is 500 - 1,000 micro-inches/second; approximately 10% are between 1,000 - 1,500 micro-inches/second; and only 20% are between 1,500 - 2,000 micro-inches/second.

Heating, Ventilating And Air Conditioning Criteria

General

The mechanical design shall be developed to meet the requirements of the osha laboratory standard, ASHRAE and the ANSI Laboratory Ventilation Standard #Z9.5.

Space Temperature And Humidity Criteria

The following inside design temperature (degrees dry bulb) and humidity (% relative humidity) conditions are recommended for all laboratory areas. Provide one thermostat per two laboratory modules, one per laboratory support room and one per office [or multiple offices facing the same side of building].

	Summer Temp	Summer Humidity	Winter Temp	Winter Humidity
A. Laboratory	72 +/-2	50% max	72 +/-2	25% min
B. Laboratory support	72 +/-2	50% max	72 +/-2	25% min
C. Office/Amenity	72 +/-2	50% max	72 +/-2	25% min
D. Freezers Rm.	72 +/-2	50% Max	72 +/-2	25% min

Ventilation Criteria

One hundred percent of the air supplied to the wet laboratory areas shall be exhausted. There shall be no recirculating of laboratory air. Supply air quantities shall be based upon heat loads, minimum dilution/ventilation requirements, and/or required make-up air for exhaust systems, whichever is greatest.

Air Change Criteria

While occupied, a minimum of 1 CFM/SF for dilution and/or removal of odors in laboratories shall be provided. Engineer shall calculate actual ACPH requirements based on exhaust device requirements and heat loads generated by equipment, people, lighting and solar heat gain.

Pressurization Criteria

All laboratories shall be negative with respect to the corridor or adjacent space, unless otherwise noted.

Filtration/Dedicated Exhaust Criteria

All laboratory areas shall be supplied with air through 30% ASHRAE (atmospheric dust spot efficiency) efficient pre-filters and 95% [or 85%] ASHRAE efficient final filters. Laboratories or equipment, which require dedicated and/or special filtration of supply or exhaust air are listed below:

A. Radioisotope fume hoods require a dedicated exhaust with carbon [and HEPA filters].

B. Class II, Type B2 biological safety cabinets (100% exhaust) may require a dedicated exhaust due to high static pressure.

C. Cold rooms will be ventilated at 0.5 CFM/square foot.

Building Operating Schedule

All laboratory mechanical, electrical and plumbing systems shall be operable 24 hours, 7 days a week with varying degrees of occupancy in a 24-hour period.

Flexibility Criteria

Air distribution systems shall be designed to afford flexibility for future redesign, primarily by providing accessibility to the duct systems throughout the facilities and, where feasible, by applying a modular layout of air distribution devices and by providing symmetry and uniformity to the branch duct layout.

Provisions shall be made to allow connection of one (1) chemical fume hood in each laboratory alcove or procedure room.

Watts/Square Foot

The HVAC system shall be sized to compensate for the following equipment heat loads (not including lights, people or solar heat gain). Any room exceeding these values may be serviced with a local chilled water fan coil unit that will recirculate and cool the room air.

	Space	watts/sf
A.	Laboratory	8
B.	Laboratory Alcove	12
C.	Lab support Rm.	12
D.	Freezers Room	16
E.	Envir Rm. (4C) provide:	4kw/room for equip. load (2 @ 20a circuits).

Noise Criteria

Ambient noise levels from the HVAC system shall not exceed NC45-50 in laboratories. Noise levels shall not exceed NC50 at 36" from the center of a fume hood with the sash 50% open.

HVAC Concept

The following HVAC concept is proposed for this facility:

Exhaust location. Each module shall be exhausted at a common location in the laboratory alcove or procedure room and can accommodate an initial or future 6' fume hood or room exhaust register.

Fume and Exhaust Hood Criteria

Chemical fume hoods shall typically be 4'-0" energy efficient bench type with vertical sashes, one 24" wide flammable base cabinet and one 24" wide corrosive acid base cabinet. Flammable base cabinets will be vented behind the fume hood baffle with 1 ½" diam. Galvanized pipe connecting to the FH exhaust above the duct collar. Fume hoods shall have an average face velocity of 92 feet per minute at 18" sash height. Fume hoods will be equipped with an audible-visual low flow alarm. The following criteria have been provided for mechanical system planning:

	Symbol description/exhaust requirement
A. Fh	4'-0" restricted sash (vertical/horizontal) bench hood: 440 CFM @ 0.22" WC.
B.	PE4 4" point exhaust: 100-150 CFM.
C.	CNPY canopy hood: 100 CFM/SF depending upon application.

Electrical criteria

Primary voltage

Laboratory areas will require 208/120 volt, 3-phase, 4 wire service for receptacles, small appliances and small (1/3 horsepower or less) motors.

Service Distribution

Each double laboratory module shall have the equivalent of 1.5 Circuit breaker panels. Each panel shall have at least 25% spare breaker capacity above initial requirements. Each 120V/20A circuit shall not exceed four (4) duplex receptacles. Alternate circuiting of adjacent duplex receptacles to minimize outages. Electrical distribution will be via surface-mounted electrical raceways at fixed wall benches and fixed island benches and overhead service distribution panels at movable benches. Duplex outlets shall be provided at a maximum of 2'-0" O.C., Unless otherwise noted. Ground fault protection will be provided for outlets within 6'-0" (distance to be confirmed by electrical engineer based on local codes) of a sink edge. Circuits shall be confined to one side of the bench to facilitate identification if the laboratory is subdivided or enlarged in the future. All receptacles, 120V and 208V, to be permanently labeled with a panel and breaker number.

Stand-by Power

It is recommended that the following items are placed on stand-by power, and this shall not be confused with life safety requirements:

A. Laboratory supply and exhaust system (60 – 75% of full load) to maintain environmental conditions, relative negative pressure of labs, exhaust from fume hoods (sash shall be completely closed in a power outage) and vented base cabinets (acid and flammable) under the hood.

B. Fume hood airflow monitor/audible–visual alarm.

C. Dedicated exhaust from radio-chemical fume hoods.

D. Environmental rooms.

E. Provide the following for freezers and incubators:

1) In-lab support zone: 2@120V/20A duplex per lab bay
2) Cell culture room: 5@120V/20A duplex.
3) Freezers room: 5@120V/20A duplex, 5@208V/20A/1PH.
4) All other "lab support" rooms: 1@120V/20A duplex per room.

Uninteruptable Power Supply (UPS) System

A central UPS system is not recommended for the laboratories. Users will be responsible to provide local UPS systems for equipment requiring this service. Emergency generator will accept load transfer within 10 seconds.

Voice/Data System

Voice/data outlets (4-gang junction box with conduit to cable tray) shall to be provided at each workstation pair, bench pair, alcove (2), equipment room (3), support room (4), office (2), conference rooms (2) and lounges (2). Provide cable tray in ler and people corridor. Provide conduit between data junction boxes and cable tray.

Artificial Lighting

The recommended illumination level to be achieved in all laboratory areas at the work surface (37" A.F.F) is 75 foot-candles. Fluorescent lighting will be acceptable in all laboratory areas except dark rooms where incandescent is required. Direct/indirect lighting fixtures are preferred in the laboratories. Provide task lighting at each workstation.

Special Wiring in Hazardous Areas

Hazardous areas and equipment shall be equipped with explosion-proof lighting fixtures, power outlets, switches and grounding (as Necessary to prevent static build-up).

Plumbing criteria

General

Piped services shall be available for potential distribution to all individual laboratories. System sizing and diversity factor to be determined by engineer.

The use of vacuum breakers on all domestic water fixtures to be evaluated by project engineer.

Cold Water System

A non-potable cold water system shall be provided to laboratory sinks, cup sinks (in fume hoods) [and safety stations (combination safety shower and eye/face wash), safety showers and eye/face wash stations] if tempered water is not employed. Capacity will be based on 1 sink outlet (3 gpm @ 35 - 40 psig) per double laboratory module, 1 cup sink outlet per fume hood and 1 sink outlet per support module.

Hot Water System

A non-potable 120° F hot water system shall be provided to laboratory sinks. Capacity will be based on 1 sink outlet (3 gpm @ 35 - 40 PSIG) per double laboratory module and 1 sink outlet per support module. Provisions for supplying water at higher temperatures for individual pieces of equipment shall be provided by dedicated steam boosters that will be supplied with the equipment.

Tempered Potable Water

A tempered potable water system shall be provided support the operation of the eyewash and safety showers.

Natural Gas

Natural gas shall be provided to selected laboratory benches, and selected lab support rooms (e.g. Microbiology lab). Capacity will be based on 1 outlets (3 CFH/outlet; all single outlets) per double laboratory module, 1 outlet per every five lab support room.

Specialty Gases

Laboratory gases (i.e. N2, H2, He, CO2, etc.) Will be provided by local use of compressed gas cylinders. Owner will furnish and install all piping, regulators, gauges, cylinders, alarms, control valves, etc

Compressed Air System

Oil free, compressed air shall be provided to laboratory benches and fume hoods laboratory at 60 psig @ -40°F dew point, 15 psi, not instrument grade. Capacity will be based on 4 outlets (1 SCFM/outlet; all single outlets) per laboratory module and 1 outlet per every two laboratory support rooms.

Vacuum System

A dry vacuum system shall be provided to laboratory benches, fume hoods and biological safety cabinets. Capacity will be based on 4 outlets (0.5 SCFM/outlet @ 15" Hg; all duplex outlets) per laboratory module and 1 outlet per every two laboratory support rooms.

Type I Reagent Grade Water System

A centralized Type I reagent grade water system with a continuous loop design shall be provided to designated laboratory sinks. Capacity will be based on 1 outlet per every four laboratory bays and 1 outlet per every five lab support rooms (0.5 Gal per hour/outlet @ 25-60 PSIG plus specific equipment consumption rates (i.e.: glassware washers and local water polishers). Local in-laboratory polishing units will be utilized

Professional association	ASTM D1193-06
A. Resistivity (megohms/cm):	18.0
B. Conductivity (microhms/cm):	5.0
C. Silicate (microg/l):	3
D. Total organic carbon (microg/l):	100
E. Sodium (microg/l)	1
F. Chlorides (microg/l)	1

Steam

A. Process steam: high pressure (60 psi) process steam shall be provided to glassware washers and other equipment with built-in steam-fired hot water temperature boosters.

B. Clean steam. High pressure (60 psi) clean steam (generated with RO water and free of all boiler additives) shall be provided to sterilizers through a central system.

Chilled/Process/Condenser Water

A. Chilled water (45-55°F) supply and return shall be provided to all water cooled environmental room condensing units, fan-coil units and specific laboratory equipment identified by owner. Chilled water for dark room processing sinks automated processors will be provided by local chiller typically part of dark room equipment package.

Floor Drains

Floor drains shall not be provided in laboratory areas except in photographic dark rooms and at specific equipment locations (i.e.: sterilizers, glassware washers, ice machines; specialized research equipment). Environmental room condensate will drain into floor drain located exterior to room and easily accessible. Floor drains at safety showers shall not be provided.

Silver Recovery

To be provided as part of the equipment fit up of the dark room.

Laboratory Waste (Drain) System

Policy and procedure will be to segregate and dispose of any toxic, radioactive or high concentration wastes through local “in-lab” safety containers, without the use of the piped waste system.

Neutralization/Monitoring

All laboratory waste will pass through a chemical neutralization system with a sampling port prior to connection to sanitary sewer [single tank with limestone chips; or single tank with limestone chips and automatic monitoring; or dual tank system with automatic tank switch-over, pH neutralization and monitoring].

Sprinkler System

All laboratory areas shall be provided with automatic wet sprinkler system protection. The system shall be designed with provisions that permit replacement of sprinkled areas with specialized local systems such as pre-action as warranted by special requirements. If a dry system is required, provide a FM 200 system.

Safety Criteria

General

It is recommended that the following safety features be provided in or accessible to each laboratory and meet osha and/or ansi requirements for configuration, operation and location.

Safety Stations

Provide safety stations consisting of a deluge shower and eye/face wash within 10 seconds travel distance from areas using chemicals. Locate safety stations at each laboratory sink (to serve lab and alcove) and 21'-4" O.C. In the linear equipment room (to serve lab support). Eye/face wash to operate independently of deluge shower. Height of eye/face washbasin, deluge shower pull ring and deluge showerhead should meet ada and ansi requirements. A safety shower shall be provided in handicap stalls in toilet rooms on lab floors.

Eye/face wash

A hand-held, counter top mounted eye, face and body wash/drench hose unit should be provided at every laboratory sink station.

Fire Extinguishers

Fire extinguishers should be located in each laboratory suite and adjacent corridor as determined by code.

Emergency Communications

A telephone should be located in each laboratory, to summon appropriate safety personnel or emergency aid.

Signage

Appropriate signage indicating, but not limited to, radioisotope, flammable, caustic, microwave or biological hazard, should be posted on each appropri-

ate laboratory entry door. Signage to be furnished by owner or accommodated in the wall mounted room name/occupants signage system, including room by room emergency egress signage.

Safety Closet or Emergency Response Team Room

Provide a central emergency response team (ERT) room in the building. Equipment will be owner furnished and installed and typically consists of the following:

A. Decontamination equipment/spill kit
B. Hepa filtered, explosion proof, wet/ dry vacuum
C. Full-face respirator
D. Tyvek suits with gloves, boots, and hoods
E. Stretcher

BioContainment Design Criteria

Architectural Criteria

Typical Planning Modules

Planning module determined by specific program requirements as developed with the client.

Ceiling Height

Minimum clear hung ceiling height shall be 9'-0" throughout.

Floor Loads

Structure shall be designed to support as a minimum, all dead loads plus a live load of 100 pounds per square foot (PSF) exclusive of partition loads. Lab areas shall be designed for a 25 PSF long term live load to account for benches and equipment, plus a 100 PSF reducible distributed live load. Local codes should govern design live load selection for the building.

Floor Vibration

At animal holding and procedure areas, velocity of slab due to walker induced vibration shall be limited to 2,000 micro inches per second.

Floor Cconstruction and Slope

A two-step structural and topping, not including final finish, concrete pour is recommended in certain areas to insure slope and drain requirements:

A. SA holding (rodent, rabbit, ferret)
floor: no slope, no floor drain (FD).
B. Decon: slope pits 1/4" per foot
to floor sink/drain.

Wall Construction

Walls shall be constructed of resinous cement panel (IR-GWB) with high-performance epoxy coating [on heavy gauge metal studs. Typically, partitions shall extend 6" above hung ceiling assembly. Designated partitions may extend to underside of structural slab for fire rating, noise (with appro-

priate sound attenuation) or cross-contamination control. See also, 1.11 – Room construction. The interior surface of the walls shall be considered the biocontainment barrier.

Corridors

Corridors shall be a minimum of 7'-0" wide. A single corridor system with suites is proposed for this facility. Aluminum [stainless-steel] wall protection shall be provided at 12" and 42" A.F.F. Clean / dirty areas will be indicated by floor colors to be determined by the architect. At least two colors will be utilized.

Doors

Doors shall be constructed and/or equipped as follows (and meet ADA requirements):

A. Minimum 48" wide by 7'-0" high @ animal holding rooms. 42" x 7'-0" doors at procedure rooms, etc. All doors shall open inward.

B. Stainless steel or [FRP door] with fully welded edges and solid filled cavity (sound attenuation / anti-vermin harborage foam material). Top and bottom to be flush, not recessed.

C. Stainless steel frame shall be fully welded (face and throat) [or FRP], epoxy grouted solid. Provide jamb guards (roller guard type), equal to LSP, mounted on corridor side.

D. Hollow metal components shall be high-performance epoxy coated.

E. Stainless steel protection plates full width of door and 36" A.F.F. in height.

F. 12"X24" view window with red laminated glass (outer layers of 1/8" clear annealed glass with inner layer of monsanto opticolor film #5557. Stainless steel closure panel on outside surface of view window is required.

G. Surface mounted sweep (adjustable) with chemical resistant brush on corridor side. Gaps shall not exceed 1/4".

H. All specified door hardware shall be set in sealant.

I. Stainless steel standard hinge continuous hinge.

J. Self-closing closer with variable delay and hold open surface mounted on room side.

K. Thresholds (if required) shall be fully epoxy grouted and installed in a bed of sealant.

L. Doors serving airlock / ante room spaces shall be electronically interlocked so that only one door may be opened at a time. In airlocks / ante rooms with more than two doors, only one shall be allowed to open at a time. All airlock doors shall be provided with emergency override feature for egress purposes.

Noise

Ambient noise levels from HVAC system shall not exceed NC35-40. Prevent acoustical levels due to intermittent activity originating outside animal holding room from exceeding background sound level by more than 10 dB.

Architectural Finishes

Following is a list of recommended architectural finishes (epoxy finishes are high solids, >95%, to minimize or eliminate off-gassing of volatile organic compounds):

A. Animal holding rooms (small animal):

Floor:	1/4" resinous epoxy [MMA] [Nor-Plan-Mega] floor with integral cove base extending 6" A.F.F.. Dudick Steri-seal HC topcoat or equal required.
Walls:	IR-GWB with reinforced high-performance epoxy coating (Tnemec 400 series with Stranlok or equal). Wall protection [stainless steel] [aluminum] required at 42" A.F.F.. [Wall protection not required; racks will be furnished with integral bumpers]

Ceiling:	IR-GWB with high-performance epoxy coating.
Casework:	none.

B. BSL-3 Labs:

Floor:	1/4” resinous epoxy [MMA] [Nor-plan-Mega] floor with integral cove base extending 6” A.F.F. Dudick Steri-Seal HC topcoat or equal required.
Walls:	IR-GWB with reinforced high-performance epoxy coating (Tnemec 400 series with Stranlok or equal). Wall protection [stainless steel] [aluminum] required at 42”A.F.F. Wall protection not required.
Ceiling:	IR-GWB with high-performance epoxy coating
Casework:	Stainless steel with solid back / void free construction. [Phenolic resin]

C. Airlock/Ante Rooms:

Floor:	1/4” resinous epoxy [MMA] [Nor-plan-Mega] floor with integral cove base extending 6” A.F.F. Dudick Steri-Seal HC topcoat or equal required.
Walls:	IR-GWB with reinforced high-performance epoxy coating (Tnemec 400 series with Stranlok or equal). Wall protection [stainless steel] [aluminum] req. at 42” A.F.F. Wall protection not required. Racks will be furnished with integral bumpers.
Ceiling:	IR-GWB with high-performance epoxy coating

D. Decon / Staging Area:

Floor:	3/8” troweled urethane mortar system with integral cove base extending 4” A.F.F. Pits shall be finished with 3/8” troweled urethane mortar system. Dudick Steri-Seal HC topcoat or equal required

Walls:	IR-GWB with reinforced high-performance epoxy coating (Tnemec 400 series with Stranlok or equal). Provide aluminum [stainless steel] wall, column, and corner protection equal to LSP Sani-rail. Sterilizer walls shall be stainless steel modular wall system.
Ceiling:	IR-GWB with high-performance epoxy coating. Provide stainless steel canopy hood above sterilizer chamber openings.

E. Main Corridor:

Floor:	3/16” troweled decorative epoxy [urethane] system. [Norplan-mega].
Walls:	IR-GWB with reinforced high-performance epoxy coating (Tnemec 400 series with Stranlok or equal). Wall protection [stainless steel] [aluminum] required at 42” A.F.F. [Wall protection not required; racks will be furnished with integral bumpers].
Ceiling:	IR-GWB with high-performance epoxy coating.

F. Personnel Entry:

Floor:	Welded seam sheet flooring equivalent to nora – Norplan Mega 3mm system with integral 6” pre-fabricated base.
Walls:	IR-GWB with high-performance epoxy coating.
Ceiling:	WGWB with high-performance epoxy coating.

G. Shower Out:

Floor:	Welded seam sheet flooring equivalent to Nora – Norplan Mega 3mm system with integral 6” pre-fabricated base. Shower floor shall be sloped to drain and shower interior flooring shall be high-performance resinous epoxy with waterproof membrane.
Walls:	Seamless solid surfacing. Shower doors to be sliding, pressure tested break-away type.
Ceiling:	WGWB with high-performance coating.

H. Mechanical Space / Interstitial Spaces:

Floor:	high-performance resinous epoxy equal to crossfield Dex-o-Tex M-Ewith waterproof membrane layer. Layout of Biocontainment Rooms below shall be impressed in flooring to indicate location above each containment room.
Walls:	Water based epoxy high-performance coating applied to IR-GWB substrate.
Ceiling:	Exposed with nitrocoat high-performance coating or equal.

Room construction:

1) Partition framing: steel stud with spacing as required by code and limiting heights. 4" CMU starter course or epoxy grout filled starter course at all partitions required.

2) Partition substrate: all gypsum wall-board (GWB) assemblies (walls and ceiling) shall have a drywall screw spacing of 6" O.C. To resist applied positive / negative pressures.

3) Partition finishes: all finishes must be applied to be monolithic and free of pinholes, dirt, debris and other protrusions. The "glove test" standard of running a nitrile glove along all surfaces shall be applied. Infrared visual testing for pinholes will be applied to all surfaces.

4) Ceilings: all ceilings must be metal framed and braced to structure to resist positive or negative pressurization of 35 PSF.

5) Casework: all casework shall be constructed to be free of internal voids to prevent contamination and vermin harborage. Additional all metal casework edges must be ground smooth and de-burred to prevent personnel injury. All casework shall be designed and provided with solid backs to facilitate decontamination.

Decontamination

All spaces to receive 1-1/2" through-ceiling ports with stainless steel ball-valves to facilitate decontamination of individual rooms. Piping arrangement on room side shall be arranged so that supply and return ports are located at opposite corners of the space. Vapor / gas decontamination generation equipment shall be located in the interstitial space above the biocontainment spaces.

Penetrations/Sealant

Special consideration shall be given to all floor, wall and ceiling penetrations to provide proper biocontainment. Following precautions are required:

A. All wall, ceiling and floor penetrations shall be sleeved and properly sealed with rtv silicone or urethane sealant to provide a smooth cleanable and airtight surface. Each penetration shall be smoke tested for integrity.

B. All device back-boxes must be specified as cast or solid and conduit must be sealed to provide barrier integrity.

C. All transitions between materials shall be sealed with RTV silicone or urethane sealant.

D. All casework, shelving, cabinetry, etc. Shall be sealed to the mounting surface to provide a smooth cleanable surface.

E. All wall, ceiling and floor transitions shall receive rtv silicone or urethane sealant.

Fixture Mounting

All wall mounted fixtures (electrical, plumbing, etc.) Shall be recess flush mounted. Lighting fixtures shall be mounted above the ceiling and shall be able to be re-lamped from the interstitial space.

Access panels

Access panels shall be located (where possible) outside of biocontainment. If access panels are re-

quired within the containment zone they shall be fully gasketed and certified gas-tight.

Windows

Windows within the biocontainment zone shall be gasketed, gas-tight, zero leakage rated windows with integral darkening blinds (except ceiling windows for illuminuation). Glazing shall be laminated and fully tempered. Ceiling windows for light fixture shall meet the same criteria.

Rack/cage Description

The basis of design cage-rack system is the tecniplast iso-cage system rack. Rack mounted turbo-fan units shall be provided with the racks.(DS: double-sided; WB: water bottle; AW: auto-watering; vMI/E: vented micro isolator with exhaust capture; PS: point supply (HEPA filtered); PE: point exhaust):

Species: Mouse

Rack Size WxLxH (in)	Cages /rack	Anmls /rack	Desc.
TBD	140	700 (5 mice/ cage max)	25g

Vermin Control

A. Pre-treatment for vermin control (boric acid or amorphous silica applied at a rate of 5g/m2 before occupancy in walls and above the ceiling.

B. Specifications should note a zero-tolerance for eating or drinking in animal areas during construction.

C. Exterior lighting near doors or vents shall be either high pressure sodium (not mercury vapor) lamps or dichrom yellow (not incandescent flood) lamps.

D. Air curtains at animal facility loading dock with 1,600 ft/min velocity

Heating, Ventilating and Air Conditioning Criteria

It should be noted that the system descriptions listed in this narrative are contingent upon University review, approval and/or budget constraints. Also, the equipment capacities listed are approximate.

Exact capacities will be determined during the subsequent design phases of this project.

HVAC Concept

Following HVAC concept is proposed for this facility:

HVAC concept. HVAC system shall be pressure-independent, variable air volume (VAV) with the following number of air changes / hr (ACH)/zone type:

I. For non-containment (NC), 6-10 ACH
II. For containment level 3 (BSL3 labs),10-12 ACH
III. For containment level 3 in the animal rooms (ABSL3 rooms), 15 ACH

There will be 3 operating modes for the containment zones:

A. 1- Normal (set at 10-15 ACH) depending on room type

B. Set-back (weekends and nights) (labs only)- this may be integrated with occupancy sensors (set at 4-6 ACH).

C. Room shut down (when rooms are taken off-line for decontamination. The commissioning program shall have various operating scenarios testing this requirement.

B. Energy conservation/pressurization adjustment. Potential to reduce air changes per hour (ACPH), go to an unoccupied set-back in a particular room (or rooms) or change pressurization shall be accommodated. Acph reduction, unoccupied set-back or pressurization change shall be controlled by building management system (BMS). All-setback conditions must not compromise negative directional airflow. Potential to employ a heat recovery system shall be evaluated by engineer.

C. Controls. All controls shall be direct digital control (DDC).
Location. Where interstitial space is not available, avoid locating serviceable components (boxes, terminal reheat units, etc.) Above animal holding room ceilings.

D. Ventilated racks/point supplies and exhausts. Supply and exhaust in all animal holding rooms shall be designed to accommodate conventional and/or ventilated racks. Ventilated racks shall require snorkel connections in ceiling for rack 3" diameter supply (HEPA filtered) and 4" diameter exhaust. Racks shall be supplied from a supplemental air system for each room that takes room air, passes it through a HEPA filter/blower, and then distributes air to each ventilated rack in room.

E. Probes. Temperature duct pressure/temperature and humidity sensors shall be located as much as is possible outside of the potentially contaminated airstream. Room side sensors shall be located to not be influenced by local disturbances.. All pressure sensors located in the contained rooms or ducts shall be filtered with 0.2 Micron filter (e.g. Matheson or millipore). All duct sensors shall be accessible for maintenance.

F. Dedicated exhaust. Provide a dedicated exhaust system for decon / sterilzer area due to saturated vapor content. Ductwork shall slope to drain. Enclosed equipment areas for washers and sterilizers shall be highly ventilated to prevent build-up of heat and moisture. Hydro-phobic HEPA filters are required in this area.

G. Terminal reheats. Terminal reheats shall fail closed.

H. Biological safety cabinets. All biological safety cabinets used with anesthetic gas shall be Class II/Type B2 (100% exhaust).

I. Humidification. Clean steam (generated with RO water)] shall be used for all humidification purposes.

J. Building management system (BMS). A single BMS for entire building will be provided. A dedicated, redundant system for biocontainment facility (i.e.: Edstrom or Rees) shall be provided.

HVAC organization

All serviceable HVAC components shall be located in the dedicated interstitial space located directly above the biocontainment zone. Valves, filters, controls, controllers, etc. Shall be tagged with applicable room numbers.

HVAC ductwork

Ductwork serving the biocontainment zones shall meet the following minimum standards. Fully welded ductwork shall be tig welded as to provide a smooth, burr free surface on the inside of the ductwork. Fully welded ductwork is required on the potentially contaminated side of the HEPA filter and up to the bio-seal isolation dampers.

Ductwork Location	Pressure Class in. W.G.	Seal Class	Leakage Class	Material
ABSL-3 supply ductwork from air-device to bubble-tight damper	+6*	A Welded	0	316 SS
All Bio-containment dedicated exhaust to HEPA filter	-6*	A Welded	0	316 SS

*To be confirmed against system capacity.

Space Temperature and Humidity Criteria

Capability to adjust individual room dry bulb temperatures in 1°F increments between 68 - 81°F and maintain a relative humidity of 30 - 60% RH throughout the year is required. A thermostat for each room is required. Humidification and dehumidification may be required. Any deviation from set point should occur gradually, typically over several hours. Following inside design temperatures and humidity conditions are typical for following species and are provided for information only (use the above design guidelines):

Species/space	dry-bulb temp (°F)
A. Mouse, rat	64 - 79
B. Rabbit	61 – 72
C. Pig	61 - 81

Ventilation Criteria

Dedicated, single-pass, directional and pressure gradient ventilation systems must be used. 100% Outside air must be used to supply the biocontainment zone and no re-circulation is allowed. Supply air criteria shall be determined by directional airflow (for biocontainment control). Supply and exhaust fans shall be interlocked to prevent over pressurization of biocontainment spaces upon fan failure.

Air Change Criteria

Ventilation of animal holding rooms shall be a minimum of 8 and a maximum of 20 (to be confirmed by engineer) fresh air changes per hour (ACPH). The maximum ACPH shall be based on calculations performed by engineer. Determination of primary and secondary enclosures may affect the minimum ACPH recommendation. Engineer shall confirm that minimum and maximum ACPH requirement is sufficient to off-set heat rejection from fully occupied cages/racks, 4 human occupants, lighting and 2 animal transfer stations. Heat generated from animals shall be calculated using average-total-heat-gain formula published by ASHRAE. Static pressure reduction caused by filter loading should be taken into account when establishing air change criteria.

Air Movement (Pressurization) Criteria

Design of HVAC system shall ensure negative, cascading airflow from areas of least hazard toward areas of most potential contamination. A minimum of .25" W.G. Of negative pressure between spaces is required. Supply and exhaust fan systems shall be interlocked to prevent over-pressurization of biocontainment spaces during fan failure scenarios.

Space	Air Movement Relationship to Adj. Area
In progress	TBD

Filtration Criteria

All room supply air should be filtered fresh air through 30% and 95% ASHRAE (atmospheric dust spot efficiency) filters. Room-side replaceable 99.97% HEPA final filter shall be provided in all biocontainment spaces. All HEPA filters must be able to be decontaminated in place before removal. Also, all HEPA filters must be able to be certified in-situ. [Bag-in-bag-out (BIBO) HEPA filters shall be located directly above the biocontainment spaces served in the interstitial space. Each filter housing shall be provided with decontamination ports, scan section, PAO injection port and recovery port.]

Building Operating Schedule

All mechanical, electrical and plumbing systems are expected to operate 24 hours, 7 days a week with varying degrees of occupancy in a 24 hour period.

Flexibility Criteria

Air distribution systems shall be designed to afford flexibility for future redesign, primarily by providing accessibility to duct systems throughout facility and, where feasible, by applying a modular layout of air distribution devices and by providing symmetry and uniformity to branch duct layout. 20% Spare capacity on all airflow systems is required.

Redundancy

Independent and dedicated N+ 1 redundant supply and exhaust fan systems shall be provided for the biocontainment spaces in the facility. Each fan unit shall be sized to accommodate 100% of the total load, however, under normal operation they will be utilized at 50%.

Building Management System

Building management system (BMS) shall monitor and/or control following in all rooms:

A. Monitor temperature and humidity with an accuracy of +/-1°F and +/-5% RH

B. Control temperature and humidity within +/-2°F and +/-10% RH of set point

C. Monitor and control air flow (supply/exhaust cfm and room air changes per hour) with an accuracy of +/-5%.

D. Monitor pressure relationship relative to adjacent spaces. Provide protected outside air reference line to establish baseline.

E. Control animal level lighting on an adjustable time and duration schedule.

F. Monitor animal level lighting state (on or off) with a photocell.

Central Control

Provide a PC type computer to perform following tasks on a room by room basis.

A. Set high/low warning and emergency alarm limits for temperature (+/-2° and +/-4°F from range), humidity (below 30% and above 70%), supply air flow (+/-15% and +/-20% from set point), exhaust air flow (+/-15% and +/-20% from set point) and pressure relationship deviation (+1 minute and +5 minutes). Record all alarm occurrences compliant with cdc regulations (one year recording time is required). Display shall be green for acceptable, yellow for warning and red for emergency.

C. Alarm upon pressurization loss or space directional airflow loss. Local horn-strobe alarms as well as building automation system notification is required.

D. Set time and duration of animal level lighting. Record and alarm all lighting states that do not conform to set times.

E. Provide written system log reports (continuous chronological list of all alarm conditions system wide), daily environmental reports (temperature, humidity, air flow and pressure average over 24-hour period with high and low value and time of occurrence), daily alarm reports (chronological list of all alarm conditions over 24-hour period by room) and selective historical reports.

F. Certain system parameters shall be monitored and controlled locally and remotely.

G. System shall be equipped with a telephone and ip addressable network [and/or pager] alarm system. System can be programmed to send selected alarm parameters of specific duration (condition is not corrected in a specified amount of time) to one or more telephone [and/or pager] numbers. Voice [and/or digital pager read-out] will state alarm parameter and room number (i.e.: "High temperature, room 104").

H. All system parameters and formats (displays, alarms, reports) shall be coordinated with animal care staff. Central control for animal facility shall only control and monitor animal facility, not entire building.

Local Controls

Provide following at each animal holding room door mounted in corridor:

A. Digital temperature monitor.
B. Digital relative humidity monitor.
C. Digital relative pressure monitor [baulin-tube] relative pressure monitor must be visible from both sides of the door.

Animal Room Exhaust Filters

In progress.

Supply/Exhaust

Air shall be supplied and exhausted in animal holding room as indicated below (PS: point supply (HEPA filtered); PE: point exhaust). Supply and exhaust shall be located as far apart as possible to facilitate through room flow.

Space	Supply	Exhaust
SA holding	ceiling (center, door)	Ceiling (in 2-4 corners), PE

Electrical Criteria

Stand-by Power

Stand-by power shall be provided to maintain the following (in addition to life safety requirements):

A. Animal holding room environmental parameters.
B. Cage-rack supply and exhaust blower units.
C. Designated emergency power receptacles colored red.
D. Freezer or cryo-preservation unit locations

Lighting

Each animal holding room and internal suite corridor shall be equipped with 3 independently controlled lighting systems, one for animals and two for humans. The three systems are as follows:

A. Animal white (T8 full spectrum fluorescent). Animal lighting system shall provide a programmable, automatic day/night cycle on an adjustable time and duration schedule with photocell confirmation of cycle controlled and monitored by the BMS. Animal lighting system shall provide 30-35 fc at 3' A.F.F. Suite corridors shall be controlled by this system as well.

B. Human white (T8 full spectrum fluorescent). Human fluorescent lighting system shall be manually controlled by an integral light switch/one-hour timer

mounted inside animal room near door. Lights shall flicker five minutes before shut-off. Human lighting system shall provide 70-100 fc at 3' A.F.F. Human and animal lighting systems can be accommodated in same multi-bulb fixture. Human light level cannot override animal night cycle (no white light during night cycle).

C. Human red (T8 full spectrum fluorescent with red film). Human red light system shall be manually controlled by an integral light switch/one-hour timer mounted outside animal room near door. Lights shall flicker five minutes before shut-off. Human red light system shall provide 15 fc at 3' A.F.F. Human and animal lighting systems can be accommodated in same multi-bulb fixture.

All lighting systems located in procedure areas (procedure rooms, laboratory spaces, any space with a biological safety cabinet) shall be provided with emergency battery ballasts to maintain continous operation in the event of power outage. All lamps shall be replaceable from the interstitial space above the biocontainment facility.

Special Electrical Fixtures

All electrical fixtures (i.e.: Electrical receptacles, data/telephone jacks, lighting fixtures, light switches, etc.) Shall be gas-tight and weatherproof while in use type. Electrical back-boxes must be cast or fully welded and conduit must be sealed to prevent breach of barrier.

Electrical Outlets

All rooms shall be equipped with wall mounted 120V/20A duplex electrical outlets mounted 4'-0" A.F.F. Outlets in animal holding rooms for rack-mounted blower units shall be mounted at 7'-0" A.F.F. See also requirements under Special Electrical Fixtures.

Data/Telephone System

All designated rooms shall be equipped with wall-mounted telephone/data quad junction box with capped conduit and waterproof cover plate. Provide cell-phone and pager capability throughout

facility. Telemetry system for chip-embedded animals shall be provided in all [or designated] animal holding rooms and specialty procedure rooms (i.e.: behavioral core). Data cabling must be gel filled type to prevent biocontainment breach.

Security System

A proximity based access system with a personal identification device shall be provided for at each entry/exit and animal holding room door and designated spaces. A closed-circuit television (CCTV) system shall be provided to monitor each entry/exit door and designated locations. Security system shall be controlled and monitored locally and remotely.

Power Distribution

Distribution panels for each ABSL-3 shall be located directly above the suite served in the dedicated interstitial space. Sub-panels required within Biocontainment shall be NEMA-4X type.

Plumbing criteria

Piping Systems

All pipes that pass through containment should have sealed pipe sleeves and zero leakage collars. Suggested piping materials by type:

Potable water:	Type K copper
Incoming service:	Steel- sched 40
Fire distribution:	Steel- sched 40
Steam piping:	Sched 80 with welded fittings
Chilled water:	Type L / steel sched 40, victaulic
Refrigerant piping:	Type L hard copper seamless with brazed joints
Drain lines through containment:	304L stainless steel
Traps in containment:	Lab-grade polypropylene
Effluent lines inside containment:	Lab-grade polypropylene
Effluent lines prior to EDS:	304L Stainless steel [double walled polypropylene]
Effluent lines down stream (post) eds:	Black iron –sched. 40

Hand Wash Sink

Provide potable hot and cold water at each fixed hand wash sink with infrared and wrist-operated controls. Hand wash sink shall be stainless steel. Provide liquid soap, glove and paper towel dispensers (type to be determined) near each hand wash sink. Hand wash sinks shall have an approved back-flow device.

Traps

All traps leaving the biocontainment zone shall be polypropylene [316L stainless steel] deep seal type with trap seals 125mm minimum depth.

Hose-bib

Provide potable hot and cold water at each hose-bib. Provide mop rack near each hose-bib station. Hose-bibs shall have an approved back-flow device.

Floor Drains

Floor drains shall not be installed within biocontainment.

Steam

Provide high pressure (>60 psi) steam to washers and sterilizers [or jackets only].

Clean Steam

Provide high pressure (>60 psi) clean steam generated with RO water to sterilizers [or chambers only]. Clean steam generated with RO water does not affect standard polycarbonate cages and does not require stainless steel piping skids for sterilizers (brass is acceptable). Clean steam distribution shall be 316 in stainless steel piping.

Hot Water

Provide 110°F water to hand wash sinks, hose bibs, washers and showers.

Hot Water Discharge

Local codes may not allow discharge of >140°F water into sanitary sewer from washing equipment. Provide integral cool-down system utilizing building chilled water system to conserve potable water

on washers and sterilizers if required. Waste piping below sterlizers

Neutralization

pH neutralization / equalization will be specified as part of the caustic digester equipment and will conform with applicable codes.

Safety Stations

Provide following personnel safety equipment where designated:

A. Safety station (SS): combination deluge shower/ full face wash (typically in internal suite corridors).

B. Eye wash (EW): hand-held hose-type eye wash/ drench hose (typically in procedure rooms).

All eyewash stations within biocontainment shall be surface mounted with all valving and actuation exposed to avoid potential contamination voids.

Specialty Gases/Services

Provide following specialty gases/services to all procedure rooms and laboratories through a central distribution system. Oxygen (O2) and carbon dioxide (CO2) require all piping components and fixtures to be lubricated, cleaned, capped, protected and delivered certified for “oxygen service”. Provide local shut-off valves as required by code. Double backflow preventers are required on all gas lines.

A. Natural gas (G). Fixtures to have serrated ends.
B. Laboratory vacuum (V). Fixtures to have ser rated ends.
C. Carbon dioxide (CO2). Provide CO2 manifold system from cylinder closets to procedure rooms. Fixtures to have serrated ends.
D. Oxygen (O2). Provide O2 manifold system from loading dock to procedure rooms. Fixtures to have serrated ends.
E. Reagent grade water (RGW). RGW shall be point-of-use polished from city-water.

Reagent Grade Water

Reagent grade water shall be provided by point-of-use water polishing systems capable of refining city-grade water to type I water. No re-circulating or loop systems shall enter the biocontainment zone.

Fire Protection/Sprinkler System

Provide exposed sprinkler heads. A low-frequency alarm (<20,000 Hz) is recommended to minimize animal discomfort and sensitivity (if allowable by code). A red strobe light is preferred over white strobe light. High-heat sprinkler heads are required adjacent to autoclave/sterilizer locations, if allowable by code, HI-FOG high-pressure mist fire suppression system shall be considered to limit the amount of potentially contaminated wastewater.

Estimated effluent discharge volumes. The following table shall be used to size the effluent decontamination system.

Device	Sink	Shower	Wash-Downs	Auto Clave	WC
# of Units					
#Use/Day					
Duration of Use					
Discharge Rage (gmp)					
Daily Discharge					

Effluent Decontamination System

All liquid effluent leaving the biocontainment zone shall be routed via fully welded 316 [304L] stainless steel piping to a direct injection steam batch biological decontamination system. Surge/ settling tanks to be sized to allow for 48hrs of accumulation

of fully loaded facility effluent output before transfer to steam “cook” tanks. Redundant tanks are required. System shall have capability to inactivate liquid effluent by maintaining 250°F cook for 100 minutes.

Vivarium Design Criteria

Architectural criteria

Typical planning modules

Planning module determined by specific program requirements as developed with the client using combined and/or subdivided spaces for economy.

Ceiling Height

Minimum clear hung ceiling height shall be 9'-0" throughout, except 10'-0" clear is preferred in cage wash area.

Floor Loads

Structure shall be designed to support as a minimum, all dead loads plus a live load of 100 pounds per square foot (PSF) exclusive of partition loads. Lab areas shall be designed for a 25 PSF long term live load to account for benches and equipment, plus a 100 PSF reducible distributed live load. Local codes should govern design live load selection for the building.

Floor Vibration

At animal holding, procedure areas, behavioral rooms, or suite, and breeding areas; velocity of slab due to walker induced vibration shall be limited to 2,000 micro inches per second. Other Vivarium areas shall be designed to 4,000 MIPS. Imaging areas shall be isolated and designed to 500 MIPS or to specific requirements as defined by equipment platform selected.

Floor Construction and Slope

A two-step structural and topping, not including final finish, concrete pour is recommended in certain areas to insure slope and drain requirements. Trench drains shall be formed concrete, prefabricated units are not acceptable. Slope floor, pit or trench to drain as noted below (all slope dimensions per foot and minimum; SA: small animal; LA: large animal):

A. SA Holding (rodent, rabbit, ferret)
floor: no slope, no floor drain (FD).
B. LA Holding (pig)

floor: slope to 1/8"; slope to 12" wide trench drain

C. Cage Wash
floor: slope to 12" wide trench drain (TD) 1/8".
Equipment pit: slope to FD 1/4".

D. Acid/detergent storage
floor: slope floor to dry sump,
capacity 240 gallons.

E. Janitor's closets
floor: no slope, no floor drain or dry sump pump.

Wall Construction

Walls shall be constructed of impact resistant gypsum wall-board (IR-GWB) on heavy gauge metal studs, except where noted otherwise. Typically, partitions shall extend 6" above hung ceiling assembly. Designated partitions may extend to underside of structural slab for fire rating, noise (with appropriate sound attenuation) or cross-contamination control. See also, Room Construction.

Corridors

Corridors shall be a minimum of 7'-0" wide. A single corridor system with suites is proposed for this facility. Aluminum wall protection shall be provided at 12" and 42" A.F.F. Clean / dirty areas will be indicated by floor colors to be determined by the architect.

Doors

Doors shall be constructed and/or equipped as follows (and meet ada requirements):

A. Minimum 48" wide by 7"-0" high @ animal holding rooms. 42" x 7'-0" doors at procedure rooms, etc.

B. Hollow metal or [FRP door] with fully welded edges and solid filled cavity (sound attenuation / anti-vermin harborage foam material). Top and bottom to be flush, not recessed.

C. Hollow metal frame shall be fully welded (face and throat) [or FRP], epoxy grouted solid. Provide jamb guards (roller guard type), equal to life science products inc., Mounted on corridor side.

D. Hollow metal components shall be high-performance epoxy painted.

E. Stainless steel protection plates full width of door and 36" A.F.F. in height. Door handle protectors shall be provided on the corridor side.

F. 12"X24" view window with red laminated glass (outer layers of 1/8" clear annealed glass with inner layer of monsanto opticolor film #5557, is required at all animal holding rooms stainless steel closure panel on outside surface of view window is required.

G. Surface mounted sweep (adjustable) with chemical resistant brush on corridor side. Gaps shall not exceed 1/4".

H. All specified door hardware shall be set in sealant.

I. Stainless steel standard hinge continuous hinge.

J. Self-closing closer with variable delay and hold open surface mounted on room side.

K. Thresholds (if required) shall be fully epoxy grouted and installed in a bed of sealant.

L. Doors serving airlock / ante room spaces shall be electronically interlocked so that only one door may be opened at a time. In airlocks / ante rooms with more than two doors, only one shall be allowed to open at a time. All airlock doors shall be provided with emergency override feature for egress purposes.

Noise

Ambient noise levels from HVAC system shall not exceed NC35-40. Prevent acoustical levels due to intermittent activity originating outside animal holding room from exceeding background sound level by more than 10 dB. In behavioral study areas, walls shall be constructed with a sound transmission coefficient of STC30 and an ambient noise criterion of NC30 from HVAC system.

Architectural finishes

Following is a list of recommended architectural

finishes (epoxy finishes are high solids, >95%, to minimize or eliminate off-gassing of volatile organic compounds):

A. Animal Holding Rooms (Small Animal):

Floor:	3/16” troweled decorative urethane [epoxy] system with integral cove base extending 6” A.F.F.
Walls:	impact resistant GWB with high-performance epoxy coating. Aluminum wall protection at 42” A.F.F. Exposed exterior corners to receive 7’-0”h x 3” x 3” stainless steel corner guards. [Wall protection not required; racks will be furnished with integral bumpers.]
Ceiling:	IR-GWB with high-performance epoxy coating.
Casework:	none.

B. Animal Holding Rooms (Large Animal):

Floor:	1/4” troweled urethane mortar system with integral cove base extending 6” A.F.F.
Walls:	Fiber resin gel-coated cement panel (Arcoplast or equivalent). Stainless steel pens required. Exposed exterior corners to receive 7’-0”h x 3” x 3” stainless steel corner guards.
Ceiling:	Fiber resin gel-coated cement panel (Arcoplast or equivalent)
Casework:	none

C. Procedure Rooms

Floor:	3/16” troweled decorative urethane [epoxy] system with integral cove base extending 6” A.F.F.
Walls:	IR-GWB with high-performance epoxy coating. Exposed exterior corners to receive 7’-0”h x 3” x 3” stainless steel corner guards.
Ceiling:	IR-GWB with high-performance epoxy coating.

Casework: stainless steel bench-top [epoxy] [phenolic resin] with integral back splash. Phenolic resin [stainless steel] cabinetry.

D. Cage Wash, Storage, Laundry, Animal Receiving

Floor: 1/4” trowled urethane mortar system [1/4” Novalac epoxy] floor with integral cove base extending 6” A.F.F. Equipment pits shall be finished with crossfield Dex-o-Tex Tek-Crete or equivalent. Trench drains and drainage pits shall be covered with a fiberglass grate equal to chemgrate.

Walls: Impact resistant GWB with high-performance epoxy coating. Provide aluminum wall, column, and corner protection equal to LSP Sani-rail in cage wash and animal receiving only. [Fiber resin gel-coated cement panel]

Ceiling: WGWB with hp-epoxy coating. Provide stainless steel canopy hood above washer and sterilizer chamber openings. [Fiber resin gel-coated cement panel (Arcoplast or equivalent)]

E. Main Corridor

Floor: 3/16” troweled urethane mortar system [1/4 novolac epoxy]

Walls: IR-GWB with high-performance epoxy coating. Provide aluminum/ stainless wall, column, and corner protection equal to LSP Sani-rail @ 12” and 42” A.F.F.

Ceiling: Mylar face act

F. Sub Corridors

Floor: 3/16” troweled decorative urethane [epoxy] system

Walls: IR-GWB with high-performance epoxy coating. Provide aluminum/ stainless wall, column, and corner protection equal to LSP Sani-rail @ 12” and 42” A.F.F.

Ceiling:	IR-GWB with high-performance epoxy coating.

G. Break

Floor:	vinyl composite tile (vct) with a 4" high applied vinyl cove base.
Walls:	Gypsum wall board (GWB) with paint.
Ceiling:	Lay-in acoustic tile.

H. Locker Rooms / Personnel Entry:

Floor:	Welded seam sheet flooring equivalent to Nora – Norplan Mega 3mm system with integral 6" pre-fabricated base and corners.
Walls:	IR-GWB with high-performance epoxy coating.
Ceiling:	WGWB with high-performance epoxy coating.

I. Mechanical Space / Interstitial Spaces:

Floor:	High-performance resinous epoxy equal to crossfield Dex-o-Tex M-E with waterproof membrane layer.
Walls:	Exposed.
Ceiling:	Exposed..

Room Construction

1) Partition framing: steel stud with spacing as required by code and limiting heights. Stud sizes to accommodate all recessed devices/equipment such as electrical panels, fire extinguisher cabinets, etc. 4" CMU starter course or epoxy grout filled starter course at all partitions required.

2) Partition substrate: all gypsum wall-board (GWB) assemblies (walls and ceiling) shall have a drywall screw spacing of [TBD] to resist applied positive / negative pressures.

3) Partition finishes: all finishes must be applied to be monolithic and free of pinholes, dirt, debris and other protrusions.

4) Ceilings: all IR-GWB ceilings shall be fully reinforced with all-thread hangers and reinforcement spacers at no more than 36" O.C.

5) Casework: all casework shall be constructed to be free of internal voids to prevent contamination and vermin harborage. Additionally all metal casework edges must be ground smooth and de-burred to prevent personnel injury. All casework shall be designed and provided by solid backs to facilitate decontamination.

Decontamination

All spaces to receive 1-1/2" through-wall ports with stainless steel ball-valves to facilitate decontamination of individual rooms. Valves shall be placed on the outside of the room to be decontaminated. Piping arrangement on room side shall be arranged so that supply and return ports are located at opposite corners of the space.

Penetrations/Sealant

Special consideration shall be given to all floor, wall and ceiling penetrations to provide proper vermin control and decontamination support. Following precautions are required:

A. All wall, ceiling and floor penetrations shall be properly sealed with rtv silicone or urethane sealant to provide a smooth cleanable surface.

B. All transitions between materials shall be sealed with rtv silicone or urethane sealant.

C. All casework, shelving, cabinetry, etc. Shall be sealed to the mounting surface to provide a smooth cleanable surface.

D. All wall, ceiling and floor transitions shall receive rtv silicone or urethane sealant.

Fixture Mounting

All wall mounted fixtures (electrical, plumbing, etc.) Shall be recess flush mounted. All ceiling fixtures shall be recessed and gasketed to prevent vermin harborage.

Access Panels

Access panels shall be located outside of animal holding rooms and procedure spaces. If access panels are required within the ahr's or pr's they shall be fully gasketed.

Windows

Windows within the animal facility shall be gasketed windows with integral darkening blinds. Glazing shall be laminated and fully tempered.

Rack/Cage Description

The basis of design cage-rack system is the tecniplast "slimline" rack. Rack mounted turbo-fan units shall be provided with the racks.(DS: double-sided; wb: water bottle; aw: auto-watering; vMI/E: vented micro isolator with exhaust capture; PS: point supply (HEPA filtered); PE: point exhaust):

Species:	Mouse	Rat	Rabbit	Ferret
Rack Size: WxLxH (in.)	TBD	TBD	TBD	TBD
Cages/Rack:	140			
Anmls/Rack:	700 (5 mice/cage max.)			
Anml Wght.:				
Description:				

Vermin Control

A. Pre-treatment for vermin control (boric acid or amorphous silica applied at a rate of 5g/m2 before occupancy in walls and above the ceiling.

B. Specifications should note a zero-tolerance for eating or drinking in animal areas during construction.

C. Exterior lighting near doors or vents shall be either high pressure sodium (not mercury vapor) lamps or dichrom yellow (not incandescent flood) lamps.

D. Air curtains at animal facility loading dock with 1,600 ft/min velocity

Heating, Ventilating and Air Conditioning Criteria

General

Recommendations from most recent guide for care and use of laboratory animals, published by the national research council (the "guide") shall be used as basis for all minimum HVAC requirements.

HVAC concept

Following HVAC concept is proposed for this facility:

A. HVAC concept. HVAC system shall be pressure-independent, variable air volume (VAV) with a minimum (8 and maximum 20) ACPH established for animal holding rooms.

B. Energy conservation/pressurization adjustment. Potential to reduce air changes per hour (ACPH), go to an unoccupied set-back in a particular room (or rooms) or change pressurization shall be accommodated. Acph reduction, unoccupied set-back or pressurization change shall be controlled by building management system (BMS). Potential to employ a heat recovery system shall be evaluated by engineer.

C. Controls. All controls shall be direct digital control (DDC). Controls to maintain pressure gradients shall be passive in lieu of active in non-ABSL3 areas. Controls shall be via edstrom watchdog system. Animal holding, procedure, behavioral, imaging and or suite rooms shall have individual control of temperature, humidity and lighting.

D. Location. Serviceable components (boxes, terminal reheat units, valves, etc.) Shall not be located above animal holding room ceilings. Serviceable components shall be located above the central corridor outside of the animal holding suites. In the event that components must be located above animal holding suite ceilings, these must be reviewed

and approved on a case-by-case basis with the architect.

E. Ventilated racks/point supplies and exhausts. Supply and exhaust in all animal holding rooms shall be designed to accommodate conventional and/or ventilated racks. Racks shall be supplied from a rack mounted supplemental air system. This supplemental rack supply system shall be capable of adjusting inside cage temperature (by adjusting the room temperature) and inside cage air changes per hour (by adjusting the speed of the HEPA filter/blower) on a room-by-room basis. One point exhaust thimble / snorkel with iris damper shall be provided for each cage rack location. Cage rack manufacturer shall provide load simulators for each point-exhaust.

F. Probes. Temperature and humidity probes shall be located within the ducts and shall be accessible from corridor.

G. Dedicated exhaust. Provide a dedicated exhaust system for cage wash area due to saturated vapor content. Ductwork shall be stainless steel, fully welded and slope to drain. Enclosed equipment areas for washers and sterilizers shall be highly ventilated to prevent build-up of heat and moisture.

H. Terminal reheats. Terminal reheats shall fail closed.

I. Biological safety cabinets. All biological safety cabinets used with anesthetic gas shall be Class II/Type B2 (100% exhaust). Interlocks between the II/B2 BSC blower unit and the exhaust fans shall be provided.

J. Humidification. Clean steam (generated with RO water) shall be used for all humidification purposes.

K. Building management system (BMS). A single BMS for entire building will be provided. A dedicated, redundant system for animal facility (i.e.: Edstrom or rees) shall be provided.

Space Temperature and Humidity Criteria

Capability to adjust individual room dry bulb tem-

peratures in 1°F increments between 68 - 81°F and maintain a relative humidity of 30 - 60% RH throughout the year is required. A thermostat for each room is required. Humidification and dehumidification may be required. Any deviation from set point should occur gradually, typically over several hours. Following inside design temperatures and humidity conditions are typical for following species and are provided for information only (use the above design guidelines):

	Species/space	dry-bulb temp (°F)
A.	Mouse, rat, ferret	64 - 79
B.	Rabbit	61 - 72
C.	Pig	61 - 81

Ventilation Criteria

One hundred percent of air supplied to animal facility shall be outside air and will be exhausted. There shall be no recirculation of this air. Supply air quantities shall be based upon heat loads, minimum dilution/ventilation requirements, and/or required make-up air for exhaust systems, whichever is greatest.

Air Change Criteria

Ventilation of animal holding rooms shall be a minimum of 8 and a maximum of 20 (to be confirmed by engineer) fresh air changes per hour (ACPH). The maximum ACPH shall be based on calculations performed by engineer. Determination of primary and secondary enclosures may affect the minimum ACPH recommendation. Engineer shall confirm that minimum and maximum ACPH requirement is sufficient to off-set heat rejection from fully occupied cages/racks, 4 human occupants, lighting and 2 animal transfer stations. Heat generated from animals shall be calculated using average-total-heat-gain formula published by ASHRAE. Static pressure reduction caused by filter loading should be taken into account when establishing air change criteria.

Air Movement (pressurization) Criteria

Design of HVAC system shall accommodate potential to adjust initial air movement (or relative pressure) of any space in future. Areas, which require positive and continuous control, are noted

with “out” or “in” to indicate required direction of air movement in relation to space named (this designation was previously described as “positive” or “negative” pressure). Rate of air movement may be varied as needed within limits required for positive control. Where indication of air movement is enclosed in parentheses, continuous directional control is required only when room or equipment within room is in use. Air movement for spaces noted as neutral may vary as NECessary to satisfy requirements. Additional adjustments may be needed when space is unused or unoccupied and air systems are shut down or reduced. Initial air movement relationship to adjacent areas should be as follows:

Space	Air Movement Relationship to Adj. Area
TBD	

Filtration Criteria

All room supply air should be filtered fresh air through 30% and 95% ASHRAE (atmospheric dust spot efficiency) filters. A 99.97% HEPA final filter shall be provided for rodent procedure rooms, rodent behavioral testing rooms, imaging, and operating rooms, only (animal holding rooms shall have supplemental HEPA/blower system at the cage-rack level).

Building Operating Schedule

All mechanical, electrical and plumbing systems are expected to operate 24 hours, 7 days a week with varying degrees of occupancy in a 24 hour period.

Flexibility Criteria

Air distribution systems shall be designed to afford flexibility for future redesign, primarily by providing accessibility to duct systems throughout facility and, where feasible, by applying a modular layout of air distribution devices and by providing symmetry and uniformity to branch duct layout.

Redundancy

Redundant and parallel systems are required for supply, exhaust, heating and cooling so that environmental conditions can be maintained in animal holding rooms with one unit out of service.

Building Management System

Building management system (BMS) shall monitor and/or control following in all rooms:

A. Monitor temperature and humidity with an accuracy of +/-1°F and +/-5%RH.

B. Control temperature and humidity within +/-2°f and +/-10%RH of set point.

C. Monitor and control air flow (supply/exhaust CFM and room air changes per hour) with an accuracy of +/-10%.

D. Monitor pressure relationship relative to corridor or adjacent space derived from summing supply/exhaust airflows in non-ABSL3 areas.

E. Control animal level lighting on an adjustable time and duration schedule.

F. Monitor animal level lighting state (on or off) with a photocell.

Central Control

Provide a computer controlled building automation system by edstrom industries – watchdog system, to perform following tasks on a room by room basis:

A. Set high/low warning and emergency alarm limits for temperature (+/-2° and +/-4°F from range), humidity (below 30% and above 70%), supply air flow (+/-15% and +/-20% from set point), exhaust air flow (+/-15% and +/-20% from set point) and pressure relationship deviation (+1 minute and +5 minutes). Record all alarm occurrences. Display shall be green for acceptable, yellow for warning and red for emergency.

B. Set time and duration of animal level lighting. Record and alarm all lighting states that do not conform to set times.

C. Provide written system log reports (continuous chronological list of all alarm conditions system wide), daily environmental reports (temperature, humidity, air flow and pressure average over 24-hour period with high and low value and time of occurrence), daily alarm reports (chronological list of all alarm conditions over 24-hour period by room) and selective historical reports.

D. Certain system parameters shall be monitored and controlled locally and remotely.

E. System shall be equipped with a telephone [and/or pager] alarm system. System can be programmed to send selected alarm parameters of specific duration (condition is not corrected in a specified amount of time) to one or more telephone [and/or pager] numbers. Voice [and/or digital pager read-out] will state alarm parameter and room number (i.e.: "High temperature, room 104").

F. All system parameters and formats (displays, alarms, reports) shall be coordinated with animal care staff. Central control for animal facility shall only control and monitor animal facility, not entire building.

G. Deactivate sensors when room cleaning is in progress. Local keyed override to be provided.

Local Controls

Provide following at each animal holding room door mounted in corridor:

A. Digital temperature monitor.
B. Digital relative humidity monitor.
C. Digital relative pressure monitor [through-the-wall tube with ball].

Animal Room Exhaust Filters

Provide a commercially available, standard size, exposed, disposable 1" thick filter in animal holding rooms at each exhaust grille and point exhaust. Filters shall be easily removable and replaceable without tools.

Supply/Exhaust

Air shall be supplied and exhausted in animal holding room as indicated below (PS: point supply (HEPA filtered); PE: point exhaust). Supply and exhaust shall be located as far apart as possible to facilitate through room flow.

Space	Supply	Exhaust
A. SA Holding	Ceiling (center, front)	Ceiling (in 2-4 corners), PE
B. LA Holding	Ceiling (center, front)	Ceiling (in 2-4 corners), PE
C.Isolation cubicle	Low (rear wall)	Ceiling (rear)

Decontamination Features

Provide electronic bubble-tight dampers for each animal holding suite on supply and exhaust duct runs for suite decontamination. Control sequences for facilitation of hydrogen peroxide vapor decontamination shall be included in the design.

Electrical Criteria

Stand-by Power

Stand-by power shall be provided to maintain the following (in addition to life safety requirements):

A. Animal holding room environmental parameters.
B. Cage-rack supply and exhaust blower units.
C. Designated emergency power receptacles colored red.

Lighting

Each animal holding room and internal suite corridor shall be equipped with 3 independently controlled lighting systems, one for animals and two for humans. The three systems are as follows:

A. Animal White (T8 full spectrum fluorescent). Ani-

mal lighting system shall provide a programmable, automatic day/night cycle on an adjustable time and duration schedule with photocell confirmation of cycle controlled and monitored by the BMS. Animal lighting system shall provide 30-35 fc at 3' A.F.F. Suite corridors shall be controlled by this system as well.

B. Human White (T8 full spectrum fluorescent). Human fluorescent lighting system shall be manually controlled by an integral light switch/one-hour timer mounted inside animal room near door. Lights shall flicker five minutes before shut-off. Human lighting system shall provide 70-100 fc at 3' A.F.F. Human and animal lighting systems can be accommodated in same multi-bulb fixture. Human light level cannot override animal night cycle (no white light during night cycle).

C. Human Red (T8 full spectrum fluorescent with red film). Human red light system shall be manually controlled by an integral light switch/one-hour timer mounted outside animal room near door. Lights shall flicker five minutes before shut-off. Human red light system shall provide 15 fc at 3' A.F.F. Human and animal lighting systems can be accommodated in same multi-bulb fixture.

Special Electrical Fixtures

All electrical fixtures (i.e.: electrical receptacles, data/telephone jacks, lighting fixtures, light switches, etc.) Shall be designed for "wash down" and shall be UL listed for weatherproof while in use service. Ground-fault circuit interrupter (GFCI) outlets and circuits shall be required adjacent to sink and basin locations as required by code. All lighting fixtures shall be recess flush mounted, sealed at perimeter and all penetrations.

Electrical Outlets

All rooms shall be equipped with wall mounted 120V/20A duplex electrical outlets mounted 4'-0" A.F.F., unless otherwise noted. All receptacles in the Vivarium shall be weatherproof [weatherproof while in use].

Data/Telephone System

All designated rooms shall be equipped with wall-mounted telephone/data quad junction box with capped conduit and waterproof cover plate. Provide cell-phone and pager capability throughout facility. Telemetry system for chip-embedded animals shall be provided in all [or designated] animal holding rooms and specialty procedure rooms (i.e.: Behavioral core).

Security System

A proximity based access system with a personal identification device shall be provided for at each entry/exit and animal holding room door and designated spaces. A closed-circuit television (CCTV) system shall be provided to monitor each entry/exit door and designated locations. Security system shall be controlled and monitored locally and remotely.

Power Distribution

Distribution panels for each animal holding suite shall be located adjacent to the suite entry door with the suite shared corridor. Panels shall not be located in animal holding or procedure rooms. Electrical panels located in cagewash areas shall be reated NEMA 4.

Plumbing criteria

Hand Wash Sink

Provide potable hot and cold water at each fixed hand wash sink with infrared and wrist-operated controls. Hand wash sink shall be stainless steel. Provide liquid soap, glove and paper towel dispensers (type to be determined) near each hand wash sink. Hand wash sinks shall have an approved back-flow device.

Hose-bib

Provide potable hot and cold water at each hose-bib. Provide mop rack near each hose-bib station. Hose-bibs shall have an approved back-flow device.

Floor Drains

Where indicated, provide minimum 6” diameter floor drains with lockable/removable grated and solid drain covers and a removable strainer basket. Drainpipes shall be minimum 4” diameter. Where designated, provide flushing trap, in lieu of rim, floor drains (FFD). Provide accessible cleanouts for all slab-on-grade floor drains.

Steam

Provide high pressure (>60 psi) steam to washers and sterilizers [or jackets only].

Clean Steam

Provide high pressure (>60 psi) clean steam generated with RO water to sterilizers [or chambers only]. Clean steam generated with RO water does not affect standard polycarbonate cages and does not require stainless steel piping skids for sterilizers (brass is acceptable). Clean steam distribution shall be 316 in stainless steel piping.

Hot Water

Provide 110°F water to hand wash sinks, hose bibs, washers and showers. 180°F hot water for washers will be generated by internal steam boosters fed by 110°F hot water.

Hot Water Discharge

Local codes may not allow discharge of >140°F water into sanitary sewer from washing equipment. Provide integral cool-down system utilizing building chilled water system to conserve potable water on washers and sterilizers if required. Boro-silicate piping shall be utilized within 6’-0” of sterilizer and cagewash discharge point on waste lines.

Neutralization

Local codes may not allow discharge of low or high pH solutions from washing equipment (allowable pH values to be determined by engineer). Washing equipment shall [not] be furnished with an integral pH neutralization system.

Safety Stations

Provide following personnel safety equipment where designated:

A. Safety station (SS): combination deluge shower/ full face wash (typically in cage wash, detergent storage and internal suite corridors).

B. Eye wash (EW): hand-held hose-type eye wash/ drench hose (typically in procedure rooms).

Specialty Gases/Services

Provide following specialty gases/services to all procedure rooms and laboratories through a central distribution system. Oxygen (O2) and carbon dioxide (CO2) require all piping components and fixtures to be lubricated, cleaned, capped, protected and delivered certified for "oxygen service". Provide local shut-off valves as required by code.

A. Natural gas (G). Fixtures to have serrated ends.

B. Laboratory vacuum (C). Fixtures to have serrated ends.

C. Carbon dioxide (CO2). Provide CO2 manifold system from loading dock to procedure rooms. Fixtures to have serrated ends.

D. Oxygen (O2). Provide O2 manifold system from loading dock to procedure rooms. Fixtures to have serrated ends.

E. Anesthesia evacuation (EVAC). Fixtures to have serrated [o qd] ends. [Class II, Type B2 BSC can be used in rodent procedure rooms.]

F. Reagent grade water (RGW). Provide Type III RGW at procedure room sinks with serrated faucet. Type I or II RGW will be provided by owner furnished and installed local units.

G. Detergent manifold system. Provide detergent manifold system from loading dock to cage wash area to accommodate alkaline, acid and neutralizer agents.

H. Soiled/clean bedding system. Provide automated bedding dispensing and disposal system from cage wash area to loading dock.

Reagent Grade Water

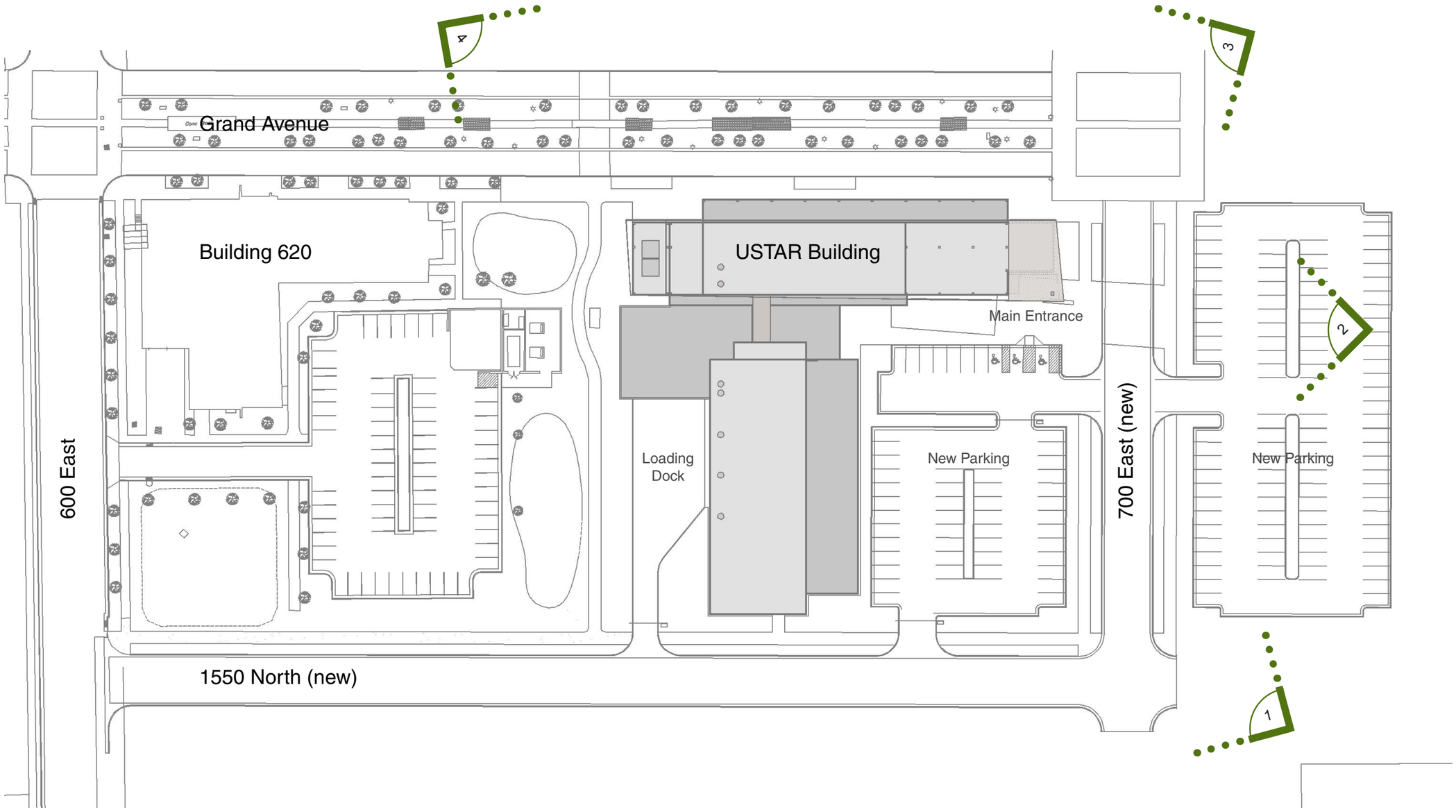
The Vivarium shall be provided with a stand-alone RO/DI water system that shall deliver Type III (18.20 Megohm-cm) reagent grade water at designated locations. Polished water is required at cage and rack wash, tunnel wash and bottle filling equipment, steam sterilizers and at designated point of use areas.

Fire Protection/Sprinkler System

Provide exposed sprinkler heads [or concealed with gasketed mounting.] A low-frequency alarm (<20,000 Hz) is recommended to minimize animal discomfort and sensitivity (if allowable by code). A red strobe light is preferred over white strobe light. High-heat sprinkler heads are required adjacent to autoclave/sterilizer locations.

Appendices 02

Appendix A



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P A Y E T T E

OVERALL SITE PLAN

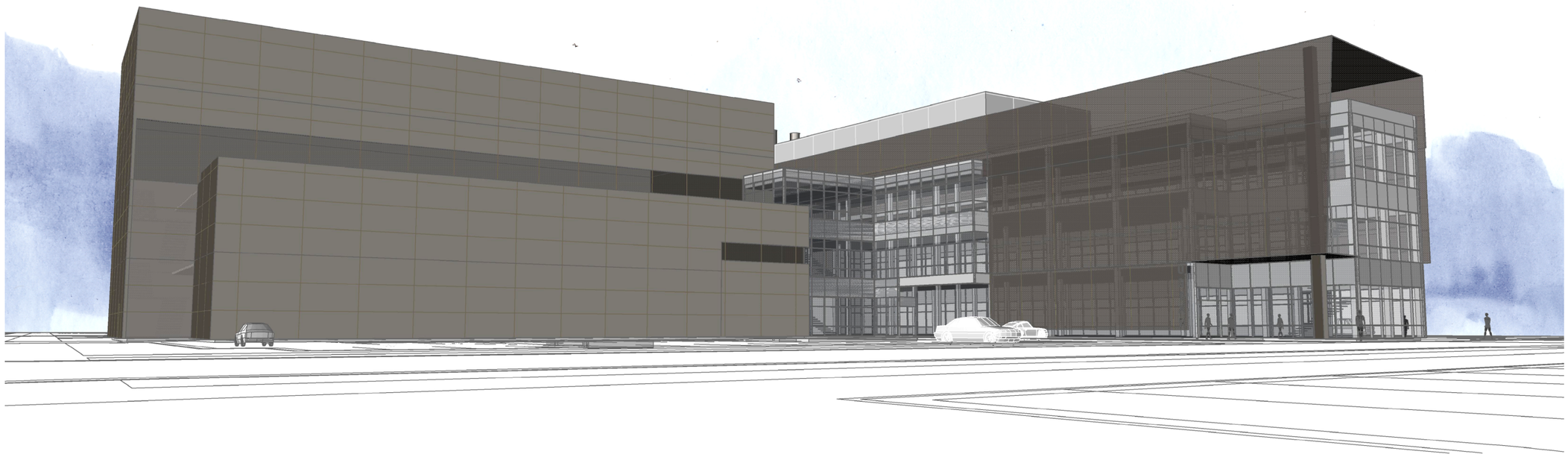
n

Not to Scale

Utah State University
USTAR Building #2 Life Sciences Research Center

Basis of Design

Schematic Design Perpectives



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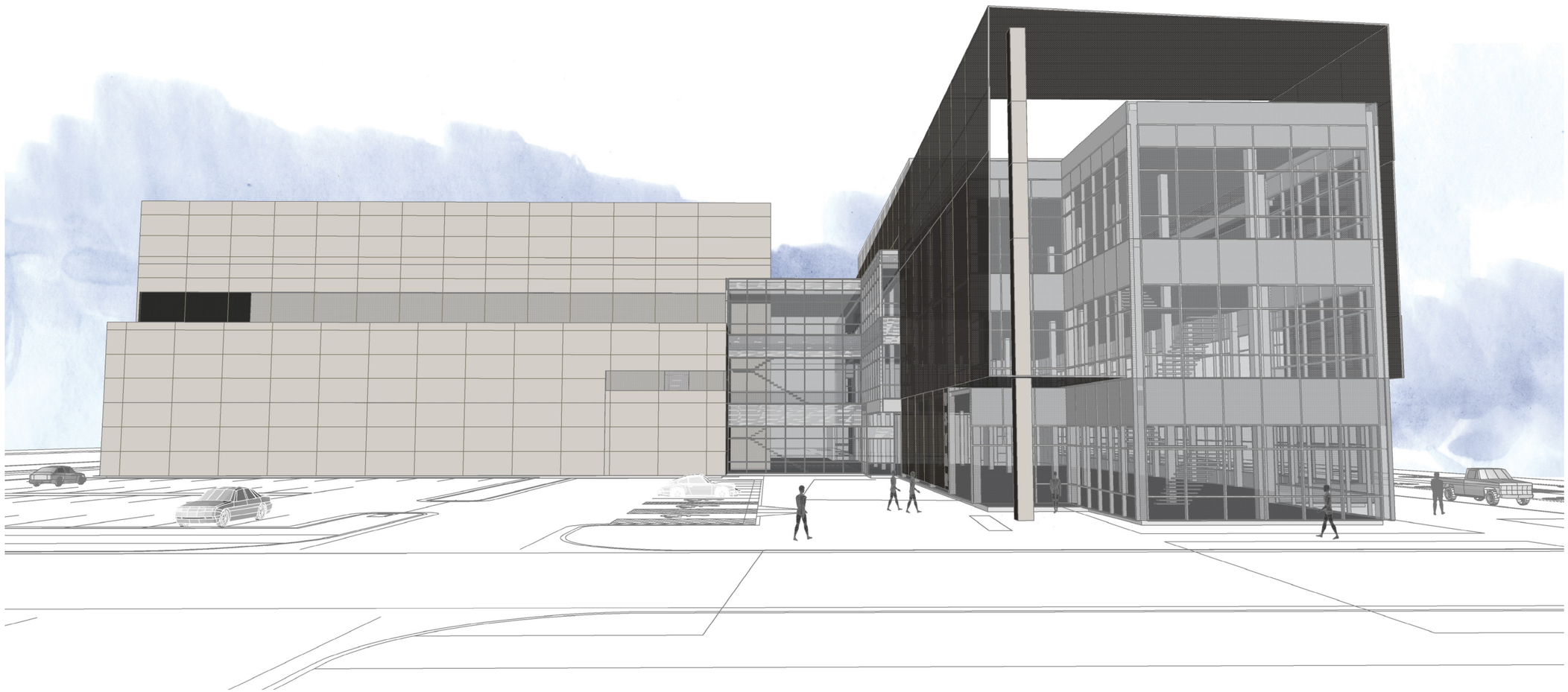
P A Y E T T E

01 - VIEW LOOKING FROM THE SOUTHEAST



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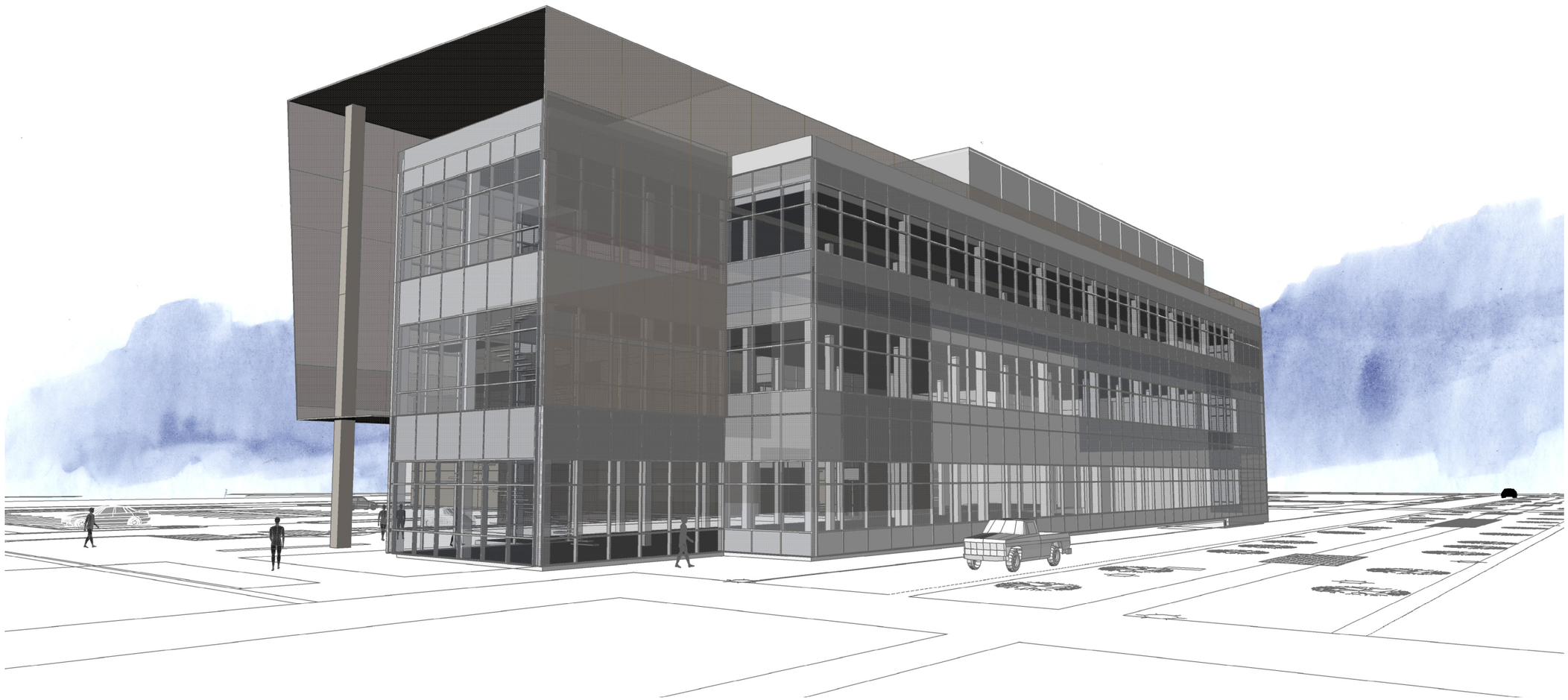
P A Y E T T E

02 - VIEW LOOKING FROM THE EAST



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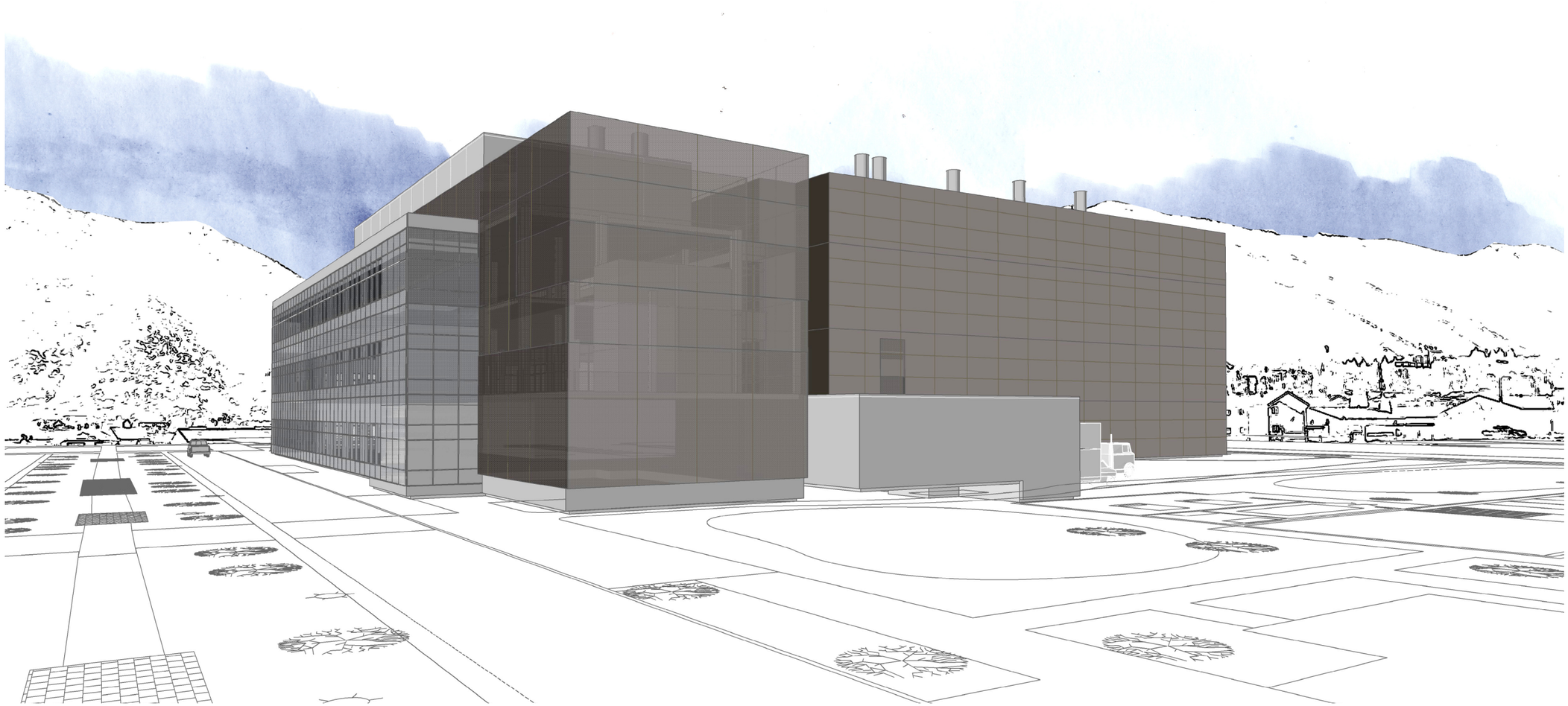
P A Y E T T E

03 - VIEW LOOKING FROM THE NORTHEAST



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P A Y E T T E

04 - VIEW LOOKING FROM THE NORTHWEST

Appendix B

CODES, STANDARDS & GUIDELINES

Primary - obligatory

2006 International Building Code
NIH/CDC Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition
(vivarium: ABSL 2 standards)
(biocontainment: ABSL 3 w/enhancements to support HPAI research)
Guide for the Care and Use of Laboratory Animals
NFPA 30 Flammable and Combustible Liquids Code
(see NFPA 45 below)

Secondary- incorporate by "reference" & authorities having jurisdiction

ANSI Z358.1 Standard for Emergency Eyewash and Shower Equipment
NFPA 45 Standard on Fire Protection for Laboratories Using Chemicals
NIH General Clinical Research Centers (grant criteria)

Tertiary- incorporate "good design practice" elements

ARS 242.1
NIH Design Policy and Guidelines
Guidelines for the Design and Construction of Health Care Facilities

Appendix C

COLIN GORDON & ASSOCIATES

Vibration and Noise Control Guidelines

Utah State University USTAR Building
Logan, UT

June 19th, 2008

In this document we provide general design parameters for the control of vibration and noise for the Utah State University USTAR Building (USU USTAR). These design parameters should be incorporated into the activities of applicable disciplines such as architectural, structural, and mechanical.

Our vibration and noise control guidelines are presented in seven subsections as follows:

(1) Vibration and Noise Criteria
(2) Site Ambient Vibration Conditions
(3) Layout
(4) Foundation Design
(5) Structural Design
(6) Mechanical Design and Isolation
(7) Acoustics

1 Vibration and Noise Criteria

Vibration criteria. There are several ways to approach vibration criteria selection for the project. When the facility is being designed for specific analytical equipment, and when the manufacturers can provide reliable criteria for specific equipment, the floors can be designed accordingly. However, in most cases, it is our experience that specific requirements have not been identified or are not available, or perhaps may not be known until after building commissioning or may change in the future. In these cases, it is common practice to use in the design one or several generic criteria, which may conservatively represent entire classes of equipment or activity.

Table 1 summarizes the vibration criteria for some areas identified for the building.

Table 1: Typical room vibration criteria (VC)

Space Use	Vibration Criterion	Designation
Office and Lab Support	400 μm/s (16,000 μin/s)	ISO office
Generic Labs	50 μm/s (2,000 μin/s)	VC-A
Vivaria	50 μm/s (2,000 μin/s)	VC-A
Computer Rooms	25 μm/s (1,000 μin/s)	VC-B
On-grade Labs / Imaging	6.2 μm/s (250 μin/s)	VC-D

Because mechanical systems affect a much larger space than the room in which they are contained, it is customary to design vibration control systems based upon the project's most stringent criterion.

The VC curve designations are described in **Appendix A.**[1] The quoted velocities refer to the maximum allowable vibrations as measured in one-third octave bands over the band center frequency range 8 Hz to 100 Hz. For VC-B and above, slightly higher velocities are allowed at lower frequencies, down to 4 Hz. The specified limits are intended to apply to vertical and horizontal (in two axes) vibration as measured on the structural floor.

It is our intention that the vibration limits apply to the facility at the condition commonly denoted "start-up" or "as-built" with all building mechanical equipment installed and operating. In order to maintain these levels after equipment is installed and operating, care must be taken in the specification, installation, and where necessary, isolation of the mechanical systems and piping associated with such equipment.

Noise criteria. Table 2 lists typical noise criteria (NC) for some common room functions as recommended by CG&A.

[1] For more information, see "Generic Criteria for Vibration-Sensitive Equipment," Colin G. Gordon, *SPIE Proceedings* Volume 1619, Pages 71-85, 1991. These criteria are also referenced in Institute of Environmental Sciences (IES) Contamination Control Division Recommended Practice 012.1 "Considerations in Cleanroom Design" IES-RP-CC012.1.

Table 2: Typical room noise criteria (NC)[2]

Room Function	NC recommended by CG&A
Clean rooms	60
Computer/server rooms	55
Light maintenance shops	55
Shop classrooms	50
Corridors and public circulation areas	45
Laboratories with fume hoods	45
Other laboratories	40
Large offices	45
Open-plan offices	45
Vivaria	45
Lab support spaces	35
Lab equipment corridor	35
Private offices	35
General classrooms	35
Libraries	30
Executive offices	30
Large lecture rooms	30
Conference rooms	25
Auditoria	25

Occasionally the NC criteria are modified to provide more stringent requirements at low frequencies. There is, however, a limit to the amount of laboratory test information available on the acoustical properties of materials (e.g., sound transmission loss, absorptive qualities, etc.), and noise control devices (e.g., silencers, absorptive treatments, wall designs, etc.), below 63 to 125 Hz.

Early in the project it must be clarified where and how the noise criteria will be applied, with respect to people and equipment. We typically apply criteria to the space-averaged noise level measured in the room.

These criteria are intended to apply to building systems noise sources only. On occasion, they may be applied to other sources, such as the room noise level due to

[2] This compilation is based on the following references, and others: *ASHRAE HVAC Applications* Chapter 42 Sound and Vibration Control (1991); Howard F. Kingsbury "Review and Revision of Room Noise Criteria" *Noise Control Engineering Journal* 43-3 May-June 1995; American National Standards Institute *Criteria for Evaluating Room Noise* ANSI S12.2-1995; Robin M. Towne et al. "The Changing Sound of Education" *Sound and Vibration* January 1997.

external noise sources (aircraft, traffic, etc.), or due to known equipment in the room. These cases are exceptional, and will not be determined without a specific request from the architect or owner.

2 Site Ambient Vibration Conditions

Site ambient vibration environment. A site vibration survey has not been carried out for this project. We typically recommend a site survey if the vibration criteria is expected to be VC-D (250 μin/s) or better or if conditions on the site are expected to be problematic (ex. the site is in proximity to a railroad or a major highway.)

3 Layout

Base building layout. The layout of the facility is important insofar as the placement of major mechanical systems relative to the vibration-sensitive areas is concerned.

- We recommend that the "energy center" lie at a horizontal distance no closer than 20m (65 ft) (if possible, further) from the nearest vibration-sensitive floor.
- Horizontal separation should also be achieved between vibration-sensitive floors and exhaust fans.
- Emergency equipment that must be periodically exercised (such as emergency generators) should be separated horizontally also.

The above are only some of the layout considerations. Others will emerge when we start reviewing early concepts.

Room layout. Location of labs and other rooms within the building, and with respect to vibration sources outside the building, influences the vibration environment achievable in the room. Ideal location is the most cost-effective way (and sometimes the only way) to achieve a good vibration environment. For example, the most sensitive labs should be located as far as possible from internal sources of vibration such as mechanical and electrical equipment, elevators, major corridors, loading docks, etc. Position with respect to external sources, such as on-site and off-site roads and central utilities buildings, should also be considered.

Likewise, layout within the lab module is important for the most efficient control of noise and vibration. One should plan on separating the equipment and equipment support mechanical equipment (such as vacuum pumps) in the labs to reduce vibration impact. Consider using a separate and acoustically sealed equipment chase to contain roughing pumps, chillers, power conditioners, and other equipment that can disturb the

equipment and personnel with excess noise.[3] The need for peripheral equipment chases will depend on whether these items of equipment are operated during times of critical use.

4 Foundation Design

Generally speaking, we have no strong preference for foundation type, i.e., mat, pile, or spread footings. Although one may have certain more desirable characteristics over another, each of those listed can be designed to meet most vibration requirements.

In our experience the amount of attenuation that can be achieved, from site ambient vibration and from vibration generated by "in-house" sources, by special foundation design is quite limited, in most instances. For example, we have found isolation breaks between different foundation systems to have insignificant effect in limiting vibration propagation. This is due to the fact that soil medium is the primary path for wave propagation.

We have had occasion to study the performance of mixed foundations such as deep drilled piers adjacent to mat foundations. Here computer models of ground/foundation interaction have shown some benefits in terms of attenuation.

Various foundation systems may be found to be beneficial for the unique soil conditions at a particular site. We can provide specific recommendations based on our review of the geotechnical reports.

5 Structural Design

Low-vibration structures can be constructed of concrete, steel, or combinations of the two. Floor designs can be divided into two generic classes, on-grade and suspended, as discussed in the following sections.

5.1. Suspended Floors

The design of suspended floors, and the types of vibration sources that control their performance, largely depends on the vibration requirements for the floor. Table 3 identifies typical structural design approaches to achieve various criteria[4].

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[3] Note that our designs in these cases are for reasonably isolated and quiet equipment, not for *anything* that a user puts in the lab, unless the specific details of the equipment are available at the time of the base building design.

[4] This table is excerpted from Hal Amick et al., "Facility Vibration Issues for Nanotechnology Research" Presented at Symposium on Nano Device Technology, May 2-3, 2002, National Chiao-Tung University, Hsinchu, Taiwan

Table 3. Generic criteria assignable to research spaces, and the Typical structural approaches to achieving them.

Space Type	*Criterion*	*Structure*
Research Offices, Computer Modeling	ISO Office	9 to 12 m (30 to 40 ft) spans, concrete slab on moderate-depth steel or concrete framing
Generic Laboratory Space, Optical Microscopes	VC-A/B	6.5 to 10 m (21 to 33 ft) spans, concrete slab on deep steel or concrete framing
High–power optical microscopes, Imaging equipment	VC-C	< 6.5 m (21ft) spans, concrete slab on deep steel or concrete framing.
Photolithography, Nanofabrication	VC-D/E	Slab-on-grade; or concrete waffle or open grillage with 3.5 to 5 m (12 to 16 ft) column spacing
Metrology, Surface Characterization, SEM, SPM, AFM	VC-E or NIST-A	Slab-on-grade
Instrument Development	NIST-A1	Pneumatically isolated inertia slab

The design elements mentioned in Table 2 primarily address vertical vibration performance. For stiff floors, input from the vibration consultant to control horizontal performance (using shear walls, moment framing, etc.) is also critical. For the less stringent floors, horizontal performance is usually dictated by the requirements of the structural engineer, although we will typically review this.

Although there is some overlap, the performance of “stiff” suspended floors necessary to achieve VC-D and better, will be controlled by mechanical sources (equipment, piping, ductwork), and performance of floors designed to meet the less stringent criteria will be controlled by the activities of personnel (walking or footfall, cart use, etc.). This is discussed in more detail in the following sections.

Design of “stiff” floors. As a result of studying the final performance of many operating floors, we have found that the vibration can be described semi-empirically by the following equations:

For Vertical Vibration: $V_V = C_1/K_V$ - - - - - (1)

For Horizontal Vibration: $V_H = C_2/\sqrt{K_H}$ - - - - - (2)

where V_V and V_H are the one-third octave band velocities at the respective vertical and horizontal resonance frequencies. It is at these resonance frequencies that the

maximum vibrations occur. C_1 and C_2 are empirically derived constants. K_V is the vertical static stiffness in the middle of the column bay (this is a local, as opposed to a global, stiffness). K_H is the "global" horizontal stiffness of the lab floor. This stiffness encompasses the sum-total stiffness of all the columns, shear walls, and other structures that serve to resist movement of the floor under horizontal loads. The fundamental vertical resonance frequencies of most current floors, with which we have been involved, lie in the range 15 to 50 Hz. Horizontal resonance (cantilever mode) frequencies are much lower, typically in the range of 4 to 8 Hz.

Design of floors subject to walker vibration impact. Relatively soft floors (VC-C and less stringent) are easily excited by the activities of personnel. There is a large body of work on the impact of walkers in particular, and CG&A has developed some unique tools to predict this type of impact. The degree of impact of a walker is a function of weight, speed (pace), gait, footwear type, and other factors.

Before the structural design based on walker impact can begin, the location of the source (person) and receiver (research equipment) within a bay or bays must be determined. Otherwise, impact is calculated in the "worst-case" condition, that is, walking at a relatively fast pace (say 100 paces/minute) adjacent to the research equipment through the center of a bay. However, less conservative assumptions may be taken in some instances to reduce project costs. Some of these considerations are as follows:

- **Walker speed.** We typically assume 100 paces/minute for "high speed" corridors. These are generally the straight, wide, general building traffic corridors outside the lab module over which the user has no control. It is our preference that high speed corridors be separated from lab areas by at least one column line. For "ghost corridors", which typically parallel high speed corridors but are inside the lab, we typically assume 85 paces/minute. For "low speed" corridors, generally obstructed areas between lab benches, we typically assume 70 to 85 paces/minute. The lab users generally have more control over the traffic in the two latter cases.
- **Walker weight.** We will assume 84 kg (185 lb) unless directed otherwise.
- **Position of walkers and equipment on the structure.** For lab layouts that are uniform with respect to the structural layout (column positions, etc.), we may wish to account for the relative stiffness of the bay at the position of the walker or research tools, especially if either of these will always be located other than at mid-bay.

The prediction of walker-generated floor vibration amplitudes is an inexact science. Experimental studies have demonstrated that the variability of amplitudes generated by a "standard" walker (85 kg at 100 paces per minute)—

going to great lengths to maintain consistency—leads to a standard deviation of over 2 decibels (about 30%). When we consider a larger population at the same speed, the variation in footwear, gait, etc., leads to a standard deviation over 3.5 decibels (about 50%), even when there is a correction for variation in weight.

5.2. On-grade floors and engineered fill

The vibration performance of an on-grade floor depends on the site ambient vibration conditions, soil conditions, foundation type, and slab thickness. With all other parameters close to ideal, the vibration criteria discussed in this document can usually be achieved on 200mm to 300mm (8" to 12") thick on-grade slabs supported by well engineered fill if required. The final recommendation for slab thickness will be made once the site and foundation details are known.

If imported fill is required, it should be examined by a Soils Engineer to ensure that it is of low swell potential and free of organic or otherwise deleterious material. In general, the fill should have 100 percent passing the 75mm (3-inch) sieve and no more than 60 percent passing the 200 sieve. For the fine fraction (passing the 40 sieve), the liquid limit and plasticity index should not exceed 30 percent and 10 percent, respectively. It should exhibit less than 1.5 percent swell potential when compacted to 95 percent of maximum dry density (ASTM D-698) at a moisture content of 2 percent below optimum, confined under a 500 kg/m^2 (100 psf) surcharge, and inundated.

5.3 Isolation Breaks

In general, we are leaning away from the use of isolation breaks in slabs, whether on-grade or elevated. This shift in position has been based upon a growing collection of data suggesting—for frequencies less than about 40 Hz—that the positive contribution of an isolation break is minimal, and may actually be harmful.

In on-grade slabs, the only purpose a break serves is to attenuate high frequency vibrations, not the low-frequency ones of primary concern. The low-frequency vibrations propagate through the soil. The reason for shifting away from them is that they can actually make the horizontal vibrations worse if they are isolating too small a segment. All things considered, the solid slab is better than a jointed slab at the frequencies generally of concern for sensitive equipment and processes. However, at higher frequencies, particularly audible frequencies, they may be quite beneficial.[5]

[5] A portion of the studies on which this position is based has been published. The effect on elevated slabs is shown dramatically in Sec. 7 of "Dynamic Characteristics of Structures Extracted from In-situ Testing", by Hal Amick, Michael Gendreau, and Ahmad Bayat, presented at the SPIE Conference on Opto-mechanical Engineering and Vibration Control, July 20, 1999, Denver, Colorado. This can be downloaded at our website, www.colingordon.com.

We recommend that if it is important to one or more users that on-grade slab breaks be used, that the breaks be no smaller than room-sized, and that the isolated part be very thick with respect to the surrounding slab. [That is, a 900mm (36”) block in a 300mm (12”) slab.]

6 Mechanical Design/Isolation

Amongst the primary sources of vibration in the building are the mechanical systems that supply the building with conditioned air, compressed air, vacuum, and general building services. Emergency systems (emergency generators, smoke exhaust fans, etc.) may also have to be included within the equipment list since these systems have to be “exercised” periodically.

It is important that all major items of equipment (with ratings in excess, say, of 5 kW) be designed and installed in such a way that the vibration they transmit to the building structure is controlled. Vibration control must also encompass mechanical systems such as ductwork and piping since these systems can also generate and transmit vibration via turbulent flow. The latter requires both isolation systems and limiting of the fluid flow velocity.

Mechanical systems associated with equipment to be installed in laboratories must also be considered in terms of their effect on the final vibration and noise environment.

Our guidelines and recommendations for mechanical equipment vibration control are as follows:

(a) Vibration Control Specification

We will provide a vibration control specification which will incorporate a vibration isolation schedule in which all major mechanical systems will be listed and assigned vibration isolation details. We require that we review purchase specifications for the individual mechanical systems such as AHUs, EFs, etc. to ensure consistency with the above specification and to add appropriate noise requirements into these specifications.

(b) Dynamic Balance of Equipment

Recommendations for the dynamic balance of rotating equipment are included in the specification. The balance standards given for “critical” fans are appropriate only to direct drive systems—with or without variable frequency drives (VFD). In general we recommend against the use of belt-driven systems, especially for critical fans within 15m (50 ft), say, of the vibration-sensitive area. The critical fans generally include all scrubbed, general, and other major exhaust fans.

(c) Ductwork and Piping

General recommendations for the isolation of ducting and piping systems—especially where these are connected to vibration-isolated equipment—will be included in the specification. It is most important to limit fluid flow velocities in pipes and ducts since turbulence associated with fluid flow can form a substantial vibration source. For this reason we recommend that air flow velocities be limited to 9 m/s (30 ft/s), and liquid flow velocities to 3 m/s (10 ft/s).

We recommend also that major pipes and ducts [in excess, say, of 100mm (4 in) in diameter and 500mm (20 in) in diameter, respectively] located under suspended highly vibration-sensitive floors be supported from the columns or the floor and not directly from the vibration-sensitive floor, even with vibration isolation hangers.

(d) Inertia Bases

We will recommend that inertia bases, complying with the requirements given in the specification, be used on all liquid pumps, and depending on the equipment specifications, on certain exhaust and make-up air fans. The structural design must take these loads into account.

(e) Fan Units and Air Handlers

We will require a high level of quality, in terms of operating efficiency, balance and vibration isolation, on the recirculation air fans, make-up air fans, and air handlers. Noise control is also an issue with these units, and with the units that serve office spaces.

For recirculation air systems, we generally prefer plug fans operating against a low static pressure, in which the operating tip speeds are low. Such fans are generally much less energetic as regards vibration, and quieter than other designs. Vaneaxial fans however may be acceptable especially if care is taken to limit flow velocities in associated plena and ductwork. Fan filter units (FFUs) may also be used effectively in certain cases, especially from a vibration standpoint, although with these there are fewer possibilities for noise control within the units.

7 Acoustics

Noise can affect both personnel and equipment within the facility, and if projected in excess into the environment, the attitudes of the neighboring communities. Control of HVAC noise and the careful selection of relevant architectural details can improve communications, speech privacy, and the general condition of work environments, and

reduce long term work-related hearing damage, fatigue, and general annoyance. As regards environmental noise, more and more frequently we are finding that facilities are required to show proof of compliance with state or local environmental noise regulations. It is best to consider external noise control, if necessary, during the design stage, rather than to have to apply as a retrofit potentially more costly noise control measures later.

The following are some general comments related to acoustics:

(a) Building layout influences sound insulation requirements between spaces of various occupancy. A carefully chosen layout reduces the need for complex and expensive noise control materials between spaces. In general, rooms containing noise sources (i.e., mechanical rooms, kitchens, HVAC shafts) should not be located adjacent to noise sensitive rooms (i.e., sensitive laboratories, conference and teleconference rooms, and private offices).

(b) Air handler and fan-filter unit submittals must be consistent with the noise requirements. The need for additional noise control in the form of duct lining, silencers, etc., will be determined and agreed at this stage.

(c) Silencer manufacturers must be approved by the acoustical consultant prior to finalization of purchase contract. Approved vendors must be able to provide current certified test data for their product based on tests in an approved test laboratory. List of suitable vendors:

1. IAC
2. Vibro-Acoustics
3. United McGill

(d) Absorbent filler materials (typically fiberglass) will be bagged in Tedlar or tight woven, non-shedding fiberglass cloth to eliminate shedding of particulates. Performance requirements and test data apply to the silencers as delivered to site.

(e) Terminal units, VAV boxes, and diffusers must be selected so that the noise they generate is consistent with the recommended Noise Criterion (NC) levels of the rooms they serve. The equipment manufacturer's NC rating may not apply to many rooms within a laboratory facility, as these ratings are usually computed for rooms with a great deal more sound absorption than is found in a typical laboratory. Terminal units shall be selected on the basis of manufacturer's certified laboratory octave band sound power levels. Diffusers should be selected for an NC requirement 5 points lower than the stated room design criterion.

(f) In-duct air velocities: To control diffuser and grille noise, we recommend that HVAC duct systems be designed such that the air velocities in Table 4 are not exceeded in each final branch before the grille or diffuser:

Table 4. Maximum In-duct Air Velocities

Room noise criterion	Supply	Return
NC-45	700 fpm (3.5 m/s)	800 fpm (4.0 m/s)
NC-40	600 fpm (3.0 m/s)	700 fpm (3.5 m/s)
NC-35	550 fpm (2.8 m/s)	600 fpm (3.0 m/s)
NC-30	500 fpm (2.5 m/s)	550 fpm (2.8 m/s)
NC-25	400 fpm (2.0 m/s)	450 fpm (2.3 m/s)

(g) HVAC breakout noise is the noise that is transmitted into a space through the walls of the ducts. This is most commonly a problem when a particular system has large ducts that pass over an acoustically sensitive space on the way to a space with a much less stringent design criterion. Breakout noise may be reduced with the use of round duct.

7.1 Sound Isolation

The partitions surrounding noise sensitive areas such as private offices, executive offices and meeting rooms should be augmented in various ways, including multiple layers of gypsum board and the addition of unfaced glass fiber batts in the stud cavities. In most cases, at least one layer of gypsum board should be taken up to the structure above and sealed air tight. Rooms with gypsum board ceilings may require fewer layers of gypsum board that extend full height.

The following are our initial recommendations for the configuration of walls separating various spaces. These recommendations will be refined as the project progresses:

Definition of Typical Wall Types

TYPE A (Typical STC: 30 to 35)
Steel studs, one layer 5/8 inch GWB each side.

TYPE B (Typical STC: 35 to 40)
Steel studs, one layer 5/8 inch GWB on each side, insulation in cavities.

TYPE C (Typical STC: 40 to 45)
Steel studs, one layer 5/8 inch GWB on each side, insulation in cavities, carry one layer of GWB up to slab.

TYPE D (Typical STC: 45 to 50)
Steel studs, two layers 5/8 inch GWB on each side, insulation in cavities, carry one layer of GWB each side up to slab.

TYPE E (Typical STC: 50+)
Double row of steel studs, otherwise same as Type D.

Wall Type Recommendations

Table 4 may be used to select the appropriate wall type by STC requirement.

Major Room Categories:

(1) Teleconference rooms, small conference rooms, training rooms, executive offices (NC 25 to 30);

(2) Private offices, conference rooms, libraries (NC 30 to 35);

(3) Open plan offices, reception areas (NC 35 to 40);

(4) Computer rooms, copy rooms, laboratories, corridors, lobbies (NC 40 to 45).

Table 4. Recommended STC ratings for wall between adjoining spaces

		Room Category			
		(1)	(2)	(3)	(4)
Room Category	(1)	50	50	50	50
	(2)	50	45	45	45
	(3)	50	45	40	40
	(4)	50	45	40	35

Notes

All doors in Type C walls or better should be solid-core with gasketing.

Wall Type E (typical STC 50+) should be used between mechanical rooms and noise sensitive spaces, such as, but not limited to, conference rooms or private offices, and should be used around mechanical rooms containing especially noisy equipment, such as, but not limited to, chillers, compressors, and large pumps.

Wall Type D (typical STC 50) should be used around regular mechanical rooms, electrical rooms, computer/control rooms containing air handling units and HVAC shafts (use shaft wall version).

* * * * *

APPENDIX A GENERIC DESIGN CRITERIA FOR VIBRATION-SENSITIVE EQUIPMENT AND PROCESSES

This appendix presents vibration criteria that have been used quite extensively for several years, particularly by the microelectronics and optoelectronics industries and research communities.

Two families of generic criteria are discussed here: (1) the VC criteria developed in the early 1980s by Eric Ungar and Colin Gordon[*]; and (2) the NIST-A criterion developed in the early 1990s for the Advanced Measurement Laboratory at the U.S. National Institute of Standards and Technology (NIST). The VC criteria were originally developed for use in the semiconductor industry, but have found application in a wide variety of technological applications. The NIST-A criterion was developed for metrology, but has gained popularity within the nanotechnology community.[†]

The VC criteria take the form of a set of one-third octave band velocity spectra labeled vibration criterion curves VC-A through VC-G, as developed by Gordon and Ungar, modified several times during the intervening years, and currently published in an IEST Recommended Practice. [‡] These are shown in Figure A.1, together with the International Standards Organization (ISO) guidelines for the effects of vibration on people in buildings.[§] The criteria apply to vibration as measured in the vertical and two orthogonal horizontal directions, and are applied to each direction separately.

For environments that are continuous and steady-state in time, the criteria apply to the "linear average" of data samples acquired over an adequate time period. In instances where the environment is impacted by occasional disturbances such as vehicular movements, "stage" movements (in tools), passing trains, etc., these may be evaluated in the "peak hold" or "maximum RMS" mode of the measuring system. If the disturbing event is long enough (i.e., "Quasi-static", or steady-state during the averaging time) the linear average mode should be used. The importance attributed to these occasional events will depend upon the frequency of occurrence and other parameters relating to the vibration-sensitive process.

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[*] Eric E. Ungar and Colin G. Gordon, "Vibration Challenges in Microelectronics Manufacturing," *Shock and Vibration Bulletin*, 53(I):51-58 (May 1983), or Gordon, C. G., and Ungar, E. E., "Vibration Criteria for Microelectronics Manufacturing Equipment," *Proceedings of Inter-Noise 83*, pp. 487-490 (July 1983).

[†] H. Amick, M. Gendreau, and C. G. Gordon, "Facility Vibration Issues for Nanotechnology Research," *Proc. Symp. on Nano Device Technology 2002*, May 2-3, 2002, National Chiao-Tung University, Hsinchu, Taiwan.

[‡] Institute of Environmental Sciences and Technology, "Considerations in Cleanroom Design," RP-CC012.2, 2005.

[§] International Standards Organization, ISO 2631 "Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration, Parts 1 and 2." Part 1 was updated 15 July 1997 and Part 2 was updated 1 April 2003.

For environments involving large areas, such as an entire cleanroom, a single location is probably not representative of the whole. The ambient vibrations of a large area may be characterized by a spectrum representing the mean plus one standard deviation spectrum, $A_{mean+sig}$, of a collection of spectra obtained at a statistically significant number of locations randomly distributed throughout the cleanroom or other area of interest. The A_{mean} and A_{sig} spectra are defined for a collection of linear spectra X_i as

$$\log(A_{mean}) = Average(\log(X_i)) \tag{A.1}$$

$$\log(A_{sig}) = StdDev(\log(X_i)) \tag{A.2}$$

The statistics are calculated for each frequency. The two spectra are combined in *log space* to obtain $A_{mean+sig}$, defined as**

$$\log(A_{mean+sig}) = \log(A_{mean}) + \log(A_{sig}) \tag{A.3}$$

When presenting data in a report, the data for a single direction (*e.g.*, vertical) may be summarized in a plot that shows four spectra: A_{min}, A_{mean}, $A_{mean+sig}$, and A_{max}. The reader can then easily see the range of the data, the statistically meaningful representations, and the spectrum used to characterize the space as a whole, $A_{mean+sig}$. In order to compare the performance of the entire space at two different times, the $A_{mean+sig}$ spectra from each set of measurements may be used.

The use of $A_{mean+sig}$ as a means for characterizing a large area infers that the data approximate a Gaussian distribution at each frequency. This is not always the case, because the mechanical "load" (i.e., the dynamic forces traveling into the floor from mechanical equipment, piping, and ducting) may not always be distributed uniformly about the space being evaluated. If it were truly Gaussian, then one could assume that at any location within the area being evaluated, there was an 84% probability that the vibrations at that location would be equal to or less than $A_{mean+sig}$. Even if the data are not truly Gaussian, it may be argued that $A_{mean+sig}$ provides a more reliable estimate of the majority of the data than either A_{max} or A_{mean}.

The application of these criteria to people and vibration-sensitive equipment is described in Table A.1. The criteria do not necessarily apply to experimental systems used in laboratory research. Such systems often have not received the benefits of dynamic modeling and vibration isolation available to the equipment manufacturer, or may be one-of-a-kind.

The main elements of the criteria are as follows:

** Carrying out statistical operations on levels expressed in decibels produces the same results as operations in log space. The latter is simply a more general format for definition.

1) The vibration is expressed in terms of its root-mean-square (rms) velocity (as opposed to displacement or acceleration). It has been found in various studies that while different items of equipment (and people) may exhibit maximum sensitivity at different frequencies (corresponding to internal resonances), often these points of maximum sensitivity lie on a curve of constant velocity. ††

2) The use of a proportional bandwidth (the bandwidth of the one-third octave is twenty-three percent of the band center frequency) as opposed to a fixed bandwidth is justified on the basis of a conservative view of the internal damping of typical equipment components. Experience shows that in most environments where adequate layout and isolation of electrical and mechanical equipment has been provided, the vibration is dominated by broadband (random) energy rather than tonal (periodic) energy.

3) The fact that some of the criterion curves allow for greater vibration velocity for frequencies below 8 Hz reflects experience that this frequency range, in most instances, lies below the lowest resonance frequency of the equipment components to which these curves apply. Relative motions between the components are, therefore, harder to excite and the sensitivity to vibration is reduced. The curves more stringent than VC-C do not relax the requirements at frequencies below 8 Hz, and the curves extend down to 1 Hz. This change was based upon the requirements of equipment with internal pneumatic vibration isolation, which in many cases shifted the frequency of greatest vibration sensitivity from greater than 8 Hz down to the range of 1 to 4 Hz. ‡‡

4) For a floor or site to comply with a particular equipment category, the measured one-third octave band velocity spectrum must lie below the appropriate criterion curve of Figure A.1. It is generally accepted that vibration measurements are accurate and repeatable only within about 1 or 2 decibels (12% or 26%), so an overly strict interpretation of a comparison with the criteria is not encouraged. (For instance, a measured value of 51 μm/s versus one of 49 μm/s, when being compared to a criterion of 50 μm/s, lies within the range of inaccuracy—less than 1 decibel—with respect to the criterion, and it may be argued that both of them meet the criterion, from a measurement accuracy perspective.)

The equipment criterion curves have been developed on the basis of data on individual items of equipment and from data obtained from measurements made in facilities before and after vibration-related problems were solved. The curves are generic in the sense that they are intended to apply to broadly defined classes of equipment and

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†† Amick, H., “On Generic Vibration Criteria for Advanced Technology Facilities: with a Tutorial on Vibration Data Representation,” *J. Institute of Environmental Sciences*, pp. 35-44, (Sept/Oct, 1997).
‡‡ E. E. Ungar, D. H. Sturz, and H. Amick, "Vibration Control Design of High Technology Facilities," *Sound and Vibration* (Jul. 1990).

processes. They are intended to apply to the more sensitive equipment within each category that is defined.

The criteria assume that equipment will be supported on benches or pedestals that are rigidly constructed and damped so that amplifications due to resonances are limited to a small value or located at non-critical frequencies. The criteria take into account the fact that certain types of equipment (such as stepper scanners) are supplied by the manufacturer with built-in vibration isolation.

The NIST-A criterion is identical to VC-E at frequencies above 20 Hz, but maintains a constant rms *displacement* amplitude at lesser frequencies. This is to accommodate some of the ultra-high-precision metrology, probe, and lithography equipment being used in nanotechnology. This is a very difficult criterion to meet at some sites with significant low-frequency vibration content.

It is important to note that these criteria are for guidance only. The "detail sizes" given in Table A.1 appear to represent experience at the time of writing. They reflect the fact that the quality of design and of built-in isolation in most equipment tends to improve as dimensional requirements become more stringent. In some instances the criteria may be overly conservative because of the high quality of built-in isolation.

Facility vibrations do not necessarily remain constant over extended periods of time. Vibrations measured during construction may not reflect the contribution of the mechanical systems in their operational state at building completion. Likewise, vibrations at a few months beyond completion may include contributions from user-installed equipment, and this contribution could change over time as layout is varied. (This variation has been called "maturation," and must be considered a normal part of the aging process.[§§]) It is important that a facility survey be carried out at a time appropriate for characterization of the operational state of interest. For example, one would not want to characterize the "as built" state using measurements made either during construction or at one year after startup.[***]

In most instances it is recommended that the advice of a vibration consultant be sought in selecting a design standard.

[§§] M. Gendreau and H. Amick, "'Maturation' of the Vibration and Noise Environments in Semiconductor Production Facilities," *Proc. ESTECH 2004*, 50th Annual Technical Meeting, Institute of Environmental Sciences and Technology (IEST), Las Vegas, Nevada, April 28, 2004

[***] H. Amick, M. Gendreau, and T. Xu, "On the Appropriate Timing for Facility Vibration Surveys," *Semiconductor Fabtech*, No. 25, March 2005, Cleanroom Section.

Table A.1: Application and interpretation of the generic vibration criterion (VC) curves (as shown in Figure A.1)

Criterion Curve	Amplitude[1] µm/s (µin/s)	Detail size[2] µm	Description of use
Workshop (ISO)	800 (32 000)	N/A	Distinctly perceptible vibration. Appropriate to workshops and nonsensitive areas.
Office (ISO)	400 (16 000)	N/A	Perceptible vibration. Appropriate to offices and nonsensitive areas.
Residential day (ISO)	200 (8 000)	75	Barely perceptible vibration. Appropriate to sleep areas in most instances. Usually adequate for computer equipment, hospital recovery rooms, semiconductor probe test equipment, and microscopes less than 40x.
Operating theatre (ISO)	100 (4 000)	25	Vibration not perceptible. Suitable in most instances for surgical suites, microscopes to 100x and for other equipment of low sensitivity.
VC-A	50 (2 000)	8	Adequate in most instances for optical microscopes to 400x, microbalances, optical balances, proximity and projection aligners, mass spectrometers other than MALDI and quadrupole or high-resolution, conventional spectrophotometers, etc.
VC-B	25 (1 000)	3	Appropriate for inspection and lithography equipment (including steppers) to 3 µm line widths, microtomes and cryotomes for 5-10 micron slices, most tissue and cell culture, except as noted below.
VC-C	12.5 (500)	1 – 3	Appropriate standard for optical microscopes to 1000x, lithography and inspection equipment (including moderately sensitive electron microscopes) to 1 µm detail size, TFT-LCD stepper/scanner processes, digital imaging and/or fluorescence with optical microscope, high-precision balances measuring quantities less than 1 mg, MALDI mass spectrometer, nano-drop spectrophotometers, microtomes and cryotomes for slices < 5 microns, tissue and cell culture of the following types: hanging drop, unstirred layers, embryonic stem cells, weakly adherent cells, very long-term cultures, chemotaxis, invasion assays.
VC-D	6.25 (250)	0.1 – 0.3	Suitable in most instances for demanding equipment, including many electron microscopes (SEMs and TEMs) and E-Beam systems, microinjection, micromanipulation, electrophysiology, confocal microscopy, quadrupole and other high-resolution mass spectrometers.
VC-E	3.12 (125)	< 0.1	A challenging criterion to achieve. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems, E-Beam lithography systems working at nanometer scales, and other systems requiring extraordinary dynamic stability.
VC-F	1.56 (62.5)	N/A	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.
VC-G	0.78 (31.3)	N/A	Appropriate for extremely quiet research spaces; generally difficult to achieve in most instances, especially cleanrooms. Not recommended for use as a design criterion, only for evaluation.

[1]As measured in one-third octave bands of frequency over the frequency range 8 to 80 Hz (VC-A and VC-B) or 1 to 80 Hz (VC-C through VC-G).

[2]The detail size refers to line width in the case of microelectronics fabrication, the particle (cell) size in the case of medical and pharmaceutical research, etc. It is not relevant to imaging associated with probe technologies, AFMs, and nanotechnology.

The information given in this table is for guidance only. In most instances, it is recommended that the advice of someone knowledgeable about applications and vibration requirements of the equipment and processes be sought.

Figure A.1. Generic Vibration Criterion (VC) Curves for vibration-sensitive equipment - Showing also the ISO Guidelines for People in Buildings (see Table A.1 for description of equipment and uses.) [From IEST RP-012.2 (2005)]

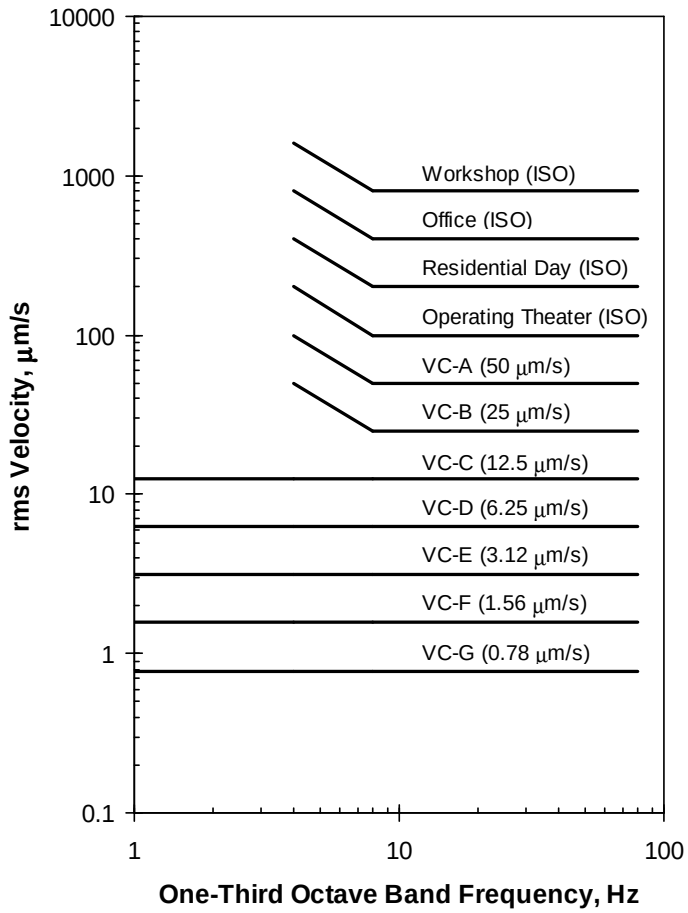


Table A.2: Numerical definition of criterion curves shown in Figure A.1

Criterion	Definition
VC-A	260 μg between 4 Hz and 8 Hz; 50 μm/s (2000 μin/s) between 8 Hz and 80 Hz
VC-B	130 μg between 4 Hz and 8 Hz; 25 μm/s (1000 μin/s) between 8 and 80 Hz
VC-C	12.5 μm/s (500 μin/s) between 1 and 80 Hz
VC-D	6.25 μm/s (250 μin/s) between 1 and 80 Hz
VC-E	3.1 μm/s (125 μin/s) between 1 and 80 Hz
VC-F	1.6 μm/s (62.5 μin/s) between 1 and 80 Hz
VC-G	0.78 μm/s (31.3 μin/s) between 1 and 80 Hz

Figure A.2. Generic Vibration Criterion (NIST-A) Curve for critical areas In nanotechnology facilities - Showing also several of the VC criteria for reference

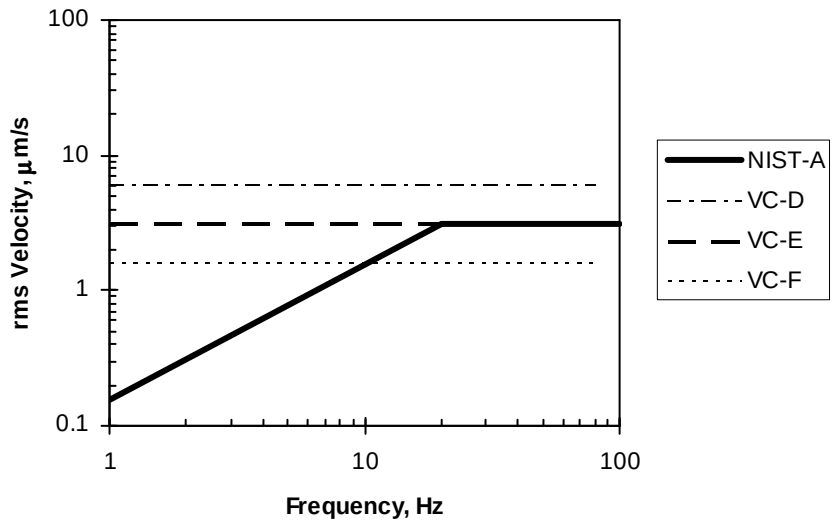
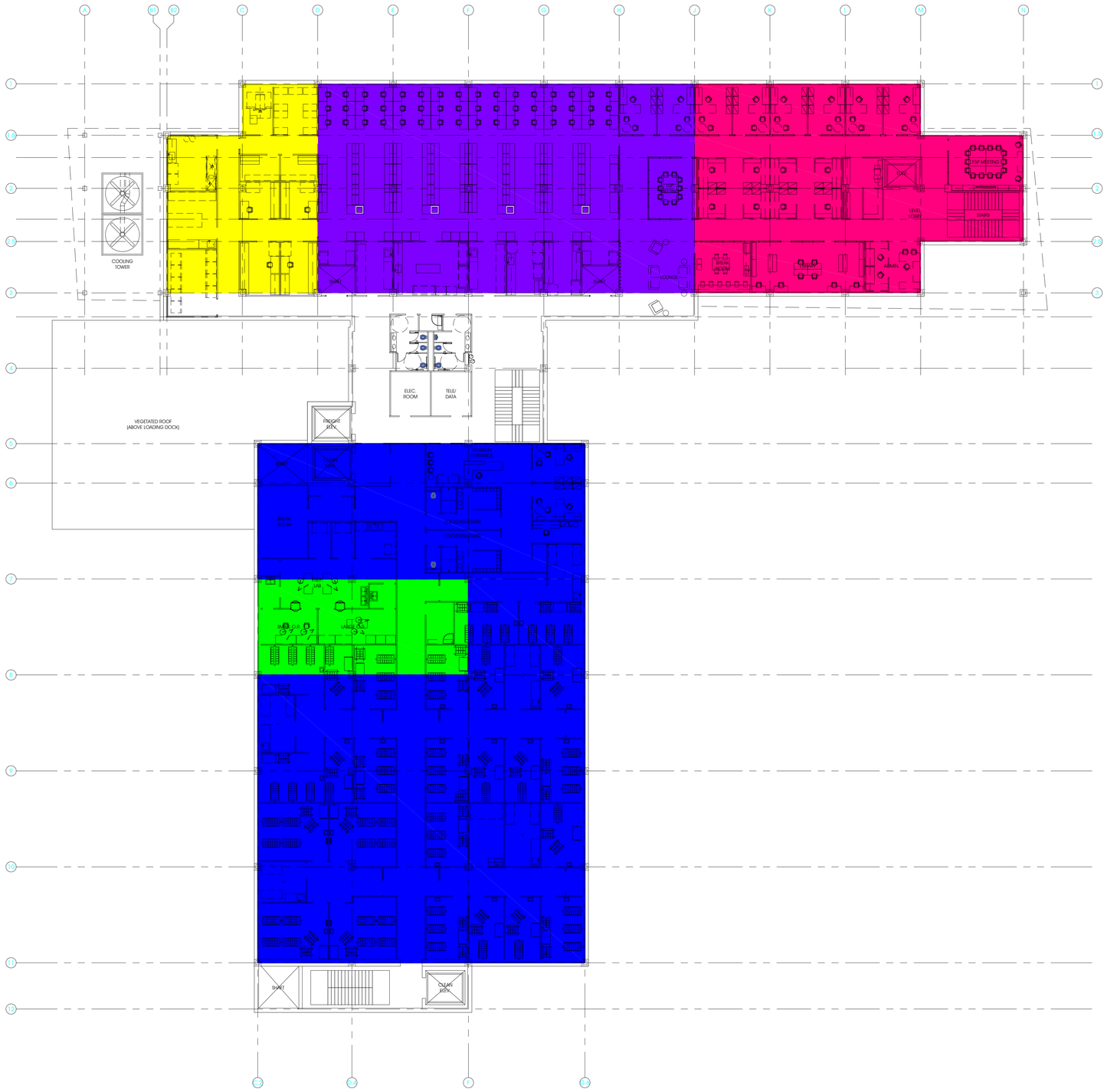


Table A.3: Numerical definition of criterion curves shown in Figure A.2

Criterion	Definition
NIST-A	0.025 µm or 25 nm (1 µin) between 1 and 20 Hz; 3.1 µm/s (125 µin/s) between 20 and 100 Hz
VC-D	6.25 µm/s (250 µin/s) between 1 and 80 Hz
VC-E	3.1 µm/s (125 µin/s) between 1 and 80 Hz
VC-F	1.6 µm/s (62.5 µin/s) between 1 and 80 Hz

Appendix D



VIBRATION DESIGN KEY

- INDICATES 8000 M-IN/SEC
- INDICATES 4000 M-IN/SEC
- INDICATES 2000 M-IN/SEC
- INDICATES 1000 M-IN/SEC
- INDICATES 500 M-IN/SEC

ALL OTHER AREAS 16,000 M-IN/SEC

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PROJECT DESCRIPTION

LIFE SCIENCES RESEARCH CENTER
UTAH STATE UNIVERSITY

USTAR BUILDING #2
LOGAN, UTAH

SHEET NAME:

STRUCTURAL VIBRATION DESIGN KEY PLAN LEVEL 2

REVISIONS

MARK	DATE	DESCRIPTION

ISSUE DATA

ISSUE DATE:	JULY 10, 2008
ISSUE TYPE:	SCHEM
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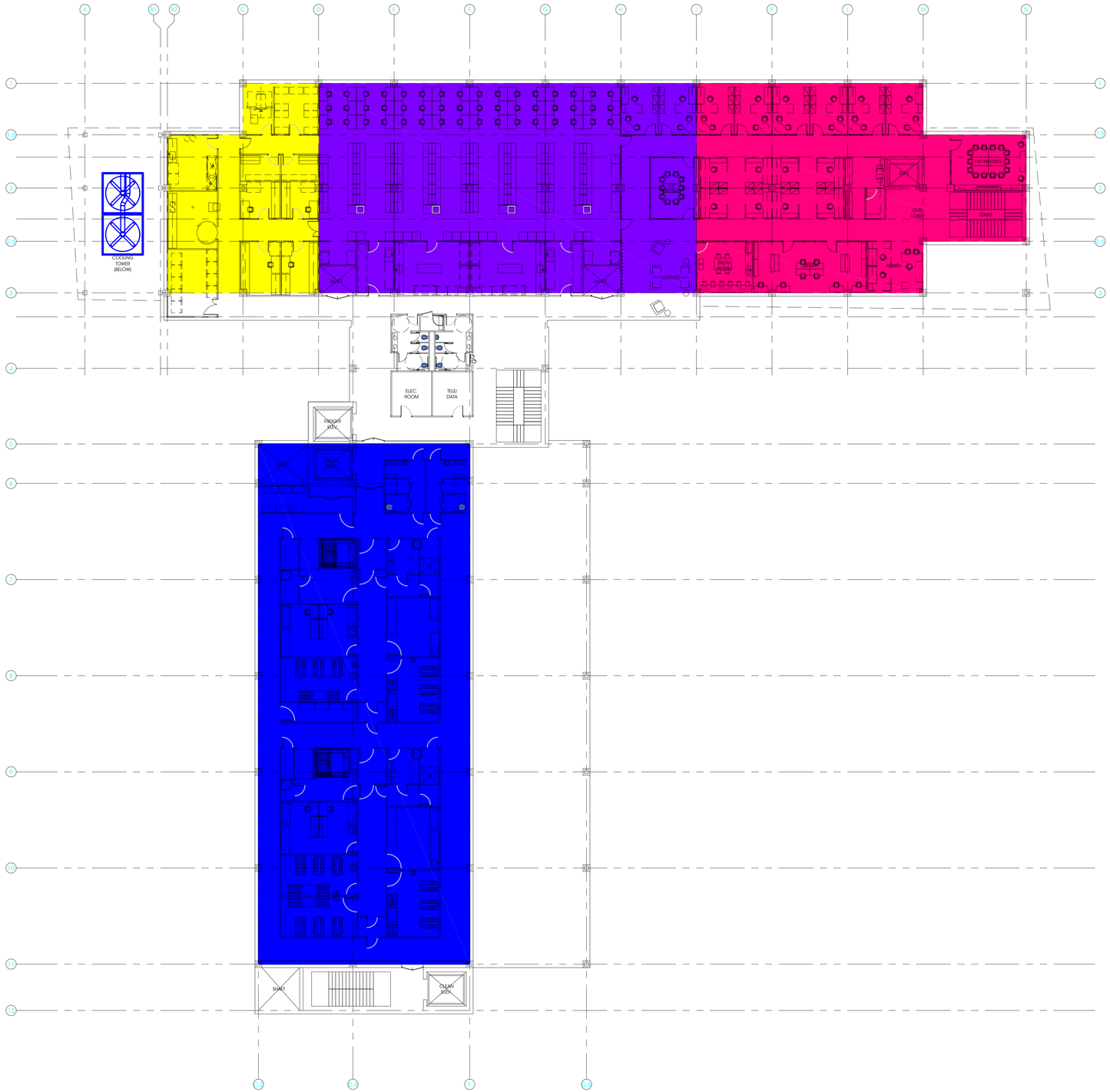

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UTAH STATE UNIVERSITY

USTAR BUILDING #2
LOGAN, UTAH

SHEET NAME:
STRUCTURAL VIBRATION DESIGN KEY PLAN LEVEL 3

REVISIONS

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Appendix E

LEED-NC

LEED-NC Version 2.2 Registered Project Checklist

#

Utah State University USTAR Building

Yes	?	No		Sustainable Sites (14 Points)		Responsible Party
6	5	3				
Y			Prereq 1	**Construction Activity Pollution Prev,** Erosion & Sediment Control plan The civil engineer will provide an erosion and sediment control plan as part of the construction documents	Req.	civil
1			Credit 1	**Site Selection**, do not devel building, hardscape, road, or parking on farmlands, undeveloped, habitat, wetlands, near water, or public park land. Project is located in an established research park for Utah State University Innovation Campus EP Credit: none	1	client
		1	Credit 2	**Development Density & Community Connectivity**, construct or renovate on prev. developed site w/ 60k sf/acre density OR community connectivity reqs. EP Credit: none	1	
		1	Credit 3	**Brownfield Redevelopment**, develop a site documented as contaminated or defined as brownfield. EP Credit: none	1	
	1		Credit 4.1	**Alternative Transportation**, Public Transportation Access, 1/2 mile of comm rail, light rail, or subway. Or 1/4 mile of 2 bus stops (city or campus) Design Team to evaluate and locate existing public transportation bus stops and Campus Bus/Shuttle stops EP Credit: transportation management plan.	1	architect
1			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms. Meet requirements for commercial/institutional or residential situations. Building to provide exterior bicycle storage and showers.changing rooms EP Credit: transportation management plan.	1	architect
		1	Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles. provide cars for 3% occup, OR preferred parking for 5% of parking capacity, OR alternative fueling stations for 3% parking capacity. EP Credit: transportation management plan.	1	
1			Credit 4.4	**Alternative Transportation**, Parking Capacity. carpool parking for 5% of parking spaces OR provide for shared vehicle programs OR no new spaces. Project will exceed the parking requirements of local zoning and will carpool/ Vanpool parking for 5% of total provided stalls. EP Credit: transportation management plan.	1	architect/civil
	1		Credit 5.1	**Site Development,** Protect of Restore Habitat. Limit site disturbances OR restore or protect 50% of native veg where previous developed or graded. Project to restore 50% or more of the site with native vegetation--may need to utilize the master plan detention pond EP Credit: restoring or protecting 75% of site area on previous devel or graded.	1	architect/civil
	1		Credit 5.2	**Site Development,** Maximize Open Space. exceed local reqs by 25% OR if no reqs then open are to match footprint OR 20% open area for project site. Project to provide open space (vegetated) within the project boundary that is equal or exceeds the building's footprint--may need to utilized the master plan detention pond EP Credit: double the open space required.	1	architect/civil
1			Credit 6.1	**Stormwater Design, Quantity Control:** IF exist. imperviousness LESS than 50% then, no increase in peak discharge rate OR stream channel protection. IFexist. imperviousness MORE than 50% then 25% decrease in stormwater runoff. Options for the Project include using vegetated roofs and pervious pavement. Detention ponds and percolating the water into the ground are other options but may be difficult with high water table. Capturing and storing storm run-off for irrigation purposes can help earn this credit.--stored in vegetated swales or underground perforated piping. EP Credit: none	1	civil/landscape

	1		Credit 6.2	**Stormwater Design, Quality Control:** plan that would reduce impervious covers, promote infiltration, capture and treat runoff of 90% of annual rainfall. EP Credit: none The Project would need to consider using vegetated roofs, vegetated swales and wetlands.	1	civil/landscape
	1		Credit 7.1	**Heat Island Effect,** Non-Roof: shade, 29 SRI, or open grid for 50% of site hardscape. OR 50% of parking under cover with roof meeting 29 SRI. Project will need to provide shade trees, paving materials with proper solar reflectance, and consider and open grid pavement system. EP Credit: if 100% rather than 50% OR 100% parking rather than 50%.	1	civil/landscape
1			Credit 7.2	**Heat Island Effect,** Roof: meet SRI requirements for 75% of roof, OR 50% vegetated roof, OR combination of vegetated and meet SRI to meet formula. EP Credit: if 100% of roof is a green roof system. The Building's roof to have a solar reflectance index within LEED requirements which essentially means a white membrane or metal roof, or combination vegetated roof.	1	architect
1			Credit 8	**Light Pollution Reduction,** exiting light amount OR automatic shutoff after hours AND exterior lighting output. The site lighting and interior lighting will minimize light pollution. EP Credit: none	1	Electrical
Yes	?	No				
3	2		**Water Efficiency**		**5** Points	
1			Credit 1.1	**Water Efficient Landscaping**, Reduce potable water for irrig by 50% through species, irrig, harvest, recycle wastewater, public non-potable H2o Project to utilize drought tolerant landscape and drip irrigation EP Credit: none	1	Landscape Architect
1			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation. use only harvest, recycled H2o, graywater, nonpotable OR no perm. irrig. landscaping Project to utilize drought tolerant landscape and temporary irrigation system which will allow the plants to get establish but then eliminate irrigation EP Credit: none	1	Landscape Architect
	1		Credit 2	**Innovative Wastewater Technologies,** reduce potable water for sewage 50% by fixtures or nonpotable water OR treat 50% on-site (infiltrate or use) EP Credit: reduction potable to 100% OR treat 100% on-site. Utilize water-conserving fixtures, capture rainwater through use of cistern constructed wetlands--high efficient filtration systems	1	Civil/Mechanical
1			Credit 3.1	**Water Use Reduction**, 20% Reduction in potable water usage than baseline calculated for toilets, urinals, lavs, showers, kitchen sinks, inside the building. Project will utilize low water use fixtures and occupancy sensors This applies to water closets, urinals, lavs, showers and sinks (non-lab) EP Credit: see 3.2.	1	Mechanical
	1		Credit 3.2	**Water Use Reduction**, 30% Reduction in potable water usage than baseline calculated for toilets, urinals, lavs, showers, kitchen sinks, inside the building. Project will utilize low water use fixtures and occupancy sensors This applies to water closets, urinals, lavs, showers and sinks (non-lab) EP Credit: meet 40% OR demonstrate a different system.	1	Mechanical
Yes	?	No				
10	3	4	**Energy & Atmosphere**		**17** Points	
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems** DFCM to hire a commissioning agent ASAP!	Req.	client
Y			Prereq 2	**Minimum Energy Performance,** meet listed provisions. Building to be designed to exceed minimum energy performance	Req.	mechanical
Y			Prereq 3	**Fundamental Refrigerant Management,** no use of CFC refrigerants. Project will not utilize CFC's	Req.	mechanical

7		3	Credit 1	**Optimize Energy Performance,** whole building energy simulation OR prescriptive compliance path (4 points) OR pcp (1 Point) **7 points = 31.5% above baseline** 1. Improve Building envelope construction to achieve a building envelope that is significantly better than code minimum through better insulating walls and roof and by using high performance glass--reducing heating and cooling energy and reducing the size of mechanical equipment needed to heat and cool the building 2. Improve building lighting beyond code minimum and employ lighting control strategies to reduce energy use associated with lighting. 3. Use variable air volume fume hoods and variable air volume supply air and general exhaust to reduce fan energy associated with tempering make-up air. 4. Use heat recovery on biosafety cabinets, fume hoods and general exhaust air. 5. Use three stage cooling, minimizing the requirement for mechanical cooling; the first two stages will be indirect and direct evaporative cooling with the third stage being mechanical cooling. 6. Fume hood exhaust and associated make-up air will be reduced during un-occupied hours and non-use time. 7. Zone temperatures will be capable of being reset to minimize energy use during un-occupied hours. 8. High efficiency steam boilers will be used for process steam needs. 9. Boiler stack economizers will be used on the high pressure steam to preheat makeup water or to preheat combustion air. 10. High pressure steam boiler burners will be variable speed. 11. Feedwater pumps serving the high pressure steam boilers will be variable speed. 12. High efficiency condensing type gas fired boilers will be utilized for heating needs. This style boiler is more efficient at part load than at full load; the building is almost always in a part load condition. 13. Reduce the static pressure drop through the supply air handlers and exhaust air handlers by reducing the air velocity in the air handlers. 14. High efficiency water cooled chillers Variable Frequency Drive control will be used to maintain high efficiency during part load conditions 15. A plate type heat exchanger will be utilized for a water side economizer to provide cooling needs throughout the winter for process cooling and other year round cooling needs where outside air economizers are not used. 16. Low pressure drop HEPA filters will be used in Animal rooms. 17. Premium efficiency motors will be used. 18. Air-side bypass around heat recovery coils will be analyzed. 19. Variable frequency drives will be provided on cooling tower fans. 20. A central ground coupled heat pump system will be analyzed. 21. A high delta T will be used for heating hot water and chilled water to reduce pumping energy. 22. High efficiency domestic water heater will be used. 23. The steam condensate will be returned from the jacket of autoclaves and washers in lieu of dumping to waste. EP Credit: none	1 to 10	
1	1	1	Credit 2	**On-Site Renewable Energy,** use on-site renewable energy self supplied. 2.5%, 7.5%, 12.5% renewable energy to earn 1, 2, or 3 points. EP Credit: none Project will be evaluating the use of geothermal (maybe) as well as photo voltaics	1 to 3	mechanical/electrical
1			Credit 3	**Enhanced Commissioning,** contract a CxA. they may be through the design team. DFCM to hire a commissioning agent ASAP! EP Credit: none	1	client
1			Credit 4	**Enhanced Refrigerant Management,** do not use refrigerants, OR select refrigerants and HVAC&R that minimize or eliminate emissions. EP Credit: none All HVAC equipment will use non CFC and non HCFC refrigerants with zero ozone depletion potential to minimize contributions to global warming. Building chillers will be R134a; smaller equipment will use R410a or R407c.	1	mechanical
	1		Credit 5	**Measurement & Verification,** implement a M&V to evaluate building/energy system performance for no less than one year of post-construction occupancy. EP Credit: none Client to determine if they want to include metering equipment and perform M&V 1 year post construction	1	client decision mechanical/electrical

	1		Credit 6	**Green Power,** provide 35% of power through a 2yr. renewable contract with an agency. EP Credit: none Client to determine if they want to purchase green power	1	client

Yes	?	No				
6	4	3		**Materials & Resources**	**13** Points	
Y			Prereq 1	**Storage & Collection of Recyclables,** recycling collection area. for paper, cardboard, glass, plastic, metal (minimum). Provide for recycling collection areas (interior and exterior)	Req.	architect/client
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof. hazardous materials are excluded. EP Credit: none	1	
		1	Credit 1.2	**Building Reuse**, Maintain 95% of Existing Walls, Floors & Roof hazardous materials are excluded. EP Credit: none	1	
		1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements EP Credit: none	1	
1			Credit 2.1	**Construction Waste Management**, recycle or salvage 50% from disposal, develop plan to identify. soil and land debris do not count. CMGC to utilize waste recycling firm EP Credit: see below.	1	cmgc
1			Credit 2.2	**Construction Waste Management**, recycle or salvage 75% from disposal, develop plan to identify. soil and land debris do not count. CMGC to utilize waste recycling firm EP Credit: recycle or salvage 95%	1	cmgc
	1		Credit 3.1	**Materials Reuse 5%**, use salvaged, refurbished, or reused material for 5% of the total value of materials on the project. equipment does not count. Architect to study options for utilizing salvaged materials EP Credit: see below.	1	architect
	1		Credit 3.2	**Materials Reuse 10%,** use salvaged, refurbished, or reused material for 10% of the total value of materials on the project. equipment excluded. Architect to study options for utilizing salvaged materials EP Credit: use salvaged, refurbished, or reused material for 15%.	1	architect
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer), use materials equal to 10% value of materials. equipment excluded. Select and specify products that utilize recycled content. EP Credit: see below.	1	architect/cmgc
	1		Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer), use materials equal to 20% value of materials. equipment excluded. Select and specify products that utilize recycled content. EP Credit: value must equal 30%.	1	architect/cmgc
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally 10% material cost. portion breakdowns are possible. equipment excluded. Select and specify products produced and manufactured regionally. EP Credit: see below.	1	architect/cmgc
	1		Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regionally 20% material cost. portion breakdowns are possible. equipment excluded. Select and specify products produced and manufactured regionally. EP Credit: value must equal 40%.	1	architect/cmgc
1			Credit 6	**Rapidly Renewable Materials,** 10 yr harvest cycle. Constitute 2.5% of total building material value based on cost. Select and specify materials that are rapidly renewable such as bamboo, agrifiber linoleum, wheatboard, cork. EP Credit: value must equal 10%.	1	architect/cmgc
1			Credit 7	**Certified Wood,** use 50% wood material cost for FSC certified material. structural, dimensional, flooring, sheathing, doors, finishes, furniture possible. Select and specify certified wood products. EP Credit: wood material cost must equal 95%.	1	architect/cmgc

Yes	?	No				
14	1		**Indoor Environmental Quality**		**15** Points	
Y			Prereq 1	**Minimum IAQ Performance,** meet requirements System design to meet requirements	Req.	mechanical
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control,** prohibit smoking and include exterior smoking area OR interior smoking with mechanical req. Utah Clean Air Act--Smoke Free Building	Req.	client
1			Credit 1	**Outdoor Air Delivery Monitoring,** monitor Co2, provide airflow to meet formula requirement. 1. Airflow measurement stations with feedback will be used for outdoor air intakes and will be controlled and monitored by the building DDC control system to provide required outside air ventilation. If the system fails to provide the required level of fresh air, a visible and audible alarm will be generated by the DDC system. 2. Conference rooms and other high density occupancy spaces (higher than 25 people per 100 sf) will have individual room CO2 sensors with feedback that are continually monitored by the DDC system, higher than desired CO2 levels will trigger increased ventilation by the variable air volume system. If system does not respond to maintain desired CO2 levels, an alarm will be generated by the DDC system. EP Credit: none	1	mechanical
1			Credit 2	**Increased Ventilation,** meet ventilation rates AND diagram and calculations OR multizone analytic model to predict airflow. Ventilation (per person) will be increased 30%. EP Credit: none	1	mechanical
1			Credit 3.1	**Construction IAQ Management Plan, During Construction**. meet SMACNA guidelines, protect material from moisture, filter air handlers. Filters will be provided on return air grille to keep ductwork clean while system is operated during construction. EP Credit: none	1	mechanical
1			Credit 3.2	**Construction IAQ Management Plan**, **Before Occupancy,** perform building air flush-out, OR IAQ testing, and meet contaminant maximum. Client to allow 16-20 day flush-out prior to occupancy. EP Credit: none	1	client/mechanical
1			Credit 4.1	**Low-Emitting Materials**, Adhesives, Sealants and Aerosols. meet requirements listed in chart. Specify, select and utilize low voc adhesives, sealants and aerosols. EP Credit: none	1	architect/cmgc
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings & Primers. meet VOC content limits for finishes, coating, stains, sealers, shellacs, etc. Specify, select and utilize low voc paints and coatings and primers. EP Credit: none	1	architect/cmgc
1			Credit 4.3	**Low-Emitting Materials**, Carpet and pad Systems must meet CRI's Green Label Plus program. adhesive must meet COV limits. Specify, select and utilize carpet and pad systems that meet CRI's Green Label EP Credit: none	1	architect/cmgc
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products. no formaldehyde (manufactured or field applied). FF&E not included. Specify, select and install composite wood and agrifiber products that are formaldehyde free. EP Credit: none	1	architect/cmgc

Yes	?	No				
1			Credit 5	**Indoor Chemical & Pollutant Source Control.** provide entryway system with mats, AND exhaust hazardous areas, AND meet MERV of 13. 1. Design to provide for permanent entry way systems in the primary direction of travel to capture dirt and particulates. 2. Exhaust will be provided from the building general exhaust system to keep areas of pollutants sufficiently negative with respect to adjacent spaces. 3. Air handlers will have MERV 13 high efficiency filters which filter outside air and return air. EP Credit: none	1	architect/mechanical
1			Credit 6.1	**Controllability of Systems**, Lighting. individual controls for 90% of occupants AND lighting system controllability for shared multi-occupant spaces. Provide individual lighting controls for 90% (minimum) of the building occupants. EP Credit: none	1	electrical
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort. individual control for 50% of occupants (operable window possible). AND multi-occupant spaces. The building mechanical system will provide individual VAV boxes to almost all rooms. Each VAV box will have its own thermostat allowing individual control or adjustment. Small offices and other non-lab spaces will have operable windows. Individual labs will each have an adjustable VAV box and thermostat. EP Credit: none	1	mechanical
1			Credit 7.1	**Thermal Comfort**, Design HVAC and envelope to meet standard. demonstrate compliance. Each space will be designed to provide comfort levels as established by ASHRAE 55-2004 Thermal Comfort for human occupancy. EP Credit: none	1	mechanical/architect
1			Credit 7.2	**Thermal Comfort**, Verification. Occupant survey within 6-18 months after occupancy. Corrective plan is 20% of occupants are unsatisfied. An assessment of the building thermal comfort satisfaction will be performed within 6 to 18 months after occupancy. If it is determined that more than 20% of occupants are dissatisfied with thermal comfort, a plan for corrective action will be established and implemented. EP Credit: none	1	mechanical
1			Credit 8.1	**Daylight & Views, Daylight 75% of Spaces**. meet glazing factor calcs OR simulation model OR measurements of reg occupied spaces. contain glare. Provide windows/views at occupied spaces. EP Credit: achieve day lighting of 95% of regularly occupied spaces.	1	architect
	1		Credit 8.2	**Daylight & Views**, **Views for 90% of Spaces.** direct line of sight for 90% of regularly occupied spaces. offices and open areas possible. Provide windows/views at occupied spaces. EP Credit: point possible, but no prescribed requirements. petition for point.	1	architect
Yes	?	No				
1	4		**Innovation & Design Process**		**5** Points	
	1		Credit 1.1	**Innovation in Design**: Provide Specific Title ss 5.2	1	architect/landscape
	1		Credit 1.2	**Innovation in Design**: Provide Specific Title we 3.2	1	mechanical
	1		Credit 1.3	**Innovation in Design**: Provide Specific Title mr 2.2	1	architect
	1		Credit 1.4	**Innovation in Design**: Provide Specific Title sophisticated lighting control system	1	electrical
1			Credit 2	**LEED® Accredited Professional. a**t least 1 accredited principal involved. ajc to provide LEED AP (Jill)	1	architect
Yes	?	No				
40	19	10	**Project Totals** (pre-certification estimates)		**69** Points	

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

Appendix F

Form A	Design Review Checklist
Project Name: USU USTAR BUILDING	

Project Information

Architect: ajc architects/Payette
Mechanical Engineer: Van Boerum Frank and Associates
Electrical Engineer: Envision Engineering
Landscape Architect: Landmark Design
Contractor: Gramoll Construction
Commissioning Agent:

Design Review Checklist

This is a preliminary checklist and meant to be used as a tool for evaluating the status of the project and should be submitted with or prior to the submission of Construction Documents. Most measures require inspection and verification during the construction phase. Points will be awarded at the end of construction. Additional forms have been provided to assist you in this process. Applicable forms should be attached to this checklist for preliminary review.

1. Design and Technology Charrette (section 5.4.A)
Please indicate that each topic below was discussed during the charrette.

☑	Natural shade to reduce heat island effect from parking lots and landscaping areas	required
☑	Shielded or reduced parking and façade lighting to reduce nigh sky pollution	required
☐	Reuse of existing building to conserve our resources	
☑	Avoiding sewer and waterway contamination	required
☑	Use local building materials and products to support local economy and reduce the environmental impacts from transportation	required
☑	Encourage the use of public transportation	required
☑	Protect wet-lands and green spaces	required
☑	Provide recycling center	required
☐	Other topics	

Please attach a brief narrative summarizing charrette concepts which are to be incorporated into the design. Submit a copy of the narrative to the design team.

	HPBRS Checklist Item	Contract Document Source	
	2. Commissioning Agent (section 5.5.A)		
☑	The specifications for commissioning agent responsibilities for fundamental building components are located in the following sections:		required

3. Life-Cycle Cost Analysis (section 5.5.B)

- ☑ Complete the Life-cycle Cost Analysis Worksheet and attach with this checklist. Items to be costed shall include a minimum of major mechanical system components and energy efficiency measures to assist in selection. — **required**

4. CFC Reduction in HVAC and Refrigeration Equipment (section 5.5.B)

- ☑ HVAC and refrigeration equipment have been specified to use no chlorofluorocarbons (CFC) base refrigerants. — **required**
- ☐ The information and details describing non-CFC HVAC and refrigeration equipment are located in the following specification sections and/or are indicated on the following drawing sheet/notes:

5. Ventilation Systems (section 5.5.D)

- ☑ The mechanical system complies with Standard 62 — **required**

6. Drainage Systems (section 5.5.E)

- ☑ The drainage system has been designed to avoid accumulation of standing water around or in the building. — **required**

7. Landscape and Irrigation Systems (section 5.5.F)

- ☑ The landscape and irrigation system has been designed according to DFCM Guidelines for Landscape & Irrigation — **required**
- ☐ Attach completed Form C

8.Fundamental Lighting Design (section 5.5.G)

- ☑ The lighting system has been designed according to IESNA Lighting Handbook — **required**

9. Mold Prevention During Construction (section 5.5.H)

- ☑ Mold prevention instructions for construction are located in the following specification sections and/or are indicated on the following drawing sheets/notes according to the HPBRS. — **required**

10. Filtration Media Replacement (section 5.5.I)

☑	Filtration media replacement instructions are located in the following specification sections and/or are indicated on the following drawing sheets/notes.	required

11. Thermal Comfort (section 5.5.J)

☑	Thermal comfort requirements have been designed according to Standard 55 (with the allowed exceptions listed in the HPBRS).	required

12. Energy Performance (section 5.6.A) Size is >75000 SF

☑	Complete form D by listing and describing each energy efficiency measure that has been incorporated in to the building design. Measures are those obtained from the energy modeler. If available, a current energy modelers list may also be submitted in lieu of form D.	required
☑	The commissioning agent's role to verify the energy efficiency measures is described in the following specification sections and/or is indicated on the following drawing sheets/notes.	required

13. Energy Performance (section 5.6.B.1) Small Building Option < 75000 SF

☐	Complete the Small Building Prescriptive Energy Form E and attach with this checklist	required

14. Daylighting (section 5.7.A.1)

		Potential Pts
☑	Daylighting was designed as the primary lighting system for ___% of the spaces as described in the HPBRS.	3
☐	Attach the completed copy of daylighting hand calculations (Form F) or the daylighting computer simulation analysis.	
☐	The commissioning agent's role to verify the daylighting measures is described in the following specification sections and/or is indicated on the following drawing sheets/notes.	

15. Evaporative Cooling (section 5.7.B.1)

☐	Evaporative cooling system was designed as described in the HPBRS section 5.7.B.1.	0
☐	The commissioning agent's role to verify the evaporative cooling systems is described in the following specification sections and/or is indicated on the following drawing sheets/notes.	

16. Demand-Controlled Ventilation (section 5.7.B.2)

☑	The ventilation system was designed as described in the HPBRS section 5.7.B.1.	1
☐	The commissioning agent's role to verify the demand-controlled ventilation systems is described in the following specification sections.	

17. Under-floor Air Distribution (section 5.7.B.3)

☐	The design incorporates an under-floor air distribution system as described in the HPBRS.	0
☐	The commissioning agent's role to verify the demand-controlled ventilation systems is described in the following specification sections.	

18. Renewable Energy (section 5.7.C.1)

☐	The design uses renewable energy to reduce ____% of the source energy use	0
☐	The renewable energy systems is described in the following specification sections and/or is indicated on the following drawing sheets/notes.	

19. Low Emitting Materials (section 5.7.D.1)

☑	Adhesives and sealants have been specified to meet the current version of USGBC LEED NC Credit 4.1 Requirements	1
☑	Paints and coatings have been specified to meet the current versions of USGBC LEED NC Credit 4.2 Requirements	1
☑	Carpets have been specified to meet USGBC LEED NC Credit 4.3 Requirements	1

☑	Composite woods have been specified to meet the current version of USGBC LEED NC Credit 4.4 Requirements		1

20. Pollutant Source Control (section 5.7.D.2)

☑	Source ventilation systems and separation walls have been designed to vent pollution sources and prevent cross contamination.		1
☑	HVAC has been designed to avoid the possibility of mold and dust accumulation according to the HPBRS.		1
☑	Particle arresting filtration is specified to meet requirements as described in the HPBRS.		1

21. Construction Indoor Air Quality (section 5.7.D.3)

☑	List where specifications require the contractor to implement an indoor air quality management plan.		1
☑	List where specifications include instructions for VOC emitting materials and products to be off-gassed in a well-ventilated staging area		
☑	List where specifications include instructions to use fans during installation of VOC emitting materials and products. Details incorporate polyethylene vapor retarders on porous materials.		
☑	List where specifications include instructions to protect HVAC fans and ductwork from accumulating dust during construction.		
☑	List where specifications include instructions to vacuum dust that has accumulated in the HVAC fans and ductwork with a HEPA vacuum and remove and oil films from metal surfaces.		
☑	List where specifications include instructions to vacuum carpet and other soft surfaces with a HEPA vacuum.		
☑	List where specifications include instructions to flush the building for 15 days with 100% outside air prior to occupancy and after substantial completion		1

22. Additional Commissioning (section 5.7.E.1)

- ☑ Commissioning agent reviewed design and made recommendations for the design prior to completion of construction documents
- ☑ Specifications include instructions for commissioning agent to review contractor submittals relative to the systems being commissioned.
- ☑ Specifications include instructions to develop a recommissioning plan to schedule commissioning activities to assure the building is continuously tuned to optimize performance.

2

23. Acoustics (section 5.7.F.1)

- ☐ Acoustical levels are limited to a maximum of _____ dBA background, and 0.6 second reverberating times.
- ☐ Provide calculations or list where the information and details illustrating compliance with acoustical criteria are located in the following specification sections and/or are indicated on the following drawing sheets/notes.

0

24. Sustainable Materials (section 5.7.G.1)

- ☑ Major materials have been specified to contain required recycled content according to the requirements in the HPBRS.

2

25. Waste Reduction (section 5.7.H.1)

- ☑ List where specifications require the contractor to reduce overall waste according to the requirements of the HPBRS. ___% of overall waste shall be recycled, composted, and salvaged.

2

26. Water Reduction Credits (section 5.7.I.1)

- ☑ Water efficient fixtures and appliances have been specified and meet the criteria in the HPBRS.
- ☑ The information and details illustrating compliance of the water efficient fixtures are located in the following specification sections and/or are indicated on the following drawing sheets/notes.

2

27. Building Performance Monitoring Multi-Building (section 5.7.J.1)

☐	The building performance monitoring system has been designed as described in the HPBRS.		0
☐	The building performance monitoring systems is described in the following specification sections and/or is indicated on the following drawing sheets/notes:		

28. System Performance Monitoring (section 5.7.J.2)

☑	Equipment to provide continuous metering for the items listed in the HPBRS has been selected according to the HPBRS.		1
☑	Lighting systems (list where noted in construction documents)		
☑	Motor Loads > 20 hp (kWh and kW) (list where noted in construction documents)		
☑	Variable speed drive operation (list where noted in construction documents)		
☑	Chillier efficiency or chiller plan efficiency (list where noted in construction documents)		
☑	Air and water economizer operation (list where noted in construction documents)		
☑	On variable volume system, supply air static pressure and volume. (list where noted in construction documents)		
☑	Boiler efficiency or boiler plant efficiency (list where noted in construction documents)		
☑	Process loads (kWh and kW) (list where noted in construction documents)		

29. Exceptional energy or environmental measures (section 5.7.K.1)

☐	Provide a detailed explanation of each exceptional energy or environmental measure not specifically addressed in the HPBRS. Include charts, graphs or other appropriate materials to convey the concept and attach to this form.		0
☐	The innovation measure is described in the following specification sections and/or is indicated on the following drawing sheets/notes:		
Total Points			22

Appendix G

USU USTAR BUILDING

DOE-2 ENERGY MODEL

SCHEMATIC DESIGN

July 7, 2008

ABSTRACT: The USU USTAR energy model was simulated using the industry standard DOE-2 engine. The front end used to run the model was eQUEST version 3.6. A simulation of the following three designs was performed: 1) ASHRAE 90.1 Energy Standard, 2) VAV-Reheat as submitted for schematic review, and 3) an alternate heat pump system.

The systems were modeled as follows:

SYSTEM MODELS:

1. Baseline: In accordance with LEED NC 2.2 requirements, the baseline model meets the guidelines established by ASHRAE Standard 90.1. The building envelope and fenestration was set using thermal property requirements as specified in ASHRAE 90.1 for baseline models. This HVAC system consists of a packaged VAV AHU with reheat complete with a hot water preheat coil, DX cooling coil and associated air cooled condensing unit, and a 100% air economizer. The hydronic heating system consists of two 80% efficient gas-fired boilers. The domestic hot water system consists of a single 78% efficient gas-fired boiler. All spaces were modeled with 100% outdoor air and exhaust. The equipment loads were modeled as 10 W/sq. ft in the vivarium and 5 W/sq. ft in the labs/offices. The process steam loads and associated equipment were not modeled at this stage of design but will be a further source of energy savings.

2. Proposed Design: The proposed design matches the aforementioned baseline model in size, orientation, shape, and thermal loads. The building envelope and fenestration were modeled with the same thermal properties used for the baseline model. The HVAC system consists of a VAV AHU with reheat complete with a hot water preheat coil, chilled water cooling coil, indirect/direct evaporative cooling, 100% economizer, and energy recovery. The chilled water system consists of two high efficiency water cooled chillers with variable speed control and two cooling towers with variable speed fans. The hydronic heating system consists of four 94% efficient gas-fired boilers. High temperature differentials were used on the hydronic systems to save pump energy. The chilled water system was modeled with a 14˚ differential and the hot water system used a 30˚ differential. The domestic hot water system consists of a single 94% efficient gas-fired boiler.

3. Heat Pump Alternate: A second proposed design was modeled using central system ground source heat recovery chillers (heat pumps) to provide the heating and cooling to the building. The model was simulated using a well field of almost 200 wells, each 300 feet in depth covering a rectangular area of approximately 2.5 acres. The assumed ground temperature is 55˚F. Unlike models 1 & 2, this model does not use 2-stage evaporative cooling. Heat recovery was modeled in a similar manner to the proposed design.

CONCLUSION:

Energy usage and utility cost savings were calculated and are depicted in the below table. The cost savings data was calculated using Rocky Mountain Power schedule 6 and Questar Gas schedule F-1. The equation used to calculate percentage improvement comes from the LEED NC version 2.2 Reference Guide under EA credit 1. The equation has the form:

Percentage improvement = 100 x (1 – Proposed Building Performance / Baseline Building Performance)

	Site Energy, MBTU			Utility Cost, $			Percentage Improvement	
Simulation	Electric	Natural Gas	Total	Electric	Natural Gas	Total	Energy	Cost
Baseline	16,615.10	19,266.60	35,881.76	355,964	115,510	471,474	---	---
Proposed design	13,896.30	11,150.10	25,046.42	294,084	67,456	361,540	30.2	23.3
Heat Pump	19,863.70	228.2	20,091.88	470,483	2,005	472,488	44.0	-0.2

Table 1. Results of DOE-2 energy analysis for the USU USTAR schematic design.

APPENDIX A

BASELINE DATA

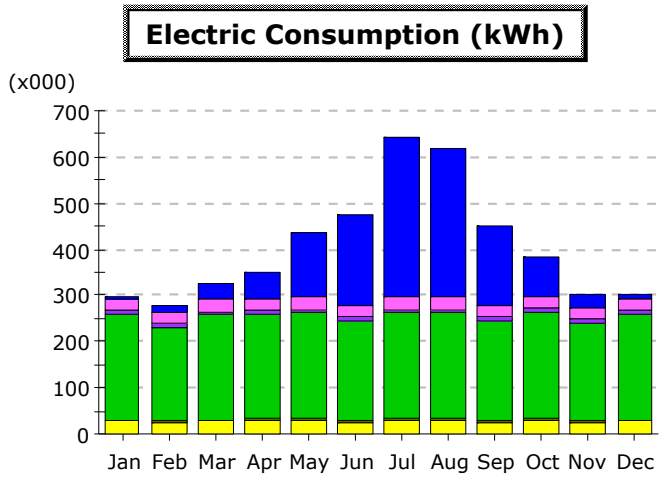
REPORT- BEPS Building Energy Performance WEATHER FILE- Salt Lake CityUTtmy2

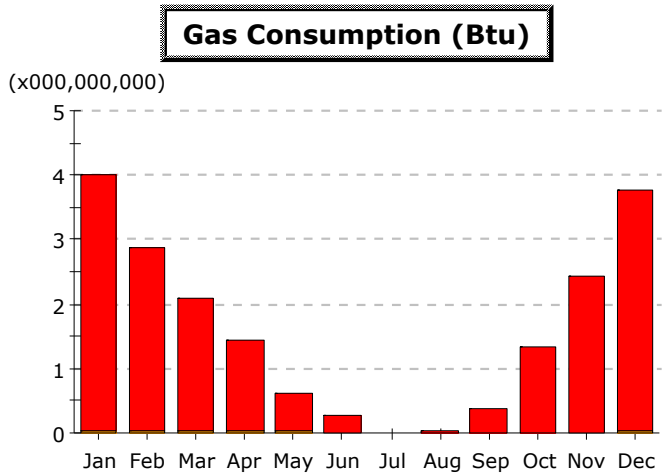
	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	1123.7	129.5	9160.8	0.0	4819.6	0.0	305.9	1075.7	0.0	0.0	0.0	0.0	16615.1
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	19055.0	0.0	0.0	0.0	0.0	0.0	0.0	211.7	0.0	19266.6
MBTU	1123.7	129.5	9160.8	19055.0	4819.6	0.0	305.9	1075.7	0.0	0.0	211.7	0.0	35881.8

TOTAL SITE ENERGY 35881.76 MBTU 307.7 KBTU/SQFT-YR GROSS-AREA 307.7 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 69112.08 MBTU 592.7 KBTU/SQFT-YR GROSS-AREA 592.7 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.0
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.





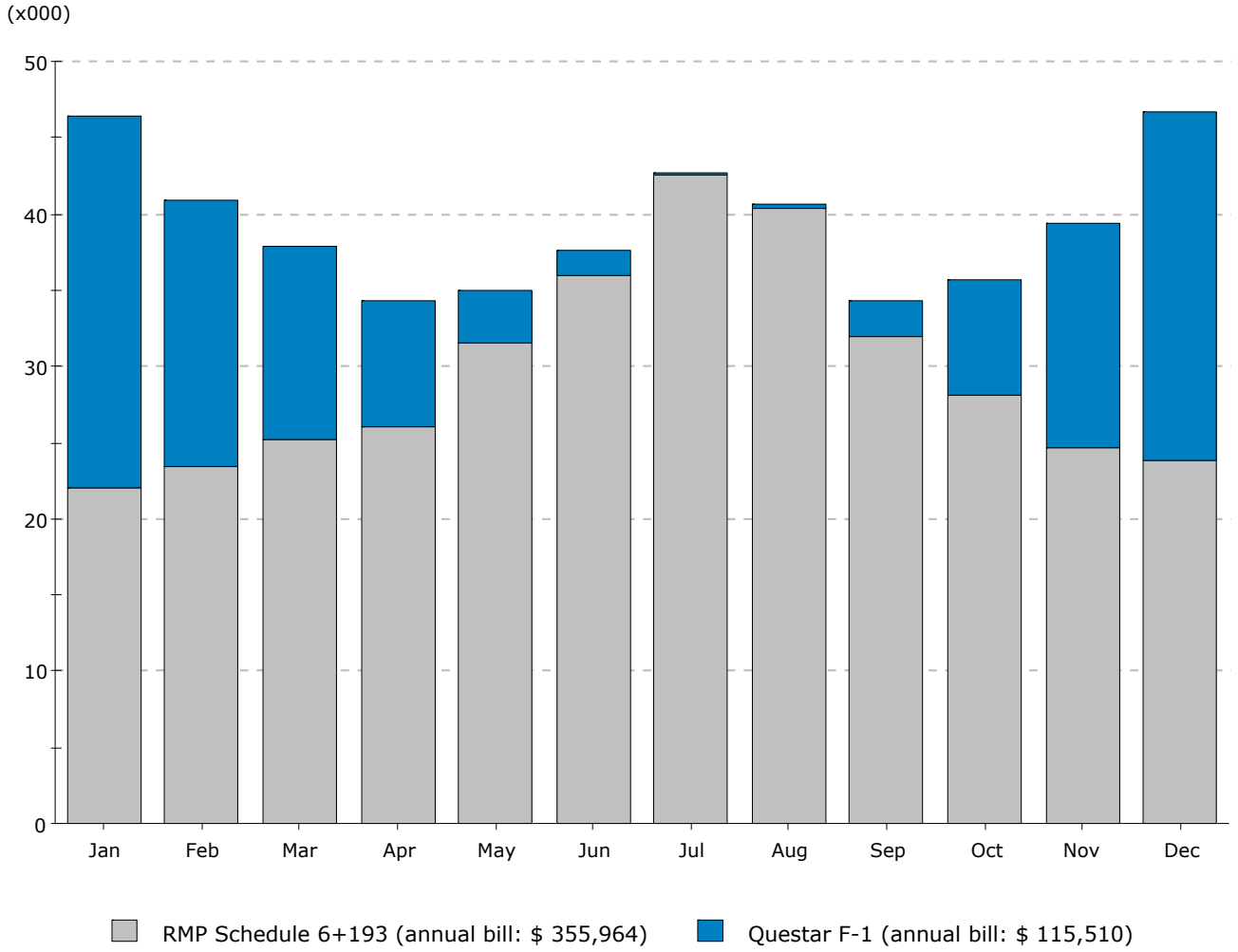
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	8.5	13.9	37.5	57.3	139.1	193.9	345.1	318.8	173.1	84.7	31.2	9.1	1,412.1
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	24.0	22.2	25.3	25.9	28.2	27.4	29.8	29.7	27.2	27.3	24.3	24.0	315.2
Pumps & Aux.	10.1	8.6	8.3	7.4	6.4	5.7	5.6	5.6	5.9	7.4	8.6	9.9	89.6
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	226.1	204.4	226.1	228.8	232.1	216.8	232.1	232.1	216.8	232.1	210.8	226.1	2,684.1
Task Lights	3.2	2.9	3.2	3.3	3.3	3.0	3.3	3.3	3.0	3.3	2.9	3.2	37.9
Area Lights	27.6	24.9	27.6	28.7	28.8	26.3	28.8	28.8	26.3	28.8	25.1	27.6	329.2
Total	299.4	276.8	327.9	351.4	438.0	473.2	644.7	618.3	452.3	383.5	302.9	299.8	4,868.2

Gas Consumption (Btu x000,000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	4.00	2.85	2.07	1.42	0.59	0.26	-	0.01	0.38	1.32	2.40	3.75	19.05
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.21
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	4.02	2.87	2.09	1.44	0.61	0.28	0.02	0.03	0.39	1.34	2.42	3.76	19.27

Monthly Utility Bills ($)



Total Annual Bill Across All Rates: $ 471,474

APPENDIX B

VAV BOILER DATA
(SCHEMATIC DESIGN BASIS)

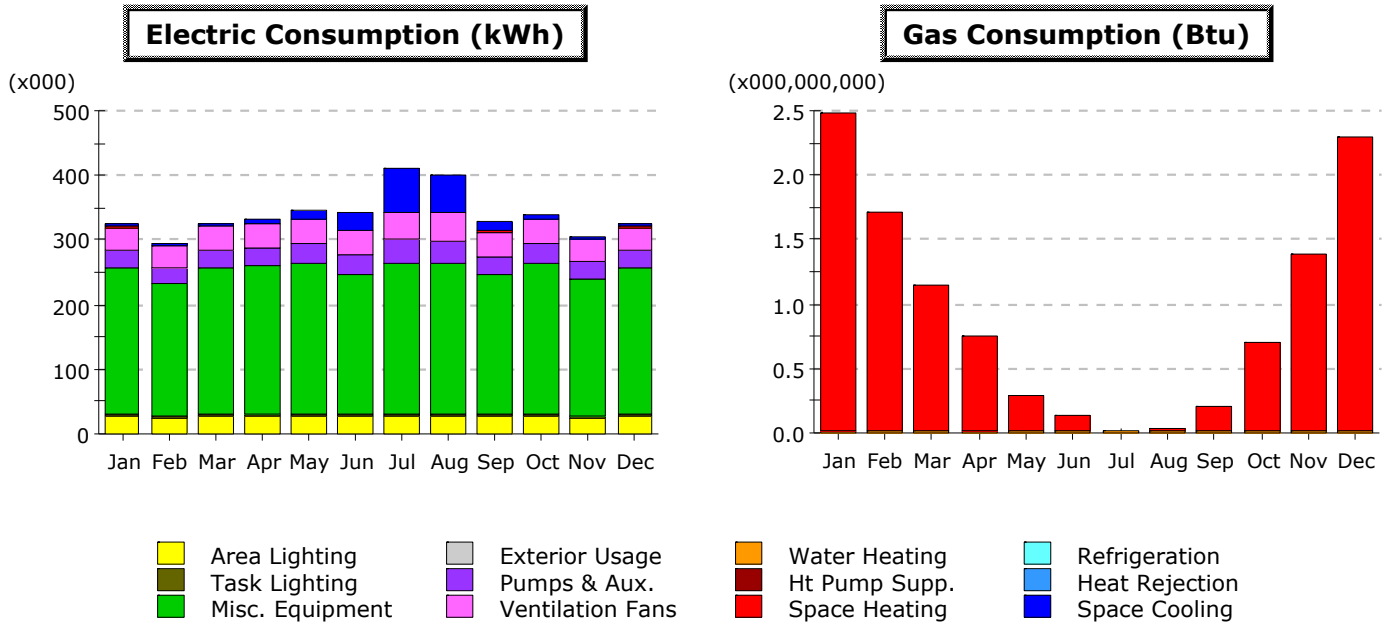
REPORT- BEPS Building Energy Performance WEATHER FILE- Salt Lake CityUTtmy2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	1123.7	129.5	9160.8	31.8	695.4	5.5	1212.6	1537.1	0.0	0.0	0.0	0.0	13896.3
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	10974.6	0.0	0.0	0.0	0.0	0.0	0.0	175.5	0.0	11150.1
MBTU	1123.7	129.5	9160.8	11006.4	695.4	5.5	1212.6	1537.1	0.0	0.0	175.5	0.0	25046.4

TOTAL SITE ENERGY 25046.42 MBTU 214.8 KBTU/SQFT-YR GROSS-AREA 214.8 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 52839.15 MBTU 453.1 KBTU/SQFT-YR GROSS-AREA 453.1 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 0.0
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

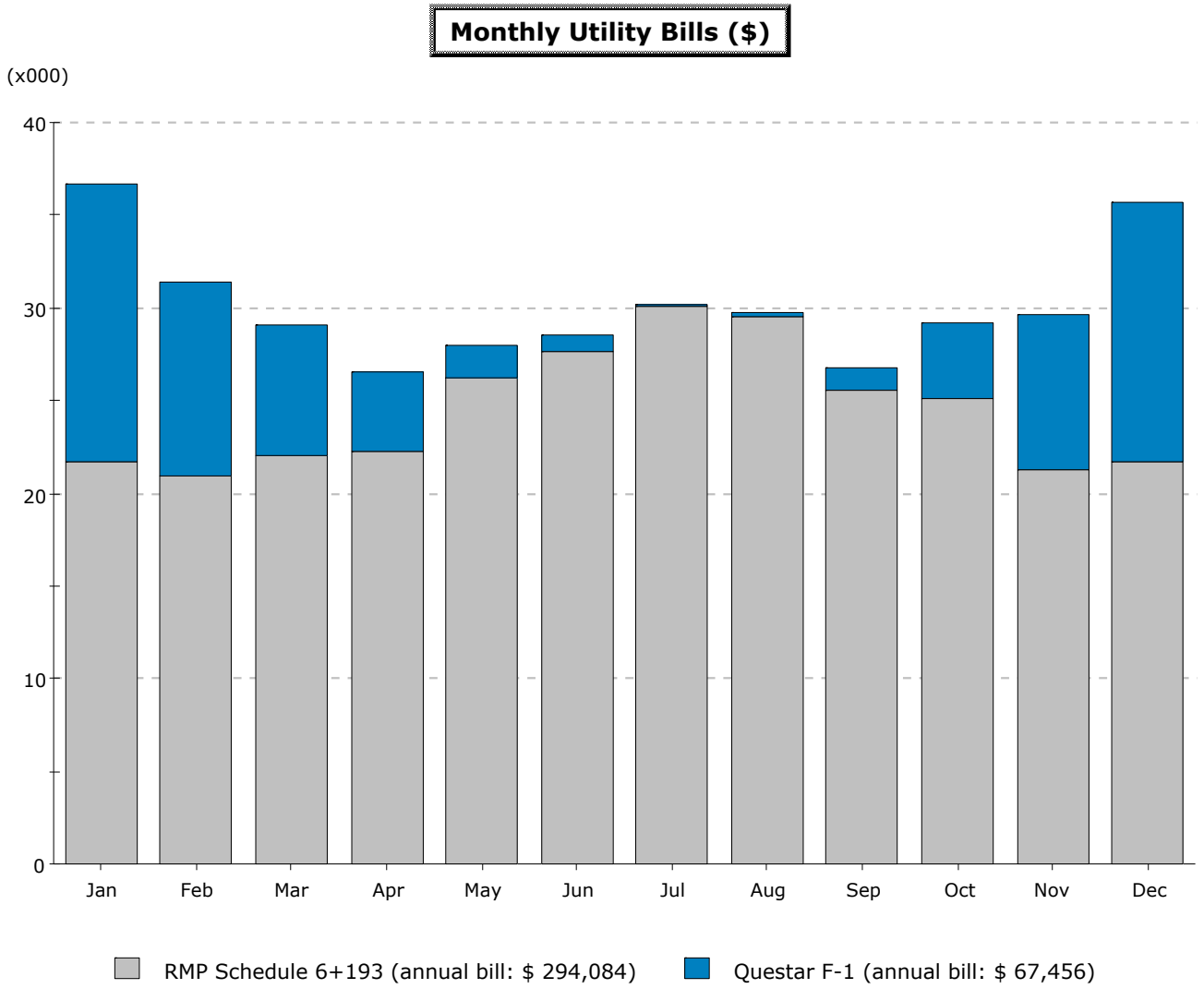


Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	1.8	2.5	3.5	4.2	11.8	26.4	68.6	59.6	14.8	6.1	2.5	1.9	203.7
Heat Reject.	-	-	-	-	0.0	0.2	0.8	0.6	0.0	0.0	-	-	1.6
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	2.0	1.5	1.0	0.7	0.3	0.1	0.0	0.0	0.2	0.6	1.2	1.8	9.3
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	34.4	31.8	36.4	37.2	40.1	38.8	42.5	42.4	38.5	39.1	34.9	34.3	450.4
Pumps & Aux.	28.9	26.1	28.8	27.9	29.3	29.9	35.6	34.5	28.6	29.0	27.9	28.9	355.3
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	226.1	204.4	226.1	228.8	232.1	216.8	232.1	232.1	216.8	232.1	210.8	226.1	2,684.1
Task Lights	3.2	2.9	3.2	3.3	3.3	3.0	3.3	3.3	3.0	3.3	2.9	3.2	37.9
Area Lights	27.6	24.9	27.6	28.7	28.8	26.3	28.8	28.8	26.3	28.8	25.1	27.6	329.2
Total	323.9	294.0	326.4	330.8	345.7	341.6	411.6	401.2	328.2	339.0	305.3	323.8	4,071.6

Gas Consumption (Btu x000,000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	2.46	1.69	1.13	0.73	0.28	0.12	0.01	0.02	0.19	0.69	1.37	2.28	10.97
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	0.02	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.18
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	2.48	1.71	1.15	0.75	0.30	0.14	0.02	0.03	0.21	0.70	1.38	2.30	11.15



Total Annual Bill Across All Rates: $ 361,540

APPENDIX C

HEAT PUMP DATA

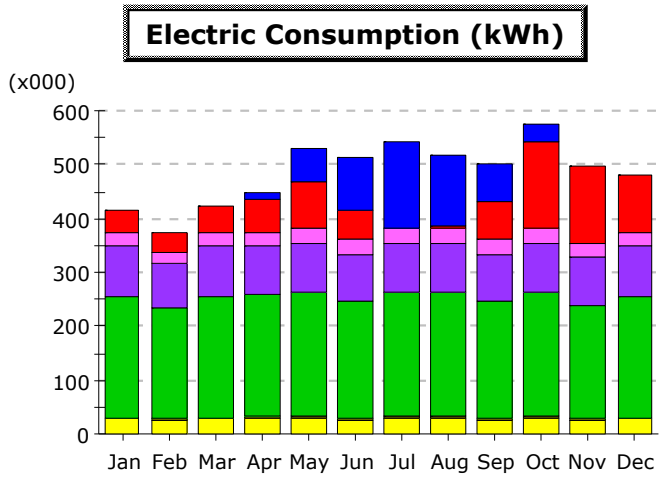
REPORT- BEPS Building Energy Performance WEATHER FILE- Salt Lake CityUTtmy2

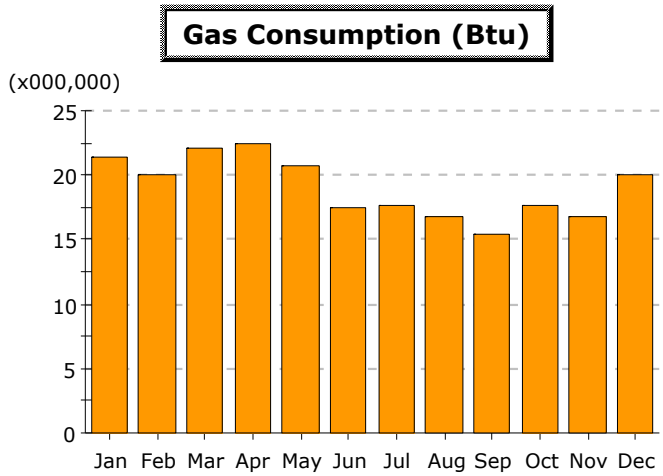
	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	1123.7	129.5	9160.8	2774.7	1939.3	0.0	3660.1	1075.6	0.0	0.0	0.0	0.0	19863.7
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	228.2	0.0	228.2
MBTU	1123.7	129.5	9160.8	2774.7	1939.3	0.0	3660.1	1075.6	0.0	0.0	228.2	0.0	20091.9

TOTAL SITE ENERGY 20091.88 MBTU 172.3 KBTU/SQFT-YR GROSS-AREA 172.3 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 59819.27 MBTU 513.0 KBTU/SQFT-YR GROSS-AREA 513.0 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 46.6
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.





Area Lighting
Task Lighting
Misc. Equipment
Exterior Usage
Pumps & Aux.
Ventilation Fans
Water Heating
Ht Pump Supp.
Space Heating
Refrigeration
Heat Rejection
Space Cooling

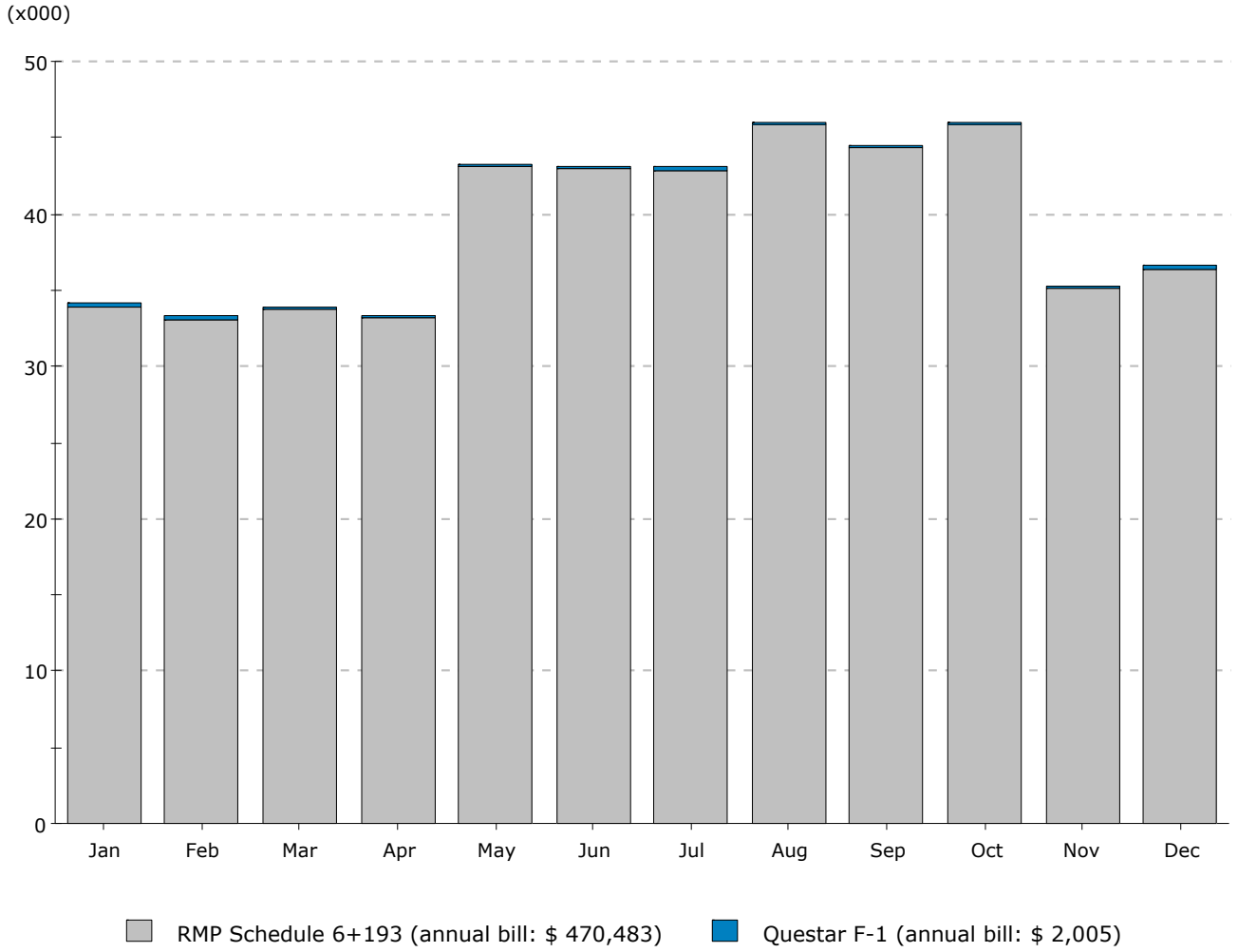
Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	2.1	9.9	61.6	99.3	160.4	130.0	68.5	35.1	1.3	-	568.2
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	40.4	37.0	48.0	61.9	86.7	53.4	1.0	4.1	73.1	159.4	143.2	104.7	813.0
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	26.8	24.2	26.8	25.9	26.8	25.9	26.8	26.8	25.9	26.8	25.9	26.8	315.1
Pumps & Aux.	91.1	82.3	91.1	88.1	91.1	88.1	91.1	91.1	88.1	91.1	88.1	91.1	1,072.4
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	226.1	204.4	226.1	228.8	232.1	216.8	232.1	232.1	216.8	232.1	210.8	226.1	2,684.1
Task Lights	3.2	2.9	3.2	3.3	3.3	3.0	3.3	3.3	3.0	3.3	2.9	3.2	37.9
Area Lights	27.6	24.9	27.6	28.7	28.8	26.3	28.8	28.8	26.3	28.8	25.1	27.6	329.2
Total	415.1	375.6	424.8	446.6	530.3	513.0	543.5	516.2	501.8	576.5	497.3	479.4	5,820.1

Gas Consumption (Btu x000,000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	-	-	-	-	-	-	-	-	-	-	-	-	-
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	21.48	20.00	22.01	22.42	20.72	17.42	17.58	16.76	15.39	17.66	16.73	20.05	228.22
Vent. Fans	-	-	-	-	-	-	-	-	-	-	-	-	-
Pumps & Aux.	-	-	-	-	-	-	-	-	-	-	-	-	-
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	-	-	-	-	-	-	-	-	-	-	-	-	-
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	21.48	20.00	22.01	22.42	20.72	17.42	17.58	16.76	15.39	17.66	16.73	20.05	228.22

Monthly Utility Bills ($)



Total Annual Bill Across All Rates: $ 472,488

Appendix H

ustar building #2, utah state university

Life Sciences Research Center

logan, utah

schematic design | project manual

july 10, 2008

prepared for:

state of utah
department of facilities construction management
4110 state office building, salt lake city, utah 84111
project no. 06292770

prepared by;

ajc architects
703 east 1700 south, salt lake city, utah 84105
project no. 0818

ajc architects

PROJECT MANUAL TABLE OF CONTENTS

UTAH STATE UNIVERSITY
USTAR – Life Sciences Lab Design
Logan, Utah

Section	Title	Pages
DIVISION 1 - GENERAL REQUIREMENTS		
(FURNISHED BY UTAH STATE UNIVERSITY)		
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	INSTRUCTIONS AND SUBCONTRACTORS LIST FORM	1 – X
	CONTRACTOR'S AGREEMENT	1 – X
	FUGATIVE DUST PLAN	1 – X
	BID BOND	1
	PERFORMANCE BOND	1
	PAYMENT BOND	1
	USU CHANGE ORDER FORM	1
	CERTIFICATE OF SUBSTANTIAL COMPLETION	1
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(FURNISHED ajc architects)		
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011400	WORK RESTRICTIONS	1 – X
012500	CONTRACT MODIFICATION PROCEDURES	1 – X
012900	PAYMENT PROCEDURES	1 – X
013100	PROJECT MANAGEMENT AND COORDINATION	1 – X
013200	CONSTRUCTION PROGRESS DOCUMENTATION	1 – X
013233	PHOTOGRAPHIC DOCUMENTATION	1 – X
013300	SUBMITTAL PROCEDURES	1 – X
	SUBMITTAL TRANSMITTAL	1
014000	QUALITY REQUIREMENTS	1 – X
0142000	REFERENCES	1 – X
015000	TEMPORARY FACILITIES AND CONTROLS	1 – X
016000	PRODUCT REQUIREMENTS	1 – X
	SUBSTITUTION REQUEST FORM	1 – X
017300	EXECUTION	1 – X
017329	CUTTING AND PATCHING	1 – X

017419	CONSTRUCTION WASTE MANAGEMENT AND DISPOSAL	1 – X
017700	CLOSEOUT PROCEDURES	1 – X
017823	OPERATION AND MAINTENANCE DATA	1 – X
017839	PROJECT RECORD DOCUMENTS	1 – X
017900	DEMONSTRATION AND TRAINING	1 – X
018113	SUSTAINABLE DESIGN REQUIREMENTS	1 – X
019113	GENERAL COMMISSIONING REQUIREMENTS	1 – X

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033300	ARCHITECTURAL CONCRETE	1 – X

DIVISION 4 - MASONRY

042000	UNIT MASONRY	1 – X

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052100	STEEL JOIST FRAMING	1 – X
053100	STEEL DECKING	1 – X
054000	COLD-FORMED METAL FRAMING	1 – X
055000	METAL FABRICATIONS	1 – X
055100	METAL STAIRS	1 – X
055213	PIPE AND TUBE RAILINGS	1 – X
055300	METAL GRATINGS	1 – X

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064023	INTERIOR ARCHITECTURAL WOODWORK	1 – X
066100	GLASS-FIBER REINFORCED COMPOSITE PANELS	1 – X

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071326	SELF-ADHERING SHEET WATERPROOFING	1 – X
071900	WATER REPELLENTS	1 – X
072100	THERMAL INSULATION	1 – X
072700	FLUID-APPLIED MEMBRANE AIR BARRIERS	1 – X
075400	THERMOPLASTIC MEMBRANE ROOFING	1 – X
076200	SHEET METAL FLASHING AND TRIM	1 – X
077200	ROOF ACCESSORIES	1 – X

078100	FIRE-RESISTIVE JOINT SYSTEMS	1 – X
078413	PENETRATION FIRESTOPPING	1 – X
078446	FIRE-RESISTIVE JOINT SYSTEMS	1 – X
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079500	EXPANSION CONTROL	1 – X

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083323	OVERHEAD COILING DOORS	1 – X
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084126	ALL-GLASSENTRANCES AND STOREFRONTS	1 – X
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092900	GYPSUM BOARD	1 – X
093000	TILING	1 – X
095113	ACOUSTICAL PANEL CEILINGS	1 – X
096500	RESILIENT BASE AND ACCESSORIES	1 – X
096516	RESILIENT SHEET FLOORING	1 – X
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096813	TILE CARPETING	1 – X
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099113	EXTERIOR PAINTING	1 – X
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101400	SIGNAGE	1 – X
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104416	FIRE EXTINGUISHERS	1 – X
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105113	METAL LOCKERS	1 – X
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220519	METERS AND GAGES FOR PLUMBING PIPING	1 – X
220523	GENERAL-DUTY VALVES FOR PLUMBING PIPING	1 – X
220529	HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT	1 – X
220548	VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT	1 – X

220553	INDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT	1 – X
220700	PLUMBING INSULATION	1 – X
221114	WATER DISTRIBUTION	1 – X
221314	SANITARY SEWERAGE	1 – X
221116	DOMESTIC WATER PIPING	1 – X
221117	PROCESSED WATER PIPING	1 – X
221119	DOMESTIC WATER PIPING SPECIALTIES	1 – X
221123	DOMESTIC WATER PUMPS	1 – X
221223	FACILITY INDOOR POTABLE-WATER STORAGE TANKS	1 – X
221316	SANITARY WASTE AND VENT PIPING	1 – X
221319	SANITARY WASTE PIPING SPECIALTIES	1 – X
221423	STORM DRAINAGE PIPING SPECIALTIES	1 – X
221429	SUMP PUMPS	1 – X
221513	COMPRESSED AIR SYSTEMS	1 – X
223100	DOMESTIC WATER SOFTENERS	1 – X
223400	FUEL-FIRED DOMESTIC WATER HEATERS	1 – X
224000	PLUMBING FIXTURES	1 – X
226600	CHEMICAL WASTE PIPING	1 – X
226700	DEIZONIZED PURE WATER SYSTEM	1 – X
226800	LABORATORY SYSTEMS	1 – X

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230513	COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT	1 – X
230516	EXPANSION FITTINGS AND LOOPS FOR HVAC PIPING	1 – X
230519	METERS AND GAGES FOR HVAC PIPING	1 – X
230523	GENERAL-DUTY VALVES FOR HVAC PIPING	1 – X
230529	HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT	1 – X
230548	VIBRATION AND SEISMIC CONTROLS FOR HVAC PIPING AND EQUIPMENT	1 – X
230553	INDENTIFICATION FOR HVAC PIPING AND EQUIPMENT	1 – X
230593	TESTING, ADJUSTING, AND BALANCING FOR HVAC	1 – X
230700	HVAC INSULATION	1 – X
230900	INSTRUMENTATION AND CONTROL FOR HVAC	1 – X
230993	SEQUENCE OF OPERATIONS FOR HVAC CONTROLS	1 – X
231113	FACILITY FUEL-OIL PIPING AND STORAGE TANKS	1 – X
231123	FACILITY NATURAL-GAS PIPING	1 – X
232113	HYDRONIC PIPING	1 – X

232123	HYDRONIC PUMPS	1 – X
232213	STEAM AND CONDENSATE HEATING PIPING	1 – X
232223	STEAM CONDENSATE PUMPS	1 – X
232500	HVAC WATER TREATMENT	1 – X
233113	METAL DUCTS	1 – X
233119	HVAC CASINGS	1 – X
233300	AIR DUCT ACCESSORIES	1 – X
233413	MIXED FLOW FANS	1 – X
233416	CENTRIFUGAL HVAC FANS	1 – X
233423	HVAC POWER VENTILATORS	1 – X
233600	AIR TERMINAL UNITS	1 – X
233713	DIFFUSERS, REGISTERS, AND GRILLES	1 – X
234100	PARTICULATE AIR FILTRATION	1 – X
235100	BREECHINGS, CHIMNEYS, AND STACKS	1 – X
235233	BOILERS AND ACCESSORIES	1 – X
235316	DEAREATORS	1 – X
235700	HEAT EXCHANGERS FOR HVAC	1 – X
235710	STEAM TO STEAM HEAT EXCHANGERS FOR HVAC	1 – X
236416	CENTRIFUGAL WATER CHILLERS	1 – X
236500	COOLING TOWERS	1 – X
237200	AIR-TO-AIR ENERGY RECOVERY EQUIPMENT	1 – X
237313	MODULAR INDOOR CENTRAL-STATION AIR-HANDLING UNITS	1 – X
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260135	ELECTRICAL BOXES AND FITTINGS	1 – X
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260156	VARIABLE FREQUENCY DRIVES	1 – X

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270781	CLOSED CIRCUIT TELEVISION (CCTV) SYSTEMS	1 – X
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321315	CONCRETE DRIVEWAY, WALK, CURB AND GUTTER	1 – X

328400	PLANTING IRRIGATION	1 – X
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