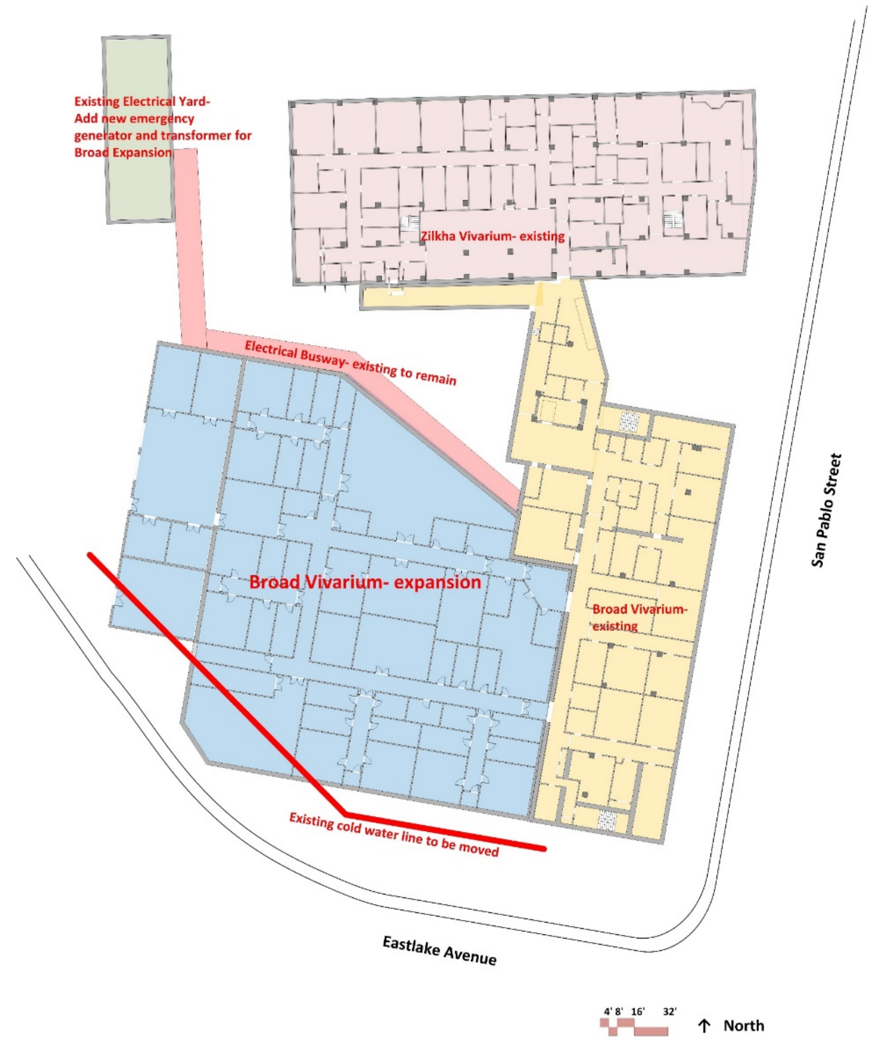


Broad Basement Expansion Feasibility Study

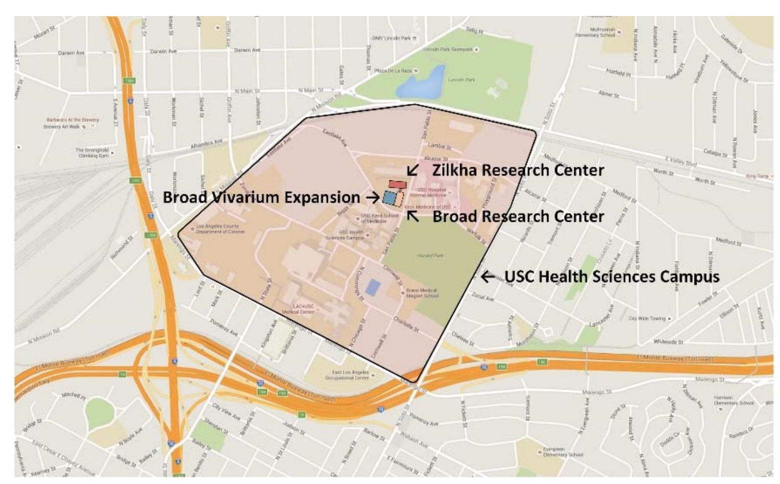
University of Southern California
Health Sciences Campus
2016 June 01


Zilkha Research Center
Broad Vivarium Expansion
Broad Research Center
USC Health Sciences Campus
North

Contents

Executive Summary

View of project site looking northeast from Eastlake Avenue



The Broad Basement Expansion Feasibility Study proposes a new 34,000 gross square foot one-story subterranean building on the USC Health Science Campus. It is programmed to support the Department of Animal Resources as an attached expansion adjacent to the Eli and Edith Broad Center basement vivarium.
This study delivers a summary of the building program requirements for a proposed vivarium expansion, a construction logistics plan, and a total project budget based on the concept design. Pending approvals by USC administration, this feasibility study will serve as a basis-of-design document for a future RFP for architectural and engineering design services to be engaged for schematic design and up to the construction administration phase.

The driver for this study is the “Long Range (10 Year) Report” prepared by the Animal Facility Planning Committee in March 2012. The Broad Basement Expansion Feasibility Study is attentive to the restraints addressed in the 2012 report and the projected growth of the HSC animal facility support areas by proposing an expandable standalone facility. This Broad expansion is capable of accommodating all internal materials for cage washing and waste bedding disposal along with specialized BSL2 procedural spaces.

While the report notes a provision of 12,500 new cages as sufficient to meet the department’s needs (as of 2012), this study discloses several possibilities for increasing cage count such as zebra fish holding converted to rodent holding depending on the need for additional holding. The program developed in this study can achieve a total rodent cage count capacity of 14,420 by maximizing the defined boundaries of the site adjacent to BCC and ZNI as well as systematically organizing the interior program based on vivarium design guidelines.
The building footprint is defined by the Broad building at the east side, the existing electrical duct bank at the north side, and Eastlake Avenue at the south side. The design is mindful of the open green space and the Research Building 3 feasibility study conducted in August 2012.

Due to industry trends, it is noted to incorporate animal watering as an extension from the Broad vivarium and provide emergency power for all environmental systems. A dedicated loading dock is located at the west end of the site allowing access up to the facility. The western perimeter also includes knockout panels to accommodate future expansion and allow continuous flow by way of two corridors from this proposed basement vivarium space and into the existing Broad basement.
The comprehensive program requirements incorporate facility needs, identified goals and objectives, and corresponding necessities through meetings with the Provost’s Office, the Executive Director of the Department of Animal Resources, Facilities Management Services, and Capital Construction Development.
Following the effort in determining program needs and layout, this study aims to serve as a foundation to drive the spatial and architectural design, system narratives, construction requirements, and the cost implications on proposing to build at this site.

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Vivarium Concept Plan

Scheme A

Assignable Program Area: ~22,000 asf

Assignable space includes program areas indicated with color.

Gross Building Area: ~34,000 gsf

Gross area includes assignable program area plus corridors, holding room suite vestibules and janitor rooms, mechanical/plumbing/electrical rooms at north side.

ASF/GSF ratio = ~65%

Total Cages: 11,200

Add 2,380 cages if Zebra Fish Room is converted to rodent holding;

Add 840 cages if Imaging Lab is converted to rodent holding;

Total Cage Capacity: 14,420

Vivarium Concept Plan

Scheme B

Scheme B moves loading dock area to south, to allow for mechanical yard at the north end, nearer to the main Mech/Elec/Plumb room zone.

Vivarium Program

Assignable space only- does not include corridors, holding suite vestibules, janitor rooms, mech/plumb/elec room

Room Name	Dimensions centerline of wall	Dimension face of wall	Area face of wall		Quantity		Subtotal by room	Subtotal by type	Cage Count	
HOLDING ROOMS								7994 asf		
Large Hold	22' x 24'	21.5' x 23.5'	505 asf	x	6	=	3032 asf		(6 cage racks x 140 cages)+(3 cage racks x 70 cages) x 6 rooms =	6300 cages
Large Hold	22' x 21'	21.5' x 20.5'	441 asf	x	1	=	441 asf		(5 cage racks x 140 cages)+(2 cage racks x 70 cages) x 1 rooms =	840 cages
Small Hold	11' x 24'	10.5' x 23.5'	247 asf	x	6	=	1481 asf		(3 cage racks/room x 140 cages/rack) x 6 rooms =	2520 cages
Small Hold	11' x 21'	10.5' x 20.5'	215 asf	x	1	=	215 asf		(2 cage racks/room x 140 cages/rack) x 1 rooms =	280 cages
Large BSL2 Hold	22' x 24'	21.5' x 23.5'	505 asf	x	1	=	505 asf		(6 cage racks x 140 cages)+(2 cage racks x 70 cages) x 1 room =	980 cages
Small BSL2 Hold	11' x 24'	10.5' x 23.5'	247 asf	x	1	=	247 asf		(4 cage racks/room x 70 cages/rack) x 1 room =	280 cages
Zebra Fish Hold	approx 40' x 53'	~39.5 x 52.5'	2074 asf	x	1	=	2074 asf		*Add 2,380 cages if converted to rodent holding	
PROCEDURE ROOMS								4793 asf		
Large Procedure	11' x 24'	10.5' x 23.5'	247 asf	x	4	=	987 asf			
Medium Procedure	11' x 21'	10.5' x 20.5'	215 asf	x	5	=	1076 asf			
Medium Procedure	11' x 20'	10.5' x 19.5'	205 asf	x	3	=	614 asf			
Medium Procedure	11' x 18'	10.5' x 17.5'	184 asf	x	1	=	184 asf			
Small Procedure	11' x 16'	10.5' x 15.5'	163 asf	x	3	=	488 asf			
BSL2 Procedure	11' x 24'	10.5' x 23.5'	247 asf	x	1	=	247 asf			
Surgery	20' x 24'	19.5' x 23.5'	458 asf	x	1	=	458 asf			
Necropsy	11' x 16'	10.5' x 15.5'	163 asf	x	1	=	163 asf			
Imaging Lab	20' x 33'	19.5' x 32.5'	575 asf	x	1	=	575 asf		**Add 840 cages if converted to rodent holding	
VIVARIUM SUPPORT								9384 asf		
Zebra Pump Room	11' x 40'	10.5' x 39.5'	415 asf	x	1	=	415 asf			
Dirty Cage Wash	36' x 27'	35.5' 26.5'	941 asf	x	1	=	941 asf			
Clean Cage Wash	36' x 27'	35.5' 26.5'	941 asf	x	1	=	941 asf			
Sterile Store	20' x 30'	19.5' x 29.5'	575 asf	x	1	=	575 asf			
Bedding Store	20' x 30'	19.5' x 29.5'	575 asf	x	1	=	575 asf			
Bedding Disposal Eq Store	20' x 20'	19.5' x 19.5'	380 asf	x	1	=	380 asf			
Feed Store	20' x 30'	19.5' x 29.5'	575 asf	x	1	=	575 asf			
Receiving	24' x 28'	23.5' x 27.5'	646 asf	x	1	=	646 asf			
Laundry	11' x 16'	10.5' x 15.5'	163 asf	x	1	=	163 asf			
Deterg/Cyl/Carcass Store	20' x 20'	19.5' x 19.5'	380 asf	x	1	=	380 asf			
Toilet/Shower/Lockers	approx 28' x 43'	~27.5' x 42.5'	1169 asf	x	1	=	1169 asf			
Break Room	12' x 18'	11.5' x 17.5'	201 asf	x	1	=	201 asf			
Office	12' x 18'	11.5' x 17.5'	201 asf	x	1	=	201 asf			
Store Room	8' x 36'	7.5' x 35.5'	266 asf	x	1	=	266 asf			
Loading Dock	40' x 50'	39.5' x 49.5'	1955 asf	x	1	=	1955 asf			
Totals								**22171 asf**		**11200 cages**
									*convert Zebra Fish to rodents	**2380 cages**
									**convert imaging lab to rodents	840 cages
									Total cage count if Zebra Fish and Imaging Lab are converted to rodent holding	**14420 cages**

USC
Capital Construction Development — PROJECT BUDGET WORKSHEET

Date: 06/01/2016
PR: USC0001309
Name: BCC - Broad Basement Expansion Feasibility Study

Gross Building Area: 34,000 GSF
Net Building Area: 34,000 SF
Cost per Gross SF: $ 1,466.31

Description: Based on June 2016 Concept Design by 'Design for Science.' GSF 34,000.

CONCEPT DESIGN ROM ESTIMATE

Code	Item		Budget	% Total Budget
15118 / 44710	Construction Contract	$	34,686,600	
	Construction	$	**34,686,600**	70%
15110 / 44331	Demolition	$	75,000	
15114 / 44350	Utility Connections	$	75,000	
15115 / 44355	Telecommunications/Data Lines	$	225,000	
15113 / 44360	Environmental Remediation	$	50,000	
15119 / 44365	Audio Visual	$	50,000	
15120 / 44366	Security	$	100,000	
15109 / 44530	Graphics / Signage	$	25,000	
15126 / 44830	Fixed Equipment - over $5K	$	100,000	
	Other Construction	$	**700,000**	1%
	Subtotal Hard Costs	$	**35,386,600**	71%
15100 / 44210	Preliminary Expenses (Programming)	$	48,700	
15102 / 44220	Architect / Engineer Fee	$	5,308,000	
15108 / 44230	Owner's Consultants	$	165,000	
15101 / 44240	Reimbursable Expenses	$	547,300	
15103 / 44250	Project Management	$	1,216,000	2.5%
15104 / 44310	Certified Inspection	$	95,000	
15105 / 44320	Soil Testing	$	25,000	
15106 / 44340	Plan Check / Permit Fees	$	707,800	
15107 / 44410	Legal / Administrative Services	$	1,000	
20230 / 44420	O&M / Misc Expenses / Shutdown	$	10,000	
	Soft Costs	$	**8,123,800**	16%
	Subtotal Hard and Soft Costs	$	**43,510,400**	87%
15125 / 44910	Total Contingency	$	6,344,200	15%
	TOTAL PROJECT BUDGET	$	**49,854,600**	100%
	Owner to Purchase Equipment Direct - Avoid Markups	$	5,000,000	
	TOTAL FUNDING REQUIRED	$	**54,854,600**	

Budget Summary

The Broad Basement Expansion Feasibility Study centers on a 34,000 gross square foot building on the Health Sciences Campus at USC. The one-story subterranean building is programmed to provide a vivarium and research lab function as well as building services. Construction and total project costs were developed by assessing the viability of the existing site and utilities with the desired program.

To achieve a single subterranean level at the area adjacent to BCC and ZNI, it requires shoring to support the following: BCC at the east side, the existing electrical duct bank at the north side, and Eastlake Avenue at the south side. The extensive shoring and use of retaining walls contribute as a unique cost to building one story below grade. Also, in order to build underground, dewatering of the site are required due to groundwater seepage at depths between 15 and 18 ½ feet. **The unique cost associated with addressing these conditions is $4,185,854.**

It is reported that the existing central plant chilled water system, high pressure steam and generators that serve the vivarium in BCC and ZNI do not have the capacity to accommodate this new facility. Consequently, the basement expansion design has included chilled water pumps within the mechanical room and noted for a new 1500 kVA generator and transformer in the existing electrical yard west of ZNI to serve this proposed building. **The unique cost associated with addressing these conditions is $1,429,710.**

Other budget impacts pertaining to existing campus utilities include electrical, chilled water, telecommunications located inside the project site along the westerly and southerly boundaries. However, while proposing a new building/basement footprint on this site prompts a series of necessary utility relocations, these are considered a usual cost to this project.

The chilled water supply and return lines originate from a service that crosses Eastlake Avenue and runs through a corner of the project site before turning east to a vault located immediately south of CHP. The BCC building is served from a vault located midway along the chilled water main. Under the proposed plan, the BCC chilled water service will be relocated to make allowances for the new below grade building.

The existing utilities service yard west of ZNI provides normal power and emergency power to BCC. Under the proposed plan, both the utility yard and the duct banks joining the yard with BCC would remain. However, as previously noted, the capacity is not available and a new generator for standby power with distribution would be added to this yard.

The telecommunication system is located around the southern perimeter of the site and it is anticipated the basement expansion will impact duct banks and they will be relocated around the building.

Further detail regarding construction and total project budget breakdowns may be found towards the end of this report.

Site Logistics

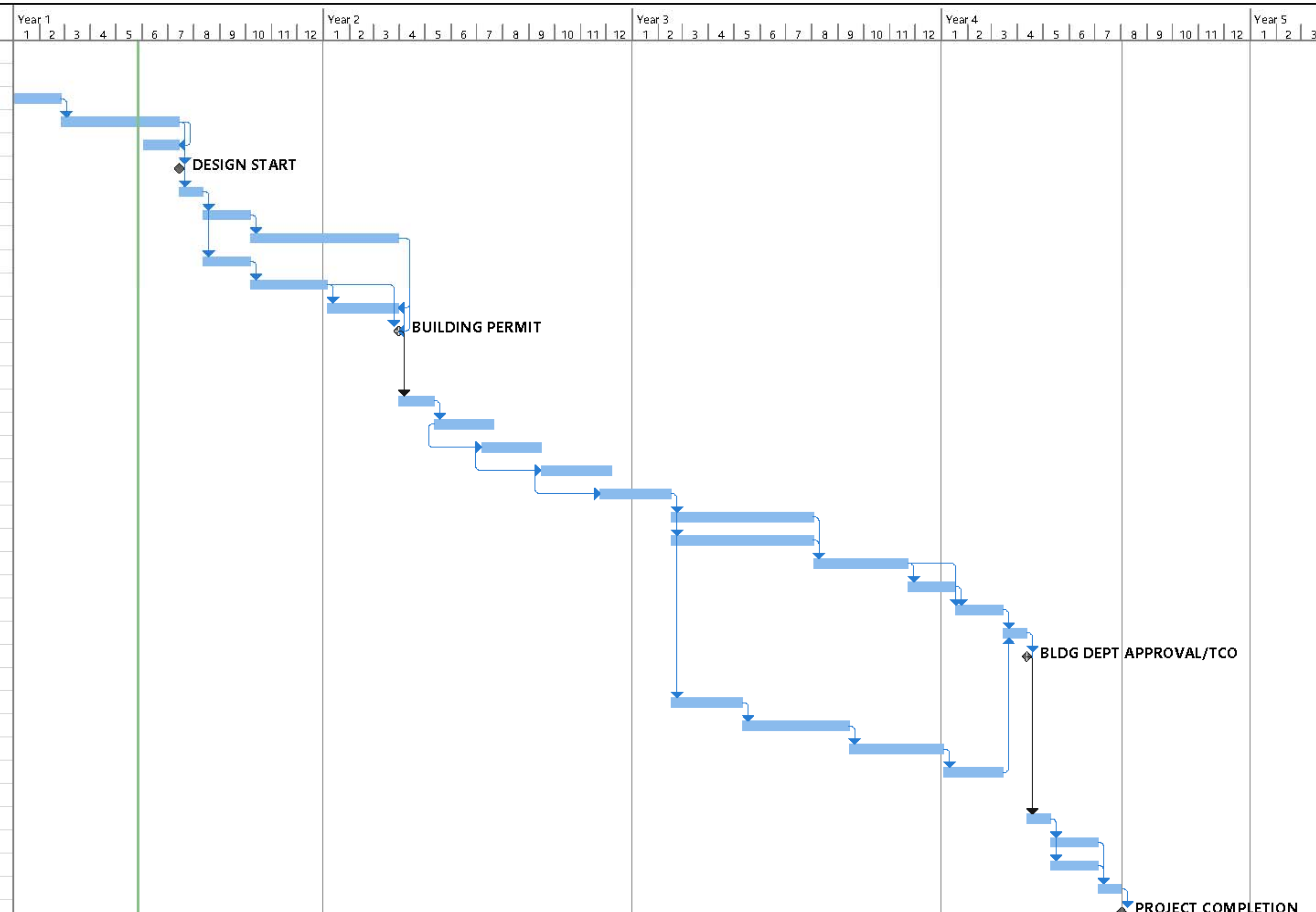
Project Schedule

USC University of Southern California

BROAD BASEMENT EXPANSION
PRELIMINARY PROJECT SCHEDULE

Hamilton Construction

ID	Task Name	Duration
1	**BROAD BASEMENT EXPANSION**	**935 days**
2	**DESIGN PHASE**	**325 days**
3	FEASIBILITY STUDY	40 days
4	PROGRAM REVIEW & PROJECT APPROVAL	100 days
5	ARCHITECT, CONTRACTOR SELECTION	30 days
6	DESIGN START	0 days
7	FINALIZE APPROVED PROGRAM	20 days
8	SCHEMATIC DESIGN	40 days
9	ENTITLEMENTS	125 days
10	DESIGN DEVELOPMENT	40 days
11	CONSTRUCTION DOCUMENTS	65 days
12	PLANCHECK & PERMIT	60 days
13	BUILDING PERMIT	0 days
14	**CONSTRUCTION PHASE**	**530 days**
15	**BASEMENT ADDITION CONSTRUCTION**	**530 days**
16	SITE PREPARATIONS & SITE CLEARING	30 days
17	UTILITY RELOCATIONS	50 days
18	SHORING	50 days
19	EXCAVATION FOUNDATIONS	60 days
20	BASEMENT STRUCTURE	60 days
21	WALL FRAMING & UTILITY ROUGH	120 days
22	MEP INFRASTRUCTURE & EQUIPMENT	120 days
23	FLOOR & WALL FINISHES	80 days
24	FIXED EQUIPMENT	40 days
25	BUILDING SYSTEMS COMMISSIONING	40 days
26	BUILDING DEPARTMENT SIGNOFFS	20 days
27	BLDG DEPT APPROVAL/TCO	0 days
28	**FINAL SITEWORK**	**280 days**
29	WATERPROOFING & BACKFILL	60 days
30	SITE UTILTIES & HARDSCPE	90 days
31	LANDSCAPING & SITE FURNISHINGS	80 days
32	PAVING & DEMOBILIZATION	50 days
33	**MOVE IN & OCCUPANCY**	**80 days**
34	MOVEABLE EQUIPMENT	20 days
35	EQUIPMENT PERFORMANCE TESTING	40 days
36	FURNISHINGS & MATERIAL STOCKING	40 days
37	MOVE IN & DEPARTMENTAL RELOCATIONS	20 days
38	PROJECT COMPLETION	0 days



*NOTE: DURATIONS SHOWN ARE IN WORKING DAYS ASSUMING A 5 DAY WORK WEEK, AND REFLECTS APPROXIMATELY 15 MONTHS FOR FEASIBILITY/DESIGN/PERMIT, 25 MONTHS FOR CONSTRUCTION & SIGNOFFS, 2 MONTHS FOR MOVE-IN & OCCUPANCY

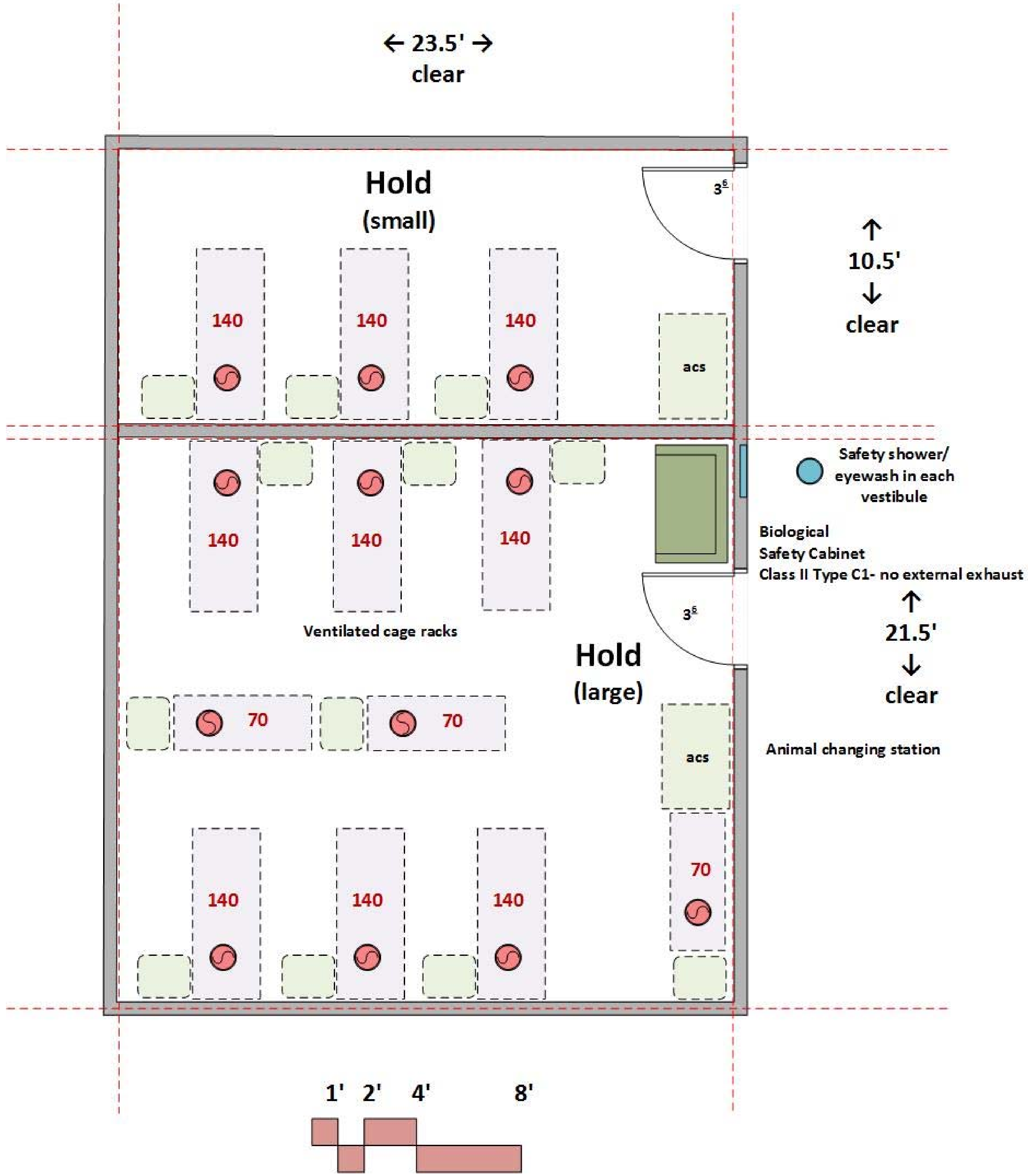
Equipment Schedule

Contractor Furnished Equipment	Manufacturer	Model	Dimensions	Quantity	Locatioon	Electrical	Plumbing	Mechanical	Remarks
Tunnel Washer	Better Built	Tunnel Washer T236	64" W x 99" H x 240" L	1	Cage Wash	480V	Steam	800 cfm exhaust	Includes bedding dispenser on clean side
		Bedding Dispenser D236	82" W x 76" H x 96" L	1		208V	Hot Water		
						115V	Cold Water		
							Compressed Air		
							Drain		
Cage Rack Washer	Better Built	R690	63" W x 98" H x 184" L	1	Cage Wash	480V	Steam	2400 cfm exhaust	Double Length
						208V	Hot Water	200 cfm exhaust	
						115V	Cold Water		
							Compressed Air		
							Drain		
Bulk Autoclave	Beta Star	VR728686	194" W x 109" H x 102" L	1	Cage Wash	480V	Steam		
						208V	Hot Water		
						115V	Cold Water		
							Compressed Air		
							Drain		
Bedding Supply/Disposal	Sure-Flo	Bedding Dispensing S210	24" W x 38" H x 51" L	1	Cage Wash	480V	Compressed Air		
		Bedding Disposal S200		1		280V	Drain		
Animal Watering System	Edstrom	RO System 790 Indigo	varies	1	Mechanical Room	115V	Cold Water		Includes ultrafilter and CMC (critical
		Ultrafilter UF-400					Drain		monitoring & control)
		Pulse CMC							
Biological Safety Cabinet II-B1	Nuaire	Allergard NU-S427-500	78" W x 63" H x 33" D	~15	Procedure Rooms	115V	Vacuum	1200 cfm exhaust	
					BSL2 Hold				
					BSL2 Procedure				
Autoclave	Consolidated	PT-SSR-3A	39" W x 74" H 67" D	1	BSL2 Procedure	208V	Steam		Pass thru model
							Hot Water		
							Cold Water		
							Compressed Air		
							Drain		
Chemical Fume Hood	Labconco	Protector Exstream	72" W x 96" H x 36" D	1	Necropsy	**115V**	Gas, Vacuum	600 cfm exhaust	**Variable Air Volume**
Washer				1	Laundry	**115V**	Hot Water		
							Cold Water		
							Drain		
Dryer				1	Laundry	208V			

Owner Furnished Equipment	Manufacturer	Model	Dimensions	Quantity	Locatioon	Electrical	Plumbing	Mechanical	Remarks
Biological Safety Cabinet II-A	Nuaire	Allergard NU-S602-500	60" W x 92" H x 30" D	~15	Holding Rooms	115V			
Animal Changing Station	Nuaire	Allergard NU-619-500	60" W x 92" H x 32" D	~15	Holding Rooms	115V			
Cage Rack 140	Allentown	403889	31" W x 78" L x ~78" H	~67	Holding Rooms	**115V**			Include fan unit with each rack
Cage Rack 70	Allentown	407632	25" W x 63" L x ~78" H	~26	Holding Rooms	115V			Include fan unit with each rack
Zebra fish aquaria				~3200	Zebra Fish Room		aquaria water		

PROGRAM ROOM DATA

The following pages provide conceptual program information for each different room type noted in the Vivarium Program. This information is meant to communicate general design intent. During Schematic Design and Design Development Phases room requirements may change.



HOLDING ROOM

Program Requirements

ARCHITECTURAL

Occupancy: B
Floor: methyl methacrylate with integral coved base
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Soundproofing in holding room walls
Aluminum wall guards at corridor
Ceiling: waterproof gypsum board with fiberglass finish and epoxy paint at 10'
no access panels inside holding rooms and procedure rooms; Limit ceiling access panels to corridor
Doors: 3'-6"x8'-0" with red glass view window
Vermin proof: all penetrations to rooms sealed
Sound attenuation: NC 35 or less; sound insulation in walls and above ceiling.
Security: card key access

STRUCTURAL

Poured in place concrete

MECHANICAL

Temperature: 70 deg F +/- 2 deg F
Humidity: 30-50% relative
100% exhaust; Air changes: 10 air changes/hour plus exhaust for ventilated cage racks
Air change rate may be higher due to equipment heat gain
Pressure: Negative or positive depending upon use
Controls: BMS environmental monitoring for temperature, humidity, pressure, and lighting; with digital display at each holding room
Provide air exhaust connections at ceiling for ventilated cage racks

PLUMBING

Domestic tepid water at safety shower/eyewash in vestibule
Floor drain at safety shower/eyewash in vestibule
Animal water to be extended from Existing Broad vivarium

ELECTRICAL

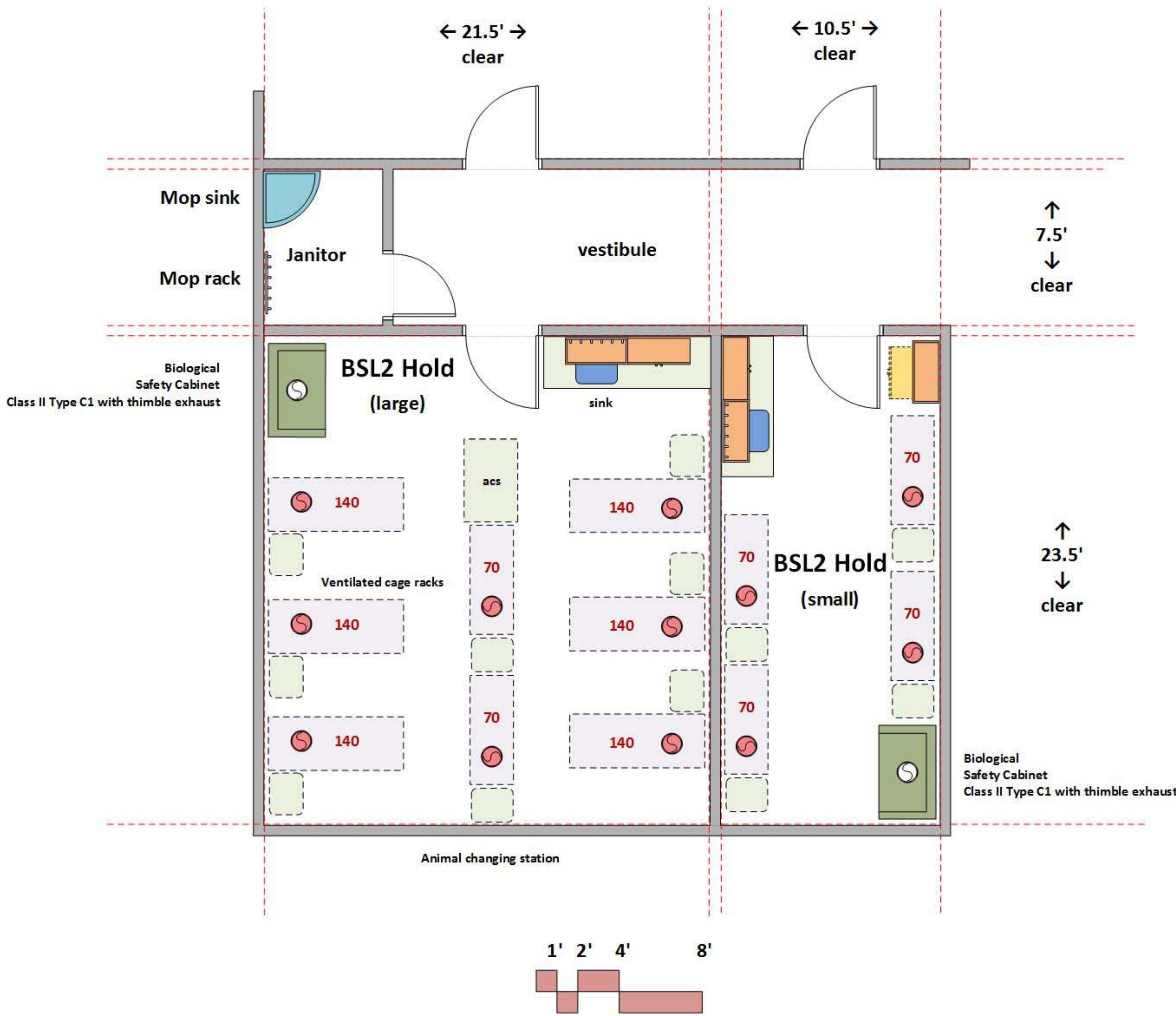
115v20a1ph outlets at walls and ceilings (cage racks)
Standby power- all MEP systems on emergency power
Hardwire and wireless data
Lighting: recessed, sealed LED at 600 LUX with circadian lighting controls
300 LUX unoccupied with manual switch for 600 LUX
White light for day cycle, red light for night cycle
Fire alarm: red strobe light

CONTRACTOR FURNISHED EQUIPMENT

Safety shower/eyewash in vestibule

UNIVERSITY FURNISHED EQUIPMENT

Ventilated cage racks
Animal changing stations
Biological safety cabinet



BSL2 Holding Room

Program Requirements

Note: Provide vestibule entry to BSL2 holding rooms during design phase

ARCHITECTURAL

Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint;
Soundproofing in holding room walls; Aluminum wall guards at corridor
Ceiling: waterproof gypsum board with fiberglass finish and epoxy paint at 10'
no access panels inside holding rooms and procedure rooms; Limit ceiling access panels to corridor
Doors: 3'-6"x8'-0" with red glass view window
Vermin proof: all penetrations to rooms sealed
Sound attenuation: NC 35 or less; sound insulation in walls and above ceiling.
Security: card key access

STRUCTURAL

Concrete slab floor

MECHANICAL

Temperature: 70 deg F +/- 2 deg F Humidity: 30-50% relative
100% exhaust; Air changes: 10 air changes/hour plus exhaust for ventilated cage racks
Air change rate may be higher due to equipment heat gain
Pressure: Negative or positive depending upon use
Controls: BMS environmental monitoring for temperature, humidity, pressure, and lighting; with digital display at each holding room
Provide air exhaust connections at ceiling for ventilated cage racks
Thimble exhaust at ceiling for biological safety cabinet

PLUMBING

Hot/Cold water at sinks
Pure water at sinks- pipe from pure water system in Broad
Animal watering to be extended from existing Broad Center

ELECTRICAL

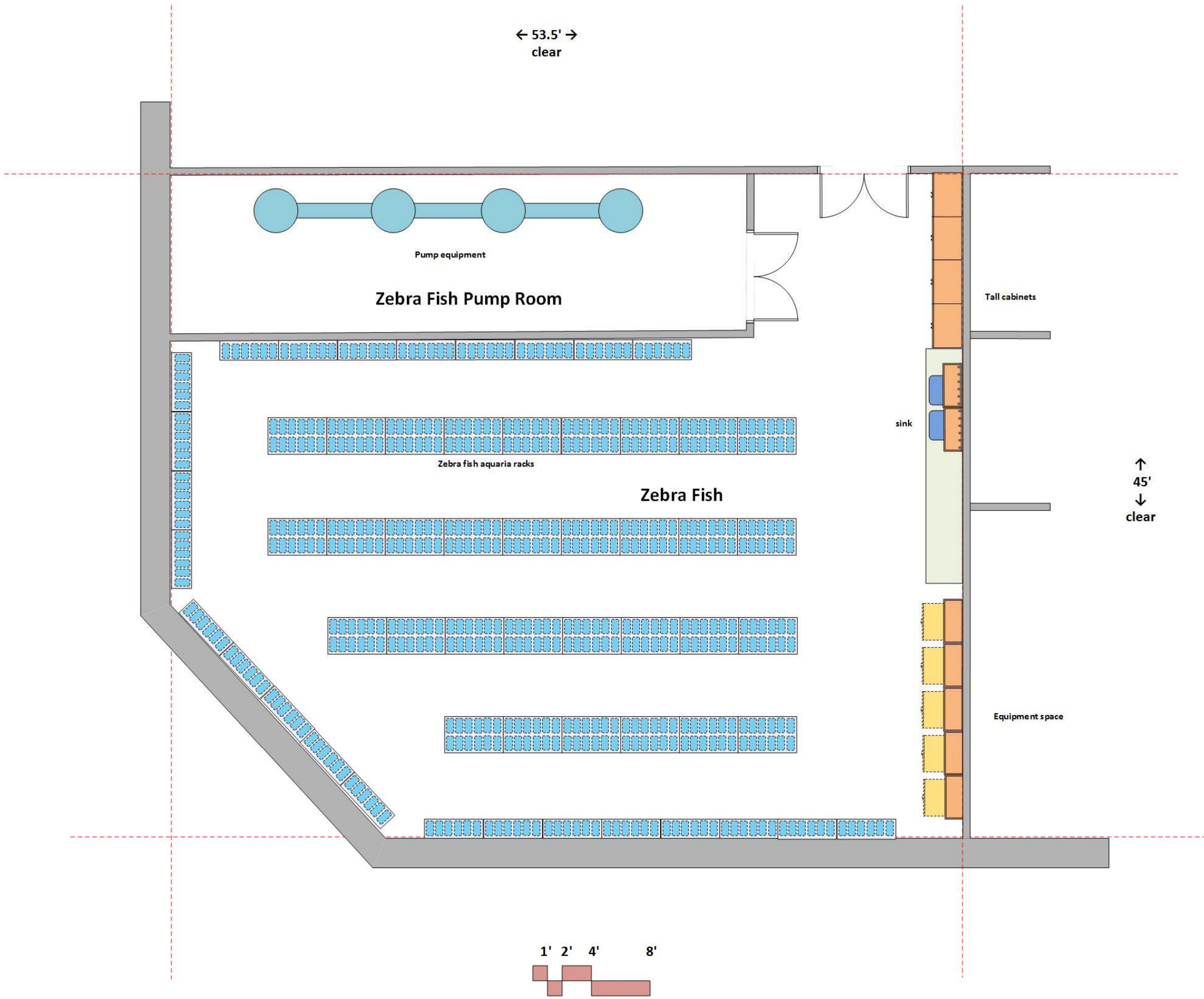
115v20a1ph outlets at walls and ceilings (cage racks) Standby power- all MEP systems on emergency power
Hardwire and wireless data
Lighting: recessed, sealed LED at 600 LUX. with circadian lighting controls
300 LUX unoccupied with manual switch for 600 LUX
White light for day, red light for night in holding rooms
Fire alarm: red strobe light

CONTRACTOR FURNISHED EQUIPMENT

Stainless steel casework, tops, sinks
Biological Safety Cabinets

UNIVERSITY FURNISHED EQUIPMENT

Ventilated cage racks
Animal changing stations



ZEBRA FISH ROOM

Program Requirements

ARCHITECTURAL

Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint;
Soundproofing in holding room walls; Aluminum wall guards at corridor
Ceiling: waterproof gypsum board with fiberglass finish and epoxy paint at 10'
no access panels inside holding rooms and procedure rooms; Limit ceiling access panels to corridor
Doors: 3'-x8' pair with view window
Vermin proof: all penetrations to rooms sealed
Sound attenuation: NC 45 or less; sound insulation in walls and above ceiling.
Security: card key access

STRUCTURAL

Poured in place concrete

MECHANICAL

Temperature: 85 deg F +/- 2 deg F Humidity: 30-50% relative
100% exhaust; Air changes: 10 air changes
Air change rate may be higher due to equipment heat gain
Pressure: Negative
Controls: BMS environmental monitoring for temperature, humidity, pressure, and lighting; with digital display at each holding room
Provide air exhaust connections at ceiling for ventilated cage racks
Thimble exhaust at ceiling for biological safety cabinet

PLUMBING

Hot/Cold water at sink
Pure water at sink- pipe from existing pure water system in Broad Center
Aquaria water system for zebra aquaria
Floor drains at each aisle between aquaria racks

ELECTRICAL

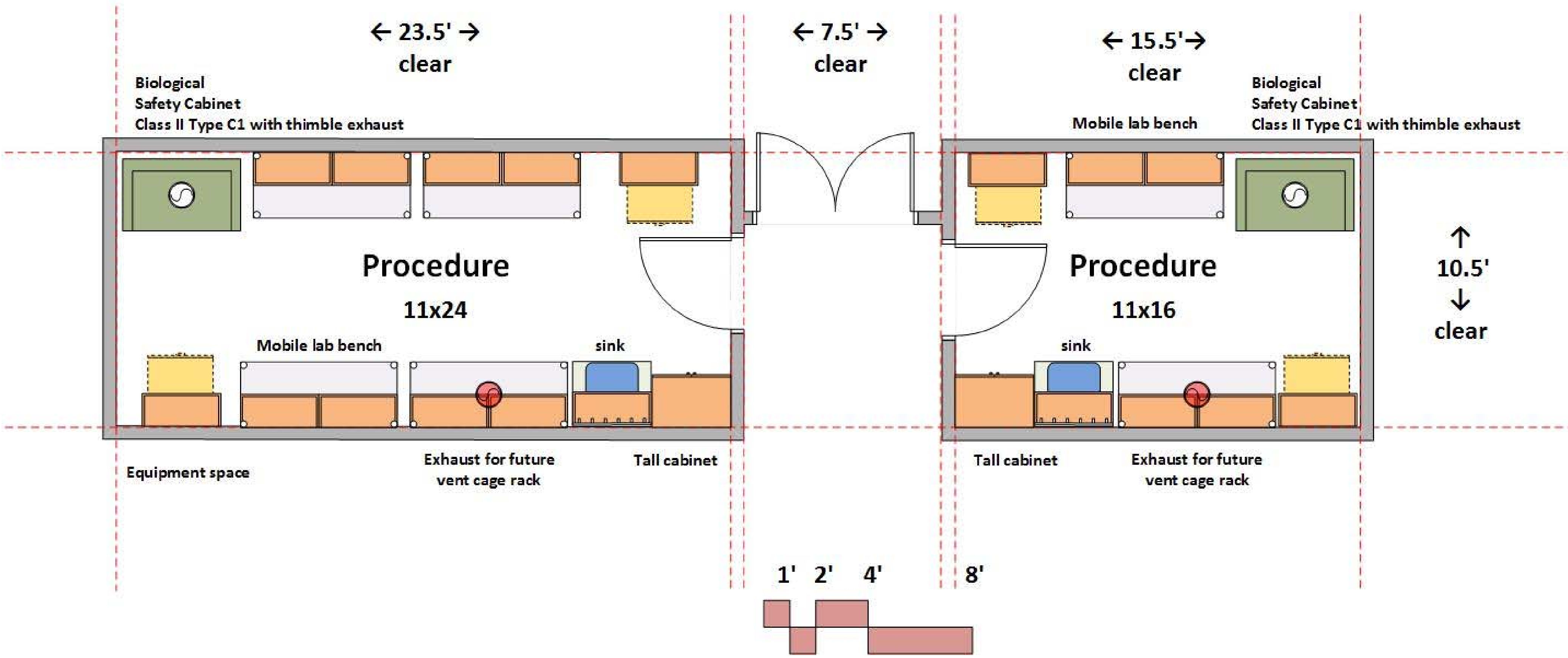
115v20a1ph outlets at walls and ceiling
Standby power- all MEP systems on emergency power
Hardwire and wireless data
Lighting: recessed, sealed fluorescent at 60 f.c. with lighting controls
Fire alarm: red strobe light

CONTRACTOR FURNISHED EQUIPMENT

Aquaria racks
Stainless steel casework, sinks, tops
Pumps for aquaria

UNIVERSITY FURNISHED EQUIPMENT

Zebra fish aquaria- ~3,200 aquaria shown at left illustration
Scientific instruments and equipment



Procedure Room

Program Requirements

ARCHITECTURAL

Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint;
Soundproofing in holding room walls; Aluminum wall guards at corridor
Ceiling: waterproof gypsum board with fiberglass finish and epoxy paint 9' clear ceiling height- no access panels inside holding rooms and procedure rooms; Limit ceiling access panels to corridor
Doors: 3'-6"x8'-0" with red glass view window
Vermin proof: all penetrations to rooms sealed
Sound attenuation: NC 35 or less; sound insulation in walls and above ceiling.
Security: card key access

STRUCTURAL

Poured in place concrete

MECHANICAL

Temperature: 70 deg F +/- 2 deg F Humidity: 30-50% relative
100% exhaust; Air changes: 10 air changes/hour plus exhaust for ventilated cage racks
Air change rate may be higher due to equipment heat gain
Pressure: Negative or positive depending upon use
Controls: BMS environmental monitoring for temperature, humidity, pressure, and lighting; with digital display at each holding room
Provide air exhaust connections at ceiling for ventilated cage racks
Thimble exhaust at ceiling for biological safety cabinet

PLUMBING

Hot/Cold water
Pure water- pipe from existing pure water system in Broad Center
Gas/Air/Vac at wall above mobile lab benches
Vac at biological safety cabinets

ELECTRICAL

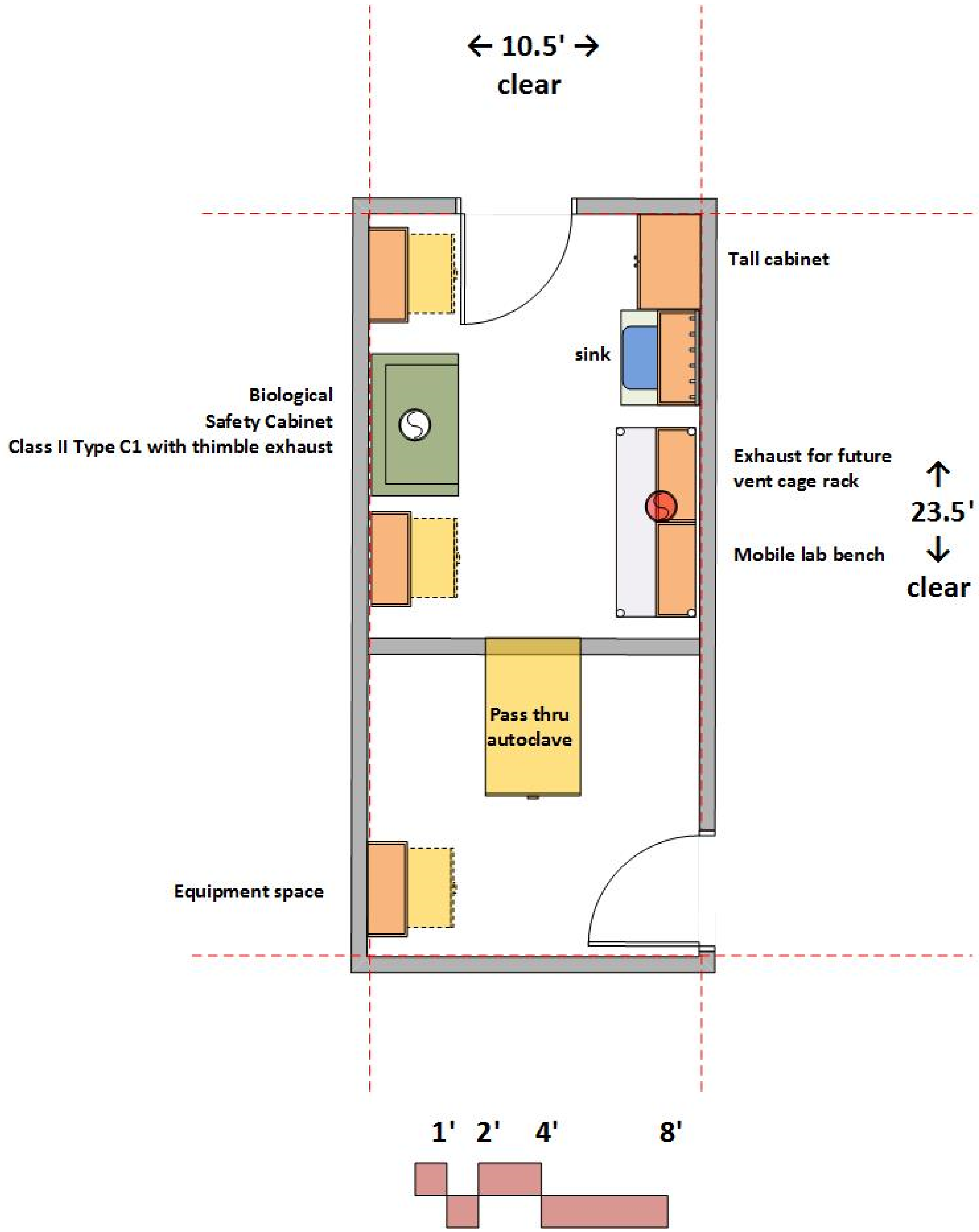
115v20a1ph outlets at walls and ceilings (cage racks)
Standby power- all MEP systems on emergency power
208v power at equipment spaces
Hardwire and wireless data
Lighting: recessed, sealed fluorescent at 60 f.c. with circadian lighting controls
30 f.c. unoccupied with manual switch for 60 f.c. White light for day, red light for night in holding rooms Fire alarm: red strobe light

CONTRACTOR FURNISHED EQUIPMENT

Biological Safety Cabinets
Mobile lab benches
Shelving above equipment space
Safety shower/eyewash- locate in vestibule

UNIVERSITY FURNISHED EQUIPMENT

Refrigerators
Freezers
Scientific instruments



BSL2 Procedure Room

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint;
Soundproofing in holding room walls; Aluminum wall guards at corridor
Ceiling: waterproof gypsum board with fiberglass finish and epoxy paint at 10'
no access panels inside holding rooms and procedure rooms; Limit ceiling access panels to corridor
Doors: 3'-6"x8'-0" with red glass view window
Vermin proof: all penetrations to rooms sealed
Sound attenuation: NC 35 or less; sound insulation in walls and above ceiling.
Security: card key access

STRUCTURAL
Poured in place concrete

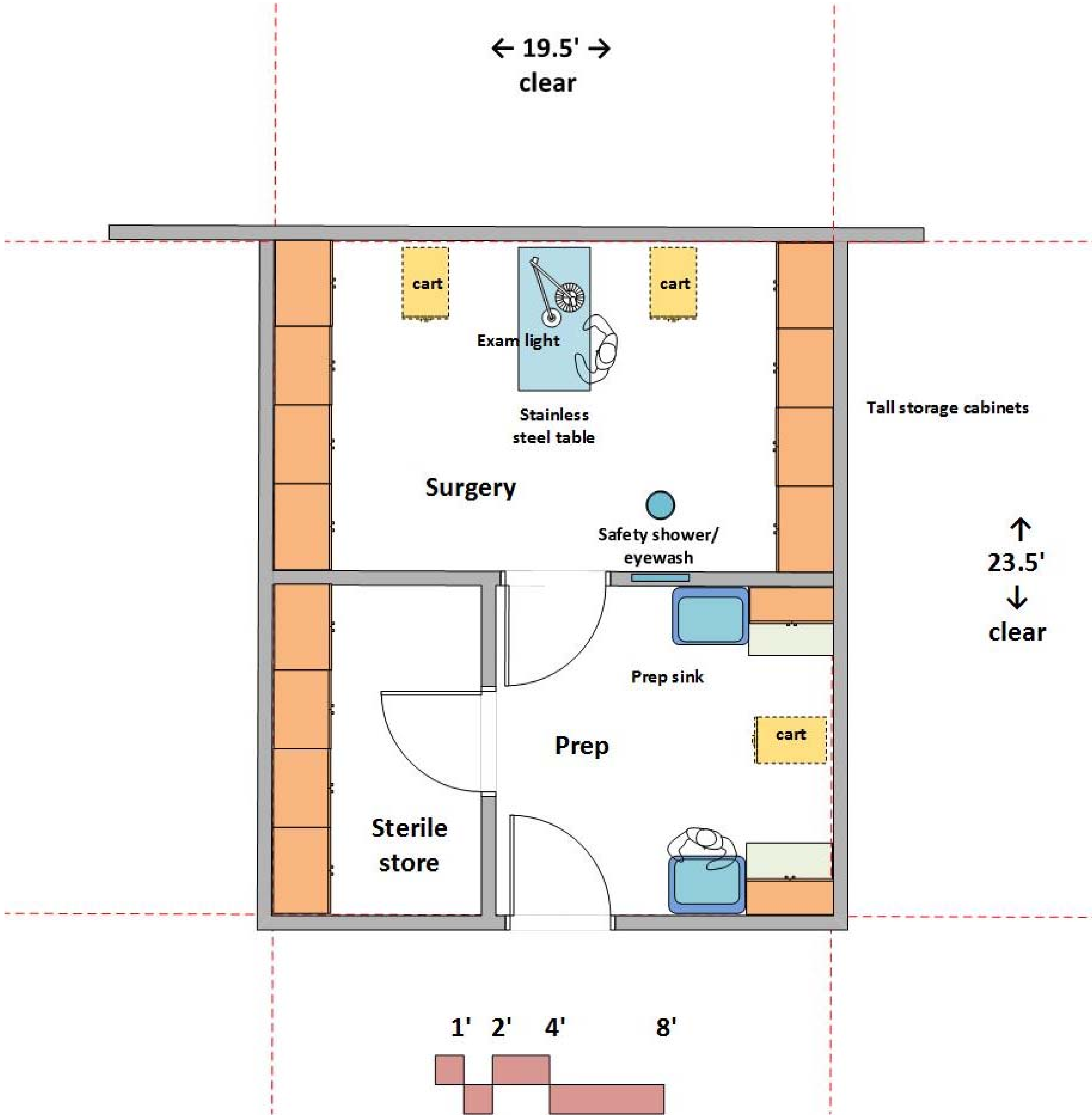
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30-50% relative
100% exhaust; Air changes: 10 air changes/hour plus exhaust for ventilated cage racks
Air change rate may be higher due to equipment heat gain
Pressure: Negative or positive depending upon use
Controls: BMS environmental monitoring for temperature, humidity, pressure, and lighting; with digital display at each holding room
Provide air exhaust connections at ceiling for ventilated cage racks
Thimble exhaust at ceiling for biological safety cabinet

PLUMBING
Hot/Cold water
Pure water- pipe from existing pure water system in Broad Center
Gas/Air/Vac at wall above mobile lab benches
Vac at biological safety cabinets
Steam at autoclave

ELECTRICAL
115v20a1ph outlets at walls and ceilings (cage racks)
Standby power- all MEP systems on emergency power
208v power at equipment spaces
Hardwire and wireless data
Lighting: recessed, sealed fluorescent at 60 f.c. with circadian lighting controls
30 f.c. unoccupied with manual switch for 60 f.c. White light for day, red light for night in holding rooms Fire alarm: red strobe light

CONTRACTOR FURNISHED EQUIPMENT
Biological Safety Cabinets
Mobile lab benches
Shelving above equipment space
Safety shower/eyewash- locate in vestibule
Pass thru autoclave- 20x20x38 chamber

UNIVERSITY FURNISHED EQUIPMENT
Refrigerators
Freezers
Scientific instruments



SURGERY

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: mylar tile at 10'
Doors: 3'-6"x8' with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 40 or less
Security: card key access

STRUCTURAL
Poured in place concrete

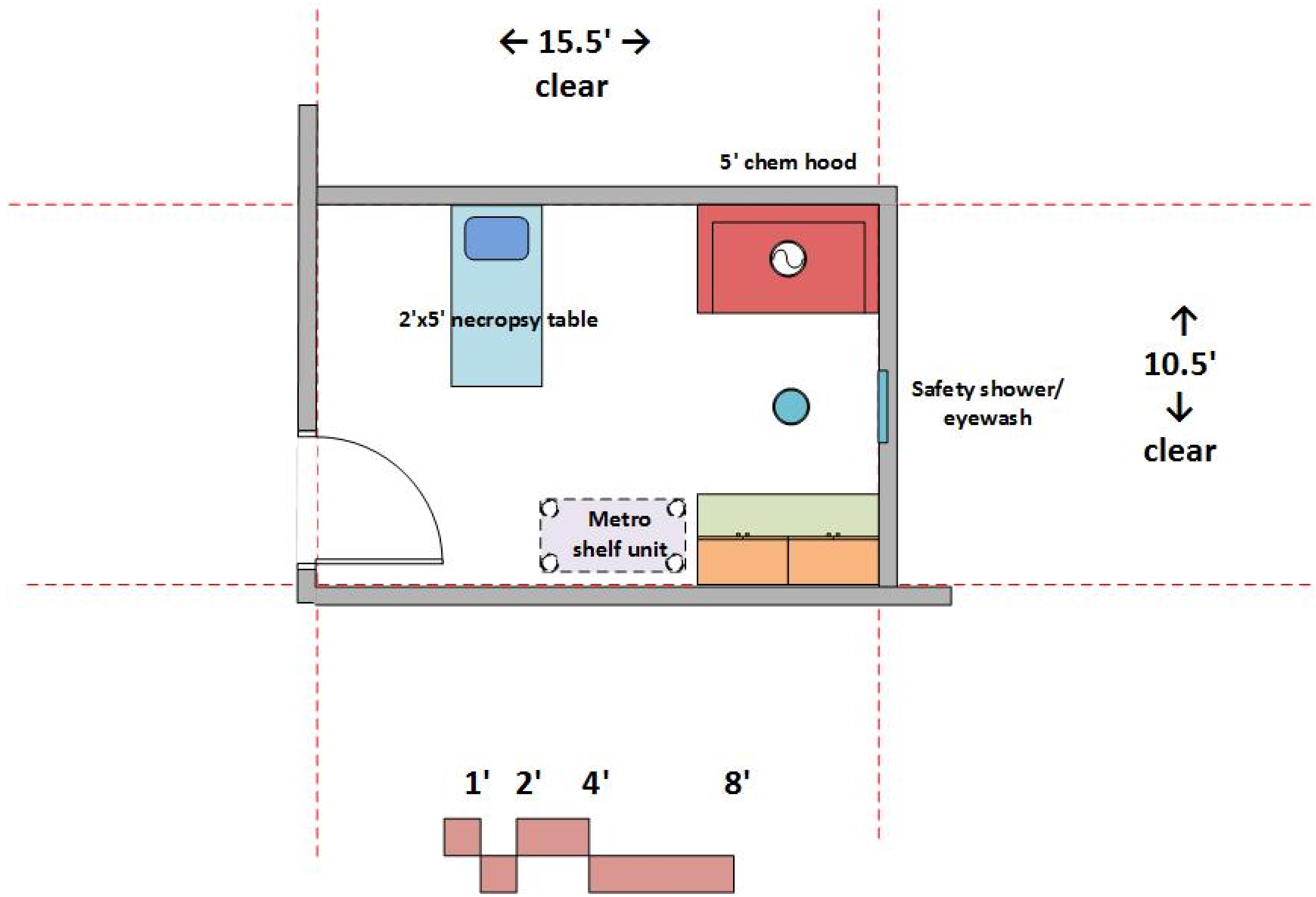
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30-50% relative
100% exhaust
Air changes: 8 air changes/hour
Pressure: Positive

PLUMBING
Hot/cold water at sinks
CO2 and 02 at surgery table
Tepid domestic water at safety shower/eyewash

ELECTRICAL
115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Stainless steel casework
Prep sinks
Exam light

UNIVERSITY FURNISHED EQUIPMENT
Stainless steel surgery table



Necropsy

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: mylar tile at 10'
Doors: 3'-6"x8' with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 40 or less
Security: card key access

STRUCTURAL
Poured in place concrete

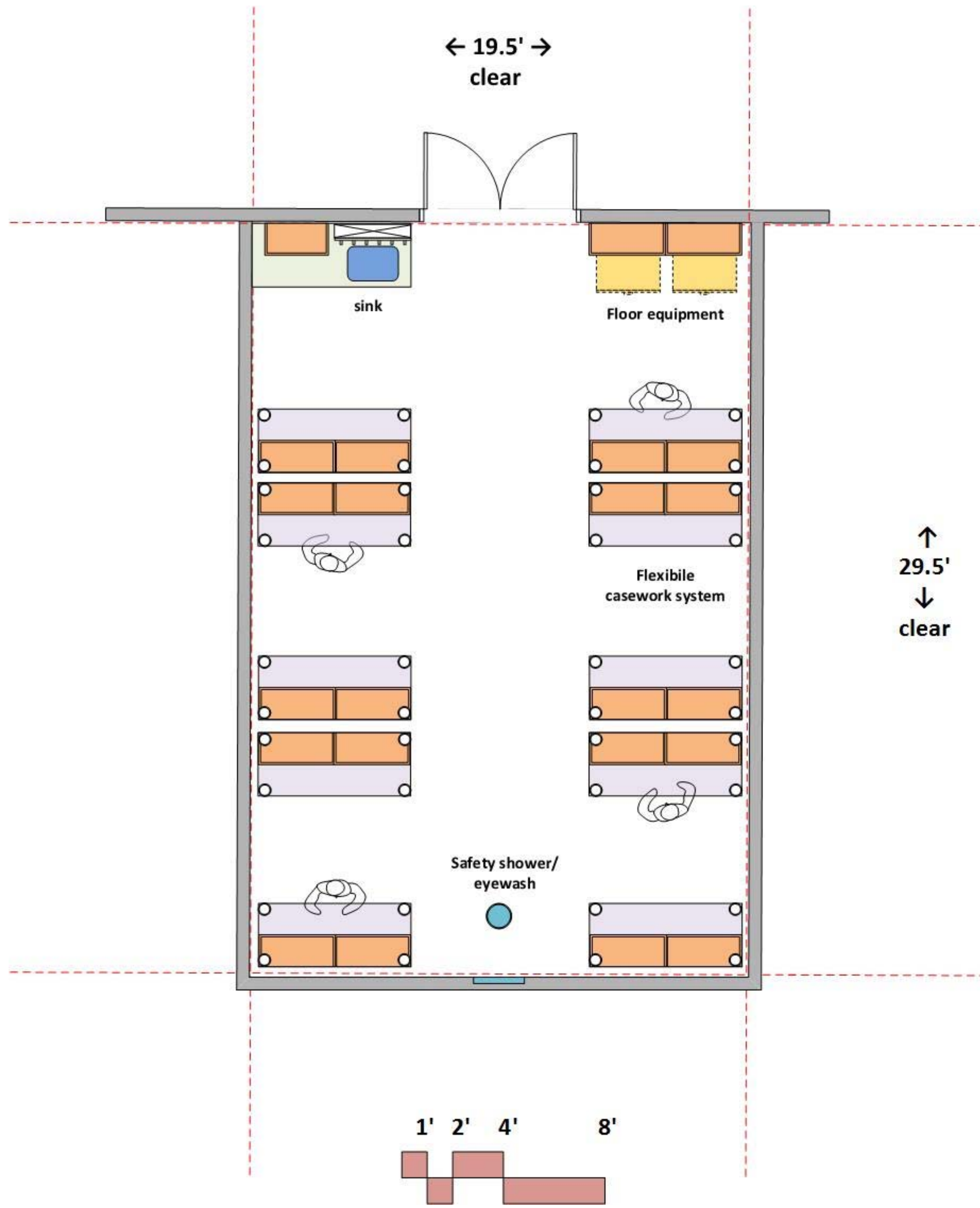
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30-50% relative
100% exhaust
Air changes: 8 air changes/hour
Pressure: Negative

PLUMBING
Hot/cold water at sink
CO2 and 02 at necropsy table
Gas/Vac at fume hood
Tepid domestic water at safety shower/eyewash

ELECTRICAL
115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Stainless steel casework
Chemical fume hood- VAV
Necropsy table

UNIVERSITY FURNISHED EQUIPMENT
Metro shelf unit



Imaging Lab

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: mylar tile at 10'
Doors: 3'x8' pair with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 40 or less
Security: card key access

STRUCTURAL
Poured in place concrete

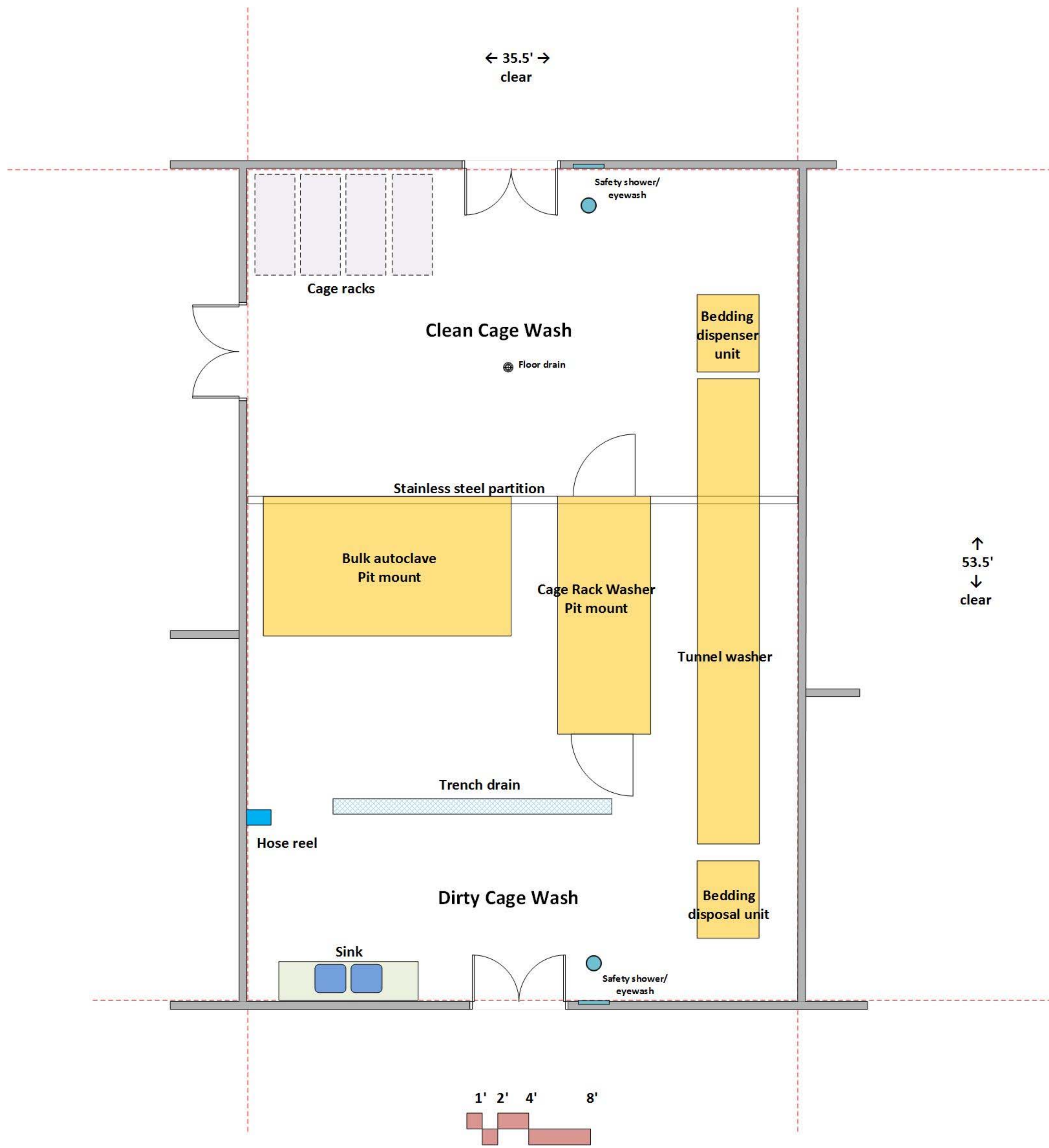
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30-50% relative
100% exhaust
Air changes: 8 air changes/hour
Pressure: Negative
Equipment exhaust at each lab table- locate at side walls

PLUMBING
Hot/cold water at sink
Pure water at sink
Gas/Air/Vac at flexible lab benches
Tepid domestic water at safety shower/eyewash

ELECTRICAL
115v20a1ph outlets at walls
208v30a1ph at equipment space
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Stainless steel casework at sink bench
Flexible casework system
Safety shower/eyewash

UNIVERSITY FURNISHED EQUIPMENT
Imaging instruments



Cage Wash

Program Requirements

Cage Wash Capacity:
Tunnel Washer- 16 cages/min x 60 min = 960 cages/hour x 6 hours/day = 7600 cages/day

ARCHITECTURAL

Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: mylar tile at 10'
Doors: 3'x8' pair with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 40 or less
Security: card key access

STRUCTURAL

Poured in place concrete

MECHANICAL

Temperature: 70 deg F +/- 2 deg F
Humidity: 30-50% relative
100% exhaust
Air changes: 8 air changes/hour
Pressure: Negative on dirty side; Positive on clean side

PLUMBING

Hot/Cold water
Steam

ELECTRICAL

115v20a1ph outlets at walls
208v60a3ph
480v100a3ph
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT

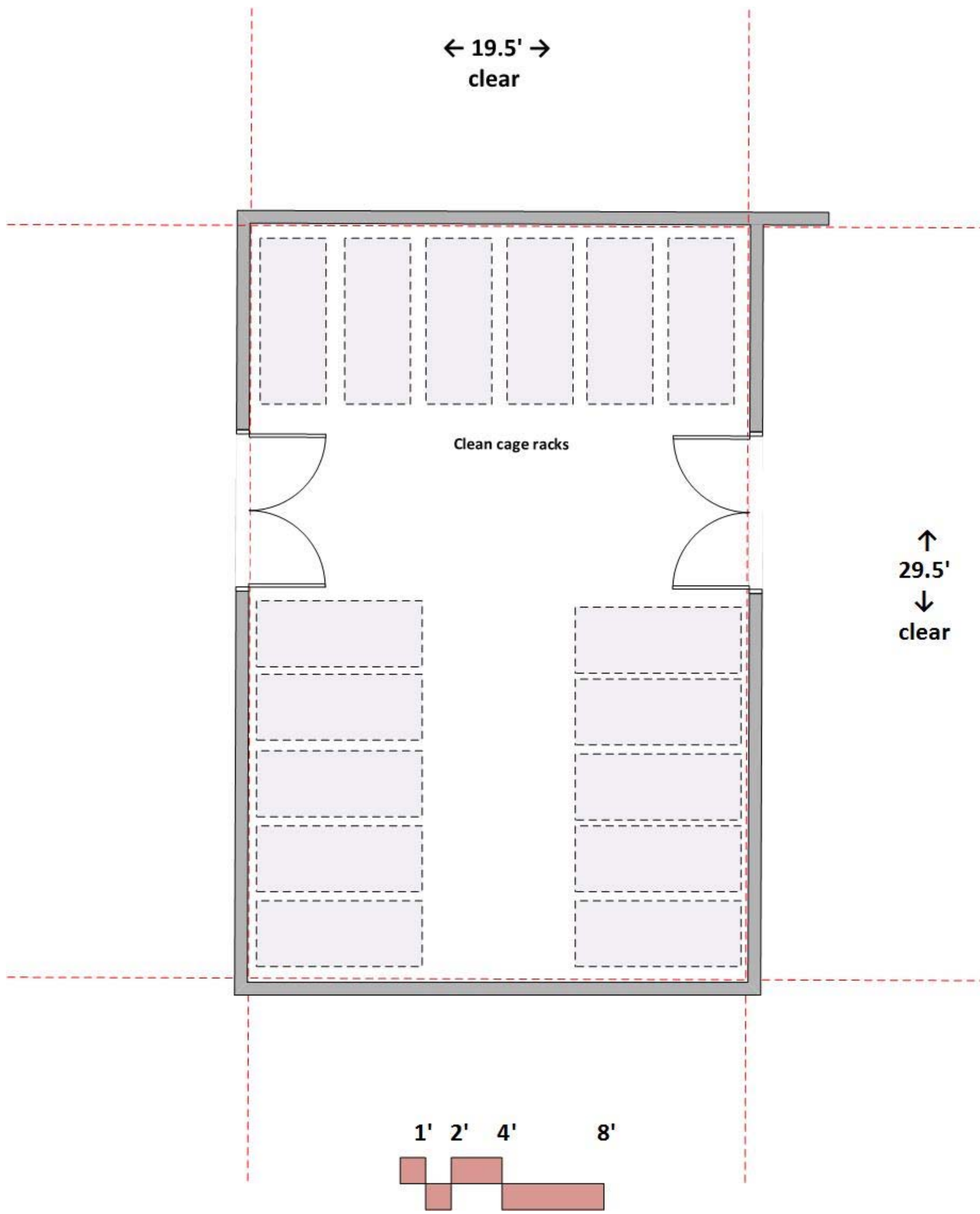
Stainless steel sinks
Hose reel
Bulk autoclave
Cage rack washer
Tunnel washer
Bedding disposal unit
Bedding dispenser unit

UNIVERSITY FURNISHED EQUIPMENT

Cage racks

Sterile Equip Store

Program Requirements



ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: mylar tile at 10'
Doors: 3'x8' pair with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 40 or less
Security: card key access

STRUCTURAL
Poured in place concrete

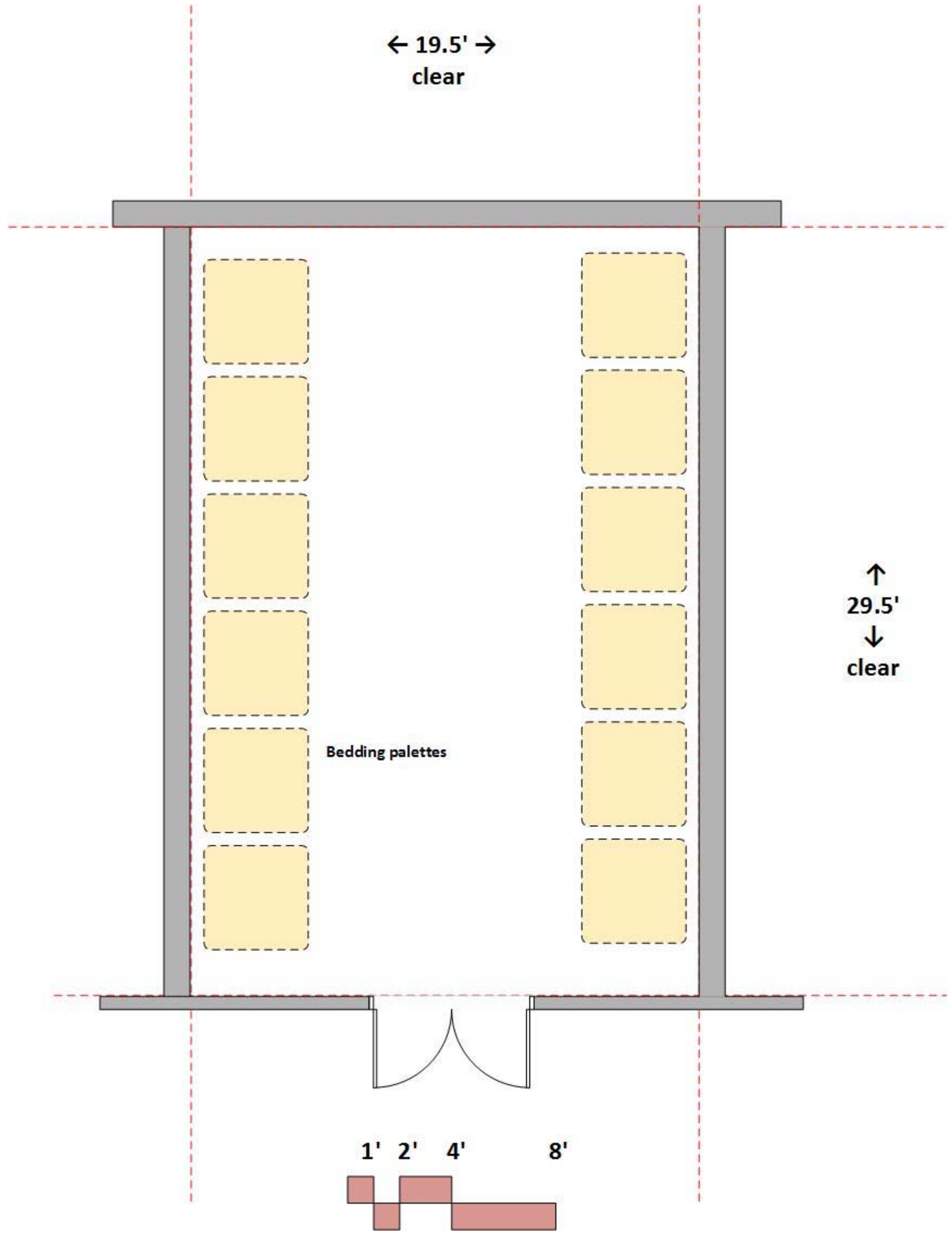
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30% relative
100% exhaust
Air changes: 4 air changes/hour
Pressure: Positive

PLUMBING
None

ELECTRICAL
115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
None

UNIVERSITY FURNISHED EQUIPMENT
Cage racks



Bedding Store

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: sealed concrete
Walls: concrete masonry units with plaster and enamel paint finish
Ceiling: open to structure
Doors: 3'x8' pair with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 45 or less
Security: card key access

STRUCTURAL
Poured in place concrete

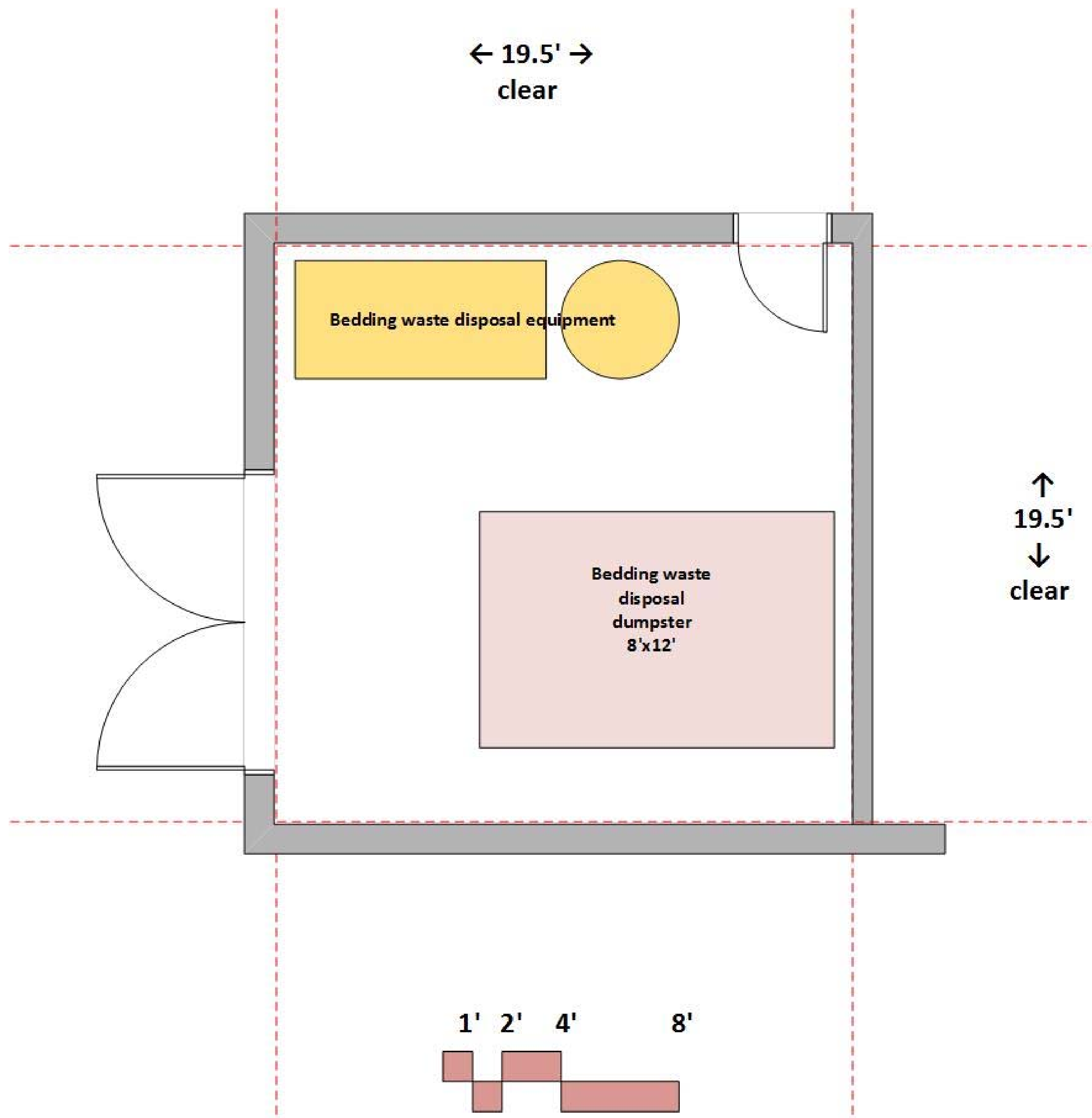
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30% relative
100% exhaust
Air changes: 4 air changes/hour
Pressure: Positive

PLUMBING
None

ELECTRICAL
115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
None

UNIVERSITY FURNISHED EQUIPMENT
Bedding palettes



BEDDING DISPOSAL EQ STORE

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: sealed concrete
Walls: concrete masonry units with plaster and enamel paint finish
Ceiling: open to structure
Doors: pair 5'x10'; 3'x8'
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 80 or less
Security: card key access

STRUCTURAL
Poured in place concrete

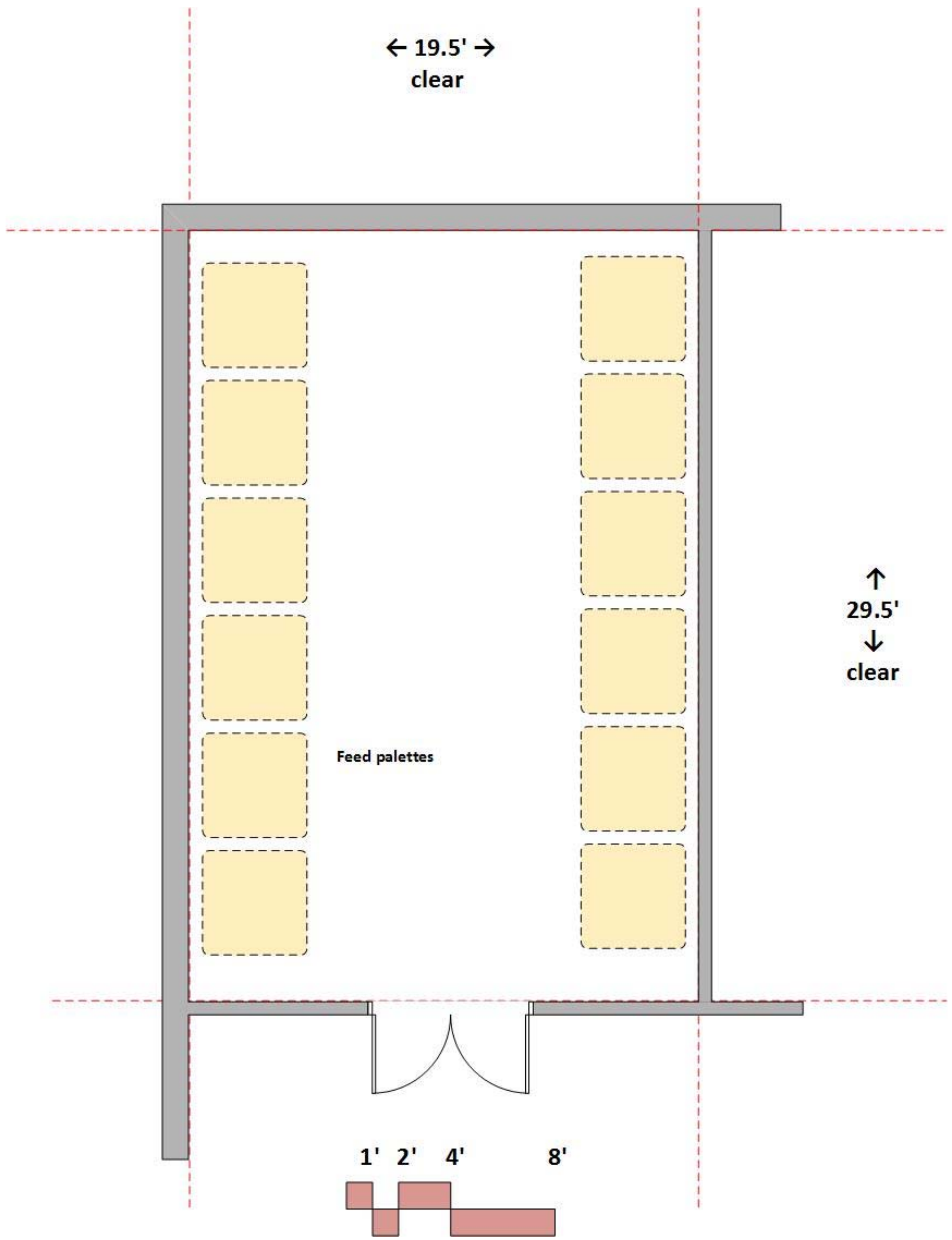
MECHANICAL
None
Natural ventilation

PLUMBING
Hapman conveyor bedding disposal system

ELECTRICAL
115v20a1ph
208v30a3ph
480v100a3ph
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Hapman conveyor bedding disposal system

UNIVERSITY FURNISHED EQUIPMENT
Bedding disposal dumpster



FEED STORE

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: sealed concrete
Walls: concrete masonry units with plaster and enamel paint finish
Ceiling: open to structure
Doors: 3'x8' pair with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 45 or less
Security: card key access

STRUCTURAL
Poured in place concrete

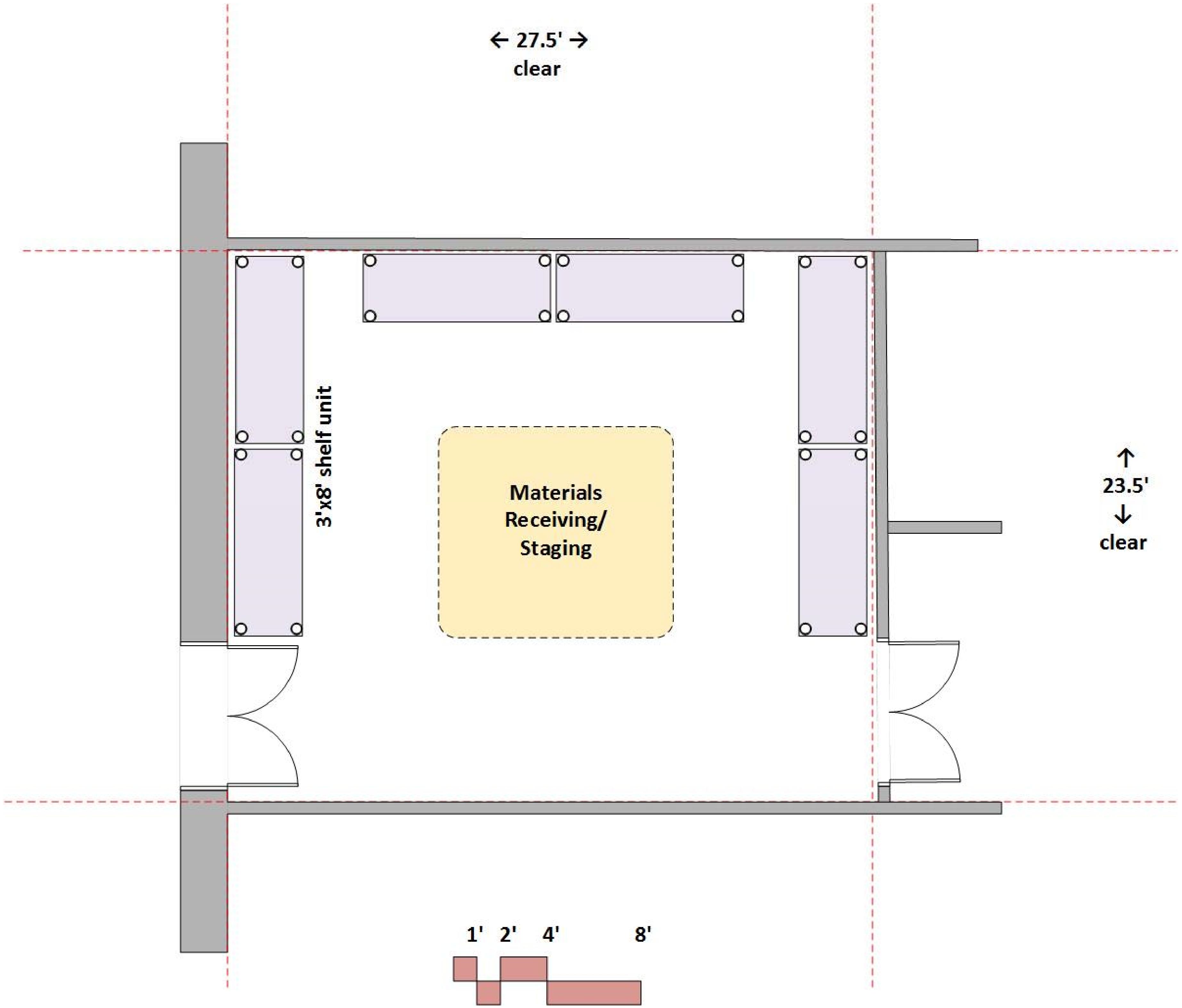
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: 30% relative
100% exhaust
Air changes: 4 air changes/hour
Pressure: Positive

PLUMBING
None

ELECTRICAL
115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
None

UNIVERSITY FURNISHED EQUIPMENT
Feed palettes



Receiving

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint;
Ceiling: mylar acoustic tile
Doors: 3'x8' pair with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 45 or less
Security: card key access

STRUCTURAL
Poured in place concrete

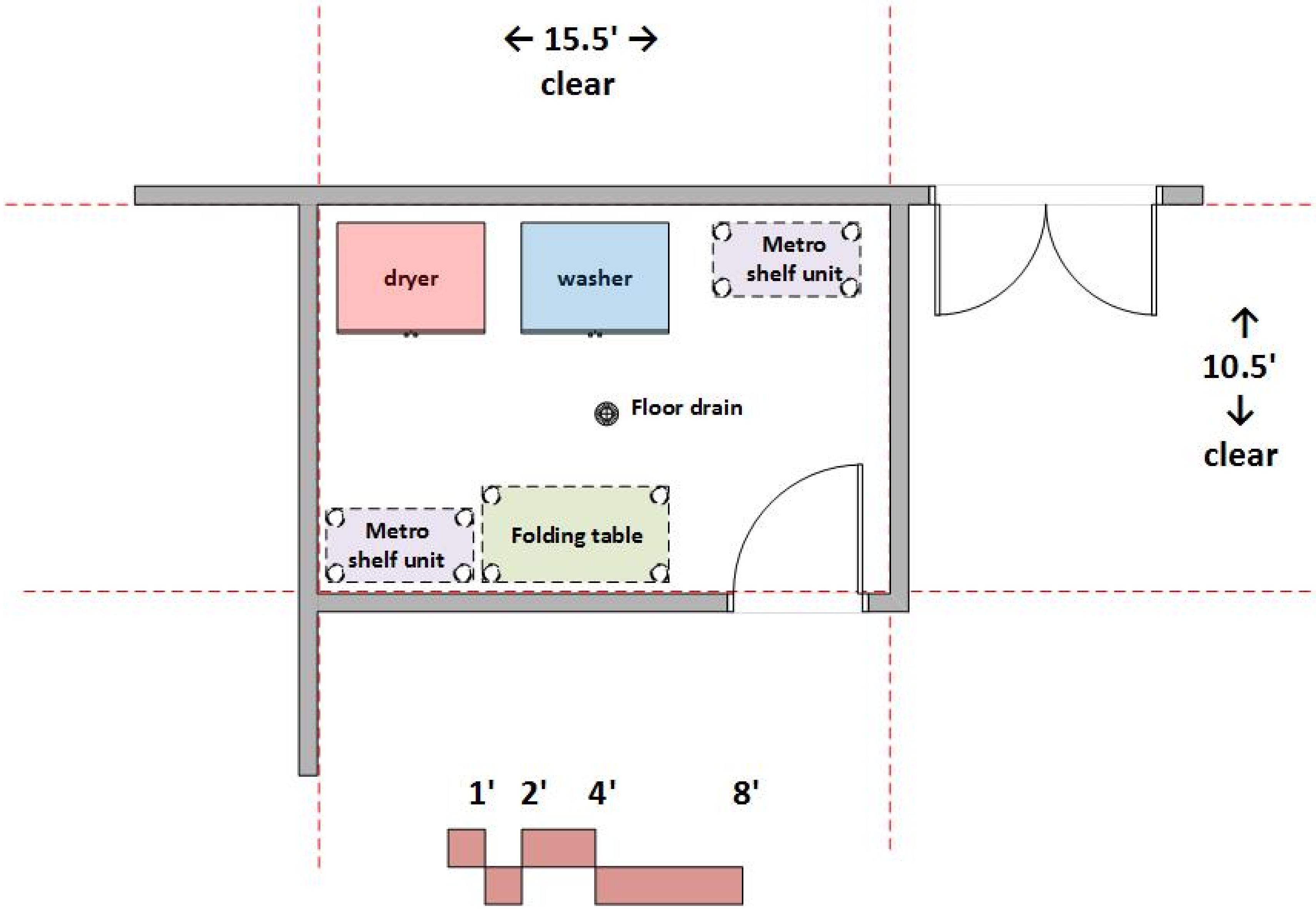
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
100% exhaust
Air changes: 6 air changes/hour
Air change rate may be higher due to equipment heat gain
Pressure: Negative

PLUMBING
None

ELECTRICAL
115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Shelf units

UNIVERSITY FURNISHED EQUIPMENT
Supplies, palettes



LAUNDRY
Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: methyl methacrylate with integral coved base.
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint;
Ceiling: mylar acoustic tile
Doors: 3'-6"x8'-0" with view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 45 or less
Security: card key access

STRUCTURAL
Poured in place concrete

MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
100% exhaust
Air changes: 6 air changes/hour
Air change rate may be higher due to equipment heat gain
Pressure: Negative

PLUMBING
Hot/Cold water at washer
Floor drain

ELECTRICAL
115v20a1ph outlets at walls
208v power at washer and dryer
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

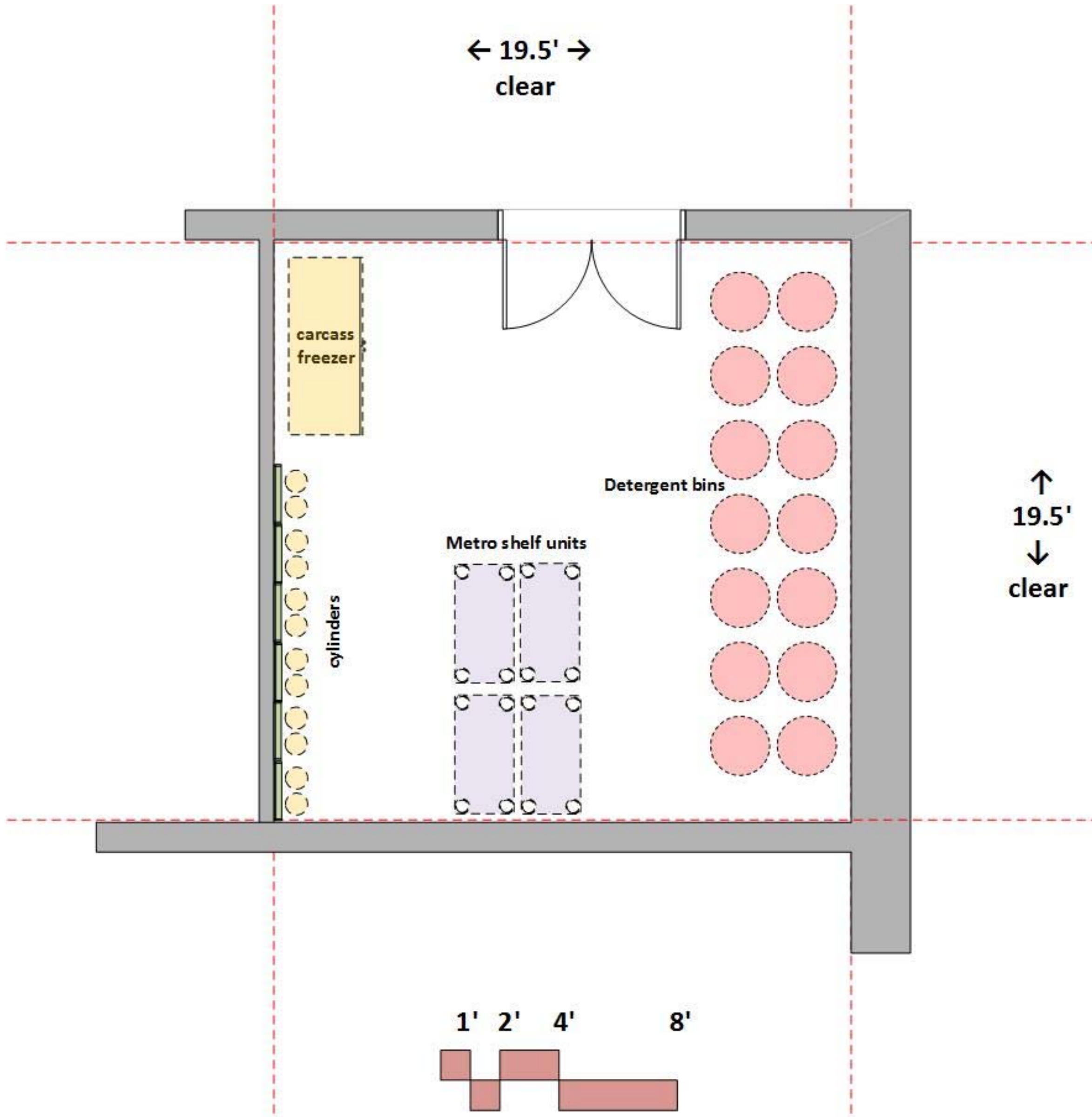
CONTRACTOR FURNISHED EQUIPMENT
Washer
Dryer

UNIVERSITY FURNISHED EQUIPMENT
Metro shelf units
Folding table

DET/CYL/CARCASS STORE

(Detergent/Cylinders)

Program Requirements



ARCHITECTURAL
Occupancy: B
Floor: sealed concrete
Walls: concrete masonry units with plaster and enamel paint finish
Ceiling: open to structure
Doors: 3'-0"x8'-0" pair view window
Vermin proof: all penetrations to vivarium sealed
Sound attenuation: NC 45 or less
Security: card key access

STRUCTURAL
Poured in place concrete

MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
100% exhaust; Air changes: 6 air changes/hour
Pressure: Negative

PLUMBING
Pipe from detergent bins to cage wash equipment
Pipe from cylinders to gas locations inside vivarium

ELECTRICAL
115v20a1ph outlets at walls and ceilings (cage racks)
Standby power- all MEP systems on emergency power
Lighting: LED at 600 LUX
Fire alarm: low volume chime

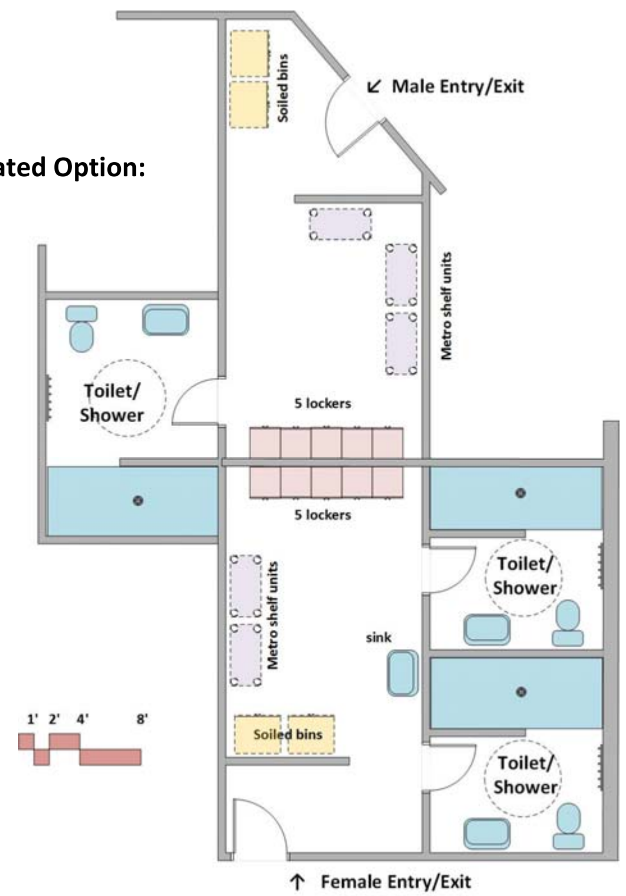
CONTRACTOR FURNISHED EQUIPMENT
Cylinder restraints

UNIVERSITY FURNISHED EQUIPMENT
Carcass freezer
Metro shelf units
Detergent bins

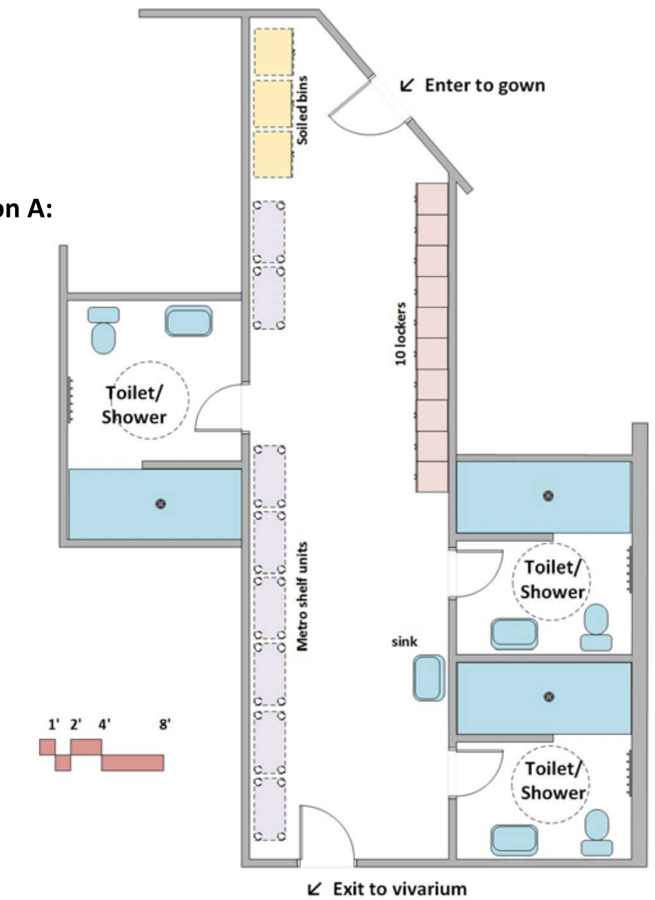
Toilet/Shower/Lockers

Program Requirements

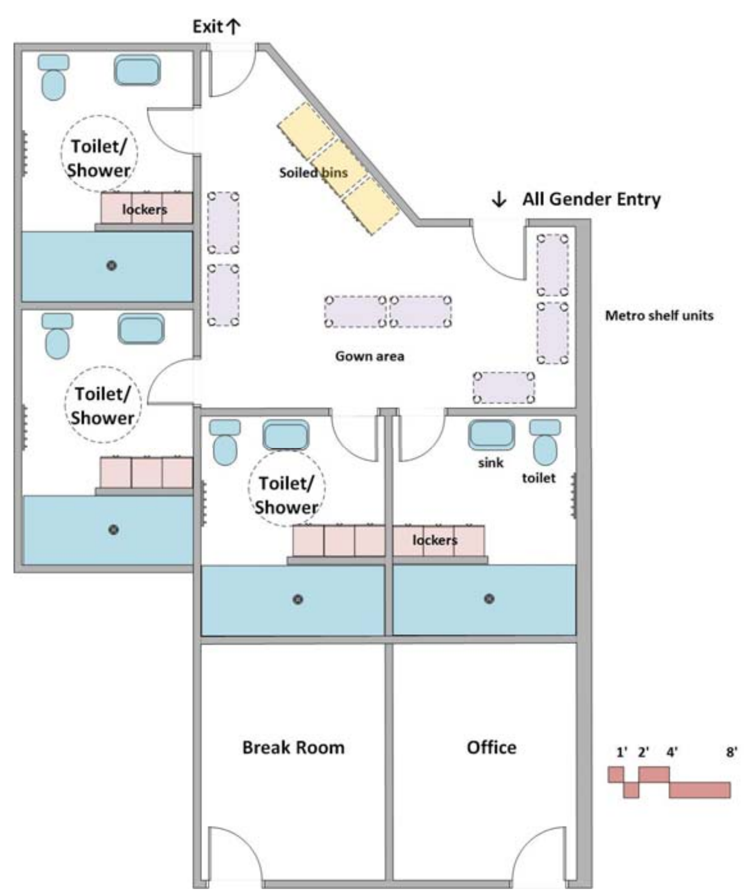
Segregated Option:



Gender Neutral Option A:



Gender Neutral Option B:



ARCHITECTURAL
Occupancy: B
Floor: ceramic tile with epoxy grout
Walls: ceramic tile with epoxy grout
Ceiling: mylar acoustic tile
Doors: 3'-0"x8'-0" with view window at corridor; no windows at toilet rooms
Vermin proof: all penetrations into vivarium interior to be sealed
Sound attenuation: NC 40 or less
Security: lockable doors at toilet/shower rooms

STRUCTURAL
Poured in place concrete

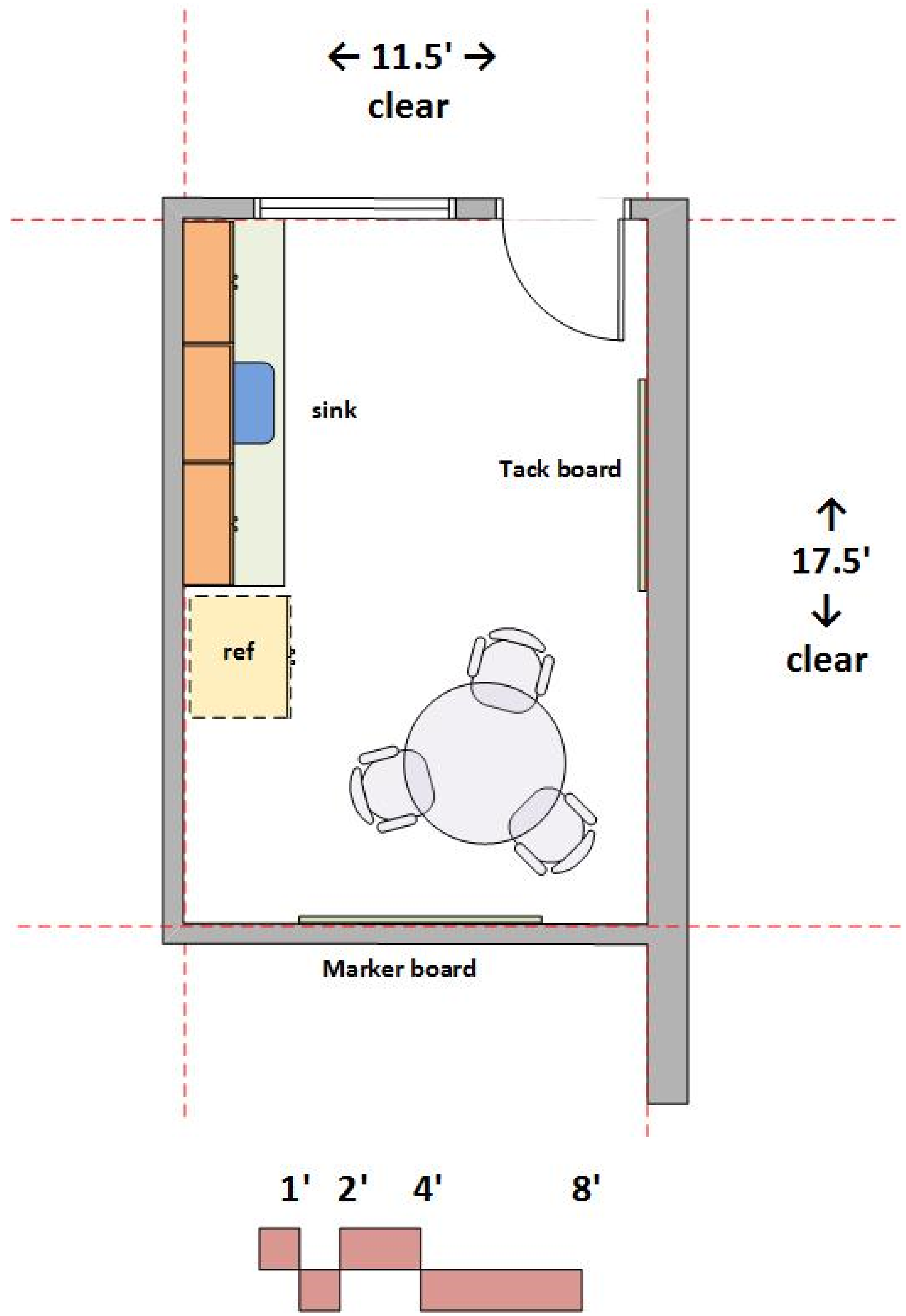
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
Air changes: 4 air changes/hour
Pressure: negative

PLUMBING
Hot/Cold water at sinks, showers
Cold water at toilets
Floor drains at showers

ELECTRICAL
115v20a1ph outlets at walls
Wired and wireless data
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Sinks, toilets, showers
Lockers

UNIVERSITY FURNISHED EQUIPMENT
Metro shelf units
Soiled bins



BREAK ROOM

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: sheet vinyl over concrete slab
Walls: metal stud with gypsum wall board & epoxy paint
Ceiling: mylar acoustic tile
Doors: 3'-0"x8'-0" with view window
Vermin proof: all penetrations into vivarium interior to be sealed
Sound attenuation: NC 35 or less
Security: card key access

STRUCTURAL
Poured in place concrete

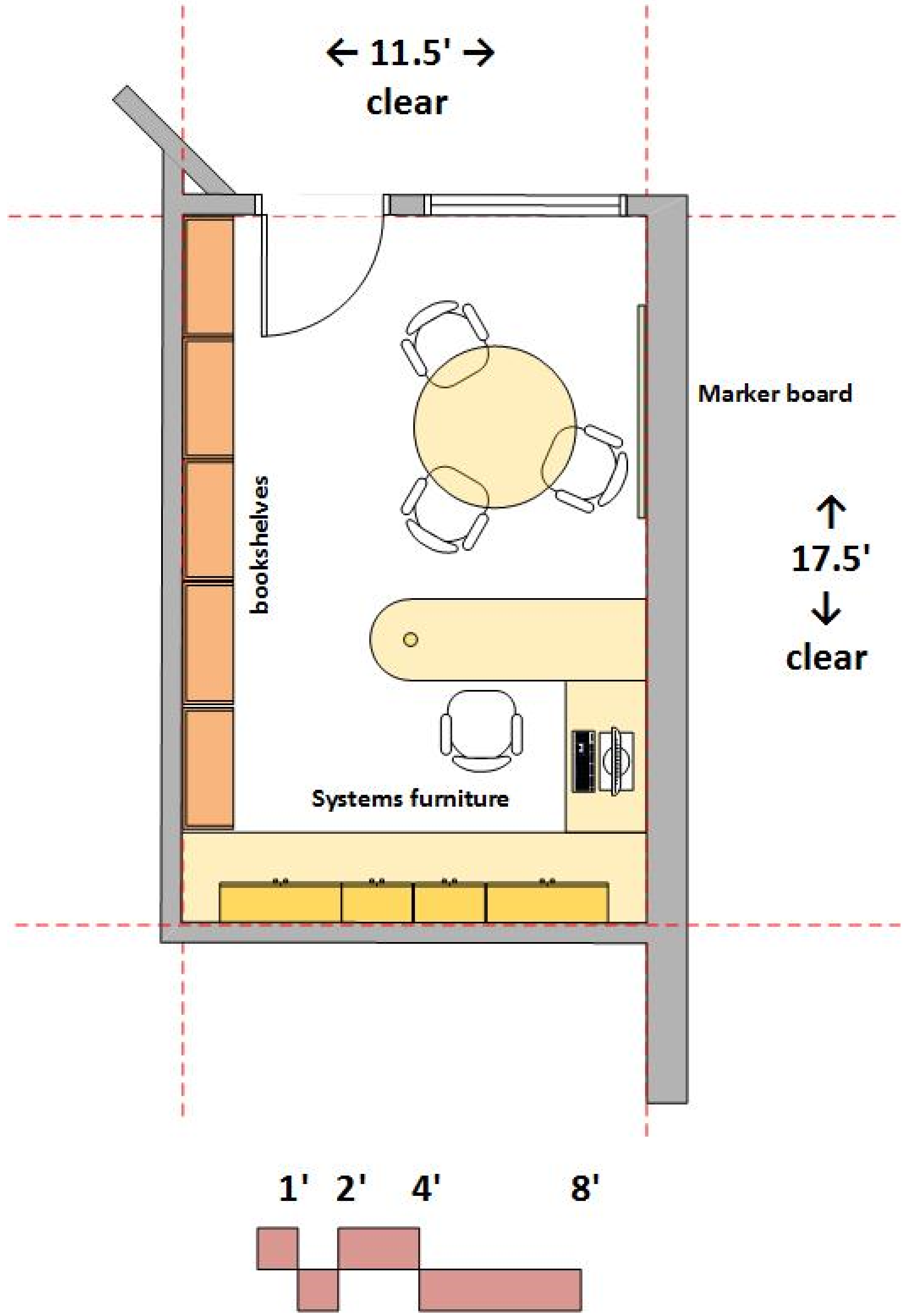
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
Air changes: 4 air changes/hour
Pressure: Positive

PLUMBING
Hot/Cold water at sink

ELECTRICAL
115v20a1ph outlets at walls
Wired and wireless data
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Phenolic resin casework, sink, top
Marker board
Tack board

UNIVERSITY FURNISHED EQUIPMENT
Refrigerator
Table and chairs



OFFICE

Program Requirements

ARCHITECTURAL
Occupancy: B
Floor: sheet vinyl over concrete slab
Walls: metal stud with gypsum wall board & epoxy paint
Ceiling: mylar acoustic tile
Doors: 3'-0"x8'-0" with view window
Vermin proof: all penetrations into vivarium interior to be sealed
Sound attenuation: NC 35 or less
Security: card key access

STRUCTURAL
Poured in place concrete

MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
Air changes: 4 air changes/hour
Pressure: Positive

PLUMBING
None

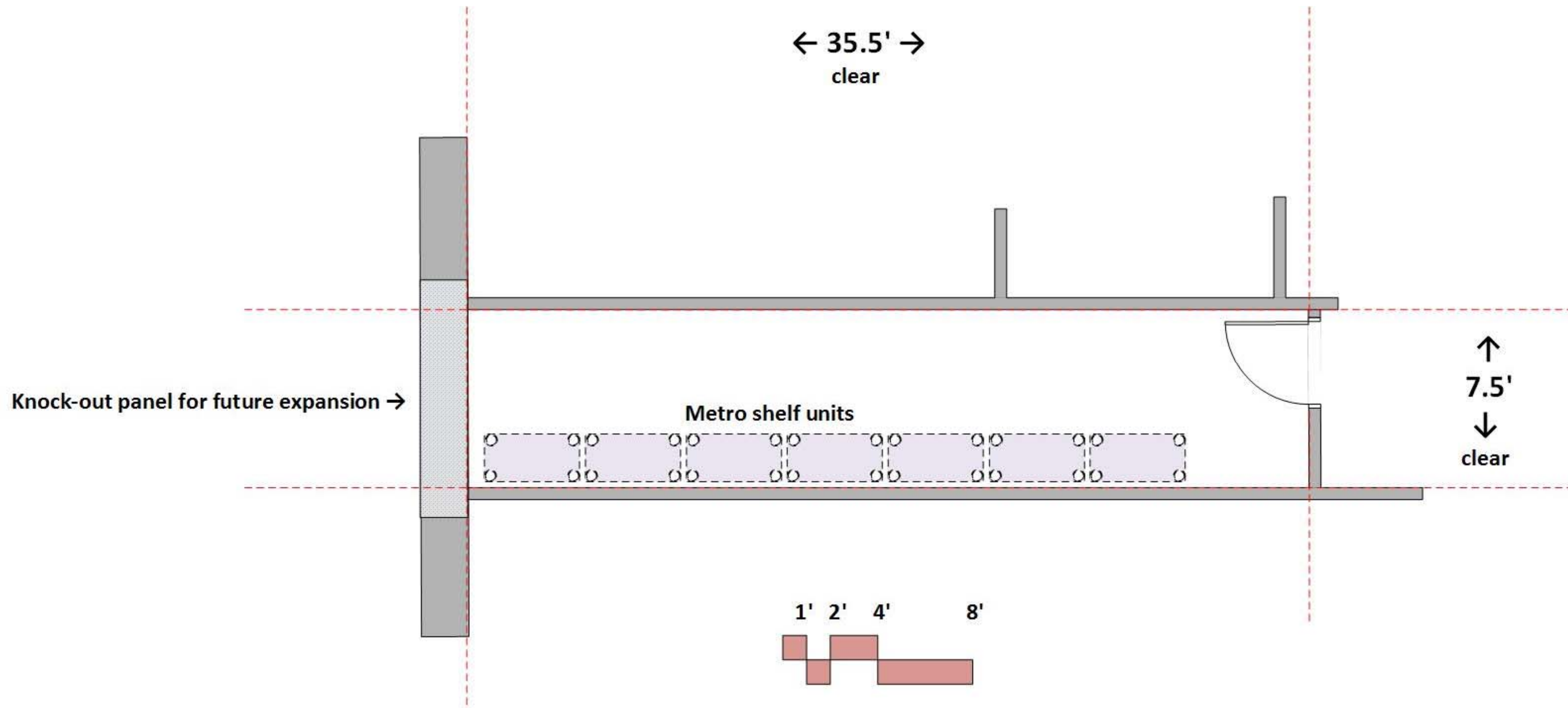
ELECTRICAL
115v20a1ph outlets at walls
Wired and wireless data
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
Marker Board
Bookshelves

UNIVERSITY FURNISHED EQUIPMENT
Office systems furniture

Store Room

Program Requirements



ARCHITECTURAL
Occupancy: B
Floor: sealed concrete
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: open to structure
Doors: 3'-6"x8'-0" with view window
Vermin proof: all penetrations into vivarium interior to be sealed
Sound attenuation: NC 45 or less
Security: card key access

STRUCTURAL
Poured in place concrete

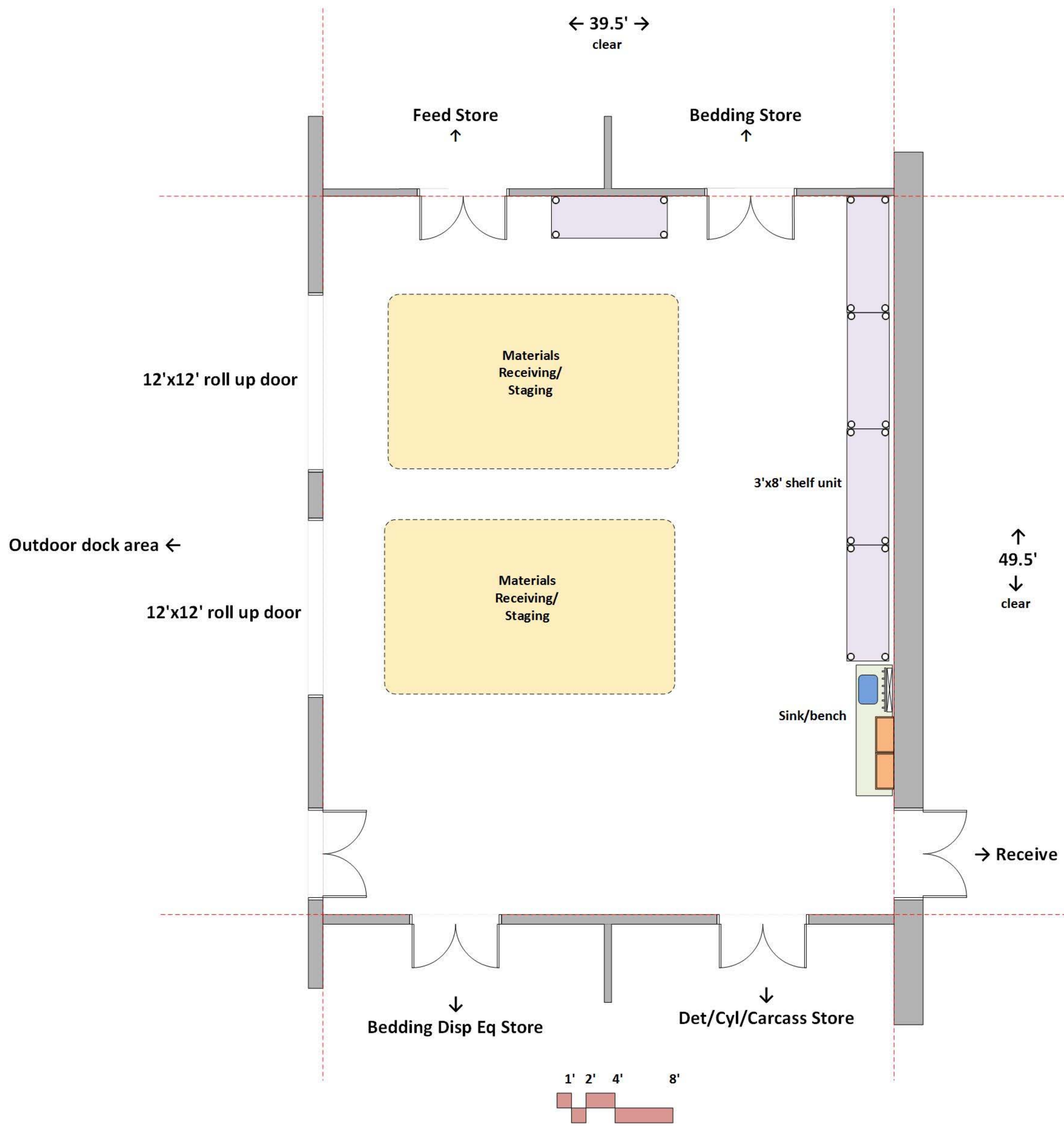
MECHANICAL
Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
Air changes: 4 air changes/hour
Pressure: Negative

PLUMBING
None

ELECTRICAL
115v20a1ph outlets at walls
Lighting: LED at 500 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT
None

UNIVERSITY FURNISHED EQUIPMENT
Metro shelf units



Loading Dock

Program Requirements

ARCHITECTURAL

Occupancy: B
Floor: sealed concrete
Walls: metal stud with concrete backer board with fiberglass finish & epoxy paint
Ceiling: open to structure
Doors: 3'-0"x8'-0" pairs with view windows; 12'x12' roll up doors
Vermin proof: all penetrations into vivarium interior to be sealed
Sound attenuation: NC 45 or less
Security: card key access; Call box at entry door at loading dock

STRUCTURAL

Poured in place concrete

MECHANICAL

Temperature: 70 deg F +/- 2 deg F
Humidity: ambient
100% exhaust
Air changes: 4 air changes/hour
Pressure: Negative

PLUMBING

Hot/Cold water at sink

ELECTRICAL

115v20a1ph outlets at walls
Standby power- all MEP systems on emergency power
208v power at perimeter walls
Hardwire and wireless data
Lighting: LED at 600 LUX
Fire alarm: low volume chime

CONTRACTOR FURNISHED EQUIPMENT

Wall bench and sink
Storage shelf units

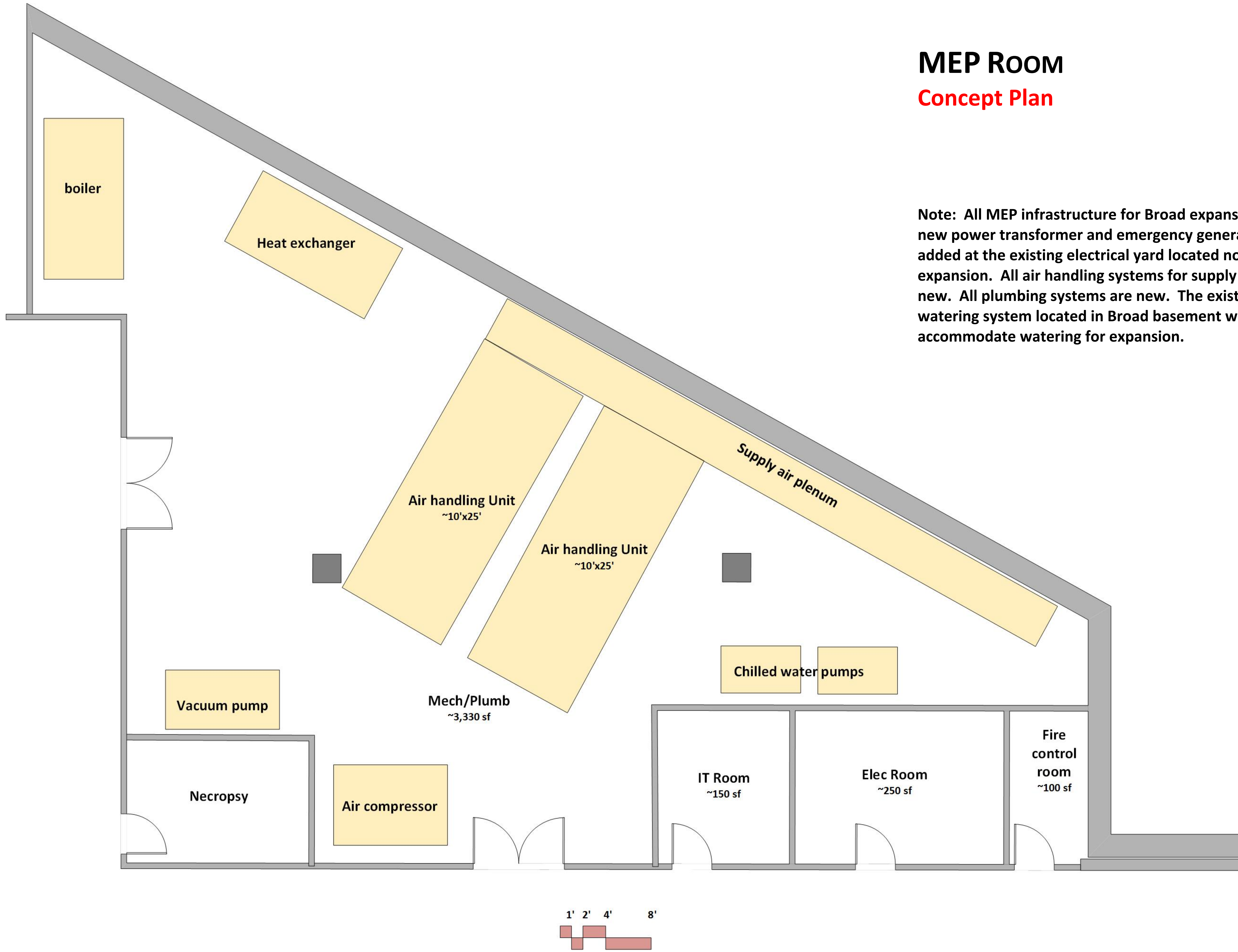
UNIVERSITY FURNISHED EQUIPMENT

Supplies

MEP Room

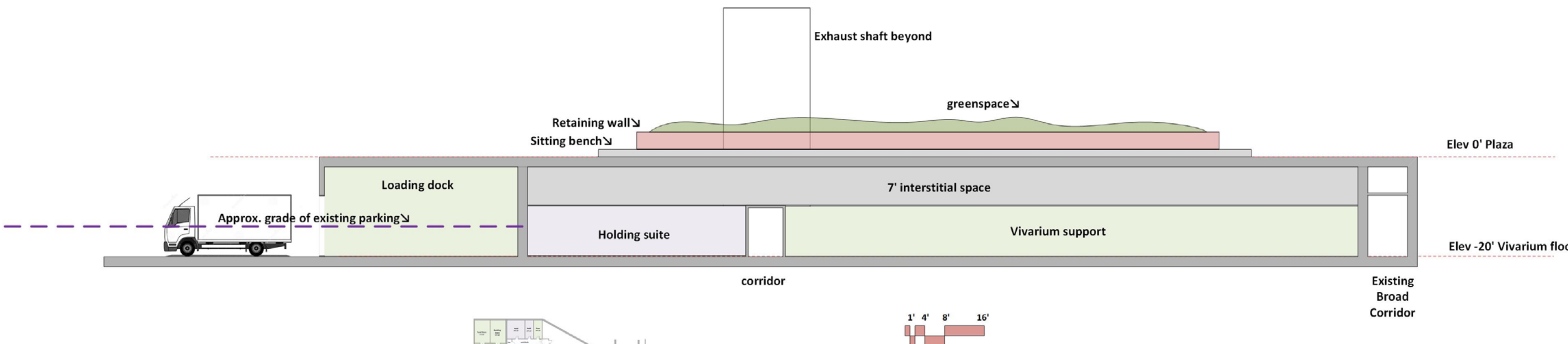
Concept Plan

Note: All MEP infrastructure for Broad expansion is new. A new power transformer and emergency generator will be added at the existing electrical yard located northwest of expansion. All air handling systems for supply and exhaust are new. All plumbing systems are new. The existing animal watering system located in Broad basement will be added to to accommodate watering for expansion.



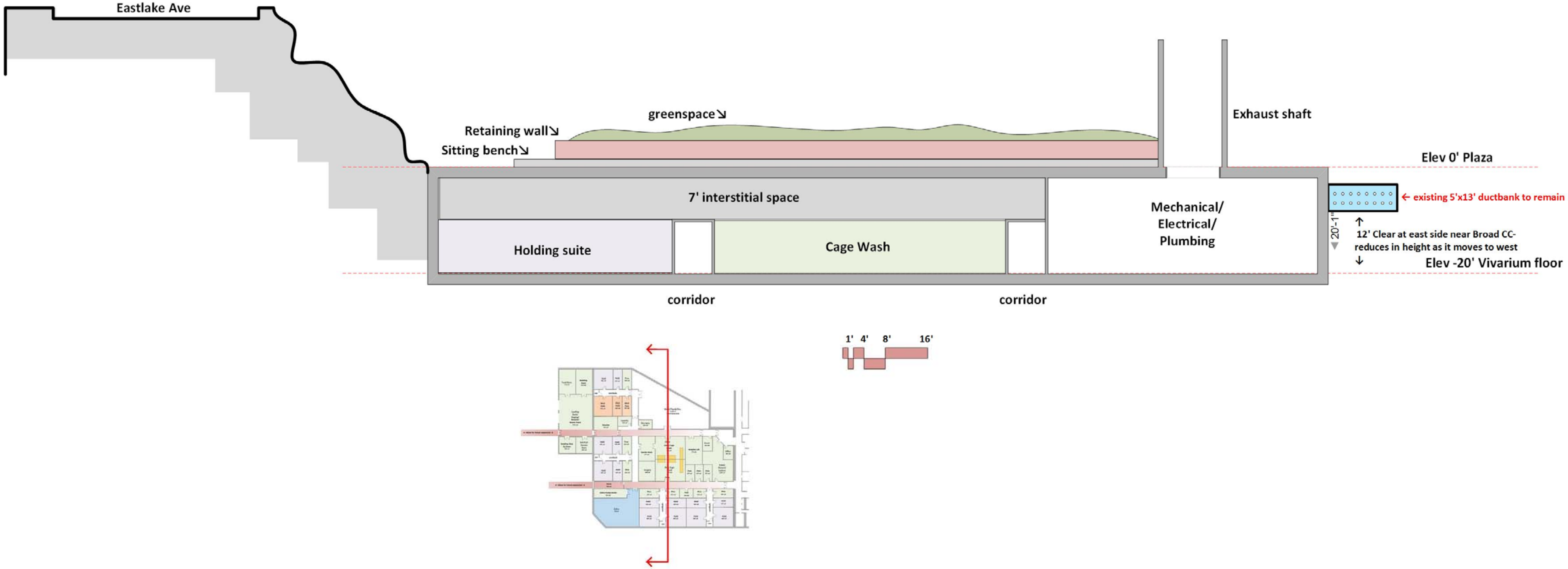
Latitudinal Section

Looking North



Longitudinal Section

Looking West



Structural Grid

Concept Plan

The structural grid serves as a conceptual test of overlaying a possible grid pattern on the proposed floor plan to verify if there are any significant conflicts between possible grid pattern and room layouts. This concept of a 36' x 36' grid pattern does not have any significant conflicts with the walls and doors of the proposed design. Other grid patterns may be considered during Schematic Design phase.

EQUIPMENT CUT SHEETS

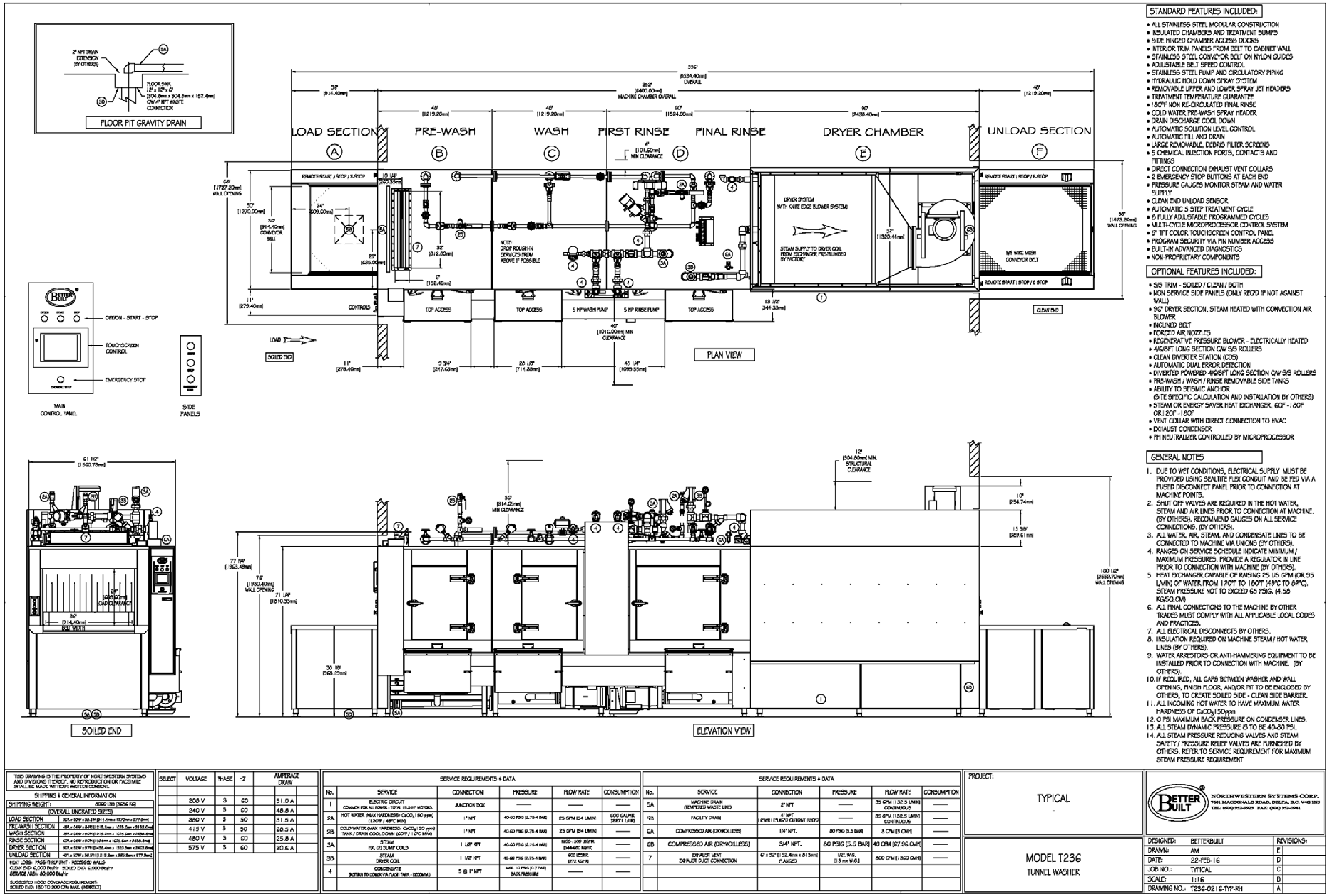
The following equipment cut sheets provide detailed information for the large equipment units in the project-

1. **Tunnel Washer**
2. **Cage & Rack Washer**
3. **Bulk Autoclave**

Other equipment cut sheets will be provided in the Schematic Design Phase, such as bedding disposal system, bedding dispenser and bedding disposal systems, biological safety cabinets, fume hood, cage racks, etc.

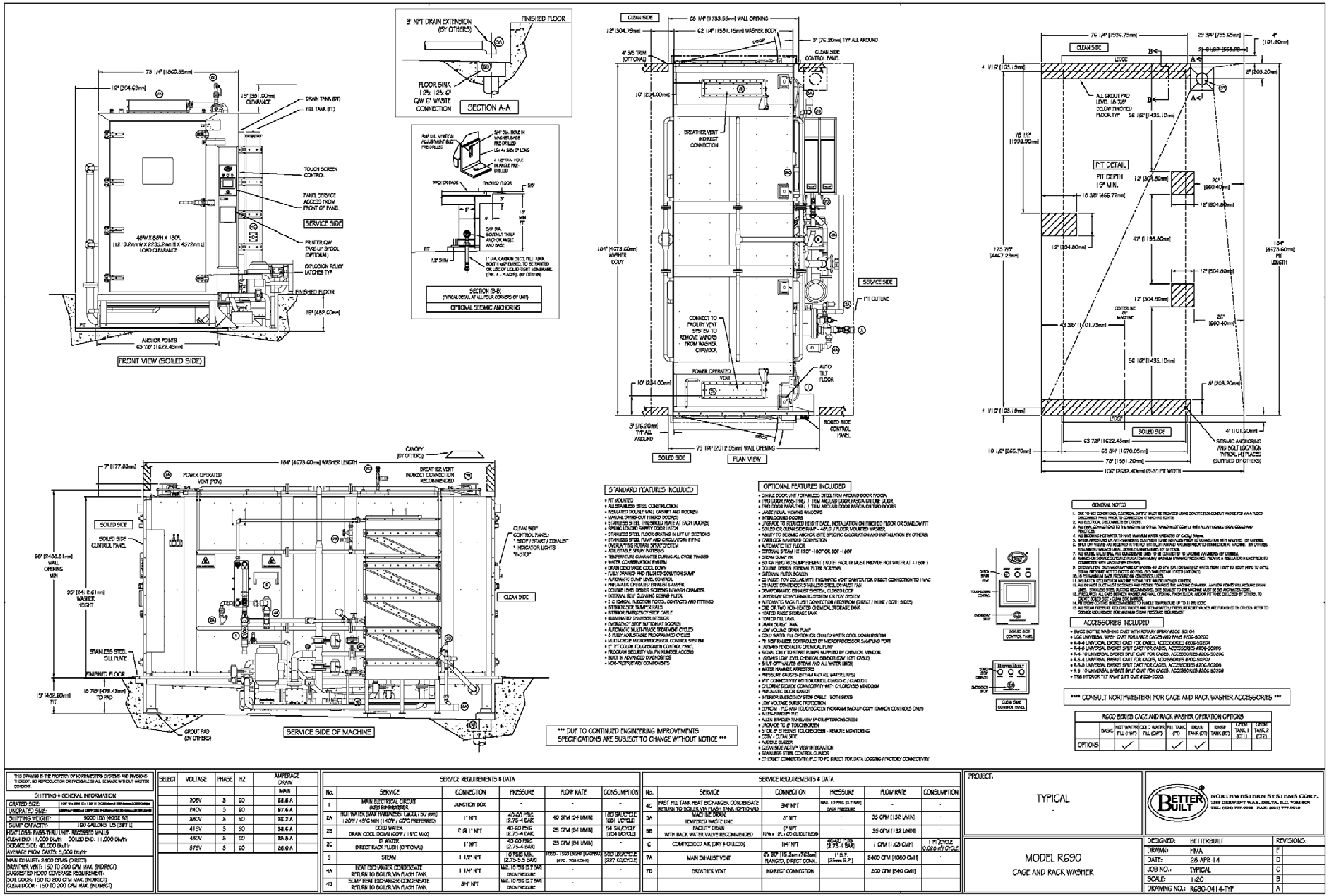
Equipment Cut Sheet

Tunnel Washer



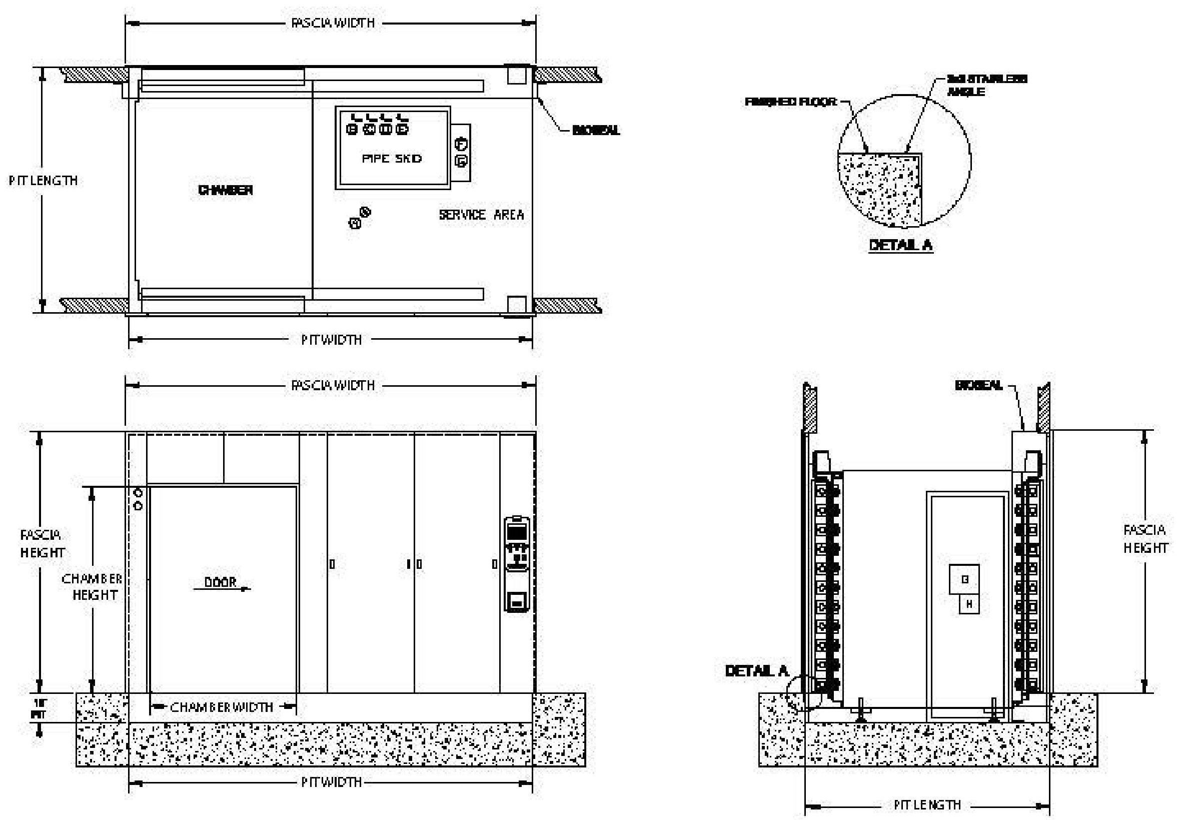
Equipment Cut Sheet

Cage & Rack Washer



Sizing and Volume
Animal Laboratory and Vivarium Autoclaves

General Arrangement Shown



Sizing

Beta Star sterilizers are available in a variety of sizes to meet your process needs. Sizes are selected based on throughput, facility size, or existing equipment including equipment carts and isolated or ventilated cage systems.

See the chart below for a list of our standard sized sterilizers. Custom sizes are available upon request. Beta Star's sectioned sterilizer chambers are assembled on-site, where building access is limited in space.

	Chamber Size in Inches						
Model	Width	Height	Length	Pit Width	Pit Length	Wall Height	Facia Width
VR 355749	35	57	49	108	65	80	110
VR 355760	35	57	60	108	77	80	110
VR 355786	35	57	86	108	102	80	110
VR 495786	49	57	86	132	102	80	146
VR 368686	36	86	86	106	102	109	122
VR 498686	49	86	86	132	102	109	148
VR 618686	61	86	86	168	102	109	170
VR 728686	72	86	86	192	102	109	194

R-V Industries, Inc. Honey Brook, PA • website: www.rvii.com

EQUIPMENT CUT SHEET
Bulk Autoclave

Animal Laboratory and Vivarium Steam Sterilization Autoclaves

BETA STAR LIFE SCIENCE EQUIPMENT

GreenVivarium.org Best Product Award

Features and Benefits

Lowest Cost of Ownership - Design characteristics from years of service experience are engineered into the ***LS Series*** sterilizers. Industrial grade components, precision machining and fabrication, proven mechanical advantages and utility conservation devices provide owners and users with a low maintenance reliable sterilizer.

Reliability - Industrial grade valves and high temperature gaskets prevent otherwise costly and common service downtime. The vessel is tested and certified to exceed national pressure vessel standards and carries a manufacturer's warranty.

Safety - Operator and technician safety is ensured through temperature and pressure monitoring, relief valves, safety interlocks and manual overrides.

Serviceability - Reduce costly maintenance downtime with easy to access consumable and expendable components.

Simplicity - The intuitive touch screen interface provides users with clearly identifiable selections to begin cycles.

Long Life Door Gasket - Beta Star's high temperature, air actuated door gaskets are seated into a machined groove that provides a close tolerance creating a less strenuous environment, extending door gasket life.

Made in the U.S.A. - Manufactured in southeastern Pennsylvania, Beta Star takes pride in their first class ASME certified fabrication and assembly plant. Over 250 employees are committed to the superior quality products we provide.

Eco Friendly - Reduce your facility's water footprint with Beta Star's utility conservation features. Mechanical and programmable conservation features are integrated into the Beta Star ***LS Series*** sterilizer.

WATER CONSERVATION

Application

Beta Star supplies sterilization cycle packages for all applications in the pharmaceutical, life science, biotechnology, laboratory, and animal care markets. All ***LS Series*** sterilizers include Pre-Vacuum, Liquid, Bio-Bag, Hard Goods, Bowie-Dick and a Vacuum Leak Test cycle as standard. Cycle parameters adhere to the guidelines for Industrial Moist Heat Sterilization referred to in document AAMI / ISO 111345-R-8/93.

Thirty total cycle recipes can be programmed and stored for specific goods or media using supervisory access. Custom cycle programming is supported by an all encompassing PLC system.

Design

Beta Star sterilizers are value engineered for maximum throughput, efficiency, serviceability, safety and reliability. Our solid stainless steel rectangular chambers offer dual steam inlet baffles for better temperature distribution, more usable space, center sloping chamber floors to minimize condensate retention, reduce dry time, and allow for simple operation cleanup.

Beta Star steam sterilizers are designed for continuous use with serviceability engineered into every sterilizer. Lengthy downtime has been eliminated through the use of industrial grade non-proprietary components. Our rigid modular frame provides a solid base and framework for easy access to our industrial grade mechanical and electrical components.

USC
Capital Construction Development

PROJECT BUDGET ASSUMPTIONS

Date: 06/01/2016
PR: USC0001309
Name: BCC - Broad Basement Expansion Feasibility Study
Account Number:
Project Manager:

Gross Building Area: 34,000 GSF
Net Building Area: 34,000 SF
Building Type:

Description: Based on June 2016 Concept Design by 'Design for Science.' GSF 34,000.

CONCEPT DESIGN ROM ESTIMATE

No.	Code	Item	Quantity	Unit	Unit Cost	Total	Adjusted Total	Comments/Assumptions
15118/ 44710	CONSTRUCTION CONTRACT							
		Based on HHC Concept Estimate dated May 25, 2016	1.00	LS	$32,686,599.00	$32,686,599		
		General Sitework: General Underground Utilities (dewatering and ductbank/building underpining all included). Finish site work minimal (building takes up 90% of footprint).	0.00	SF	$30.00	$0		
		Electrical Infrastructure (high level ROM from Andrea 02.08.16)	0.00	LS	$2,000,000.00	$0		
		Electrical Infrastructure (prorated equivalent for project only 02.19.16)	0.00		$1,000,000.00	$0		
		Ditto Steam (from Mark Mosley 02.08.16 - see concept report)	0.00	LS	$7,000,000.00	$0		
		Steam Infrastructure (prorated equipvalent for project only 02.19.16)	0.00	LS	$1,000,000.00	$0		
		Ditto CW (from Mark Mosley 02.08.16) "$2.5-$3M"	0.00	LS	$2,500,000.00	$0		
		% Cost of Enclosure	0.00	LS	$100,000.00	$0		
		Divert existing CW line	0.00	LS	$175,000.00	$0		
		Escalation from present day (assumes two years to mid-point construction)	1.00	LS	$2,000,000.00	$2,000,000		
					TOTAL	$34,686,599	$34,686,600	

No.	Code	Item	Quantity	Unit	Unit Cost	Total	Adjusted Total
15122/ 44711	OTHER CONSTRUCTION						
		N/A	0.00	SF	$0.00	$0	
			0.00	SF	$0.00	$0	
			0.00	SF	$0.00	$0	
					TOTAL	$0	$0
N/A / 44713	OCIP						
		N/A	0.00	SF	$0.00	$0	
			0.00	SF	$0.00	$0	
			0.00	SF	$0.00	$0	
					TOTAL	$0	$0

Notes:

[a] *Current day estimate-assumes design commence within next few months and mid-point construction in two years. ADD 5% PA for escalation thereafter*

[b] *Consider backbone infrastructure funded from elsewhere ($11.5M or $4.6M)*

[c] **Disregard last. Above estimate includes for all self-contained utilities.**

[d]

15112/ 44330	SITE PREPARATION	Quantity	Unit	Unit Cost		
	Specific work related to site - dewatering and shore/underpin existing buildings/ductbank **(Included in HHC number above)**	0.00	LS	$750,000.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

15110/ 44331	DEMOLITION	Quantity	Unit	Unit Cost		
	Included in line item 44710.	0.00	NA	$0.00	$0	
	Document existing buildings' conditions (physical inside and out, vibration levels, noise, etc.)	1.00	LS	$75,000.00	$75,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$75,000	**$75,000**

15114/ 44350	UTILITY CONNECTION	Quantity	Unit	Unit Cost		
	Sewer/storm/water connections, etc.	1.00	LS	$75,000.00	$75,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$75,000	**$75,000**

15115/ 44355	TELECOMMUNICATIONS / DATA LINES	Quantity	Unit	Unit Cost		
	Headend equipment, servers, phones, data and phone line distribution	1.00	LS	$225,000.00	$225,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$225,000	**$225,000**

BUDGET DETAILS
Continued

		Quantity	Unit	Unit Cost		
15113/ 44360	**ENVIRONMENTAL REMEDIATION**					
	Soil and plant material disposal	1.00	LS	$50,000.00	$50,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$50,000	**$50,000**
15119/ 44365	**AUDIO VISUAL**					
	A/V and security	1.00	LS	$50,000.00	$50,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$50,000	**$50,000**
151120 44366	**SECURITY**					
	Security systems	1.00	LS	$100,000.00	$100,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$100,000	**$100,000**
15116/ 44510	**LANDSCAPING**					
	Included in line item 44710	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**
15109/ 44530	**GRAPHICS / SIGNAGE**					
	Included in line item 44710	0.00	NA	$0.00	$0	
	(Code related signage only)	0.00	NA	$0.00	$0	
	Wayfinding signage	1.00	EA	$25,000.00	$25,000	
		0.00	NA	$0.00	$0	
				TOTAL	$25,000	**$25,000**
15123/ 44010	**FURNISHINGS UNDER $5,000 UNIT PRICE**					
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	

		Quantity	Unit	Unit Cost	Total	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

15127/ 44810	FURNISHINGS OVER $5,000 UNIT PRICE	Quantity	Unit	Unit Cost	Total	
	Included in line item 44830	0.00	GSF	25	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

15124/ 44020	MOVEABLE EQUIPMENT UNDER $5,000 UNIT PRICE	Quantity	Unit	Unit Cost	Total	
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

15128/ 44821	MOVEABLE EQUIPMENT OVER $5,000 UNIT PRICE	Quantity	Unit	Unit Cost		
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

15117/ 44030	FIXED EQUIPMENT UNDER $5,000 UNIT PRICE	Quantity	Unit	Unit Cost		
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

15126/ 44830	FIXED EQUIPMENT OVER $5,000 UNIT PRICE	Quantity	Unit	Unit Cost		
	Fixed equipment, casework, and specialities	0.00	LS	$2,500,000.00	$0	
	Includes Owner Allowance for moveable equipment and cages (assumes 12,000 cages)	0.00	NA	$0.00	$0	
	Fixed and moveable equipment including cages and FF&E (assumes 12,000 cages)	0.00	LS	$5,000,000.00	$0	
	FF&E Only (See Equipment below the line. Owner will not want to pay various fees on markups - Purchase direct.)	1.00	LS	$100,000.00	$100,000	
		0.00	NA	$0.00	$0	
				TOTAL	$100,000	**$100,000**

N/A / 44822	MOVABLE EQUIPMENT - COMPUTERS	Quantity	Unit	Unit Cost		
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

N/A / 44840	VEHICLES	Quantity	Unit	Unit Cost		
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

N/A / 44850	SCIENTIFIC EQUIPMENT PURCHASES	Quantity	Unit	Unit Cost		
	N/A	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$0	**$0**

TOTAL HARD COSTS **$ 35,386,600**

15100/ 44210	PRELIMINARY EXPENSES (PROGRAMMING)	Quantity	Unit	Unit Cost		
	Initial Feasibility Study	1.00	LS	$48,700.00	$48,700	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	**$48,700**	**$48,700**

15102/ 44220	ARCHITECT / ENGINEER	Quantity	Unit	Unit Cost		
	Architect/Consultants - 15%	0.15	%	$ 35,386,600	$5,307,990	
	(Structural/dewatering/MEP/ductbank/etc., will cause to be high)	0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	**$5,307,990**	**$5,308,000**

15108/ 44230	CONSULTANTS	Quantity	Unit	Unit Cost	
	Geo/Methane	1.00	LS	$165,000.00	$165,000
		0.00	NA	$0.00	$0

		Quantity	Unit	Unit Cost		
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$165,000	$165,000

15101/ 44240	REIMBURSABLE EXPENSES	Quantity	Unit	Unit Cost		
		0.10	%	$5,472,990.00	$547,299	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$547,299	$547,300

15104/ 44310	CERTIFIED INSPECTION	Quantity	Unit	Unit Cost		
	Survey	1.00	LS	$20,000.00	$20,000	
	Certified inspections	1.00	LS	$75,000.00	$75,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$95,000	$95,000

15105/ 44320	SOIL TESTING	Quantity	Unit	Unit Cost		
	Soil testing	1.00	LS	$25,000.00	$25,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$25,000	$25,000

15106/ 44340	PLAN CHECK / BUILDING PERMIT	Quantity	Unit	Unit Cost		
		0.02	%	$35,386,600.00	$707,732	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$707,732	$707,800

15107/ 44410	LEGAL / ADMINISTRATIVE SERVICES	Quantity	Unit	Unit Cost		
	ARC Reprographics	1.00	LS	$1,000.00	$1,000	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
		0.00	NA	$0.00	$0	
				TOTAL	$1,000	$1,000

20230/ 44420	O&M / MISCELLANEOUS EXPENSES	Quantity	Unit	Unit Cost

BUDGET DETAILS
Continued

		Quantity	Unit	Unit Cost	Total		
	FMS (Allowance) - Assistance with existing conditions	1.00	LS	$10,000.00	$10,000		
		0.00	NA	$0.00	$0		
		0.00	NA	$0.00	$0		
		0.00	NA	$0.00	$0		
				TOTAL	**$10,000**	**$10,000**	
15111/ 44610	**MOVING EXPENSES**	**Quantity**	**Unit**	**Unit Cost**			
	No anticipated cost for moving animals during construction	1.00	LS	$0.00	$0		
		0.00	NA	$0.00	$0		
		0.00	NA	$0.00	$0		
				TOTAL	**$0**	**$0**	
	TOTAL SOFT COSTS						**$ 6,907,800**
	SUBTOTAL PROJECT COSTS						**$ 42,294,400**
15125/ 44910	**TOTAL CONTINGENCY**	**Quantity**	**Unit**	**Unit Cost**	**Total**		
	Total Contingency for project is 15% of both hard and soft cost estimates (line 27)	15.0%	%	$42,294,400.00	$6,344,160		
				TOTAL	**$6,344,160**	**$6,344,200**	
							$ 48,638,600
15103/ 44250	**PROJECT MANAGEMENT**	**Quantity**	**Unit**	**Unit Cost**			
	Project management fee of % of total project budget not including project management fee	2.5%	%	$48,638,600.00	$1,215,965		Per Project Management Fee Structure revised 6/26/15.
	Additional Project Management Fee						Extra Fee charged for:
				TOTAL	**$1,215,965**	**$1,216,000**	
	TOTAL PROJECT BUDGET						**$ 49,854,600**

$49,854,600
$0 s/b $0

Notes:

NA - Not Applicable
SF - Square Footage
% - Percent
LS - Lump Sum
EA - Each
YD - Yard

Project Management Fee:

-	49,999	10.0%
50,000.00	99,999	8.0%
100,000.00	249,999	7.0%
250,000.00	499,999	6.0%
500,000.00	999,999	5.5%
1,000,000.00	1,999,999	5.0%
2,000,000.00	2,999,999	4.5%
3,000,000.00	4,999,999	4.0%
5,000,000.00	9,999,999	3.5%
10,000,000.00	19,999,999	3.0%
20,000,000.00		2.5%

Hard Costs	$	35,386,600
Soft Costs & PM Fees	$	8,123,800
Subtotal	$	43,510,400
Contingency	$	6,344,200
PROJECT BUDGET	**$**	**49,854,600**

Rev 06.26.15

Applicable Codes & Standards

The following codes and standards shall apply to the design and construction of the proposed vivarium addition. The latest edition shall be used for all codes and standards.

Report of the Health Sciences Campus Long Range (10 Year) Animal Facility Planning Committee **2012 March 25**

Guide for the Care and Use of Laboratory Animals

NIH Vivarium Design Guidelines

Biosafety in Microbiological and Biomedical Laboratories

California Building Codes

ANSI Z358.1 Standard for Safety Showers and Eyewashes

ANSI Z9.5- American National Standards for Laboratory Ventilation

NFPA 45- Standard on Fire Protection for Laboratories Using Chemicals

Report of the
Health Sciences Campus Long Range (10 year)
Animal Facility Planning Committee

March 25, 2012

1. Overview and Charge of the Committee

The Long Range Animal Facilities Planning Committee for the Health Sciences Campus (HSC) was formed in October, 2011 by Vice President for Research Randolph Hall to examine future directions and planning for animal research facilities during the next 5 to 10 year period. The impetus for this committee arose from several factors:

- Concerns from faculty members, department chairs, institute directors, and research administrators on the HSC that the lack of adequate animal facility housing and procedure spaces were impeding existing research programs and limiting faculty recruitment due to capacity restrictions. This concern was repeated and confirmed in faculty surveys conducted in late 2010 and 2011.
- USC published its master plan for the Health Sciences Campus in 2011. In this overall campus plan, two factors were of concern relative to animal housing space: 1) The campus master plan recommended a significant expansion of research laboratory space, and 2) The plan showed several existing buildings that contain animal facilities as demolished and replaced over the next 10 to 20 years
- A previous Animal Facility Master Plan was written by an external consultant in 2002 and projected needs for 10 years. However, elements of this plan, including construction of some new animal research space, were not implemented on the HSC It was recommended by Dr. Donald Casebolt, Director of Animal Resources, that USC revisit the plan in the context of the other concerns regarding animal facility space and usage.

The committee included the following members:

- Randolph W. Hall, Vice President for Research
- Roberta Brinton, Professor
Department of Pharmacology and Pharmaceutical Sciences
- Donald B. Casebolt, Director
Department of Animal Resources
- Robert Maxson, Professor
Department of Biochemistry and Molecular Biology
- Alapakkam Sampath, Associate Professor
Department of Physiology and Biophysics
- Laurie Stone, Executive Director of Land Use and Planning
University Real Estate
- Henry Sucov, Associate Professor
Departments of Cell and Neurobiology and Biochemistry and Molecular Biology
- James Weiland, Associate Professor
Department of Ophthalmology
- Leslie Weiner, Professor
Department of Neurology
- Margarita Zeichner-David, Research Professor
Department of Biomedical Sciences & Center for Craniofacial Molecular Biology

The following were factors considered as part of the committee discussions. As general attributes, animal research facilities must:

- Provide an optimal environment for animal care.
- Provide a safe working environment for research and animal care staff.
- Prevent catastrophic research losses in case of disaster
- Maximize research quality.
- Maximize research productivity.
- Maximize operational efficiency and adaptability
- Control costs
- Accommodate future growth in research programs and recruitment

2. Animal Facility Summaries and Recommendations

The total amount of animal research space on the Health Sciences Campus is 39,154 net square feet (NSF). Of this space, facilities in HMR, CSC, MMR, and PSC may be eliminated at some point in the future as part of the HSC master plan. These facilities total 18,322 NSF. The committee discussed this large amount of potentially lost space as a concern. In addition, certain actions such as strategic renovations of existing facilities were discussed in the context of which facilities are most likely to be eliminated during the next ten years and beyond, to provide adequate housing space during the interim period.

This section describes the current status of animal research facilities on the Health Sciences Campus including net square feet of animal housing and support space, and positive and negative attributes of each facility. Under each facility description, recommendations are made.

2.1 Condition of Existing Spaces and Recommendations

Hoffman Medical Research (HMR) contains 6,766 NSF of animal housing and 6,488NSF of support spaces (13,245 total NSF). Animals housed include Mice (1,866 cages); Rats (154); Guinea Pigs (31); Rabbits (31); Dogs (14); Swine (12); and Chickens (75).

Positive attributes of HMR include the basement large animal and procedure area that was renovated in 2004-2005, which includes modern housing for dogs and swine, surgery, and procedure rooms.

Negative attributes are that the tower facility and freight elevator are inefficient and impossible to sanitize or separate clean and dirty materials; there are no procedure room spaces for rodents available; the cage washing facility is not designed for rodent cage handling and the 2002 Master Plan called for no rodent housing in HMR; automatic watering is available only in some areas of the tower; ventilated caging is used in some rooms, but without direct exhaust leading to odor problems; and partial emergency backup power only to exhaust fans, not to supply air systems or heating/air conditioning. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system.

HMR Recommendations: The status of HMR in the HSC Master Plan is that it will eventually be demolished and replaced with a research and education building. However, because the building may remain for at least ten years, the committee discussed options to keep the building in operation during this time frame. It is recommended that HMR be provided with full emergency backup power and automated environmental monitoring and control. In addition, due to constraints on efficiency and sanitation resulting from the freight elevator and cage wash area, the majority of the rodent census in HMR should be moved to RB3 once it opens. Some smaller amount of rodent capacity may remain for faculty located in HMR and PSC.

The Department of Animal Resources is vacating office spaces on the first and second floor of HMR during February 2012. The rooms within the animal facility tower have been determined to be within the animal facility ventilation system. Because HVAC is usually the most expensive mechanical system to construct in an animal facility, it should be relatively inexpensive to convert these spaces back to animal housing and procedure spaces. It should be noted that the amount of space is small (1,020 NSF) but will contribute to the overall capacity for animal housing and procedure space.

The renovations would consist of the following:

- Replacement of flooring materials throughout (including elevator vestibules) with epoxy aggregate flooring.
- Replacement of wooden doors with metal doors.
- Reopening floor existing drains in HMR 214.
- Placing a hand washing sink in the central areas of HMR 214.
- Repainting walls and ceilings with epoxy-based paint.
- Installation of light timers for each room.
- Installation of automatic watering.

Cost estimates are currently under development and it is anticipated that the work can be accomplished during 2012.

Mudd Memorial Research (MMR) contains 1,501 NSF of animal housing and 1,304 NSF of support space (2,805 total NSF). Animals housed include mice (535 cages); and rats (50).

There are no positive attributes of MMR. Negative attributes are that the facility is very small and houses a small number of rodents in standard caging; the cage washing facility is not designed for rodent cage handling and does not allow for separation of clean and dirty materials; automatic watering is not available; there is no individual temperature control of rooms; and there is no emergency backup power to environmental systems. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system. The 2002 Master Plan called for closure of this facility.

MMR Recommendations: The status of MMR in the HSC Master Plan is that it is demolished and replaced with a research and education building. The committee recommends closure of this facility as soon as RB3 opens and replacement space is available.

3

Doheny Eye Foundation (DOH) contains 2,780 NSF of animal housing and 2,966 NSF of support space (5,746 total NSF). Animals housed include mice (734 cages); rats (308); rabbits (21); and swine (4).

Positive attributes are that the facility was renovated in 2010, including addition of six runs for large animal housing, cage washing facility, and additional procedure spaces. A new air handler was installed using existing ducts and controls.

Negative attributes are that there are problems with temperature and air balance control in some rooms following the renovation; and there is no emergency backup power to environmental systems. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system.

DOH Recommendations: The status of DOH in the HSC Master Plan is that it remains in service. The committee recommends that this facility remain in operation with two specific recommendations to provide individually ventilated cages and racks for all of the rodents housed in DOH and to provide full emergency backup power and automated environmental monitoring and controls to the facility.

Pharmaceutical Science Center (PSC) contains 108 NSF of animal housing and no support space. It currently houses 40 frogs.

This single room houses a small number of frogs for a single research program. A negative attribute is that there is no emergency backup power to environmental systems.

PSC Recommendations: The status in the HSC Master Plan is that the PSC building is to be renovated. It is not known whether this room will remain for animal housing. The facility should remain open, and if eliminated at some point due to building renovation, the frogs can be moved to another facility.

Zilkha Neurogenetic Institute (ZNI) contains 4,399 NSF of animal housing and 4,872 NSF of support space (9,271 total NSF). Animals housed include mice (5,637 cages); rats (88); and zebrafish (822 tanks). Zebrafish are being moved to the BCC facility.

Positive attributes of ZNI are that it is a relatively new facility (opened in 2003) that provides mouse and rat housing for multiple programs in high capacity ventilated racks with automatic watering. Full emergency backup power is available.

Negative attributes are that waste bedding disposal moved to far end of the building and the cage washing facility will handle all cages for both ZNI and BCC. An automated bedding disposal system was requested as part of the BCC construction but was removed from the budget. Also, there is no redundancy of mechanical systems for ZNI or BCC (steam supply was lost for two months in 2011).

4

ZNI Recommendations: The status of ZNI in the HSC Master Plan is that it remains within the research core area. With possible interconnection to RB3 in the future, the issues of waste bedding disposal and redundancy of mechanical systems should be addressed.

Broad Center for Regenerative Medicine and Stem Cell Research (BCC) contains 3,874 NSF of animal housing and 1,941 NSF of support space. Future housing (2012) will include mice (4,800 cages) and zebrafish (3,200 tanks).

Positive attributes are that BCC is a new facility to open in early 2012 that provides mouse and rat housing for multiple programs in high capacity ventilated racks with automatic watering, and centralized zebrafish housing and support. Full emergency backup power is available.

Negative attributes of BCC are that all materials for washing must be transported to and from ZNI and there is no redundancy of mechanical systems for ZNI or BCC.

BCC Recommendations: The status of BCC in the HSC Master Plan is that it remains within the research core area. With possible interconnection to RB3 in the future, the issues of waste bedding disposal and redundancy of mechanical systems should be addressed.

Clinical Sciences Center (CSC) contains 1,424 NSF of animal housing and 731 NSF of support space. Animals housed include mice (1,668 cages); and rats (29).

Positive attributes of the facility are that it provides mouse and rat housing for programs in CSC and CSA buildings that are somewhat distant from other animal facilities.

Negative attributes are that the rooms are very small; the cage washing area is too small for the number of cages; Dirty bedding is dumped in the hallway which is not appropriate for facility sanitation and health and safety reasons; there are no procedure spaces; there are no exhaust connections for high capacity ventilated racks and no automatic watering lines are available; and there is no emergency backup power to environmental systems. In addition, the facility is not equipped with an automated environmental control, monitoring, and alarm system.

CSC Recommendations: The status in HSC Master Plan is that CSC will eventually be demolished and replaced by patient parking structure. However, during committee discussions, it was noted that the CSC building may remain intact for the next ten years or possibly longer. Also the CSC facility houses a significant rodent census and serves the needs of faculty researchers in the CSC and CSA buildings, which are somewhat distant from the other animal facilities, and the facility is also closely associated with the existing imaging core facility. For these reasons, renovation of CSC is recommended.

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The room sizes cannot be completely resolved, but a reasonable renovation project should be developed to address deficiencies, as noted below:

- Expand the cage washing area into an adjoining room near the dirty side to allow for space to handle the number of cages and to dump dirty bedding within the cage washing room rather than in the hallway.
- Replace the cage washer and autoclave which are 15-20 years old with more efficient models.
- Add a fully equipped procedure room by conversion of a small holding room or one of the restroom/locker room areas.
- Add electrical connections for high capacity ventilated racks.
- Add automatic watering systems for all holding rooms.
- Purchase ventilated racks and caging for all holding rooms.
- Add emergency backup power and automated control and monitoring to environmental systems in the facility.

These renovations will result in a facility that will be capable of a modest increase in mouse cage census to about 1,900 cages (232 cages more than present) while maintaining efficiency and an adequate standard of animal care.

2.2 Specialized Procedure Spaces

Procedure spaces within animal facilities are currently for general use to the degree possible, and this will continue for future facilities. Possible exceptions will be space for animal biosafety level 2 (ABSL2) and animal biosafety level 3 (ABSL3) research, spaces for neurobehavioral research and behavioral phenotyping of rodents, expansion of support facilities for the transgenic rodent core laboratory, and other specialized research requiring separation of animals from general population rooms. These spaces must be located within centralized facilities that are accessible to faculty and research staff members from all areas of the HSC.

Currently, there is no space for ABSL3 research, because this requires a dedicated facility or area within a facility. ABSL2 research is conducted within existing facilities by separation of animals, and application of administrative controls such as signage, wearing personal protective clothing, and special handling of waste materials. However, the Institutional Biosafety Committee has expressed concerns about this approach and recommends construction of a dedicated ABSL2 facility.

At the present time, behavioral research and other specialized research requiring procedural space is similarly conducted within existing animal facilities. However, there is a significant concern from faculty conducting this research that there is insufficient space for this work, and that much of the work could be conducted within core areas that could be efficiently shared among various investigators. In addition, existing spaces do not allow for adequate control over lighting, noise and vibration, separation of animals from research personnel, and other factors that are impediments to research involving rodent behavioral phenotyping that are extremely sensitive to environmental factors.

Animal imaging is currently conducted in CSC. A major disadvantage is that this facility is used by investigators housing animals in various HSC facilities, and there is limited capacity in CSC

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for this number of animals. This means that animals have to be transported to and from CSC from other facilities, which precludes efficient study design and ease in imaging at multiple time points. Imaging facilities in clinical buildings are used for large animals and procedures are conducted either in very early or in late evening hours. For PET imaging, delivery of isotopes from a cyclotron is necessary. Currently, the cyclotron is in CSC. A new cyclotron will likely be purchased and placed in CSC.

The existing transgenic/knockout rodent core laboratory is located within the ZNI animal facility. Because of expanded work involving these rodent models and needs of researchers to develop models involving multiple gene insertions or deletions, there will need to be an expansion of physical facilities to support this model development.

Areas for general procedures, ABSL2, ABSL3, rodent neurobehavioral testing, transgenic/knockout core, and other specialized procedures should be constructed in a new research building (RB3) on the HSC. The location of imaging facilities should also be considered in this building.

2.3 Conversion of Mouse Housing to Individually Ventilated Cages with Automatic Watering

Many of the rodents on the HSC are housed in traditional microisolation cages and are provided water in water bottles. This includes the entire rodent census in the CSC and MMR and a portion of the cages in DOH and HMR for a total of 3,300 cages (one third of the total on the HSC).

The advantages of ventilated caging systems that have been well described (Lipman, NS, Rodent Facilities and Caging Systems, pp. 265-288 in Hessler, JR and Lehner, NDM eds. Planning and Designing Research Animal Facilities, Elsevier, 2009).

The advantages of ventilated caging systems are as follows:

1. Environmental conditions for the animals housed are greatly improved by preventing the buildup of ammonia, carbon dioxide, water vapor, and heat load within the cages compared with standard filter topped cages.
2. Airborne microbial contamination and allergen loads within the rooms are reduced, thus improving worker safety.
3. Increased housing density within rooms is possible, partially due to points 1 and 2.
4. Cage changing frequencies can be reduced. At USC, individually ventilated cages are changed once per week rather than twice per week. This greatly reduces the labor requirements for mouse care and helps to contain costs charged to investigators for daily care. An animal care technician can care for about 1,000 cages in individually ventilated racks, versus 500-600 in static racks.
5. Lowered pre-weaning mortality with less frequent cage changes have been described.
6. Less frequent cage washing and autoclaving increases the usable life of the plastic cage and other components.
7. These caging systems allow USC to further implement green and sustainable technologies. For example, by converting the CSC facility from static cages to ventilated cages, we estimate that we will save over 250,000 gallons of water per year for washing cages, and send over 30 tons less waste bedding material to the local landfill.

The costs for the purchase and maintenance of individually ventilated cages and racks are compared with static cages and racks in the table below. The return on investment including the purchase costs for either cage type is 1.25 years ($86,000 divided by $70,124). The return on investment for replacement of existing static cages with ventilated cages is 2.7 years ($186,000 divided by $70,124). Note that the calculations do not include the lowered costs for solid waste disposal that are also half as much when using ventilated cages compared with static cages.

Table 1. Cost Comparison of Static Versus Ventilated Microisolation Mouse Cages

Item	Static Microisolation	Ventilated Microisolation	Cost Difference
Purchase cost for 1,000 cages	$100,000	$186,000	$86,000
Costs per year per 1,000 cages			
Technician costs	$91,688	$45,844	$45,844
Bedding costs	$13,870	$6,935	$6,935
Cage washing chemical costs	$5,400	$2,700	$2,700
Cage washing utilities costs	$22,290	$11,145	$11,145
Cage replacement costs	$7,000	$3,500	$3,500
Total cost per year per 1,000 cages	$140,248	$70,124	$70,124

Because some rooms in HMR and all of the rooms in DOH are equipped with automatic watering systems, the racks can be put into service immediately in those facilities to eliminate the use of water bottles. In the CSC, addition of an automatic watering system will be required. This can be accomplished during renovation of the facility, and is on the list of features to be added during the renovation.

It is not feasible to add individually ventilated racks to MMR, but once RB3 is completed, the MMR facility should be closed and the rodent census in that building moved to RB3. Any ventilated racks purchased and used in HMR should be moved to RB3 once it opens and the majority of mice in HMR are moved to RB3.

2.4 Emergency backup generator and automated environmental control, monitoring, and alarm systems for animal facilities

During the most recent site visit of the Association for Assessment and Accreditation of Laboratory Animal Care (AAALAC) in October 2010, the site visit team cited a lack of emergency backup power in many of the USC animal facilities. The newer facilities in ZNI and BCC are equipped with full emergency power on all environmental systems.

Facilities that will remain in service in the medium- to long-term that are not equipped with emergency backup power are in HMR, DOH, CSC, MMR, and PSC. Projects to develop emergency power capacity for HVAC environmental systems and lighting must be developed for these facilities to be compatible with standards for continued accreditation, or the facilities should be closed.

A related concern which is highlighted in the Eighth edition of the Guide for the Care and Use of Laboratory Animals is the provision of automated environmental control, monitoring, and alarm systems for animal research facilities. These systems are not provided in most of the older animal research facilities on the HSC campus and should be added to the facilities that remain open. The provision of these systems to all facilities will insure continued AAALAC accreditation and scientific integrity of the research being conducted, and will prevent possible catastrophic losses of animals or research data.

3. Trends and Projections in Animal Facility Usage

Data on animal census for the past five years for key species were presented to the committee. Discussion on these trends was as follows:

Rodents: The committee was in agreement that rodent census (particularly mice) would be the major area of growth in the next 5 to 10 years. The average daily census of mouse cages on the HSC has increased from 6,354 cages in 2007 to 10,860 cages in 2011. There was associated discussion about the possible need for rat housing increases due to model development using transgenic and knockout rats as this technology was developed at USC. Over the past five years, the average rat census has increased from 500 in 2007 to almost 800 in 2011.

Zebrafish: The census numbers for zebrafish have increased dramatically over the past five years, from essentially no fish to a current census of 10,000. While it is unknown whether recruitment of investigators using this model will increase, it was agreed that ongoing expansion in a central zebrafish facility within the BCC facility will allow for a tripling of capacity and potential recruitment of at least one or two more zebrafish users. It was concluded that this was sufficient for the known need during the next five to ten years.

Nonhuman Primates: Nonhuman primate research has declined at USC in recent years, and there are currently no nonhuman primates housed. The committee agreed that research using nonhuman primates would need to be conducted in properly constructed and high security facilities that are specifically designed for this purpose. In many cases, investigators may need to consider smaller studies using USC facilities, but outsource larger studies to contract research organizations or regional primate research centers. In addition, these facilities are better equipped for development of translational work and implementation of Good Laboratory Practices. It was also concluded that cognitive neuroscience research at a level requiring nonhuman primates would not ever be a priority at USC. This eliminates the need for extensive nonhuman primate housing, surgical, and procedural spaces.

It was concluded that USC should maintain some capacity for nonhuman primate research at a fairly limited level in a properly constructed and secure facility.

Other Large Animal Species: The HMR facility is essential for accommodating large animals such as dogs, swine, and small ruminants. There is a small capacity for these species in DOH,

consisting of only six runs. Translational studies will continue to be required and will use these species. Therefore this capacity must be replaced prior to the eventual closure of that building. When HMR is closed, its replacement should be conceived as a "translational health" research facility, focused on larger species.

Miscellaneous Species: A variety of other species such as guinea pigs, rabbits, and chickens are housed in HSC facilities (primarily in HMR). While the committee members did not expect a significant growth in the use of these other species, their use will continue at least at current levels and planning to accommodate these species must be included if HMR is eliminated at some time in the future.

3.1 Projected Needs for Rodent Housing

While the committee anticipated that future growth in animal based research would be significant, particularly for mouse models, some uncertainty exists in predictions. This uncertainly includes factors such as:

- NIH funding may decline in future years. Thus, animal usage per investigator may have reached or surpassed its peak.
- Continued growth depends on continued recruitment. Likely areas for future recruitment, and possible animal population sizes for major investigators, are unknown.
- The type of research will affect the recruitment needs of new faculty, For example, two recent recruitments on the HSC have involved mouse numbers that far exceed the average number of mice needed for other recruitments in recent years.

Current Housing

At 100% of capacity, the HSC will soon have sufficient space to accommodate 19,681 cages (Table 1). However, because it is difficult to continuously fill every cage, the HSC can more realistically accommodate a cage census of just below 17,000 cages (measured at 85% of capacity). To achieve even this lower capacity, an additional 2,240 new cages must be purchased to fill available space. Once these new cages are purchased, sufficient space will be available to serve a census growth of approximately 3,500 cages.

Table 2. Mouse Census and Capacity on Health Science Campus

	Existing Capacity		Current Census	New Capacity Added		Census	Net Census
	100%	85%		100%	85%	Committed	Available
BCC	-	-	-	4,800	4,080	4,048	32
CSC	1,848	1,570	1,610	(336)	(286)	(422)	96
DOH	1,100	930	908	280	238	(324)	584
HMR	2,855	2,310	1,915	840	714	(202)	1,311
MMR	734	624	566	-	-	-	58
ZNI	6,580	5,600	5,680	980	833	(613)	1,366
Total	**13,117**	**11,034**	**10,679**	**6,564**	**5,579**	**2,487**	**3,447**
Implementation of the new Guide						1,500	1,947
Cages to be purchased to provide new added capacity (HMR and DOH) = 2,240 (100% capacity) or 16 double sided ventilated racks							

Projected Needs with Continued Constant Annual Growth

Figure 1 forecasts future average daily census through 2021 under the assumption that census grows at the same annual rate as the last five years.

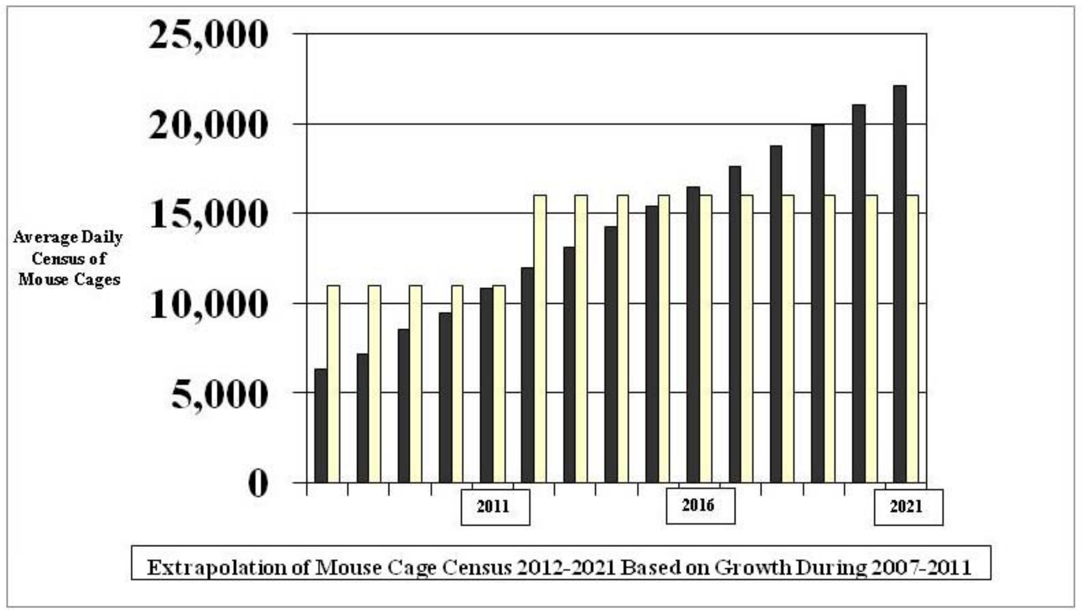

Figure 1. Projected Mouse Census with Constant Annual Growth

Under this assumption, 16,000 cages in 2012 (due to the opening of the BCC facility) will be sufficient to accommodate growth for approximately four years. The planned addition of 840 cages in HMR and 280 cages in DOH will accommodate approximately one additional year of growth, meaning by 2017 average daily census will exceed 85% of the total number of cages available (the recommended target).However, this number of cages may be exceeded prior to 2017 based on recent faculty recruitments. Two faculty members are adding about 2,000 cages during 2012, placing the census growth well above what is predicted by extrapolation.

An additional factor contributing to this deficit in the future is implementation of the Eighth edition of the Guide for the Care and Use of Laboratory Animals. These guidelines require additional cage space for female rodents with litters, and it is estimated that this may result in a 15% increase in mouse cages based on our existing census. If this change is fully implemented, we will only be able to accommodate two years of growth at the current rate.

Cage Census Based on Square Footage of Laboratory Space

The Health Science Campus currently has 163,057 NSF of assignable laboratory space in the ZNI, HNRT, and BCC buildings. In these three buildings, there are 50,782 NSF of space that are not assigned to an investigator (and are available to house laboratories of new recruited faculty). Investigators housed in the occupied laboratories (112,275 NSF of space) have a total rodent

census of 8,100 cages. This census includes the projected census of newly recruited investigators in these buildings. Dividing 112,275 by 8,100 yields a factor of 0.072 cages per NSF of laboratory space. By applying this factor, the census will increase by approximately 3,700 once all unassigned laboratory space is filled. This growth in census is 253 cages larger than available capacity.

Needed Cage Capacity for RB3

RB3 should be sized to accommodate any new needs created by laboratories housed therein, combined with any existing space deficit and any needed replacement of existing facilities.

New Needs: When adding the new RB3 building, estimated to be 100,000 NSF, an additional 7,200 cages are needed, based on .072 cages per NSF. If we assume that census is 85% of total cage capacity, then 8,470 cages will be needed to accommodate new activities. This assumes that RB3 is configured 100% for wet lab research. The need will be reduced if a portion of the building is focused on dry lab research.

Space Deficit: The current capacity, once Broad is fully operational and additional cages are acquired, is slightly below the projected need, with a projected 253 cage deficit.

Replacement of Existing Space: The entire MMR facility should be closed by the time RB3 is completed (624 mouse cages). HMR mouse facilities (3,150 cages) should be closed upon RB3 completion if feasible. Combined, replacement of these facilities would require 3,774 new cages.

Provision of 12,500 new cages will accommodate all of these needs.

3.2 Projected Needs for Other Animal Housing

Large Animal Housing: Large animal space: Large animal housing and support spaces in the HMR basement total to 5,037 NSF. This space must be replaced in a new building prior to Hoffman Hall's eventual closure.

Other Animal Housing: Housing and support spaces for these species in HMR (6,633 NSF), MMR (1,805 NSF), and PSC (106 NSF) facilities total to 8,544 NSF. Assuming no further growth in the use of miscellaneous species, this amount of space will be required to remain open in these facilities or to be replaced in a new building. We recommend closure of MMR, which would add 1,805 NSF to the RB3 requirement.

3.3 Industry Standard

One industry standard publication states that within large biomedical research buildings, there should be an allowance for up to 20 percent of laboratory space to be allocated as animal facility space (Norton, JN and Brouwer, AB, The Planning, Design, and Construction Process, pp. 17-44 in Hessler, JR and Lehner, NDM eds. Planning and Designing Research Animal Facilities, Elsevier, 2009.

The ZNI, HNRT, and BCC buildings provide 163,057 NSF of laboratory space. Using this factor, 32,611 NSF of animal housing space would be required. The ZNI facility provides 9,271 NSF and the BCC facility provides 4,158 NSF (13,429 NSF for both buildings). This is 19,182 NSF less than the predicted need based on this model. While it does appear that our existing animal housing space is meeting projected needs, this deficit indicates that USC has provided less animal space than other institutions.

3.4 Projected Needs for Specialized Research Spaces

From previous plans for the RB3 space (February 2005) the following square foot estimates were included for programs in these areas. Additional information on a neurobehavioral core was provided by the ZNI Director during 2011. Following are NSF estimates for these spaces:

Imaging:

7T horizontal MRI	777 NSF
9.4 or 11.7 T MRI	588 NSF
4.5T horizontal MRI	777 NSF
Equipment room (3@333 NSF)	993 NSF
Control room (3@221 NSF)	663 NSF
Animal Prep (3@165 NSF)	495 NSF
Total	4,293 NSF

Animal Biosafety Level 2/3:

Biosafety holding (4@253 NSF)	1,012 NSF
Procedure room (4@121 NSF)	484 NSF
Decontamination	182 NSF
Lockers (2@121 NSF)	242 NSF
Total	1,920 NSF

Neurobehavioral Core:

Behavior testing (6@120 NSF)	720 NSF
Ante-room (6@100 NSF)	600 NSF
Procedure	280 NSF
Total	1,600 NSF

Transgenic Core:

Surgery (2@363 NSF)	726 NSF
Injection (2@363 NSF)	726 NSF
Office (2@121 NSF)	242 NSF
Cryopreservation	182 NSF
LN2 Tanks	66 NSF
Total	1,942 NSF

These space estimates are only approximations and must be reviewed and recalculated based on programming exercises for the RB3 facility, and based on current needs for the types of spaces.

4. Construction of New Animal Facility Space in Research Building 3

Once all existing laboratories are filled with investigators in Norris, Zilkha and Broad, we project that the USC's mouse housing capacity will be less than the future need based on projections of increased census extrapolated from current growth, projections of committee members on likely areas of growth, and construction of additional research space. In addition, some existing research laboratory space is unoccupied and when filled, some of the research projects for recruited faculty will involve animal models. This need should be accommodated in the next research building (Research Building 3).

Research Building 3 will be located adjacent to the existing ZNI and BCC facilities, creating an opportunity to centralize HSC animal facilities into a combined RB3/ZNI/BCC facility. The advantages of centralization relate to the efficiency of shared facilities. We recommend the provision of additional space (possibly shelled) to accommodate the eventual closure of other animal facilities, including MMR (immediately upon opening RB3) and HMR (at some point in the future before it is demolished). A centralized animal research facility in RB3 could interconnect on the basement level with the ZNI and BCC facilities (the ZNI/BCC/RB3 facility). This would allow for access to the facility for faculty and research staff members from all areas of the HSC.

USC should consider the overall space efficiency of various approaches to programming and constructing the space. For example, the efficiency of the rodent facility space will be high by avoiding long interconnecting hallways such as those between the ZNI and BCC facilities, and by the exclusive use of high density ventilated racks with automatic watering systems. There should be efforts to provide as many larger rooms as possible, which are more space efficient. However, this will be offset by many smaller rooms that would be required for biosafety, neurobehavior, and imaging areas. Management efficiency would be greatly improved by providing as much automation as possible such as the automated dirty bedding disposal system.

Another efficiency factor to consider is that if large animals (dogs, swine, ruminants, and nonhuman primates) and miscellaneous animals (rabbits, chickens, guinea pigs, reptiles, amphibians) are eventually located in RB3, the space efficiency of the large/miscellaneous species areas will be much higher because redundant space would not be needed for a cage wash, storage, personnel area, loading dock etc. If HMR is maintained for a number of years, the housing spaces for large and miscellaneous species could be added later adjacent to the RB3 rodent spaces, if the space is reserved for future use as a shelled area and there are no impediments to expanding the basement is some manner.

In summary, the following features and attributes are recommended for the facility:

- Additional rodent housing in efficient, high capacity individually ventilated cage systems to accommodate growth in rodent census, most of the rodent census in the HMR and all of the rodent census in the MMR facilities.
- Large animal housing to replace space in the HMR basement, or shelled space to be converted to large animal housing when HMR closes.
- Miscellaneous animal housing to replace space in HMR, MMR, and PSC, or shelled space to provide miscellaneous species housing when these facilities close.

- Animal biosafety level 2 and 3 spaces.
- Neurobehavioral and other specialized procedure core spaces.
- Animal imaging spaces.
- Transgenic and knockout rodent core laboratory spaces.
- Core cage washing and materials handling spaces
- Dedicated loading dock space and automated dirty bedding/clean bedding handling systems for the three interconnected facilities.

5. Summary and Recommendations

The Health Science Campus benefits from several modern animal facilities, along with some outdated facilities in need of renovation or replacement. Once the Broad facility is opened and additional cages are acquired, sufficient housing will be available to accommodate most needs generated by new faculty recruitment in Zilkha, Norris and Broad, assuming that the intensity of animal research (cages per square foot of laboratory) does not exceed the present. However, the HSC will run out of space if the Eighth edition of the Guide for the Care and Use of Laboratory Animals mandates a significant reduction in mice per cage, or if new major mouse researchers are recruited to USC.

The committee makes the following long term recommendations:

1. Construct new animal facility space in the basement of the new RB3 building, including 12,500 mouse cages (assuming 100,000 new NSF of wet lab space) and space for large animals and miscellaneous animal species to accommodate the eventual closure of the HMR facility. Space for large animals and miscellaneous species could remain as shelled space or flexible expansion space until the need for replacement of HMR is imminent. When RB3 opens, close the MMR facility and move the majority of rodent housing from HMR into RB3. The facility would interconnect with existing ZNI and BCC facilities and contain sufficient animal housing and procedural spaces to accommodate researchers from all areas of the HSC.

2. In the RB3 facility, include sufficient procedural spaces to accommodate the needs of faculty and research staff members from throughout the HSC. Procedural spaces would include those for animal biosafety levels 2 and 3, neurobehavioral core procedures, transgenic/knockout animal core, and imaging for rodents. Rodent imaging should include all modalities used in contemporary research, to eliminate the need for transporting animals to different facilities. Imaging for large animals would be possible as an optional addition in the future, as shelled space or flexible expansion space.

In addition, the committee makes the following short term recommendations:

1. Provide emergency backup power and automated environmental monitoring and control functions to all existing HSC animal facilities that will remain open.

3. Purchase additional high capacity individually ventilated racks and cages for mice and rats to use throughout all HSC animal facilities that will remain open.

4. Renovate the CSC animal facility to provide individually ventilated racks and correct deficiencies in the cage washing facility.

5. Provide additional tools for faculty and research staff members to make efficient use of existing mouse holding facilities and to maintain mouse census at the minimum levels needed to accomplish research goals. As examples, the Department of Animal Resources has already held seminars on rodent breeding methods and should continue similar educational efforts. In addition the DAR could make software available to track and document rodent breeding programs for individual laboratories.

Environment, Housing, and Management

This chapter provides guidelines for the environment, housing, and management of laboratory animals used or produced for research, testing, and teaching. The design of animal facilities combined with appropriate animal housing and management are essential contributors to animal well-being, the quality of animal research and production, teaching or testing programs involving animals, and the health and safety of personnel. An appropriate program provides environments, housing, and management that are well suited for the species or strains of animals maintained and takes into account their physical, physiologic, and behavioral needs, allowing them to grow, mature, and reproduce normally while providing for their health and well-being.

Terrestrial Animals& Environment

Microenvironment and Macroenvironment

The *microenvironment* of a terrestrial animal is the physical environment immediately surrounding it; that is, the primary enclosure such as the cage, pen, or stall. It contains all the resources with which the animals come directly in contact and also provides the limits of the animals' immediate environment. The microenvironment is characterized by many factors, including illumination, noise, vibration, temperature, humidity, and gaseous and particulate composition of the air. The physical environment of the secondary enclosure, such as a room, a barn, or an outdoor habitat, constitutes the *macro environment*. Although the microenvironment and the macro environment are generally related, the microenvironment can be appreciably different and affected by several factors, including the design of the primary enclosure and macro environmental conditions. Evaluation of the microenvironment of small enclosures can be difficult. Available data indicate that temperature, humidity, and concentrations of gases and particulate matter are often higher in the animal microenvironment than in the macro environment, while light levels are usually lower. Micro environmental conditions can directly affect physiologic processes and behavior and may alter disease susceptibility.

Temperature and Humidity

Maintenance of body temperature within normal circadian variations necessary for animal well-being. Animals should be housed within temperature and humidity ranges appropriate for the species, to which they can adapt with minimal stress and physiologic alteration. The ambient temperature range in which thermoregulation occurs without the need to increase metabolic heat production or activate evaporative heat loss mechanisms is called the *thermo neutral zone (TNZ)* and is bounded by the lower and upper critical temperatures (LCTs and UCTs).To maintain body temperature under a given environmental temperature animals adjust physiologically (including their metabolism) and behaviorally(including their activity level and resource use). For example, the TNZ of mice ranges between 26°C and 34°C; at lower temperatures, building nests and huddling for resting and sleeping allow them to thermo regulate by behaviorally controlling their microclimate. Although mice choose temperatures below their LCT of 26°C during activity periods, they strongly prefer temperatures above their LCT for maintenance and resting behaviors. Similar LCT values are found in the literature for other rodents, varying between 26-30°C for rats and 28-32°C for gerbils. The LCTs of rabbits (15-20°C) and cats and dogs (20-25°C) are slightly lower, while those of nonhuman primates and farm animals vary depending on the species. In general, dry-bulb temperatures in animal rooms should be set below the animals' LCT to avoid heat stress. This, in turn, means that animals should be provided with adequate resources for thermoregulation (nesting material, shelter) to avoid cold stress. Adequate resources for thermoregulation are particularly important for newborn animals whose LCT is normally considerably higher than that of their adult conspecifics. Environmental temperature and relative humidity can be affected by husbandry and housing design and can differ considerably between primary and secondary enclosures as well as within primary enclosures. Factors that contribute to variation in temperature and humidity between and within enclosures include housing design; construction material; enrichment devices such as shelters and nesting material; use of filter tops; number, age, type, and size of the animals in each enclosure; forced ventilation of enclosures; and the type and frequency of contact bedding changes. Exposure to wide temperature and humidity fluctuations or extremes may result in behavioral, physiologic, and morphologic changes, which might negatively affect animal well-being and research performance as well as outcomes of research protocols. These effects can be multigenerational. The dry-bulb temperatures listed in Table 3.1 are broad and generally reflect tolerable limits for common adult laboratory animal species, provided they are housed with adequate resources for behavioral thermoregulation; temperatures should normally be selected and maintained with minimal fluctuation near the middle of these ranges. Depending on the specific housing system employed, the selection of appropriate macro- and micro environmental temperatures will differ based on a variety of factors, including but not limited to the species or strain, age, numbers of animals in the enclosure, size and construction of the primary enclosure, and husbandry conditions (e.g., use/provision of contact bedding, nesting material and/or shelter, individually ventilated cages). Poikilotherms and young birds of some species generally require a thermal gradient in their primary enclosure to meet basic physiological processes. The temperature ranges shown may not apply to captive wild animals, wild animals maintained in their natural environment, or animals in outdoor enclosures that have the opportunity to adapt by being exposed to seasonal changes in ambient conditions. Some conditions require increased environmental temperatures for housing (e.g., postoperative recovery, neonatal animals, rodents with hairless phenotypes, reptiles and amphibians at certain stages of reproduction).The magnitude of the temperature increase depends on housing details; sometimes raising the temperature in the microenvironment alone (e.g., by using heating pads for postoperative recovery or radiant heat sources for reptiles) rather than raising the temperature of the macro environment is sufficient and preferable. Relative humidity should also be controlled, but not nearly as narrowly as temperature for many mammals; the acceptable range of relative humidity is considered to be 30% to 70% for most mammalian species.

TABLE 3.1 Recommended Dry-Bulb Macro environmental Temperatures

Mouse, rat, hamster, gerbil, guinea pig: 20-26deg C; 68-79deg F.

Rabbit :16-22deg C; 61-72deg F.

Dry-bulb room temperature settings for rodents are typically set below the animals' LCT to avoid heat stress, and should reflect different species-specific LCT values. Animals should be provided with adequate resources for thermoregulation (nesting material, shelter) to avoid cold stress.

Micro-environmental relative humidity may be of greater importance for animals housed in a primary enclosure in which the environmental conditions differ greatly from those of the macro environment (e.g., in static filter-top isolator cages).Some species may require conditions with high relative humidity (e.g., selected species of nonhuman primates, tropical reptiles, and amphibians;). In mice, both abnormally high and low humidity may increase preweaning mortality. In rats, low relative humidity, especially in combination with temperature extremes, may lead to ringtail, a condition involving ischemic necrosis of the tail and sometimes toes. For some species, elevated relative humidity may affect an animal's ability to cope with thermal extremes. Elevated micro environmental relative humidity in rodent isolator cages may also lead to high intracage ammonia concentrations, which can be irritating to the nasal passages and alter some biologic responses. In climates where it is difficult to provide a sufficient level of environmental relative humidity, animals should be closely monitored for negative effects such as excessively flaky skin, ecdysis (molting)difficulties in reptiles, and desiccation stress in semi aquatic amphibians.

Ventilation and Air Quality

The primary purpose of ventilation is to provide appropriate air quality and a stable environment. Specifically, ventilation provides an adequate oxygen supply; removes thermal loads caused by the animals, personnel, lights, and equipment; dilutes gaseous and particulate contaminants including allergens and airborne pathogens; adjusts the moisture content and temperature of room air; and, where appropriate, creates air pressure differentials(directional air flow) between adjoining spaces. Importantly, ventilating the room (i.e., the macro environment) does not necessarily ensure adequate ventilation of an animal's primary enclosure (i.e., the microenvironment),that is, the air to which the animal is actually exposed. The type of primary enclosure may considerably influence the differences between these two environments—for example, differences may be negligible when animals are housed in open caging or pens, whereas they can be significant when static isolator cages are used. The volume and physical characteristics of the air supplied to a room and its diffusion pattern influence the ventilation of an animal's primary enclosure and are important determinants of the animal's microenvironment. The type and location of supply air diffusers and exhaust registers in relation to the number, arrangement, location, and type of primary and secondary enclosures affect how well the microenvironments are ventilated and should therefore be considered. The use of computer modeling for assessing those factors in relation to heat loading, air diffusion patterns, and particulate movement may be helpful in optimizing ventilation of micro and micro environments. Direct exposure of animals to air moving at high velocity (drafts) should be avoided as the speed of air to which animals are exposed affects the rate at which heat and moisture are removed from an animal. For example, air at20°C moving at 60 linear feet per minute (18.3 m/min) has a cooling effect of approximately 7°C. Drafts can be particularly problematic for neonatal homeotherms (which may be hairless and have poorly developed mechanisms for thermoregulatory control), for mutants lacking fur, and for semi aquatic amphibians that can desiccate. Provision of 10 to 15 fresh air changes per hour in animal housing rooms is an acceptable guideline to maintain macro environmental air quality by constant volume systems and may also ensure micro environmental air quality. Although this range is effective in many animal housing settings, it does not take into account the range of possible heat loads; the species, size, and number of animals involved; the type of primary enclosure and bedding; the frequency of cage changing; the room dimensions; or the efficiency of air distribution both in the macro environment and between the macro- and microenvironments. In some situations, the use of such a broad guideline might over ventilate a macro environment containing few animals, thereby wasting energy, or under ventilate a microenvironment containing many animals, allowing heat, moisture, and pollutants to accumulate. Modern heating, ventilation, and air conditioning (HVAC) systems (e.g., variable air volume, or VAV, systems) allow ventilation rates to be set in accordance with heat load and other variables. These systems offer considerable advantages with respect to flexibility and energy conservation, but should always provide a minimum amount of air exchange, as recommended for general use laboratories. Individually ventilated cages (IVCs) and other types of specialized primary enclosures, that either directly ventilate the enclosure using filtered room air or are ventilated independently of the room, can effectively address animals' ventilation requirements without the need to increase macro environmental ventilation. However, cautions mentioned above regarding high velocity air should be considered. Nevertheless, the macro environment should be ventilated sufficiently to address heat loads, particulates, odors, and waste gases released from primary enclosure. If ventilated primary enclosures have adequate filtration to address contamination risks, air exhausted from the microenvironment may be returned to the room in which animals are housed, although it is generally preferable to exhaust these systems directly into the building's exhaust system to reduce heat load and macro environmental contamination. Static isolation caging (without forced ventilation), such as that used in some types of rodent housing, restricts ventilation. To compensate, it may be necessary to adjust husbandry practices, including sanitation and cage change frequency, selection of contact bedding, placement of cages in a secondary enclosure, animal densities in cages, and/or decrease in macro environmental relative humidity to improve the microenvironment and heat dissipation. The use of recycled air to ventilate animal rooms may save energy but entails risks. Because many animal pathogens can be airborne or travel on fomites (e.g., dust), exhaust air recycled into HVAC systems that serve multiple rooms presents a risk of cross contamination. Recycling air from non-animal use areas (e.g., some human occupancy areas and food, bedding, and supply storage areas) may require less intensive filtration or conditioning and pose less risk of infection. The risks in some situations, however, might be too great to consider recycling (e.g., in the case of nonhuman primates and biohazard areas). The exhaust air to be recycled should be filtered, at minimum, with 85-95% ASHRAE efficient filters to remove airborne particles before it is recycled. Depending on the air source, composition, and proportion of recycled air used (e.g., ammonia and other gases emitted from excrement in recirculating air from animal rooms), consideration should also be given to filtering volatile substances. In areas that require filtration to ensure personnel and/or animal safety (e.g., hazardous containment holding), filter efficiency, loading, and integrity should be assessed. The successful operation of any HVAC system requires regular preventive maintenance and evaluation, including measurement of its function at the level of the secondary enclosure. Such measurements should include supply and exhaust air volumes, fluctuation in temperature and relative humidity, and air pressure differentials between spaces as well as critical mechanical operating parameters.

Illumination

Light can affect the physiology, morphology, and behavior of various animals. Potential photo stressors include inappropriate photoperiod, photo intensity, and spectral quality of the light. Numerous factors can affect animals' needs for light and should be considered when an appropriate illumination level is being established for an animal holding room. These include light intensity and wavelength as well as the duration of the animal's current and prior exposure to light, and the animal's pigmentation, circadian rhythm, body temperature, hormonal status, age, species, sex, and stock or strain. More recent studies in rodents and primates have shown the importance of intrinsically photosensitive retinal ganglion cells (distinct from rods and cones) for neuroendocrine, circadian, and neurobehavioral. These cells can respond to light wavelengths that may differ from other photoreceptors and may influence the type of lighting, light intensity, and wavelength selected for certain types of research. In general, lighting should be diffused throughout an animal holding area and provide sufficient illumination for the animals' well-being while permitting good housekeeping practices, adequate animal inspection including for the bottom-most cages in racks, and safe working conditions for personnel. Light in animal holding rooms should provide for both adequate vision and neuroendocrine regulation of diurnal and circadian cycles. Photoperiod is a critical regulator of reproductive behavior in many animal species, so inadvertent light exposure during the dark cycle should be minimized or avoided. Because some species, such as chickens, will not eat in low light or darkness, such illumination schedules should be limited to a duration that will not compromise their well-being. A time-controlled lighting system should be used to ensure a regular diurnal cycle, and system performance should be checked regularly to ensure proper cycling. Most commonly used laboratory rodents are nocturnal. Because albino rodents are more susceptible to phototoxic retinopathy than other animals, they have been used as a basis for establishing room illumination levels. Data for room light intensities for other animals, based on scientific studies, are not available. Light levels of about325 lux (30-ft candles) approximately 1 m (3.3 ft) above the floor appear to be sufficient for animal care and do not cause clinical signs of phototoxic retinopathy in albino rats. Levels up to 400 lux (37-ftcandles)as measured in an empty room 1 m from the floor have been found to be satisfactory for rodents if management practices are used to prevent retinal damage in albinos. However, the light experience of an individual animal can affect its sensitivity to photo toxicity; light of130-270 lux above the light intensity under which it was raised has been reported to be near the threshold of retinal damage in some individual albino rats according to histologic, morphometric, and electro physiologic evidence. Some guidelines recommend a light intensity as low as 40 lux at the position of the animal in midcage. Rats and mice generally prefer cages with low light intensity, and albino rats prefer areas with a light intensity of less than 25 lux. Young mice prefer much lower illumination than adults. For animals that have been shown to be susceptible to phototoxic retinopathy, light should be between130 and 325 lux in the room at cage level. Light intensity decreases with the square of the distance from its source. Thus the location of a cage on a rack affects the intensity of light to which the animals within are exposed. Light intensity may differ as much as 80-fold in transparent cages from the top to the bottom of a rack, and differences up to 20-fold have been recorded within a cage. Management practices, such as rotating cage position relative to the light source or providing animals with ways to control their own light exposure by behavioral means (e.g., nesting or bedding material adequate for tunneling), can reduce inappropriate light stimulation. Variable-intensity lights are often used to accommodate the needs of research protocols, certain animal species, and energy conservation. However, such a system should also provide for the observation and care of the animals. Caution should be exercised as increases in daytime room illumination for maintenance purposes have been shown to change photoreceptor physiology and can alter circadian regulation.

Noise and Vibration

Noise produced by animals and animal care activities is inherent in the operation of an animal facility and noise control should be considered in facility design and operation. Assessment of the potential effects of noise on an animal warrants consideration of the intensity, frequency, rapidity of onset, duration, and vibration potential of the sound and the hearing range, noise exposure history, and sound effect susceptibility of the species, stock, or strain. Similarly, occupational exposure to animal or animal care practices that generate noise may be of concern for personnel and, if of sufficient intensity, may warrant hearing protection. Separation of human and animal areas minimizes disturbances to both human and animal occupants of the facility. Noisy animals, such as dogs, swine, goats, nonhuman primates, and some birds (e.g., zebra finches),should be housed away from quieter animals, such as rodents, rabbits, and cats. Environments should be designed to accommodate animals that make noise rather than resorting to methods of noise reduction. Exposure to sound louder than 85 dB can have both auditory and non-auditory effects—for example, eosinopenia, increased adrenal gland weights, and reduced fertility in rodents and increased blood pressure in nonhuman primates—and may necessitate hearing protection for personnel (OSHA 1998). Many species can hear sound frequencies inaudible to humans; rodents, for example, are very sensitive to ultrasound. The potential effects of equipment (such as video display terminals; and materials that produce noise in the hearing range of nearby animals can thus become an uncontrolled variable for research experiments and should therefore be carefully considered. To the greatest extent possible, activities that generate noise should be conducted in rooms or areas separate from those used for animal housing. Because changes in patterns of sound exposure have different effects on different animals, personnel should tyro minimize the production of unnecessary noise. Excessive and intermittent noise can be minimized by training personnel in alternatives to noisy practices, the use of cushioned casters and bumpers on carts, trucks, and racks, and proper equipment maintenance (e.g., castor lubrication). Radios, alarms, and other sound generators should not be used in animal rooms unless they are part of an approved protocol or enrichment program. Any radios or sound generators used should be switched off at the end of the working day to minimize associated adverse physiologic changes. While some vibration is inherent to every facility and animal housing condition, excessive vibration has been associated with biochemical and reproductive changes in laboratory animals and can become an uncontrolled variable for research experiments. The source of vibrations may be located within or outside the animal facility. In the latter case, ground borne vibration may affect both the structure and its contents, including animal racks and cages. Housing systems with moving components, such as ventilated caging system blowers, may create vibrations that could affect the animals housed within, especially if not functioning properly. Like noise, vibration varies with intensity, frequency, and duration. A variety of techniques may be used to isolate ground borne and equipment-generated vibration. Attempts should be made to minimize the generation of vibration, including from humans, and excessive vibration should be avoided.

Terrestrial Housing

Microenvironment (Primary Enclosure)

All animals should be housed under conditions that provide sufficient space as well as supplementary structures and resources required to meet physical, physiologic, and behavioral needs. Environments that fail to meet the animals' needs may result in abnormal brain development, physiologic dysfunction, and behavioral disorders that may compromise both animal well-being and scientific validity. The primary enclosure or space may need to be enriched to prevent such. An appropriate housing space or enclosure should also account for the animals' social needs. Social animals should be housed in stable pairs or groups of compatible individuals unless they must be housed alone for experimental reasons or because of social incompatibility. Structural adjustments are frequently required for social housing (e.g., perches, visual barriers, refuges),and important resources (e.g., food, water, and shelter) should be provided in such a way that they cannot be monopolized by dominant animals. The primary enclosure should provide a secure environment that does not permit animal escape and should be made of durable, nontoxic materials that resist corrosion, withstand the rigors of cleaning and regular handling, and are not detrimental to the health and research use of the animals. The enclosure should be designed and manufactured to prevent accidental entrapment of animals or their appendages and should be free of sharp edges or projections that could cause injury to the animals or personnel. It should have smooth, impervious surfaces with minimal ledges, angles, corners, and overlapping surfaces so that accumulation of dirt, debris, and moisture is minimized and cleaning and disinfecting are not impaired. All enclosures should be kept in good repair to prevent escape of or injury to animals, promote physical comfort, and facilitate sanitation and servicing. Rusting or oxidized equipment, which threatens the health or safety of animals, needs to be repaired or replaced. Less durable materials, such as wood, may be appropriate in select situations, such as outdoor corrals, perches, climbing structures, resting areas, and perimeter fences for primary enclosures. Wooden items may need to be replaced periodically because of damage or difficulties with sanitation. Painting or sealing wood surfaces with nontoxic materials may improve durability in many instances. Flooring should be solid, perforated, or slatted with a slip-resistant surface. In the case of perforated or slatted floors, the holes and slats should have smooth edges. Their size and spacing need to be commensurate with the size of the housed animal to minimize injury and the development of foot lesions. If wire-mesh flooring is used, a solid resting area may be beneficial, as this floor type can induce foot lesions in rodents and rabbits. The size and weight of the animal as well as the duration of housing on wire-mesh floors may also play a role in the development of this condition. When given the choice, rodents prefer solid floors(with bedding) to grid or wire-mesh flooring. Animals should have adequate bedding substrate and/or structures for resting and sleeping. For many animals (e.g., rodents) contact bedding expands the opportunities for species-typical behavior such as foraging, digging, burrowing, and nest building. Moreover, it absorbs urine and feces to facilitate cleaning and sanitation. If provided in sufficient quantity to allow nest building or burrowing, bedding also facilitates thermoregulation. Breeding animals should have adequate nesting materials and/or substitute structures based on species-specific requirements

Specialized housing systems (e.g., isolation-type cages, IVCs, and *gnotobiotic* isolators) are available for rodents and certain species. These systems, designed to minimize the spread of airborne particles between cages or groups of cages, may require different husbandry practices, such as alterations in the frequency of bedding change, the use of aseptic handling techniques, and specialized cleaning, disinfecting, or sterilization regimens to prevent microbial transmission by other than airborne routes. Appropriate housing strategies for a particular species should be developed and implemented by the animal care management, in consultation with the animal user and veterinarian, and reviewed by the IACUC. Housing should provide for the animals' health and well-being while being consistent with the intended objectives of animal use. Expert advice should be sought when new species are housed or when there are special requirements associated with the animals or their intended use (e.g., genetically modified animals, invasive procedures, or hazardous agents). Objective assessments should be made to substantiate the adequacy of the animal's environment, housing, and management. Whenever possible, routine procedures for maintaining animals should be documented to ensure consistency of management and care.

Environmental Enrichment

The primary aim of environmental enrichment is to enhance animal well-being by providing animals with sensory and motor stimulation, through structures and resources that facilitate the expression of species typical behaviors and promote psychological well-being through physical Gnotobiotic: germ-free animals or formerly germ-free animals in which the composition of any associated microbial flora, if present, is fully defined exercise, manipulative activities, and cognitive challenges according to species- specific characteristics. Examples of enrichment include structural additions such as perches and visual barriers for nonhuman primates; elevated shelves for cats and rabbits and shelters for guinea pigs, as well as manipulable resources such as novel objects and foraging devices for nonhuman primates; manipulable toys for nonhuman primates, dogs, cats, and swine; wooden chew sticks for some rodent species; and nesting material for mice. Novelty of enrichment through rotation or replacement of items should be a consideration; however, changing animals' environment too frequently may be stressful. Well-conceived enrichment provides animals with choices and a degree of control over their environment, which allows them to better cope with environmental stressors. For example, visual barriers allow nonhuman primates to avoid social conflict; elevated shelves for rabbits and shelters for rodents allow them to retreat in case of disturbances; and nesting material and deep bedding allow mice to control their temperature and avoid cold stress during resting and sleeping. Not every item added to the animals' environment benefits their well being. For example, marbles are used as a stressor in mouse anxiety studies, indicating that some items may be detrimental to well-being. For nonhuman primates, novel objects can increase the risk of disease transmission; foraging devices can lead to increased body weight; shavings can lead to allergies and skin rashes in some individuals; and some objects can result in injury from foreign material in the intestine. In some strains of mice, cage dividers and shelters have induced overt aggression in groups of males, resulting in social stress and injury. Social stress was most likely to occur when resources were monopolized by dominant animals.

Enrichment programs should be reviewed by the IACUC, researchers, and veterinarian on a regular basis to ensure that they are beneficial to animal well-being and consistent with the goals of animal use. They should be updated as needed to ensure that they reflect current knowledge.

Personnel responsible for animal care and husbandry should receive training in the behavioral biology of the species they work with to appropriately monitor the effects of enrichment as well as identify the development of adverse or abnormal behaviors. Like other environmental factors (such as space, light, noise, temperature, and animal care procedures), enrichment affects animal phenotype and may affect the experimental outcome. It should therefore be considered an independent variable and appropriately controlled. Some scientists have raised concerns that environmental enrichment may compromise experimental standardization by introducing variability, adding not only diversity to the animals' behavioral repertoire but also variation to their responses to experimental treatments. A systematic study in mice did not find evidence to support this viewpoint, indicating that housing conditions can be enriched without compromising the precision or reproducibility of experimental results. Further research in other species may be needed to confirm this conclusion. However, it has been shown that conditions resulting in higher-stress reactivity increase variation in experimental data. Because adequate environmental enrichment may reduce anxiety and stress reactivity, it may also contribute to higher test sensitivity and reduced animal use.

Space

An animal's space needs are complex and consideration of only the animal's body weight or surface area may be inadequate. Important considerations for determining space needs include the age and sex of the animal(s), the number of animals to be co housed and the duration of the accommodation, the use for which the animals are intended (e.g., production vs. experimentation), and any special needs they may have (e.g., vertical space for arboreal species or thermal gradient for poikilotherms). In many cases, for example, adolescent animals, which usually weigh less than adults but are more active, may require more space relative to body weight. Group-housed, social animals can share space such that the amount of space required per animal may decrease with increasing group size; thus larger groups may be housed at slightly higher stocking densities than smaller groups or individual animals. Socially housed animals should have sufficient space and structural complexity to allow them to escape aggression or hide from other animals in the pair or group. Breeding animals will require more space, particularly if neonatal animals will be raised together with their mother or as a breeding group until weaning age. Space quality also affects its usability.

Enclosures that are complex and environmentally enriched may increase activity and facilitate the expression of species-specific behaviors, thereby increasing space needs. Thus there is no ideal formula for calculating an animal's space needs based only on body size or weight and readers should take the performance indices discussed in this section into consideration when utilizing the species-specific guidelines presented in the following pages. Consideration of floor area alone may not be sufficient in determining adequate cage size; with some species, cage volume and spatial arrangement may be of greater importance. In this regard, the *Guide* may differ from the US Animal Welfare Regulations (AWRs) or other guidelines. The height of an enclosure can be important to allow for expression of species specific behaviors and postural adjustments. Cage height should take into account the animal's typical posture and provide adequate clearance for the animal from cage structures, such as feeders and water devices. Some species—for example, nonhuman primates, cats, and arboreal animals—use the vertical dimensions of the cage to a greater extent than the floor. For these animals, the ability to stand or to perch with adequate vertical space to keep their body, including their tail, above the cage floor can improve their well-being. Space allocations should be assessed, reviewed, and modified as necessary by the IACUC considering the performance indices (e.g., health, reproduction, growth, behavior, activity, and use of space) and special needs determined by the characteristics of the animal strain or species(e.g., obese, hyperactive, or arboreal animals) and experimental use (e.g., animals in long-term studies may require greater and more complex space).At a minimum, animals must have enough space to express their natural postures and postural adjustments without touching the enclosure walls or ceiling, be able to turn around, and have ready access to food and water. In addition, there must be sufficient space to comfortably rest away from areas soiled by urine and feces. Floor space taken up by food bowls, water containers, litter boxes, and enrichment devices (e.g., novel objects, toys, foraging devices) should not be considered part of the floor space. The space recommendations presented here are based on professional judgment and experience. They should be considered the minimum for animals housed under conditions commonly found in laboratory animal housing facilities. Adjustments to the amount and arrangement of space recommended in the following tables should be reviewed and approved byte IACUC and should be based on performance indices related to animal well-being and research quality as described in the preceding paragraphs, with due consideration of the AWRs and PHS Policy and other applicable regulations and standards.

Laboratory Rodents

Consideration should be given to the growth characteristics of the stock or strain as well as these of the animal. Weight gain may be sufficiently rapid that it may be preferable to provide greater space in anticipation of the animal's future size. In addition, juvenile rodents are highly active and show increased play behavior. Other considerations may include culling of litters or separation of litters from the breeding group, as well as other methods of more intensive management of available space to allow for the safety and well-being of the breeding group. Sufficient space should be allocated for mothers with litters to allow the pups to develop to weaning without detrimental effects for the mother or the litter.

Studies have recently evaluated space needs and the effects of social housing, group size, and density; and housing conditions for many different species and strains of rodents, and have reported varying effects on behavior (such as aggression) and experimental outcomes. However, it is difficult to compare these studies due to the study design and experimental variables that have been measured. For example, variables that may affect the animals' response to different cage sizes and housing densities include, but are not limited to, species, strain (and social behavior of the strain), phenotype, age, gender, quality of the space (e.g., vertical access), and structures placed in the cage. These issues remain complex and should be carefully considered when housing rodents.

Social Environment

Appropriate social interactions among members of the same species (conspecifics) are essential to normal development and wellbeing. When selecting suitable social environment, attention should be given to whether the animals are naturally territorial or communal and whether they should be housed singly, in pairs, or in groups. An understanding of species-typical natural social behavior (e.g., natural social composition, population density, ability to disperse, familiarity, and social ranking) is key to successful social housing. Not all members of a social species are necessarily socially compatible. Social housing of incompatible animals can induce chronic stress, injury, and even death. In some species, social incompatibility may be sex biased; for example, male mice are generally more prone to aggression than female mice, and female hamsters are generally more aggressive than male hamsters. Risks of social incompatibility are greatly reduced if the animals to be grouped are raised together from a young age, if group composition remains stable, and if the design of the animals' enclosure and their environmental enrichment facilitate the avoidance of social conflicts. Social stability should be carefully monitored; in cases of severe or prolonged aggression, incompatible individuals need to be separated. For some species, developing a stable social hierarchy will entail antagonistic interactions between pair or group members, particularly for animals introduced as adults. Animals may have to be introduced to each other over a period of time and should be monitored closely during this introductory period and thereafter to ensure compatibility. Single housing of social species should be the exception and justified based on experimental requirements or veterinary-related concerns about animal well-being. In these cases, it should be limited to the minimum period necessary, and where possible, visual, auditory, olfactory, and tactile contact with compatible conspecifics should be provided. In the absence of other animals, enrichment should be offered such as positive interaction with the animal care staff and additional enrichment items or addition of a companion animal in the room or housing area. The need for single housing should be reviewed on a regular basis by the IACUC and veterinarian.

Husbandry

Animal colony managers should be judicious when purchasing, transporting, storing, and handling food to minimize the introduction of diseases, parasites, potential disease vectors (e.g., insects and other vermin), and chemical contaminants in animal colonies. Purchasers are encouraged to consider manufacturers' and suppliers' procedures and practices (e.g., storage, vermin control, and handling) for protecting and ensuring diet quality. Institutions should urge feed vendors to periodically provide data from laboratory-based feed analyses for critical nutrients. The user should know the date of manufacture and other factors that affect the food's shelf life. Stale food or food transported and stored inappropriately can become deficient in nutrients. Upon receipt, bags of feed should be examined to ensure that they are intact and unstained to help ensure that their contents have not been potentially exposed to vermin, penetrated by liquids, or contaminated. Careful attention should be paid to quantities received in each shipment, and stock should be rotated so that the oldest food is used first. Areas in which diets and diet ingredients are processed or stored should be kept clean and enclosed to prevent the entry of pests. Food stocks should be stored off the floor on pallets, racks, or carts in a manner that facilitates sanitation. Opened bags of food should be stored in vermin-proof containers to minimize contamination and to avoid the potential spread of pathogens. Exposure to elevated storage room temperatures, extremes in relative humidity, unsanitary conditions, and insects and other vermin hastens food deterioration. Storage of natural-ingredient diets at less than 21°C (70°F)and below 50% relative humidity is recommended. Precautions should be taken if perishable items—such as meats, fruits, and vegetables and some specialty diets (e.g., select medicated or high-fat diets)—are fed, because storage conditions may lead to variation in food quality. Most natural-ingredient, dry laboratory animal diets stored properly can be used up to 6 months after manufacture. Non-stabilized vitamin C in manufactured feeds generally has a shelf life of only 3 months, but commonly used stabilized forms can extend the shelf life of feed. Refrigeration preserves nutritional quality and lengthens shelf life, but food storage time should be reduced to the lowest practical period and the manufacturers' recommendations considered. Purified and chemically defined diets are often less stable than natural-ingredient diets and their shelf life is usually less than 6 months; they should be stored at 4°C(39°F) or lower. Irradiated and fortified autoclavable diets are commercially available and are commonly used for axenic and microbiologically defined rodents, and immunodeficient animals. The use of commercially fortified autoclavable diets ensures that labile vitamin content is not compromised by steam and/or heat. But consideration should be given to the impact of autoclaving on pellets as it may affect their hardness and thus palatability and also lead to chemical alteration of ingredients. The date of sterilization should be recorded and the diet used quickly.

Feeders should be designed and placed to allow easy access to food and to minimize contamination with urine and feces, and maintained in good condition. When animals are housed in groups, there should be enough space and enough feeding points to minimize competition for food and ensure access to food for all animals, especially if feed is restricted as part of the protocol or management routine. Food storage containers should not be transferred between areas that pose different risks of contamination without appropriate treatment, and they should be cleaned and sanitized regularly. Management of caloric intake is an accepted practice for long-term housing of some species, such as some rodents, rabbits, and nonhuman primates, and as an adjunct to some clinical, experimental, and surgical procedures. Benefits of moderate caloric restriction in some species may include increased longevity and reproduction, and decreased obesity, cancer rates, and neurogenerative disorders. Under standard housing conditions, changes in biologic needs commensurate with aging should be taken into consideration. For example, there is good evidence that mice and rats with continuous access to food can become obese, with attendant metabolic and cardiovascular changes such as insulin resistance and higher blood pressure. These and other changes along with a more sedentary lifestyle and lack of exercise increase the risk of premature death. Caloric management, which may affect physiologic adaptations and alter metabolic responses in a species-specific manner, can be achieved by reducing food intake or by stimulating exercise. In some species (e.g., nonhuman primates) and on some occasions, varying nutritionally balanced diets and providing "treats," including fresh fruit and vegetables, can be appropriate and improve well-being. Scattering food in the bedding or presenting part of the diet in ways that require the animals to work for it (e.g., puzzle feeders for nonhuman primates) gives the animals the opportunity to forage, which, in nature, normally accounts for a large proportion of their daily activity. A diet should be nutritionally balanced; it is well documented that many animals offered a choice of unbalanced or balanced foods do not select a balanced diet and become malnourished or obese through selection of high-energy, low-protein foods. Abrupt changes in diet, which can be difficult to avoid at weaning, should be minimized because they can lead to digestive and metabolic disturbances; these changes occur in omnivores and carnivores, but herbivores are especially sensitive. Water Animals should have access to potable, uncontaminated drinking water according to their particular requirements. Water quality and the definition of potable water can vary with locality. Periodic monitoring for pH, hardness, and microbial or chemical contamination may be necessary to ensure that water quality is acceptable, particularly for use in studies in which normal components of water in a given locality can influence the results. Water can be treated or purified to minimize or eliminate contamination when protocols require highly purified water. The selection of water treatments should be carefully considered because many forms of water treatment have the potential to cause physiologic alterations, reduction in water consumption, changes in micro flora, or effects on experimental results. Watering devices, such as drinking tubes and automated water delivery systems, should be checked frequently to ensure appropriate maintenance, cleanliness, and operation. Animals sometimes have to be trained to use automated watering devices and should be observed regularly until regular usage has been established to prevent dehydration. It is better to replace water bottles than to refill them, because of the potential for microbiologic cross contamination; if bottles are refilled, care should be taken to return each bottle to the cage from which it was removed. Automated watering distribution systems should be flushed or disinfected regularly. Animals housed in outdoor facilities may have access to water in addition to that provided in watering devices, such as that available in streams or in puddles after a heavy rainfall. Care should be taken to ensure that such accessory sources of water do not constitute a hazard, but their availability need not routinely be prevented. In cold weather, steps should be taken to prevent freezing of outdoor water sources.

Bedding and Nesting Materials

Animal bedding and nesting materials are controllable environmental factors that can influence experimental data and improve animal well-being in most terrestrial species. Bedding is used to absorb moisture, minimize the growth of microorganisms, and dilute and limit animals' contact with excreta, and specific bedding materials have been shown to reduce the accumulation of intracage ammonia. Various materials are used as both contact and noncontact bedding; the desirable characteristics and methods of evaluating bedding have been described. The veterinarian or facility manager, in consultation with investigators, should select the most appropriate bedding and nesting materials. A number of species, most notably rodents, exhibit a clear preference for specific materials, and mice provided with appropriate nesting material build better nests. Bedding that enables burrowing is encouraged for some species, such as mice and hamsters. No type of bedding is ideal for all species under all management and experimental conditions. For example, in nude or hairless mice that lack eyelashes, some forms of paper bedding with fines (i.e., very small particles found in certain types of bedding) can result in periorbital abscesses while cotton nestlets may lead to conjunctivitis. Bedding can also influence mucosal immunity. Softwood beddings have been used, but the use of untreated softwood shavings and chips is contraindicated for some protocols because they can affect metabolism. Cedar shavings are not recommended because they emit aromatic hydrocarbons that induce hepatic microsomal enzymes and cytotoxicity and have been reported to increase the incidence of cancer. Prior treatment with high heat (kiln drying or autoclaving) may, depending on the material and the concentration of aromatic hydrocarbon constituents, reduce the concentration of volatile organic compounds, but the amounts remaining may be sufficient to affect specific protocols. The purchase of bedding products should take into consideration vendors' manufacturing, monitoring, and storage methods. Bedding may be contaminated with toxins and other substances, bacteria, fungi, and vermin. It should be transported and stored off the floor on pallets, racks, or carts in a fashion consistent with maintenance of quality and avoidance of contamination. Bags should be stored sufficiently away from walls to facilitate cleaning. During autoclaving, bedding can absorb moisture and as a result lose absorbency and support the growth of microorganisms. Therefore, appropriate drying times and storage conditions should be used or, alternatively, gamma-irradiated materials if sterile bedding is indicated. Bedding should be used in amounts sufficient to keep animals dry between cage changes, and, in the case of small laboratory animals, it should be kept from coming into contact with sipper tubes as such contact could cause leakage of water into the cage.

Sanitation

Sanitation—the maintenance of environmental conditions conducive to health and well-being—involves bedding change (as appropriate),cleaning, and disinfection. *Cleaning* removes excessive amounts of excrement, dirt, and debris, and *disinfection* reduces or eliminates unacceptable concentrations of microorganisms. The goal of any sanitation program is to maintain sufficiently clean and dry bedding, adequate air quality, and clean cage surfaces and accessories. The frequency and intensity of cleaning and disinfection should depend on what is necessary to provide a healthy environment for an animal. Methods and frequencies of sanitation will vary with many factors, including the normal physiologic and behavioral characteristics of the animals; the type, physical characteristics, and size of the enclosure; the type, number, size, age, and reproductive status of the animals; the use and type of bedding materials; temperature and relative humidity; the nature of the materials that create the need for sanitation; and the rate of soiling of the surfaces of the enclosure. Some housing systems or experimental protocols may require specific husbandry techniques, such as aseptic handling or modification in the frequency of bedding change. Agents designed to mask animal odors should not be used in animal housing facilities. They cannot substitute for good sanitation practices or for the provision of adequate ventilation, and they expose animals to volatile compounds that might alter basic physiologic and metabolic processes.

Bedding/Substrate Change

Soiled bedding should be removed and replaced with fresh materials as often as necessary to keep the animals clean and dry and to keep pollutants, such as ammonia, at a concentration below levels irritating to mucous membranes. The frequency of bedding change depends on multiple factors, such as species, number, and size of the animals in the primary enclosure; type and size of the enclosure; macro- and micro environmental temperature, relative humidity, and direct ventilation of the enclosure; urinary and fecal output and the appearance and wetness of bedding; and experimental conditions, such as those of surgery or debilitation, that might limit an animal's movement or access to clean bedding. There is no absolute minimal frequency of bedding changes; the choice is a matter of professional judgment and consultation between the investigator and animal care personnel. It typically varies from daily to weekly. In some instances frequent bedding changes are contraindicated; examples include portions of the pre- or postpartum period, research objectives that will be affected, and species in which scent marking is critical and successful reproduction is pheromone dependent.

Cleaning and Disinfection of the Microenvironment

The frequency of sanitation of cages, cage racks, and associated equipment (e.g., feeders and watering devices) is governed to some extent by the types of caging and husbandry practices used, including the use of regularly changed contactor noncontact bedding, regular flushing of suspended catch pans, and the use of wire-bottom or perforated-bottom cages. In general, enclosures and accessories, such as tops, should be sanitized at least once every 2 weeks. Solid-bottom caging, bottles, and sipper tubes usually require sanitation at least once a week. Some types of cages and housing systems may require less frequent cleaning or disinfection; such housing may include large cages with very low animal density and frequent bedding changes, cages containing animals in gnotobiotic conditions with frequent bedding changes, individually ventilated cages, and cages used for special situations. Other circumstances, such as filter-topped cages without forced-air ventilation, animals that urinate excessively (e.g., diabetic or renal patients), or densely populated enclosures, may require more frequent sanitation. The increased use of individually ventilated cages (IVCs) for rodents has led to investigations of the maintenance of a suitable microenvironment with extended cage sanitation intervals and/or increased housing density. By design, ventilated caging systems provide direct continuous exchange of air, compared to static caging systems that depend on passive ventilation from the macro environment. As noted above, decreased sanitation frequency may be justified if the microenvironment in the cages, under the conditions of use (e.g., cage type and manufacturer, bedding, species, strain, age, sex, density, and experimental considerations), is not compromised. Verification of micro environmental conditions may include measurement of pollutants such as ammonia and CO2,microbiologic load, observation of the animals' behavior and appearance, and the condition of bedding and cage surfaces. Primary enclosures can be disinfected with chemicals, hot water, or a combination of both. Washing times and conditions and post washing processing procedures (e.g., sterilization) should be sufficient to reduce levels or eliminate vegetative forms of opportunistic and pathogenic bacteria, adventitious viruses, and other organisms that are presumed to be controllable by the sanitation program. Disinfection from the use of hot water alone is the result of the combined effect of the temperature and the length of time that a given temperature (cumulative heat factor) is applied to the surface of the item. The same cumulative heat factor can be obtained by exposing organisms either to very high temperatures for short periods or to lower temperatures for longer periods. Effective disinfection can be achieved with wash and rinse water at 143-180°For more. The traditional 82.2°C (180°F) temperature requirement for rinse water refers to the water in the tank or in the sprayer manifold. Detergents and chemical disinfectants enhance the effectiveness of hot water but should be thoroughly rinsed from surfaces before reuse of the equipment. Their use may be contraindicated for some aquatic species, as residue maybe highly deleterious. Mechanical washers (e.g., cage and rack, tunnel, and bottle washers) are recommended for cleaning quantities of caging and movable equipment. Sanitation of cages and equipment by hand with hot water and detergents or disinfectants can also be effective but requires considerable attention to detail. It is particularly important to ensure that surfaces are rinsed free of residual chemicals and that personnel have appropriate equipment to protect themselves from exposure to hot water or chemical agents used in the process. Water bottles, sipper tubes, stoppers, feeders, and other small pieces of equipment should be washed with detergents and/or hot water and, where rabbits and some rodents, such as guinea pigs and hamsters, produce urine with high concentrations of proteins and minerals. These compounds often adhere to cage surfaces and necessitate treatment with acid solutions before and/or during washing. Cleaning with ultrasound may be a useful method for small pieces of equipment. If automated watering systems are used, some mechanism to ensure that microorganisms and debris do not build up in the watering devices is recommended; the mechanism can be periodic flushing with large volumes of water or appropriate chemical agents followed by a thorough rinsing. Constant recirculation loops that use properly maintained filters, ultraviolet lights, or other devices to disinfect recirculated water are also effective. Attention should be given to the routine sanitation of automatic water delivery valves (i.e., lixits) during primary enclosure cleaning. Conventional methods of cleaning and disinfection are adequate for most animal care equipment. However, it may be necessary to also sterilize caging and associated equipment to ensure that pathogenic or opportunistic microorganisms are not introduced into specific-pathogen-free or immune compromised animals, or that experimental biologic hazards are destroyed before cleaning. Sterilizers should be regularly evaluated and monitored to ensure their safety and effectiveness. For pens or runs, frequent flushing with water and periodic use of detergents or disinfectants are usually appropriate to maintain sufficiently clean surfaces. If animal waste is to be removed by flushing, this will need to be done at least once a day. During flushing, animals should be kept dry. The timing of pen or run cleaning should take into account the normal behavioral and physiologic processes of the animals; for example, the gastro colic reflex in meal-fed animals results in defecation shortly after food consumption.

Cleaning and Disinfection of the Macroenvironment

All components of the animal facility, including animal rooms and support spaces (e.g., storage areas, cage-washing facilities, corridors, and procedure rooms) should be regularly cleaned and disinfected as appropriate to the circumstances and at a frequency based on the use of the area and the nature of likely contamination. Vaporized hydrogen peroxide or chlorine dioxide are effective compounds for room decontamination, particularly following completion of studies with highly infectious agents or contamination with adventitious microbial agents. Cleaning implements should be made of materials that resist corrosion and withstand regular sanitation. They should be assigned to specific areas and should not be transported between areas with different risks of contamination without prior disinfection. Worn items should be replaced regularly. The implements should be stored in a neat, organized fashion that facilitates drying and minimizes contamination or harborage of vermin.

Assessing the Effectiveness of Sanitation

Monitoring of sanitation practices should fit the process and materials being cleaned and may include visual inspection and microbiologic and water temperature monitoring. The intensity of animal odors, particularly that of ammonia, should not be used as the sole means of assessing the effectiveness of the sanitation program. A decision to alter the frequency of cage bedding changes or cage washing should be based on such factors as ammonia concentration, bedding condition, appearance of the cage and animals, and the number and size of animals housed in the cage. Mechanical washer function should be evaluated regularly and include examination of mechanical components such as spray arms and moving headers as well as spray nozzles to ensure that they are functioning appropriately.

If sanitation is temperature dependent, the use of temperature-sensing devices (e.g., thermometers, probes, or temperature-sensitive indicator strips) is recommended to ensure that the equipment being sanitized is exposed to the desired conditions. Whether the sanitation process is automated or manual, regular evaluation of sanitation effectiveness is recommended. This can be performed by evaluating processed materials by microbiologic culture or the use of organic material detection systems (e.g., adenosine triphosphate [ATP] bioluminescence)and/or by confirming the removal of artificial soil applied to equipment surfaces before washing.

Waste Disposal Conventional, biologic, and hazardous waste should be removed and disposed of regularly and safely. There are several options for effective waste disposal. Contracts with licensed commercial waste disposal firms usually provide some assurance of regulatory compliance and safety. On-site incineration should comply with all federal, state, and local regulations. Adequate numbers of properly labeled waste receptacles should be strategically placed throughout the facility. Waste containers should be leak proof and equipped with tight-fitting lids. It is good practice to use disposable liners and to wash containers and implements regularly. There should be a dedicated waste storage area that can be kept free of insects and other vermin. If cold storage is used to hold material before disposal, a properly labeled, dedicated refrigerator, freezer, or cold room should be used that is readily sanitized. Hazardous wastes must be rendered safe by sterilization, containment, or other appropriate means before their removal from the facility. Radioactive wastes should be kept in properly labeled containers and their disposal closely coordinated with radiation safety specialists in accord with federal and state regulations; the federal government and most states and municipalities have regulations controlling disposal of hazardous wastes. Compliance with regulations concerning hazardous-agent use and disposal is an institutional responsibility. Infectious animal carcasses can be incinerated on site or collected by a licensed contractor. Use of chemical digesters (alkaline hydrolysis treatment) may be considered in some situations. Procedures for on-site packaging, labeling, transportation, and storage of these wastes should be integrated into occupational health and safety policies. Hazardous wastes that are toxic, carcinogenic, flammable, corrosive, reactive, or otherwise unstable should be placed in properly labeled containers and disposed of as recommended by occupational health and safety specialists. In some circumstances, these wastes can be consolidated or blended. Sharps and glass should be disposed of in a manner that will prevent injury to waste handlers.

Pest Control

Programs designed to prevent, control, or eliminate the presence of or infestation by pests are essential in an animal environment. A regularly scheduled and documented program of control and monitoring should be implemented. The ideal program prevents the entry of vermin and eliminates their harborage in the facility. For animals in outdoor facilities, consideration should be given to eliminating or minimizing the potential risk associated with pests and predators. Pesticides can induce toxic effects on research animals and interfere with experimental procedures. They should be used in animal areas only when necessary and investigators whose animals may be exposed to them should be consulted beforehand. Use of pesticides should be recorded and coordinated with the animal care management staff and be in compliance with federal, state, or local regulations. Whenever possible, nontoxic means of pest control, such as insect growth regulators and nontoxic substances (e.g., amorphous silica gel), should be used. If traps are used, methods should be humane; traps that catch pests alive require frequent observation and humane euthanasia after capture.

Emergency, Weekend, and Holiday Care

Animals should be cared for by qualified personnel every day, including weekends and holidays, both to safeguard their well-being and to satisfy research requirements. Emergency veterinary care must be available after work hours, on weekends, and on holidays. In the event of an emergency, institutional security personnel and fire or police officials should be able to reach people responsible for the animals. Notification can be enhanced by prominently posting emergency procedures, names, or telephone numbers in animal facilities or by placing them in the security department or telephone center. Emergency procedures for handling special facilities or operations should be prominently posted and personnel trained in emergency procedures for these areas. A disaster plan that takes into account both personnel and animals should be prepared as part of the overall safety plan for the animal facility. The colony manager or veterinarian responsible for the animals should be a member of the appropriate safety committee at the institution, an “official responder” in the institution, and a participant in the response to a disaster.

Quality of Life

There is no unequivocal data relating to the quality or quantity of an animal’s activity to its physical or psychological well being. Housing an animal in a cage does not necessarily limit the amount of activity in which the animal engages, although the form of activity may be changed. The need for exercise or induced activity is subject to the judgment of the animal care professional based on an understanding of the species or breed temperament, age, history, physical condition, nature of the research, and expected duration of vivarium residence.

The vivarium is a workplace. The environment should be aesthetically pleasing to employees and consistent with the needs of investigators engaged in animal research. The vivarium must provide for the health and safety of the staff and provide an environment for highly sensitive animal subjects, compatible with the requirements and protocol of research. The vivarium should be efficient, secure, and easy to maintain and perform animal caretaking services. Sufficient air supply, filtration, and exhaust shall be provided to minimize unpleasant animal odors and animal allergens. Provision of natural light, if feasible, adequate work space, color, and ergonomic furniture systems are integral to a pleasing, functional, and effective work

Animal housing must be designed to ensure animal well-being, to meet research requirements, to be cleanable and easily maintained, and to minimize experimental variables (maximize predictability). The facility must promote a healthy social environment for the animals. The characteristics of each species must be considered in deciding how to house a diverse census of animals. Windows or skylights in housing areas are inappropriate. Natural light may be provided in administrative areas if feasible.

Illumination in occupied animal holding spaces is generally 35 to 85 foot candles. LED lighting is recommended because it generates less heat.

Acoustical control is an important consideration and should be evaluated carefully in the design phase. Most animals are stimulated by noise. Noise can cause stress in animals, and induce unwanted variables into research studies.

Without views to the outside, or significant landmarks with the facility, orientation becomes a significant planning issue in vivarium design. A map of the corridor system should be provided in the hallway. Each room should have a number clearly displayed at its entry. Color or other wayfinding methods should be considered and evaluated

Flexibility and Adaptability

The vivarium should be adaptable. The spaces should be able to accommodate changes in function without having to make major changes to the facility. Custom designed spaces should be avoided where possible. The vivarium and its accompanying utility services should be planned and designed to be adaptable to changes in animal species and research protocol.

Care should be given to plan and design of the building systems to permit ease of accessibility for routine inspection, maintenance, and repair without entering the animal holding rooms. All systems should be planned to be accessible to all spaces which require them and be configured so they can be extended, added, or deleted in an unobtrusive manner.

Planning Module

A modular planning scheme should be used, as much as practical, in the planning and design of animal housing and procedure space. Where possible, rooms shall be clustered to provide separate zones for small and large animals, taking into account the difference in rack dimensions, waste disposal requirements, caretaking requirements, investigators, protocols, disease status, and airflow requirements.

Utility systems within the vivarium must be capable of providing all the services necessary for scientists to conduct their research and the animal husbandry staff to properly care for the animals. Provisions should be made for future utility services to accommodate unanticipated demands brought about by new technologies or changes in research protocol. A certain amount of reserve capacity should be designed into the primary building systems to accommodate increased animal densities.

In animal facilities, the most common unit of space is the animal housing/holding room. The width of the room is determined by the number and types of animals, the way in which they are housed, and the cleaning methodology which will be employed. Room length is determined based on housing/caging options, and must accommodate service space for sinks, cleaning equipment, etc. The height of the holding room is primarily a function of the maximum rack height anticipated. There must also be enough space above the rack to provide a uniform airflow distribution in the room.

Circulation

Vivarium corridors should be a minimum of seven feet clear, which allows the simultaneous passage of two animal cage racks. A unidirectional single corridor system is recommended. Contact between clean and dirty materials can be minimized by scheduling pickups and deliveries, covering cages during transport, and using a unidirectional circulation system.

Zoning

The zoning of a vivarium facility consists of three major components. First, an administrative and management support zone, which includes offices, break rooms, etc.; second a transitional zone which includes gowning areas, lockers, toilets; and third, an animal housing, procedure, and support zone. The facility layout should be planned in order to minimize the personnel traffic in the holding areas.

Within the vivarium, the flow of materials, cages, animals, and personnel must be accommodated in an efficient and economical manner. Adjacencies should be planned to maximize operational affinities and minimize travel distances. Relationships between deliveries, quarantine, housing, procedure rooms, cage wash, staff locker rooms, and administration spaces must be effectively planned. The design must also consider adjacencies based upon the variety of species that are anticipated for the vivarium.

Circulation space is a critical factor in controlling contaminants within the vivarium. Planning of circulation focuses on the movement of cages and racks in the facility, since this is the most intensive use of the space. During the planning phase, the design team (user, architect, engineer, veterinarian, lab consultant) decides the extent to which the corridor system helps manage the potential for contamination and to what extent management dictates certain protocols of time and direction of movement.

The objective of security is to ensure the safety of animals, staff, equipment, and data. Vivarium users shall take into account security at the site, building, vivarium, and room levels. Air intakes and any central utilities must be safeguarded from intruders.

Locations and quantities of docks must be based on an operations concept for the specific facility. The quantity and types of materials that will be received and discharged, the need for security, quality control functions, accessibility for vehicles of multiple sizes, temporary storage and staging, recycling, pest management, waste disposal, materials storage, and staff marshaling are key issue to address in the planning and design of the facility.

Housing/Holding Areas

In designing animal housing areas, it is essential to plan for anticipated species usage and caging type. The housing or caging system is one of the most important considerations in the design of a vivarium facility. It should be carefully planned and designed to facilitate animal well being; meet research requirements; minimize experimental variables; and be isolated from heat, vibration, and noise sources. The caging system should provide adequate space to permit freedom of movement and normal postural adjustments; a comfortable environment; and an escape-proof enclosure that confines animals safely with easy access to food, water, and ventilation. The caging system must meet the biological needs of animals. All holding rooms must be designed to be easily cleanable and minimize pest harborage. Consideration should also be given to the accommodation of records and supplies.

Furniture and Equipment

Cantilevered benchtops with rolling metal cabinets are preferred because of the ease of cleaning. Countertop materials may be epoxy or phenolic resin where corrosive chemicals are used, or stainless steel for washing areas. A variety of equipment is used in vivarium facilities. Equipment may include caging systems, sterilizers, tunnel washers, cage rack washers, freezers, tables in procedure rooms, surgery and necropsy tables and other related equipment

Finishes and Materials

Animal facility finishes must be strong and durable enough to meet the demands of cart traffic, frequent cleaning, and the use of high-pressure, high-temperature water, abrasives, and caustic cleaners. All joints between dissimilar materials must be accessible, easily cleanable, and caulked.

Floors should be smooth, durable, moisture-proof, nonabsorbent, skidproof, and resistant to the adverse effects of disinfectants, high-temperature water, and detergent cleaning, as well as chemicals used in holding and procedure rooms and continuous movement of cages and equipment. Resinous epoxy flooring, troweled on, is recommended, and offers the best protection. Floor covering should be carried up the walls, at least six inches, to provide an integral flooring base for ease of cleaning. If thresholds are used, they must be of the type to permit the easy wheeling of cages or other equipment through the vivarium.

Walls must be free from cracks, unsealed penetrations, or imperfect junctions with ceilings and floors. They should be constructed of materials capable of withstanding scrubbing with detergents and disinfectants and high-pressure water, and be capable of withstanding the impact of cages, carts, and racks. Walls must also provide sound isolation. Ceramic tile and glazed block, though nonporous materials, are not recommended. The number of exposed joints increases the possibility of failure and the opportunity for dirt to collect. Concrete masonry units are effective if they are coated, and the joints are tooled flush. The block may be plastered, or a block filler may be used. Fiberglass wall systems are also appropriate, and provide a durable, cleanable partition system. Bumper guards on walls in corridors and holding rooms will prevent cages, racks, and handcarts from colliding with and damaging walls.

Ceilings must be smooth, moisture-proof, free from imperfect junctions with the wall, and capable of withstanding scrubbing with detergents, disinfectants, and water under pressure. Most ceilings may be constructed of moisture resistant gypsum board with epoxy paint, or a fiberglass panel system. Surface mounted lights and exposed piping is not permitted.

Windows, if any, are to be nonoperable, sealed and caulked. Doors should be sized to easily accommodate passage of cages, racks, and other equipment. Door size is a minimum of 44 inches wide by 82 inches high. Heavy (16 gauge) stainless steel doors in stainless steel frames or fiberglass doors in fiberglass frames are recommended. Door frames should be completely sealed to prevent the harboring of pests. Doors should be sealed top and bottom and be provided with vision panels with light-tight covers, locks, kick plates, fixed bristle sweeps, and closers. Doors should be equipped with bumper rails.

Vibration Attenuation

Consideration must be given to vibration of floor framing systems caused by mechanical and electrical equipment such as pumps, chillers, fans, emergency generators, and transformers and other sources such as foot traffic, and movement of heavy equipment. Many animals are extremely sensitive to vibration, and it can produce detrimental effects on research. Every effort must be taken to control vibration and to locate vibration sources away from animals and activities sensitive to vibration. The following consideration should be made during the design phase:

- The structural system should be relatively stiff so that any vibration that is transmitted occurs at high frequencies. Vibrations occurring at higher frequencies are more easily dampened with the use of isolation tables and other vibration dampening systems than vibrations occurring at lower frequencies.
- The structural system should have relatively short column spacing.
- Vivarium spaces should be located away from sources of vibration.
- Vivarium facilities should be located on grade-supported slabs. This not only helps with vibration attenuation, but also pits required for cage and rack washing equipment are more easily accommodated and the risk of water leakage to lower levels is eliminated.
- On framed floors, corridors and vivarium spaces should not be framed on the same structural bay.

HVAC

HVAC systems must meet the requirements published in *The Guide for the Care and Use of Laboratory Animals*. Temperature, humidity, and air-change rate must be carefully controlled and monitored on a continuous basis. Systems must have adequate ventilation capacity to control fumes, odors, and airborne contaminants and offset the heat load of lab animals.

The HVAC system must be reliable and redundant and operate without interruption. HVAC systems must be designed to maintain relative pressure differentials between spaces and must be efficient to operate, both in terms of energy consumption and maintenance.

HVAC systems for vivarium facilities must be independent from other building HVAC systems. These systems must maintain a safe and comfortable environment for animals, be adaptable, and be capable of maintaining environmental conditions in any of the holding rooms for any of the species anticipated to be housed in the facility. The HVAC system must be designed to provide backup in the event of component failure. Central HVAC systems should be provided with multiple chillers, pumps, cooling towers, etc., to improve reliability. Recirculation of air in a vivarium facility is prohibited.
Animal facilities must be designed with special attention to air quality, acoustics, airflow quantities, diffusion characteristics, means of delivery, delivery temperature, air velocity, and air distribution. Distribution should prevent cross contamination between individual spaces; air flow shall flow from areas of least to areas of higher contamination potential, i.e., from “clean” to “dirty” areas. Air supply terminals may be located at the ceiling level or close to ceiling level if located on sidewalls. Exhaust should be located near the floor level. It is preferable to have several exhaust points in animal rooms. Air distribution and diffusion devices shall be selected to minimize temperature differentials in the space.

Vivarium spaces must be protected against contamination from outside sources, including particulates brought in from the outside in the HVAC airstream. Generally, the vivarium must remain at a negative air pressure relative to the clean corridors and other non-vivarium spaces, but positive with respect to the outside environment. Relative pressure inside the vivarium is a series of complex relationships. Some of these relationships may change as research and animal populations change. The HVAC system must be capable of maintaining these relationships, and capable of adapting as need s change.

Clean areas, including the clean side of the cage and rack wash, the clean corridor, and bedding dispensing, diet, and preparation areas must be positive relative to animal holding areas or soiled areas. Animal housing areas are generally negative to clean areas and positive relative to service corridors and soiled areas. The HVAC system must be adaptable so that pressure relationships can be modified as required over the life of the building.

Plumbing

Types of plumbing in the vivarium may include wash systems, waste drainage systems, animal drinking water systems, and medical gas systems. The plumbing design must minimize the potential for accumulating dirt and providing pest harborage and access to animal care areas. All pipes, mounting brackets, and supports are to be caulked and sealed during installation. The following criteria should be considered in the plumbing system design:

- Minimize exposed piping inside animal rooms
- Install piping with standoff support to aid in proper cleaning
- Avoid insulation of pipes
- Minimize pipe penetrations, with any penetrations carefully sealed
- Use piping materials that do not use toxic releasing compounds during manufacturing
- Carefully evaluate drainage design so as to prevent clogged drains

Large quantities of liquid waste leave the vivarium through the sewer systems. The system must be adequately sized, particularly if it is mixed with feces and bedding. A six inch waste line is recommended for animal holding rooms.

Electrical

Conduits in vivaria should be concealed. Surface mounted conduits in wash down areas should be Intermediate Metallic Conduit (IMC) or rigid galvanized steel with threaded couplings. Conduits should be sealed with conduit sealer such as Duxseal at each device/junction box. Surface metal boxes should be cast metal. Conduits entering or leaving device boxes, junction boxes, pull boxes, etc., should be sealed at each box with a nonhardening sealant such as Duxseal. Surface metal raceway with snap-on covers should not be used in vivaria due to the requirements for wash down cleaning.

The following loads are required to have stand-by power:

- Operating rooms
- Animal ventilation fans
- Ventilated cage racks
- CCTV cameras and equipment
- Security system
- Switch controlled minimal lighting in animal holding rooms

Health and Safety

Animal holding areas must be designed with employee movement requirements in mind. Specifications for vivarium equipment should include a requirement that sharp edges and other protuberances that may cause injury to either personnel or animals should be avoided. Due to the frequent washing down of surfaces, floor areas should be slightly sloped to drains to reduce pooling of water and the probability of slips and falls.

All electrical systems and apparatus must be connected to a ground fault circuit interrupter (GFCI) to prevent electrical shock.

Where hazardous chemicals and cleaners are used, eyewash stations and safety showers are required. Eyewash stations should be available within 75 feet of the location of chemical use.

Waste storage must be located on the “dirty” side of the facility. This area must be sufficiently large for the storage of waste materials generated in the facility. This location should be near exit doors and should provide sufficient room to facilitate movement of waste containers/carts in a sage manner, with minimal ergonomic stress.

The NIH design guidelines are for reference, and should be implemented as appropriate. Some sections may apply more than others.

Section 2-4: Animal Research Facilities

Section 2-4: Animal Research Facilities

2-4-00 Design Requirements

The purpose of this section is to develop NIH Programs of Requirements (POR) and other planning and programming documents and shall not be used for design review. Concept or schematic designs shall be reviewed against the POR.

Space utilization of NIH animal research facilities shall be in accordance with Paragraph 2-2-20.B in Volume II of the HHS Facilities Program Manual.

• Excellence in design with commitment to quality by the design and management team is a primary goal for all NIH.
• Designs for new animal research facilities shall include considerations for future expansion including horizontal and vertical expansion. Building massing shall be consistent with the current master plan.
• Columns shall not fall within the animal research facility planning module so as to prevent interference with facility space planning and layouts and inefficient use of valuable space.
• Interstitial space shall be designed to scale. A model or full size mockup of the interstitial space is required.
• The laboratory planning module shall be considered the primary building module in multiuse facilities due to the importance of the laboratory planning module to functional and safety issues.

A. Program Objectives:
Program objectives must be determined as early in the planning process as possible. It is crucial to identify the variety of species that the facility should be expected to accommodate over time; the temperature and humidity range that each species can tolerate; and the degree of flexibility and adaptability required within the facility to accommodate different species. The designer shall determine the cost impact of making some or all areas of the facility more flexible than other areas. In order to provide for an environment within the animal research facility that meets the program objectives, the designer will collect data on spatial allocations, functional adjacencies, user requirements, staffing projections, flexibility requirements, redundancy requirements, security requirements, architectural finishes, fixed equipment needs and circulation of personnel, materials, animals and waste.

A.1 Planning Criteria:
The animal research facility will be designed to house animals in an appropriate species specific environment that meets or exceeds all applicable policies, guidelines and regulations as outlined in the Guide for the Care and Use of Laboratory Animals (Guide), PHS policy and animal welfare regulations. In addition, facilities must meet the minimum requirements to be accredited by the American Association for Accreditation of Laboratory Animal Care, (AAALAC). The ideal facility will:
• Meet projected holding and programmatic requirements, while providing for expansion and flexibility in space utilization;
• Provide for efficiency of management through innovation and flexible design;
• Be cost effective in design, construction, operation, maintenance;
• Utilize innovative design and construction to minimize future energy, maintenance, labor, and expansion costs; and
• Provide an ergonomic and user friendly work environment.
• Include redundancies.
• Have capacity for increased holding space.

A.2 Space Requirements:
The space requirements for animal facilities vary greatly. Requirements are dependent on the specific use of the facility, type and density of animals housed, type of caging and racking systems, number of investigators utilizing the facility, and operational methodologies of the facility. Each proposed facility shall require careful analysis by the A/E and consultation with users to determine adequate space requirements.

Criteria for animal housing space is set forth in the DRM. The space requirements for a facility shall consider the total animal population, number of species, isolation requirements, number of animals per room, and number of investigators and research projects anticipated. The assignment of support space is based on protocol, equipment, and process and can be determined only on the basis of an evaluation of the specific project program of the facility users. Application of these space criteria requires the A/E to analyze functional requirements in light of specific project needs.

A.2 Specialized Design and Review by DOHS Community Health Branch (CHB):
Animal facilities present some of the most challenging circumstances to an effective pest management program and the performance of integrated pest management (IPM) services. Additional care and attention shall be paid during all phases of planning, design, and construction of animal facilities. Some components that require specialized design and review by DOHS Community Health Branch (CHB) include:

- Building integrity (site design, building envelope, exterior building lighting).
- Receiving areas.
- Interior wall, floor, and ceiling finishes.
- Door types, locations, and materials.
- Wall and door protection design and materials.
- Access panels.
- Sealing locations and details.
- Interior lighting.
- Cage wash design.
- Solid waste disposal, recycling, and storage facilities.
- Floor drains.
- Locker rooms and break rooms.
- Administration areas.

These items shall be evaluated and reviewed with respect to the overall program requirements of the entire building, specific animal species, size of the facility, and anticipated future use(s) of the facility.

2-4-10 Design Guidance:
This Section describes in general and specific terms the NIH requirements for the planning and design of facilities that house animals and related functions. Considerable animal research is conducted at the NIH in order to support NIH's mission to improve the health of the American people through biomedical research. The Guide for the Care and Use of Laboratory Animals (The Guide) published by National Academy Press covers all aspects of the care and use of laboratory animals, including institutional policies for monitoring animals and providing care. The Guide should serve as an aid to develop policies governing the care and use of animals based on the institution's particular requirements and in compliance with applicable federal, state and local laws and regulations.

In the U.S., research facilities requiring the use of animals must conform to The Guide to be accredited by the American Association for Accreditation of Laboratory Animal Care (AAALAC). For accreditation the environment within the facility must provide for the health, safety, comfort and well being of the animals and staff. Plans for building and renovations of animal facilities must be reviewed and approved by the Office of Animal Care and Use (OACU). Animals are not allowed to be housed in laboratories or spaces other than approved animal housing facilities for longer than 24 hours unless the area is established as a satellite animal housing facility. Establishing a satellite animal housing facility may require shortterm design modifications that facilitate monitoring the local environment OACU requirements.

A. Animal Research Facility Trends:
Biomedical research is heavily dependent on animal research to create animal models for the study of human disease processes. Fluctuations in the animal species of choice may vary from time to time and for this reason the facilities must be capable of meeting ever changing animal research requirements. The design of these facilities must be flexible and adaptable.

A great deal of animal research at NIH involves genetic mutations and manipulation (trans-genic technology) of specific animal traits and testing these traits by performing behavioral studies, imaging studies, and biochemical studies. Toxicology studies are performed to observe the effects drugs have on developmental and metabolic processes and on behavior patterns.

Long term observation of animals may dictate design features for a specific species. Until recently rodents and nonhuman primates have been the primary research animals of choice. There has been a dramatic increase in the use of aquatic species (zebra fish, sea urchins and other marine species) resulting in the adaptation and renovation of older facilities and the potential need to accommodate aquatic species in new facilities. Large animals (primarily sheep and pigs) are used for cardiothoracic surgery and require pre and post operative holding space. Dogs, cats and chickens are used for specific types of research but are used in small numbers.

There is a trend to provide better and species specific "enrichment" for nonhuman primates and large animals. Enrichment requirements will impact on design of the facility if the program calls for play rooms, natural light, views of activity, group housing, animal runs, and storage of toys.

Other trends in animal research facilities include an increased use of robotic cage wash equipment to supplement staff shortages and reduce staff injuries; heightened security measures; more extensive and expensive environmental controls to protect unique animal colonies; and an increased need for support facilities within the animal research facility such as diagnostic labs, imaging equipment, conference rooms, special function and core suites. Each of these trends demands special design considerations that must be addressed in the planning process.

B. Animal Research Facility Activities:
The activities performed in an animal research facility include, but are not limited to, providing routine animal and environmental maintenance, performing animal research and providing general administrative services. In addition, an animal research facility requires a significant amount of support space. Environmental maintenance includes bedding changes, food preparation, routine cage washing, room cleaning, local filter maintenance, pest management and waste disposal.

Routine animal maintenance includes daily animal examination, routine pathology to determine colony health status and animal breeding for colony maintenance. Animal research includes genetics studies, animal testing that requires the administration of drugs, chemicals, or biological agents, pathology, diagnostics, surgical procedures, imaging, phenotyping, behavioral studies and record keeping of a highly detailed nature. Animal research facility administration areas should provide space for a central reception area, veterinarian offices, office support staff areas, and technical and laboratory supervisory staff offices. Animal research support activities include animal shipping and receiving, decontamination of materials entering the facility, storage and dispensing of animal feed and bedding, cage washing, laundry services, cold storage of medical pathological waste, and animal caretaker requirements such as lockers and a lunch room.

C. Design Goals and Objectives:
The NIH will provide state-of-the-art animal research facilities to enhance and maintain its position as the world leader in biomedical research. The NIH will accomplish this goal by constructing new animal research facilities and renovating older ones to meet ever changing biomedical research requirements. These guidelines will be applied to new animal research facilities and, to the extent possible, to renovation projects. The following goals and objectives define the minimum recommended program requirements and recommendations for the design of animal research facilities.

C.1 Quality of Life and Environmental Considerations:
The immediate environment directly and indirectly affects an animal's biological and behavioral responses. Noise, light, vibration, sound, species thermal requirement ventilation, etc. of the animal's cage affect the quality of life and may adversely impact the research. At a minimum, animal holding and procedure areas must be designed to ensure animal well being, to meet research requirements, able to be sanitized and easily maintainable, and to minimize experimental variables and maximize predictability.

C.2 Animal Well Being:
The facility should support a healthy social environment for the animals that mimics the animal's natural social environment. The characteristics of each species must be considered in deciding how to house a diverse animal species. There is very little data comparing the relationship of quality or quantity of an animal's activity to its physical or psychological well being. A cage does not necessarily limit the amount of animal activity although it may alter the form of activity the animal can pursue. The need for exercise or induced activity is subject to the judgment of the animal science professional based on an understanding of the species or breed, its temperament, age, history, physical condition, nature of the research, and expected duration of animal research facility residence. Examples of supplementary activity that can be provided include furnishing a treadmill or exercise wheel, walking on a leash, providing access to a run, or releasing an animal from its cage into an animal play room/activity area. Provisions shall be made for animals with specialized locomotion patterns to express these patterns, especially when animals are held for long periods. For example, ropes, bars, and perches are appropriate for brachiating nonhuman primates.

C.3 Employee Well Being:
The animal research facility is also a workplace for employees. Therefore, the occupational health and safety of personnel must be considered. The environment shall be aesthetically pleasing to employees and consistent with the needs of investigators engaged in animal research. It should be efficient, secure, and easy to maintain and perform animal care taking services. Sufficient air supply, filtration, and exhaust shall be provided to minimize unpleasant animal odors and animal allergens. Provision of natural light, adequate work space, color, and ergonomic furniture systems are integral to a pleasing, functional, and effective work environment that will enhance productivity and aid in the recruitment and retention of quality personnel. In order to provide for an environment within the animal research facility that meets these goals, refer to animal facility space descriptions for information that impacts the quality of life of the animals and their caretakers.

C.4 Graphics/Signage:
Without views to the outside or significant landmarks within the facility, orientation becomes a planning issue in an animal facility. It is recommended that a map of the

corridor system be provided at strategic junctures in the hallway. Alternative way finding elements might be used such as directional markers on the walls, color coded corridors or artistic symbols designating room or corridor use. Each room shall have a room number clearly displayed at its entry.

C.5 Other Amenities:

Amenities such as lounges, break areas, training rooms, staff offices, and conference rooms should be provided. Placement and size of these rooms should be carefully thought out in order to maintain the integrity of the degree of facility contamination control that is defined in the program. Locker and shower facilities should be provided outside of the animal barrier area for staff whose work does not involve animal contact.

C.6 Natural Light:

Natural light is not recommended in areas that will house animals that require regulated lighting cycles. These include but are not limited to rodents, rabbits, and fish. Windows may be desired in areas that house large animals such as nonhuman primates, dogs, or farm animals. With the exception of facilities housing larger farm species, most animal rooms should be equipped with artificial lighting systems that control the diurnal lighting cycle. Through the use of innovative design and construction, diurnal variation can be maintained. If windows or door vision panels are to be placed in animal rooms, veterinarians shall be consulted for placement of windows and window treatments.

The negative aspects of windows in animal facilities frequently dominate design, and opportunities can be missed to enhance the personal work environment with natural lighting. Windows should be provided in personnel and administrative areas.

C.7 Lighting and Controls:

Fluorescent lighting is recommended in an animal facility. However, discussions shall be held with the veterinarian and researchers regarding the light spectrum and light covers of fluorescent lamps. Light covers should diffuse and soften the light so as to have a minimal effect on animals that may have higher than normal light sensitivity. Lighting should be suitable to the space and cleaning methods in the room, recessed, ceiling mounted and sealed to prevent vermin infestation.

Lighting control is a major consideration particularly in small animal holding rooms. Lighting control is typically required for large animal holding or procedure rooms as well. Light intensity can have an impact on research results under certain circumstances and may differ by species. Whenever possible, lighting should be centrally controlled, on emergency power and monitored at the room level. Monitoring of the lighting control system should be independent from the method used to control the lights. Consideration should be given to direct measurement of room illumination or monitoring the electrical circuit feeding the room light. The ideal system would provide a local warning light alarm and, if required, remote audible alarms signaling lighting failures. Light monitoring control systems shall also be capable of providing reports for status and alarm conditions. Although it may be possible to group several rooms on a single timer, this should be discussed with the users. Animal protocols often call for diurnal lighting cycles (circadian rhythm) to be reversed or altered in length for the researchers needs or for the desired results of the experiment. These studies require lighting controls and automatic timers in all holding rooms and isolation cubicles. "Red light" or other lighting options within holding rooms, as determined by users, should be considered so researchers can enter a room during the dark cycle without affecting the animals.

C.8 Noise:

Acoustical control is an important planning consideration and shall be evaluated during design. By examining adjacencies, the effects of noise can be addressed in the design layout. Most animals are stimulated and may be stressed by noise. Different species of animals will have different tolerances for high or low frequency noises. Certain frequencies can have an adverse affect on sensitive animals. These issues must be discussed with facility users.

Power ventilated racks generate noise. The rack density in a room will affect the noise level. Mechanical equipment may generate noise frequencies that are not noticeable to humans but will potentially affect animals housed near the source of the noise. This is further exacerbated by the requirement of hard, easily cleaned surfaces throughout. Most animals are stressed by noise, except for large animals not involved in behavioral testing. Equipment that generates noise should be remote or acoustically isolated from animal holding rooms wherever possible.

Large animals tend to be noisier than small animals although avian species (birds) are noisier in relation to their size than rodents. Animal species that generate noise should be isolated from those that are noise sensitive by either distance or sufficient acoustical isolation. Noise conductivity through the duct system should be taken into consideration.

Although rodents can adjust to constant low level background noise, background noise should be minimized or removed through the use of innovative design.

In all situations, it is imperative to eliminate the effects of sudden and variable noise producing elements, such as fire alarms, throughout the animal holding environments.

C.9 Vibration Stability:

Vibration stability is important to maintaining a constant experimental environment for sensitive animals such as rodents. Therefore, rodent holding and test rooms should be located away from areas such as a cage wash, major circulation corridors where racks are frequently in transit, mechanical rooms and elevator shafts. Vibration is not as much of an issue for large animals except in behavior testing rooms. Vibration studies should be performed to determine how best to achieve the maximum allowable vibration levels as determined by instruments and animals to be used in the area. See Chapter 5 Structural

Vibration stability is required in an animal facility where specialized equipment will be used such as animal imaging equipment, electron microscopy, and electrophysiology procedures including intracellular data collection equipment. Vibration stability will be of greater concern if the animal facility is located in an upper level of a building rather than at ground level because of structural considerations. Sensitive pieces of equipment may require an isolation slab. Some equipment can be stabilized using a dampening device.

D. Animal Research Facility Planning Parameters

D.1 Ratio of Holding Rooms to Procedure Rooms:
During the programming stage the users should be consulted on whether animal holding rooms house multiple species and whether animal holding rooms and procedure rooms should be designed to be interchangeable with minimal structural modification. Flexibility in design of these critical areas provides for rapid accommodation of future programmatic changes and efficient space utilization.

As a general rule of thumb, one procedure room for every three to four small animal holding rooms should be considered. Clusters of isolation cubicles should have at least one procedure room per cluster. Suites should have a minimum of one procedure room within the suite. The ratio of procedure rooms to holding rooms for large animals shall be determined by scientific requirements and the specific program requirements of the facility. Most large animal holding facilities will require an extensive surgical suite with its accompanying specialty procedure and prep rooms. Terminal procedures and necropsies on large animals are ideally conducted in separate locations from the surgical suite but can be performed in a necropsy/perfusion room or in a specially designated procedure room. Room should be arranged to provide airflow from the least contaminated area to the most contaminated area.

D.2 Animal Research Facility Support Space:
The ratio of animal facility support space to holding and procedure space is generally 2:1 or higher. Support space includes bedding and feed storage, decontamination or quarantine areas for incoming animals and materials, a laundry, feed preparation areas, administrative areas, break areas, meeting/training rooms, lockers for animal caretakers, gowning areas, cage wash, autoclaves, marshalling areas, diagnostic laboratories, pharmacy, storage areas and housekeeping closets. Storage areas should include space for cage and rack equipment, general support supply storage, and locked cabinets for investigators to store small research specific items.

Shared use spaces may include surgical suites, imaging suites, behavioral suites, transgenic suites, radiology rooms and irradiator(s), in addition to the operational support spaces. Shared use, central or core facilities may be considered as part of support space or as part of procedure/holding space depending on how the program chooses to define the space. The definition of this space should be established early in the programming process to facilitate net to gross calculations.

D.3 Office and Administrative Space:
Animal facility administrative areas should be designed using standard administrative space parameters. There may be a programmatic need for separate offices for government and contract supervisory staff. Administration offices should be located near the main animal facility entrance. This locates the management personnel in a position to observe the movement of personnel and equipment into or out of the facility. Guests, vendors and service people should have access to the animal facility administrative areas without entering the animal housing and support areas. Each veterinarian, manager and contract project officer should have a private office. Space should be allowed for office equipment such as copying machines and fax machines. A separate area for housing centralized computers and monitoring equipment should be considered. The administrative area should include conference rooms, a break room and access to toilet facilities that are separate from those used by the animal caretakers. Office and administrative space should have a positive pressure relationship to animal research facilities.

D.4 Flexibility and Adaptability:
Animal research facilities should be designed to maximize the animal holding capacity and accompanying utility services. The animal facility should be flexible and adaptable to accommodate changes in function and protocols without having to make major changes to the facility. Spaces should be designed to hold multiple species over time as protocols change. Individually planned or customized spaces are to be avoided. Flexibility in design of these critical areas provides for rapid accommodation of

future programmatic changes and efficient space utilization.

D.5 Expansion/Renovation Considerations:
Vertical and horizontal expansion of an animal research facility shall be considered during the planning phase. It must be possible to construct any expansion with minimal interference to the operation of the facility and the least disturbance to the animal population. When planning for expansion, ensure that all utilities are compatible with existing utility systems, built-in equipment, etc.

D.6 Planning Module:
Modular planning techniques have traditionally been employed to provide for an adaptable facility. Modular planning schemes should be used, to the maximum extent possible, for animal housing and procedure space. Modular planning is based upon a concept of three dimensional units of space and services, which are used in a repetitive fashion for each type of function within the animal facility. The dimensions of the structural bay, both vertically and horizontally, must be carefully evaluated with respect to the laboratory planning module if the animal facility is component of the laboratory facility, mechanical distribution, and future expansion plans. The planning module must be developed on the basis of an evaluation of operations and protocols and the anticipated numbers and species of animals.

In animal facilities, the most common unit of space is the animal housing/holding room. Ideally, when planning a multifunction animal research building, the animal holding room modular size should be determined based on cage or rack system size. This scheme may or may not be similar in size and configuration to the standard laboratory module. The width of the animal room is determined by the number and types of animals, the way in which they are housed whether by cage or rack, and the cleaning methodology that will be employed. Room length is determined based on housing/caging options and minimum aisle width between racks but also must accommodate service space for sinks, cleaning equipment, and change stations etc. The height of the animal room and doors is primarily a function of the maximum rack height anticipated including rack fans. There must also be enough space above the rack to provide a uniform airflow distribution in the room.

Wherever possible, rooms should be clustered to provide separate zones for small and large animals taking into consideration the differences in rack dimensions, waste disposal requirements, acoustical and vibration requirements, care taking requirements, investigators, protocols, disease status, and airflow requirements.

Animal Facility Holding, Procedure and Support Module Variations: The length, width and height of the animal facility modules are dependent on the intended use of the space. There may be a need to a have a variety of different size small animal holding rooms with or without individual or shared anterooms. Animal holding and procedure suites are a combination of modules used for a specific research purpose. Within a suite, the rooms may be subdivided or positioned differently than in the general layout of the animal facility. Other support spaces such as the cage wash or the administrative areas are composed of multiple modules without wall divisions to accommodate large pieces of equipment or open office space.

E. Services and Systems:
Utility systems within the animal research facility must be capable of providing all the services necessary for scientists to conduct their research and for the animal husbandry staff to properly care for the animals. It is equally important that provisions be made for utility services to accommodate unanticipated demands brought about with new technologies or through changes in research protocols. A percentage of reserve capacity should be designed into the primary building systems to accommodate increased animal densities. All components of the utility systems should be planned and designed to allow all required access, maintenance and repairs without entering the animal holding or procedure rooms. Maintenance spaces should be configured so it can be expanded without displacing animal research functions whenever possible.

E.1 Connection of Utilities to Animal Facility Space:
Utility services must be distributed to each individual space. The connection point of each service should be in a uniform position relative to the space and detailed to provide simple extension into the space without disruption of adjacent modules. These services may run in interstitial space, allowing animal holding or procedure space to change without increasing or upgrading capacity or location of central infrastructure systems. Changes would be primarily to terminal systems, i.e., piping and power connections to apparatus and equipment within the space.

E.2 Services and Systems Distribution Concepts:
HVAC units serving animal facilities should be designed with redundant heating, ventilating, and air conditioning system arrangements or with standby equipment with capability to ensure continuous operation during equipment failure, power outages, and scheduled maintenance outages. It is acceptable to have a common air intake system for both animal holding and other parts of the building. The animal area exhaust system must be independent of the non-animal exhaust systems of the building.

Utilities and services including communication and information systems should be organized into specific zones, both horizontally and vertically, to provide distribution of systems and services that can be extended to each animal holding and procedure module. The choice of design and locations of the utility distribution system(s) is a product of utility function, cost effectiveness and ease of access for maintenance, future services, and remodeling during the life of the animal research facility. At a minimum, a percentage of the holding and procedure rooms shall be designed for interchangeability of use. The percentage and locations of rooms with drains should be determined during programming.

E.3 Special Considerations for the Connection of Utilities to Animal Facility Space:
The following are special considerations for the connection of utilities to animal facility modules or space.

• Small animal holding rooms other than isolation cubicles shall each have a sink. Isolation cubicles are not required to have a sink but a sink should be located in an adjacent procedure location/room. In all situations hand washing sinks should be convenient to all holding locations. Large animal holding rooms shall have a sink outside the holding room area or suite.
• Non human primates and farm animal holding rooms and aquatic tank rooms require floor drains. Most animal rooms at NIH are not hosed down so drains should be avoided except in areas that may be converted to hold aquatic or large animal species in the future. When floor drains are present, consideration should be given to the appropriate size of the drain lines, maintenance of the drain traps, drain caps and flush systems and floor slopes to drains.
• The type of animal watering system should be determined (automatic or bottled) during programming. If automatic watering is not desired at the onset, consideration should be given to designing a system that can accommodate a percentage of automatic watering for possible future needs. Consideration should be given for the quality of water required. In some situations highly purified water such as RO may be required. In many cases there is an additional requirement for the treatment of the water prior to distribution (i.e. chlorination, acidification or neutralization). Remote monitoring of the water treatment process is required. In order to accommodate water treatment concerns appropriate equipment, piping and plumbing systems must be considered.
• Consideration must be given to steam connections, clean steam and reverse osmosis (RO) water with additional polishing systems in the cage wash and bottle filling area of the facility. Clean steam connections will be required wherever there is an autoclave. The users should also be consulted as to the need for RO water in dishwashers, if required and frequency of RO drops in procedure rooms.
• The racking/caging system for small animals should be determined as early as possible in the planning process in order to determine the type and number of duct connections. Different racking systems may have different types of connections. Alternate rack configuration will affect the placement of those connections. Considerations must be given to ducts above the plenum and the location and length of the exhaust taps. In addition, some racking systems are now designed with dynamic LAN line connections.
• Placement of electrical outlets and weatherproof or waterproof protective covering for the outlets should be carefully considered for all animal holding rooms. Electrical loads must be sufficient to accommodate all the needs of animal holding and procedure rooms. Ideally, electrical outlets servicing ventilated power turbo units and other equipment should be located high enough to prevent draping electrical cords, which may prove to be a safety hazard. Also racking systems shall be connected to the emergency power system.
• LAN line connections. Consideration must be given for the requirement of LAN connections within the animal holding room. In addition, some racking systems are now designed with dynamic local area network (LAN) line connections. Provide for at least one LAN connection for laptop use.

F. General Staffing Patterns of an NIH Animal Facility:
The number of staff in an animal research facility will vary according to the size of the facility. Staff will include veterinary staff including a chief veterinarian and subordinate veterinarians, administrative staff, research and technical support staff, supervisory and staff level animal caretakers and support staff for feed and bedding preparation and cage wash. In addition, research staff will regularly enter and leave the facility.

G. Space Descriptions:
Animal research facilities present a wide assortment of planning challenges. The challenges range from differences in environmental requirements by species and building zones to the durability and water resistance of the architectural finishes to room flexibility that can accommodate a variety of species over time. This section of the manual presents information for the designer to use in planning the animal facility space requirements in relation to the species needs and caging systems and the zone the space occupies.

G.1 Animal Housing and Holding Areas:
Generally, any area where animals are held for more than 24 hours is treated as holding area. Housing/holding areas are usually located in a defined specific pathogen free (SPF) zone of the animal facility. However, there are

instances where conventional housing is required for "dirty" animals such as a quarantine room or an area of the facility specifically for research using non-SPF or "dirty" animals.

In an effort to increase the facilities flexibility, it is essential to plan for both anticipated and potential species usage and rack and caging type. The animal housing or caging system chosen is one of the most important elements to consider in the planning process. Animal housing and most procedure space should be carefully designed to facilitate animal wellbeing; meet research requirements; minimize experimental variables; and provide isolation from wide temperature and humidity variations, vibration, and noise sources .The caging system should provide adequate space to permit freedom of movement and normal postural adjustments; a comfortable environment; and an escape proof enclosure that confines animals safely with easy access to food, water, and ventilation. The caging system must also meet the biological needs of animals, e.g. maintenance of body temperature, waste elimination and reproduction. Ideally the chosen caging system should be: a) ergonomically friendly; b) of proven design and functionality; c) be durable; d) maximize available holding space; and e) be a standard shelf item with readily available replacement parts. All holding rooms must be designed to be easily cleanable and minimize pest harborage. Refer to Section 1-11 Integrated Pest Management. Consideration should be given to providing space to record data and to store records and supplies. All caging systems and animal holding rooms must meet or exceed all requirements out lined in the Guide for the Care and Use of Laboratory Animals, PHS policy and animal welfare regulations.

Small Animal Requirements: Small animals include mice, rats, hamsters, guinea pigs, reptiles, fish and birds. Each species will have different caging and environment requirements. Each species must be held in separate rooms or cubicles unless, in the case of rodents, ventilated racks are used to house them in order to provide separation of animals at the rack or cage level. Each rodent rack should provide for either bottle or automatic watering systems. Where isolation or quarantine space is required, space should be considered for a separate anteroom or procedure rooms.

A small animal holding room should be capable of housing different species at different times and in different caging systems. In most situations, holding rooms should not have windows although the doors may have an observation window or view port that can be made light tight or provided with red film. If windows are present within an animal holding room, systems must be in place to guarantee that the room's normal diurnal variation can be maintained. In addition, windows must be designed to preclude the visualization of animals from outside of the building and also to address security issues. Anterooms are optional for most animal holding rooms (dependent upon animal biosafety level), but should be considered on an as needed basis for the facility.

Small animal holding rooms should be located convenient to a central cage wash, but at a minimum they should be separated from the cage wash by a corridor. Likewise, to minimize the impact of noise and vibration the holding rooms should be separated from mechanical rooms or other noise generating areas in the facility. This is particularly necessary for barrier areas where genetically sensitive animals are held.

Design features and finishes should encourage effective sanitation while at the same time be safe for personnel and durable. All surfaces should be water resistant, impact resistant and skid resistant. Electrical outlets should prevent shock hazards and have weatherproof covers in areas within the vivarium.

Each small animal holding room shall have a sink with hot and cold water within the room. There should be a place to hang a mop, ideally near the sink in each room. Consideration must be given to the various management styles, which may be utilized within each animal holding room. Some situations may require the use of biological safety cabinets (BSC) or a laminar flow change hood or transfer station. The impact of these systems and, in the case of ventilated racking systems, motors, must be considered in determining the rooms heat load and air circulation patterns.

Rodents: Rodents include mice and rats. Mouse cages may hold up to five mice per cage. Rat cages are larger than mouse cages and can accommodate up to four animals depending on size. Sometimes rats and mice are housed in the same room. Mixing species in a room should be avoided if at all possible. However, if this becomes necessary, ducted ventilated racks or other environment isolation equipment should be used.

Mice and rats are housed in "shoebox" type cages that are stacked in racks specifically designed for this purpose. There are numerous caging and racking systems on the market. Racks may be single sided and placed parallel to the room walls or double sided and placed perpendicular to the wall. Room configurations utilizing a combination of the two systems have also been used with success. There are also systems that can be arranged in a "T" formation. The proposed rack layout will determine the projected facility holding capacity. Ideally, the rack arrangement should allow adequate space for a caretaker to roll a cart up to or between the racks for animal transfers, bedding changes, and for maintenance items that may be include feed barrels, mop racks and trash cans. Consideration should also be given to providing a flexible layout that can accommodate someone with a disability to maneuver between the racks if required. The minimum recommended space between racks is 915 mm. Some animal facility programs may require a biological safety cabinet or a change station in each holding room to make cage and bedding changes, rodent transfers or to perform minor procedures. The designer should allow room for a changing station in addition to the holding racks when this need is identified in the program. Consideration should be given for the additional heat load provided by change cabinets or ventilated racking systems.

Reptiles and Amphibians: Reptiles and amphibians can be held in aquarium type glass or plastic tanks or they can be held in modular flexible species holding rooms. Temperature and humidity control and lighting are the only special requirements for reptiles. The temperature should range between 20-29.5OC and the relative humidity should range between 33%- 60%. The users should determine whether or not they want UV light in the room. UV light provides vitamin D to the reptiles. If UV lights are installed, a UV warning light must be installed outside the room in addition to an auto-off switch that is activated upon opening the door.

Birds: Most species are held in small animal cages or they can be held in modular flexible species holding rooms. The type of bird containment will depend on the species, the study and the investigator's requirements. Some birds might be held in cages while other species might require an aviary that mimics their natural environment. Although a drain is not required in a bird holding room, the room cleaning method must be closely reviewed. If the room will be hosed, then the floor shall have a drain.

Aquatics: Aquatics include fish, sea urchins and amphibians. The trend in aquatic tank holding rooms for fish is to have a single large room that can hold many tank racks with integrated water circulation and filtration systems. However, there may be different requirements for other aquatic species. Lighting shall be timer controlled for circadian rhythm studies. Amphibians are sensitive to temperature differences and may require "sunning" areas. Noise and vibration can adversely affect aquatic species and should be controlled or buffered as much as possible.

Water is the life support medium for aquatic species. The water system supporting the various components of the system must be sized properly. A major concern for the designer of an aquatic facility is the water weight. Aquatic holding rooms must be designed to structurally support the load.

Water temperature, quality, pH, degree of hardness and salinity must be tailored to the specific aquatic species and must be closely monitored to avoid disastrous effects on the population. The levels of ammonia, nitrates, chlorine, dissolved oxygen and carbon dioxide in the water must also be monitored.

In some cases, a percentage of supply water can recirculate. Recirculation parameters shall be discussed with the user representatives designing the building. The location of pumps and other mechanical equipment associated with the aquatic facility is a critical design feature and shall be located remotely from the holding rooms so as not to create noise and vibration. Appropriate filtration should be considered for the removal of particulates and nitrogenous wastes. A flow monitoring system should be incorporated in the system to detect a loss in pressure or decline in water levels. Emergency power should be considered for the pumps and lights in the aquatic facility. Floor drains should be installed in all tank and procedure rooms where aquatic species will be housed. Floor drains are essential and flood proofing is an important feature to consider in design especially if the holding tanks are on an upper floor. Floors should be sloped 3 mm to 10 mm to the drain. Drains should be rust proof and flush with the floor. Consideration should be given to providing some way of trapping and removing debris from the drain opening (i.e. removable basket). Other flood proofing considerations include putting a small berm and a tight seal sweep at the door base. All ceilings, walls, sills and floors should be water resistant. All lighting fixtures should be splash resistant. All electrical boxes and conduits should be corrosion resistant and splash resistant UL listed wet location minimum 85 PSI or minimum IP65 rated. The HVAC system should work in tandem with the water supply system in controlling the room and water temperature. Note that in order to maintain the desired water temperature; the room temperature may not be ideal for those who have to work in the room.

In order to define space usage in an aquatics facility, the following shall be considered and provided per program requirements:

• Space for the nursery, procedure space in small rooms off the tank areas, and for raising aquatic food (i.e., shrimp).

An aquatics facility may require easy access to a fume hood because highly carcinogenic and teratogenic chemicals are used to create mutations in fish. A holding area may be required close to the fume hood for short term holding of fish that have been treated with mutagens. These needs should be discussed with the potential users.

Cubical Housing: Cubicles are small rooms or containment compartments within a larger room or suite of rooms. Cubicle housing may be used for isolating animals of different health statuses, for conducting timed day/night studies, for separation of different species or for specialized barrier areas. Cubicles offer the advantage of isolating a small segment of the animal population and permit housing of multiple species in a single room. Cubicles are particularly useful for quarantine of incoming animals and may preclude the need for a separate quarantine room. Cubicles are also useful in the containment of hazardous substances used in animal studies, provide an added degree of security, and reduce odors and allergens. Cubicle housing areas should be designed to have either positive or negative air pressure in relation to adjacent spaces based on intended use of the cubicle. If the cubicles are prefabricated units, they can be readily disassembled to convert the room to other uses. Ideally, cubicles should be designed to accept two single-sided rodent racks or one double-sided unit or one non human primate racking unit. Although management may decide to utilize static non-ventilated cages within the cubicle, cubicles should be equipped with two exhaust drops to be used if ventilated caging is used in the area. If overhead doors are used on this type of space, consider providing automatic door operators, which must be provided with safety devices that prevent injury to the operator, which must be provided with safety devices that prevent injury to the operator.

A higher level of protection can be attained through the provision of individual air supply and exhaust in each cubicle. Air may pass through a high efficiency particulate air (HEPA) filter at the supply, exhaust, or both. Each cubicle may also have its own lighting and watering system. Access to a manual over ride must be restricted through the use of a key or card key system. Uniform lighting is ideal throughout the cubicle but because cubicles are small light may not reach the back of the holding rack. Therefore considerations should be given to specifying vertical fluorescent lighting to be installed in the corners of the cubicle in addition to ceiling lights. If vertical lighting is utilized, the bottom of the tube should be specified to be 457.2 mm from the floor. The fixtures must be sealed and gasketed.

Containment Suites: As a minimum, all animal facilities at the NIH shall be designed as ABSL2 facilities. Containment suites shall have negative air pressure relative to adjoining areas. For specific requirements refer to the Center for Disease Control and Prevention (CDC) NIH publication "Biosafety in Microbiological Laboratories" for animal biosafety level (ABSL) planning and design

Isolation Areas: Isolation cubicles should be provided to house animals that may have an infectious disease or animals that may be more susceptible to disease (i.e. immuno-compromised, etc.). Ideally, cubicles should be designed to accept two single-sided rodent racks or one double-sided unit or one NHP racking unit. Although management may decide to utilize static non-ventilated cages within the cubicle, cubicles should be equipped with two exhaust drops to be used if ventilated caging is used in the area. Isolation rooms should be on the "dirty" side of the animal facility, perhaps near the necropsy/perfusion room.

Procedure Rooms: Animal procedure rooms may be either shared or dedicated. A shared procedure room provides space for working with animals from multiple animal rooms and frequently involves multiple investigators, and possibly more than one species. Dedicated animal procedure rooms provide space for working with animals maintained in a single room or a small cluster of animal rooms that may have direct access to the procedure laboratory. Procedure rooms should be equipped with a fume hood and/or BSCs, sink with eyewash, stainless steel counters with downdraft sinks/tables for rodent surgery, exam lights, refrigerator and wall-mounted or mobile cabinets. Alternatively, ducted BSC can be considered for areas that use small amounts of chemicals or radioisotopes. Class II, B1 or B2 BSCs may require increased exhaust and make-up air, which is more energy intensive.. There should be sufficient electrical outlets to support all anticipated equipment. Central gas (oxygen, carbon dioxide, etc.), a passive gas scavenger line, vacuum and high pressure air may be needed in some or all procedure rooms. A low bench top may be needed for either a desk surface or a microscope. Procedure rooms should be designed so that they can be converted to animal holding rooms.

Behavioral Testing Rooms: The requirements for behavioral testing rooms will be driven by the species to be tested. All behavioral testing rooms should have the same HVAC as other animal holding/procedure areas. All behavioral testing rooms should be light tight, acoustically protected, and have IT connections to data collection areas outside of the testing room. All testing room requirements shall be reviewed with the users.

Rodent testing rooms may require deep countertops at desk/table height to hold special equipment. The rooms should have shelving for storage of testing equipment. Floor material in rodent testing rooms can be shall be epoxy. Rodent testing rooms shall have light cycle controls. At least one rodent testing room should be capable of holding a water tank. This room should have a sink and a drain. The floor in the water tank room should be of a water-proof material. The water tank rooms will require a video camera mounted above the tank with connections to a data collection system. If the data collection system is to be within the tank room, a visual barrier must protect it so that light or movement from video screens or personnel does not distract animals. Each wall of the room should have either a light box or a tack board to mount cue cards.

Summary Space Schedule Animal Housing:
The designer should develop an overall planning module for animal holding rooms based on the proposed racking and caging systems.

G.2 Diagnostic/Pathology Laboratory
Diagnostic/Pathology Laboratory: Diagnostic laboratory services are ancillary to the treatment area and facilitate diagnosis of animal health status. The services may include gross and microscopic pathology, clinical pathology, hematology, microbiology, clinical chemistry, and other appropriate procedures. The space will be equipped with stainless steel countertops with an integral sink, a refrigerator, downdraft tables, hand wash sink with eyewash, and casework. CO2 is the only central gas that may be required the need for compressed air medical grade oxygen or vacuum should be discussed with the user. Specialized fume hoods may be required as determined by the users. A ducted biosafety cabinet (Class II type B1) or a non ducted BSC may be required for examination of infectious specimens. Low bench tops may be required for microscopes. The diagnostic laboratory will be equipment intensive. There should be adequate electrical outlets to handle many small tabletop pieces as well as larger pieces such as incubators or centrifuges or scintillation counters. The room pressure should be negative by a minimum of -12.5 Pa (-0.05” w. g.) in relation to adjoining areas

Necropsy/Perfusion: This area provides space for examining deceased animals or performing terminal procedures. It is ideally located either near the diagnostic pathology lab or on the circulation route that is used for waste to exit the facility. It must be equipped with a downdraft table (sized for species held in the facility) that is equipped to collect hazardous chemical waste, a stainless steel counter, eyewash, sink, and casework. A fume hood or ducted biosafety cabinet may be needed. CO2, gas, vacuum and a gas scavenger line shall be provided. Provisions should be made for carcass storage. Either a refrigerator/freezer in the room or, for large animals, adjacent walk-in refrigerators are recommended

G.3 Animal Surgery
Functional areas for surgery should include a surgical support area i.e. storage, instrument prep, lockers and janitorial rooms; an animal prep area, a surgeon prep area i.e. scrub area, lockers/change room, restroom; operating room(s), and post surgical recovery/intensive care area. Intensive care/recovery rooms should be located near the surgical suite. The surgical suite should be located away from high traffic corridors and potential sources of contamination such as cage wash, necropsy, and waste storage. Ideally, separate locker, housekeeping, and toilet facilities should be provided as an integral part of the surgical suite. The surgical suite should have windows for observation and an intercom system connected to all rooms of the suite. Ideally the suite should be an isolated unit with controlled/restricted assess. Surgical suites are designed differently based on the types of animals used. Survival surgery for small animals may be conducted in procedure rooms or in operating rooms.

Locker Room: This area provides space for surgical personnel to change before and after surgery. Lockers should be provided for short term storage of personal items. Consideration should be given to planning a janitor's closet (with a floor mounted mop sink) and a toilet room in this area.

Surgeon Scrub Room: This room shall have hands free direct access to the surgical suite/operating rooms. It should be equipped with a hands free scrub sink and disposable scrub brush dispenser. The scrub area shall be an isolated area, not utilized as a thoroughfare for animals or supplies.

Animal Surgical Prep Room: This area provides space for holding and preparing the animal subject for surgery. The room should have two separate doors to provide one way traffic flow into the surgical area and out to the general circulation/housing area. It should have direct hands free access to the operating suite/room. The prep room will be equipped with a procedure table, storage cabinet, stainless steel counter, sink, eyewash, with wall cabinets. A down draft table, as well as a wet prep table may be required. The prep room should have vacuum, a waste anesthesia gas scavenger line, compressed medical gas lines (i.e. oxygen, medical grade air, nitrogen, etc.) are required at each procedure table/location. A controlled access drug box should be considered in the prep room. There should be space for a refrigerator and a portable anesthesia unit.

Operating Room: This area provides space for surgical procedures on animals. In order to maintain a sterile environment, consideration should be given to a door lock system that will lock the operating room door from the outside if the door to the adjacent room is open. Compressed medical gases (i.e. oxygen, medical grade air, nitrogen, etc.), waste anesthesia gas scavenger units, and vacuum lines shall be provided. Overhead surgical lights and a double light box to view x-rays are suggested. Operating rooms are equipment intensive and require additional electrical outlets to support fixed and mobile equipment needs. All of the operating rooms should have easy access to a central fluid warming cabinet and contain a viewing window to the exterior surgical suite corridor.

Recovery Room: This area provides space for animals recovering from surgery and the effects of anesthesia. The recovery room/cubicle shall be designed to meet the requirements of non human primates or other large animal intensive or post operative recovery care. Each room or cubicle should be able to house one or more specialized environmental support units designed to provide a controlled environment (i.e. oxygen tension, humidity, temperature, etc.) or single cages or holding racks depending on the species to be accommodated. Ideally the room should have two doors to provide one way movement from the surgical suite and out to the general circulation to return the animal to its housing unit. The room or cubicle should be equipped with a bench top, sink and an oxygen line. Compressed medical gas, vacuum, as well as a refrigerator and drug storage areas is required. A controlled access drug box should be provided. Desk space should be provided for computer monitoring equipment and charting area.

Surgical Supply and Surgical Work Room: This room will provide space for surgical supplies and work space. It should have direct access to the operating room and the general circulation corridor. It will be equipped with lockable casework, sink cabinets, and sterilizers. The room is organized with one way flow from dirty to clean. Cleaning equipment such as sinks, washers, ultrasonic cleaners, and autoclaves are accessed from the dirty side, with instrument pack, prep, and storage on the clean side, toward the operating room. RO or DI water may be needed for instrument wash equipment. Clean steam is required for the sterilizers. The designer should evaluate the need for gas, heat and steam sterilizers/autoclaves within the facility. If EtO sterilizers are required, special exhaust must be provided.

G.6 Decontamination and Receiving:
This space is used to decontaminate the containers in which newly received animals and materials arrive so as to reduce the transfer of vermin or contamination from outside the facility. Animals may be transferred from their delivery containment unit into clean holding units at this location or they may be moved to the holding room to be transferred locally. If equipment or other materials will be chemically decontaminated in this area, consideration should be given to providing a grid floor with a chemical collection unit under the grid that can automatically neutralize the chemicals before they enter the sewage system. A large drain and hose bib with backflow preventer will be required for this space if materials will be chemically decontaminated. The space should be located between the animal loading dock and quarantine. It shall be equipped with a sink with eyewash, drain, hose bib with backflow preventer, desk and bench top. Adequate storage should be provided for both waste and clean equipment. Caretakers in rodent receiving areas may use temporary isolation cabinets to separate animals from different sources.

Vestibules: Vestibules should be located as required to prevent contamination of animal holding areas and clean areas of the animal facility, for sound isolation, and for security. Vestibules may be appropriate at the point of entry into the facility, into a suite of isolation rooms, between areas that hold different species or between animal and administrative areas. Doors are to be equipped with bristle type door sweeps. Consideration should be given to provisions for staff to gown/degown at entry vestibules. A cross over bench or pull down seat should be considered in gowning areas as well as space to store clean gowning paraphernalia and discard bins.

G.7 Cage Wash:
The cage wash houses equipment for cleaning and sanitizing animal cages, trays, lids, and water bottles. In addition, the cage wash area may house bedding disposal and bedding filling equipment and storage for clean bedding. During the planning phase, the method and route for feeding, bedding delivery and bedding disposal between the loading dock and the cage wash must be defined. Automated delivery and discard systems for bedding, food and waste are available and should be considered for large facilities. These systems may have special space requirements at the loading dock and in the cage wash area. The cage wash should be convenient to animal holding but distant from administration offices and personnel areas.

The cage wash equipment may include a bottle washer, a cage and rack washer, tunnel type washers, acid neutralization tanks, robotic equipment and an autoclave. The auto clave should be of sufficient size to contain full size or multiple cage racks. In some applications, a large, pass-thru autoclave with controls on both sides may be adequate to serve the needs of both the clean and dirty sides. This may eliminate the need for duplication of expensive capital equipment. The autoclave should be provided with "clean" steam to extend the useable life of the equipment. Provide sufficient space for maintenance needs to include exhaust of the mechanical space and sufficient lighting levels. The species housed in the facility, the capacity of the facility, the number of wash cycles per week, the number and duration of staff shifts, and redundancy/capacity of other washers determine the equipment type, size and complexity.

The cage wash area should be divided into a "dirty" side and a "clean" side. A third area containing the wash equipment should be considered in large cage wash operations between the clean and dirty sides. There should be no personnel access between the two sides. The sides may be divided by a glass or stainless steel partition with a telephone or paging system for communication.

Access to the dirty side should be through double doors opening in the direction of traffic. Automatic openers should be installed to control the doors. The doors should be impact resistant and have door sweeps. The dirty area must be designed for wash down activities. Linear space is needed to marshal incoming cages and racks; for dumping bedding; cage break down; emptying bottles and loading washers. The dirty area should be equipped with a sink, bedding dump station, waste disposal equipment, automatic water manifold flush station, chemical neutralization, pre-wash stall with a grid floor, a water fountain and emergency eyewash and shower. A pit may be required to prep or descale the racks and cages.

The clean area is equipped with a large autoclave, bedding dispenser, animal drinking water flush station, and water bottle filler. Linear space for marshalling is also required on the clean side. A unisex toilet room and water fountain should be provided in both dirty and clean areas. Both sides should be designed to promote proper cleaning and minimize pest harborage.

Cage and rack washers feature a chamber of sufficient size to accommodate two or more cage racks or large cages. The rack washer should be placed in a pit to eliminate the need for ramps. Pits must be surfaced with rustproof grating materials, easily accessible and cleanable. Separate pits shall be designed for equipment pit(s) and drip pit(s). Grating covered drip pits must extend into the clean area to allow the clean rack to drip dry (provide separation between the dirty and clean pits). The equipment pit should be sealed, and the space around the washing equipment should be sealed to form a complete barrier between the clean and dirty sides of the cage wash area. The tunnel washer transports cages on a continuously moving conveyor through a pre-rinse, detergent wash, rinse, final freshwater rinse, and drying sequence. These units are also suited for water bottles, small cages, and other small equipment. There should be a minimum of 1.2 m (4’-0”) clearance around the tunnel washer for maintenance. A common enclosed equipment service space must be provided between the clean and dirty side to provide for cage wash equipment maintenance. Noise exposure to personnel must be considered when selecting cage rack washers. An operating noise level of 85 dBa should not be exceeded.

Efficiency of water usage must be considered in planning, as this will impact the type of equipment purchased. Some water used in the rinse process may be recycled. Water may have to be treated to eliminate chemical and mineral deposits. Acid neutralization, depending on the size of the facility, may be required and should be considered during the planning phase.

There is a trend towards robotizing some or all of the cage wash functions in larger facilities. The facility has to have sufficient through put to warrant the cost of robotic equipment. Safety walls must separate the areas where people enter the robotic area from the actual equipment. Redundancy should be considered when designing a robotic cage wash facility. Consideration should be given to having one robotic cage wash line and one conventional cage wash line. Provide enough linear queuing space on both “clean” and “dirty” sides. A robotic cage wash requires a marshalling area, conveyor belts, a bedding dump station, an automated cage handler, an index tunnel washer, a cage and rack washer for larger or non standard size cages, a steam sterilizer, bedding dispenser, bottle filling station, and other equipment associated with the robotic system. Additional robotic systems options such as dust control equipment may be considered.

All materials and finishes should be moisture resistant, sealed. Finishes in the cage wash area should stand up to frequent high pressure water cleaning. The type of equipment used in a cage wash will require electrical source, high temperature, high volume water, and large quantities of clean steam. The HVAC requirements of the cage wash area must be carefully evaluated to ensure the safety and comfort of the personnel working in this environment.

Storage: Adequate storage space must be planned for clean cage racks, bedding and feed, any special clothing and supplies, cleaning chemicals, husbandry supplies, and procedure room supplies and equipment. Storage for chemicals and detergent drums shall be located away from heavy traffic zones. Wire mesh shelving is recommended.

Cage/Rack Repair Room/Shop:
A cage/rack repair room is used primarily for large animal equipment and should be located near the large animal holding area and near the large animal cage wash entry. Equipment will be repaired and will then need to be washed. The repair shop does not have to be within the confines of the animal holding area although it is desirable to have it within the facility. Adequate electrical outlets should be provided for shop equipment. Task lighting may be required. Bench top space is required.

Feed and Bedding Storage:

This area will provide space for bulk storage of feed and bedding. Calculate feed and bedding storage for the "worst case scenario" of the species that the facility may have to accommodate and protect storage space from being "squeezed out" of the facility

Laundry:
Clean linen, either from within the facility or from a commercial laundry is distributed though the receiving office to locker rooms and gowning rooms. Based on program requirements, a laundry area may need to be provided within the animal facility. Space must also be provided to accommodate receiving clean linens if laundry is serviced outside the animal facility.

Feed/Diet Preparation Room:
Many animals require special diets. The feed preparation room shall have sinks with heavy duty garbage disposal and drain boards to wash and sanitize fresh produce. Shelving and storage cabinets are also required. One or more commercial size refrigerators and freezers will be required for food storage. An icemaker may also be required. Counter tops with adequate electrical outlets should be provided for "standard kitchen" equipment such as blenders and hot plates to prepare the food.
Cold Storage for Animal Carcasses: Both the necropsy room and the loading dock require some form of cold storage to hold animal carcasses for examination and for disposal. A refrigerator is adequate for storage of small animals but a walk in cold storage room will be required for larger animals, located at the loading dock. The room should have open mesh or slat stainless steel shelves. The floor should have a drain and a lip at the door to contain any fluid spills. Separate storage facilities must be provided to house animal carcasses that contain radioactivity. These storage facilities must not have floor drains. If animal carcasses or remains contain radionuclides they are handled like other radioactive materials.

Equipment Storage:
This area will provide space for shelves to store equipment.

G.9 Animal Caretaker:
Rooms for animal caretakers shall be provided in a transitional zone between the animal zone and the administrative areas so caretakers do not need to degown for convenience functions. Transitional areas include break rooms and gowning areas.

Break Rooms:
Break rooms serve as interaction space for the animal facility staff. They should be located in the vicinity of the administration and changing areas, have a comfortable atmosphere, and be equipped with chairs, tables, bookcases, counter, microwave, ovens, refrigerator, vending machines, white boards, tack board and space for time cards if required. Trash and recycling receptacles should also be provided.

Gowning Areas: Locker, toilet, sinks and showers shall be provided for gowning prior to entering animal holding areas and for degowning after leaving the animal holding areas. Sufficient space is required for storage of protective clothing. A crossover bench or pull down seat shall be provided as well as a sanitizable display case. These rooms shall be equipped with individual full size lockers for staff. The locker must provide for the storage of clean facility scrubs and facility specific shoe storage. Space for hanging street clothing (jackets, sweaters etc) prior to gowning shall be provided. There should be a place to collect soil laundry, to plug in hair dryers, storage shelving, a mirror and lighting. Material and finishes selected shall be antimicrobial. These spaces must be designed and constructed using moisture resistant materials and wall hung fixtures to allow for ease of cleaning. If PAPRs or cartridge respirators are used in the facility, then a decon station, changing station, and storage must be provided

Locker Rooms:
Locker rooms with toilets, sinks, showers, and lockers shall be provided for staff to change in and out of uniforms. These rooms require finishes identical to vivarium finishes and shall have independent circulation routes for the varied types of access required. Provide the following:

- Adequate number of lockers to meet anticipated staffing requirements, sized to provide adequate storage for personal possessions. They shall have bulkheads or sloped tops, filler panels, perforated door panels, and solid (grouted) bases.
- Benches, open storage for facility footwear, space to hang clean uniforms and space for hampers.
- Showers with vanity alcoves with small shelf and bench.
- Adequate number of toilets and sinks for anticipated staff size, complete with countertops, mirrors, vanity lighting, electrical for electrical receptacles for hand dryers and automatic paper towel dispensers.
- A dry vanity area including full length mirror vanity lights; shelf and electrical outlet may be considered.

Space should be provided for copying machines, FAX machines, files, shelves and other routine office equipment. In addition, space is required for central computer systems. This area does not have the stringent air change requirements that the animal holding areas have. File rooms should be located in the Animal Facility Office area. File rooms should be lockable.

Conference Rooms/Training Rooms:

Conference rooms/training rooms should be provided for formal and informal meetings of staff and for periodic training. Conference areas shall be utilized on a shared basis and be designed in accordance with National Fire Protection Association (NFPA) occupant loads. Conference rooms should be equipped to accommodate flexible seating arrangements. There should be white boards, electrical connections for audio visual equipment, a screen, and adjustable overhead lighting, data and telephone lines.

Reception Area:
In light of heightened security, the animal facility should have a central reception area where guests and vendors can be met and directed appropriately. The reception area should be located as close to the main entrance of the facility as possible. It should have a reception desk, chairs and low tables.

Housekeeping Closets:
The animal facility must be equipped with appropriate sized housekeeping closets located throughout the facility to adequately serve its needs. A housekeeping closet must be provided with both supply air and exhaust to reduce humidity and control odors. Closets should be fitted with wire mesh shelving, mop and broom hangers, a mop sink and adequate lighting. Closets should be sized to hold cleaning supplies and equipment only. The interior of the closet must be finished with materials and surfaces that are cleanable, moisture resistant and durable.

H.1 Public Zones:
Public zones include public corridors and elevators, multiuse loading docks, supply rooms, laboratories outside of barrier areas, and areas where staff wear street clothes. Public zones are categorized as “dirty” because there is no control of potential animal contaminants in these areas.

H.2 Transitional Zones:
Transition zones are defined as areas of movement between public areas and animal holding and procedure areas or between zones housing different animal species that could potentially transmit diseases between each other if they were in close contact. Transitional zones may include airlocks, gowning areas, locker rooms, feed and storage areas, and dedicated “clean” and “dirty” animal elevators.

H.3 Specific Pathogen Free (SPF) Zones:
SPF zones refer to areas where animals are free of defined diseases. The degree of SPF may vary in different parts of the facility just as the degree of “clean” and “dirty” may vary. The level of SPF and “clean”/“dirty” will be defined by the veterinarians and the users of the facility. Most housing/holding areas are located in the SPF zone. An exception to this occurs when “dirty” animals (non defined disease status) are needed for the research. A separate housing area that contains isolation housing and/or has an airlock shall be provided for this purpose.

H.4 Contaminated Zones:
Contaminated zones are areas where dead or infected/diseased animals are located or where “dirty” equipment is transported or stored. There are instances where conventional housing is required for “dirty” animals such as a quarantine room or an area of the facility specifically for research using “dirty” (non SPF) animals. Circulation routes must be closely examined in these situations so as to minimize cross contamination of SPF animals. Physical barriers and air pressure relationships shall be designed to minimize cross contamination.

“Dirty” corridors are those used for moving soiled cages and materials to the “dirty” side of the cage wash facility. Rooms where necropsies or perfusions (terminal procedures) are performed are defined as “dirty”. A single corridor system can be managed so as to provide the desired degree of cleanliness and species separation defined by the facility program.

H.5 Zone Relationships:
Early in the planning process, the Project Officer and the Programmer should work with the facility representatives to prepare a POR that includes functional and adjacencies flow charts that will facilitate the design process. In addition to impacting the ease of doing animal model based science, the arrangement of critical adjacencies will greatly impact the quality of life of the animals, the caretakers, and the veterinarians. Appropriate adjacency planning shall mitigate interference from noise and vibrations, economize circulation routes, and maintain the appropriate degree of cleanliness of the facility.

Within the animal research facility and the loading dock, the flow of materials, cages, animals, and personnel shall be accommodated in an efficient and economical manner. Adjacencies shall be planned to maximize operational efficiencies, minimize travel distances and maintain zonal relationships. It is also essential that designs consider adjacencies based upon the variety of species that are anticipated for the animal research facility.

H.6 Circulation of People, Animals and Materials:
Circulation space is a critical factor in controlling contaminants and enhancing operations and procedures within the animal research facility. Planning of circulation focuses on the movement of cages and racks in the facility. Most importantly, during the planning, phase the design

team decides the extent to which the corridor system helps manage the potential for contamination and to what extent management dictates certain protocols of time and direction of movement. Personnel, equipment and supplies should move from areas of least contamination to areas of greater contamination. Movement of personnel, equipment and supplies should be planned to minimize the potential for contamination of cleaner areas. Consideration should be given to the equipment and areas required to permit circulation of supplies, personnel and equipment. For example, autoclaves located near the dirty cage wash permits the circulation of contaminated caging back into the cage wash area. Convenient location of locker rooms and shower facilities in many cases permits personnel to move from dirtier areas back into cleaner situations. Consideration should be given to directional airflow and odor control.

H.7 Corridors:
Commonly accepted circulation systems include a single corridor, a dual clean and dirty corridor, or a single corridor with unidirectional flow.

Single Corridor System:
In single corridor scheme traffic flow is in both directions between the animal holding room and the cage wash area. The most significant advantage of a single corridor system is its efficiency of space utilization. The disadvantage is the potential for cross contamination in the corridor when clean and soiled cages share space. Congestion caused by moving animals, cages, and supplies through a single corridor is also problematic. Contact between clean and dirty materials can be minimized by carefully scheduling pickups and deliveries, covering cages when moving them, and by using a unidirectional circulation system. With this management technique, congestion and contamination can be minimized. Single corridor systems shall be equipped with appropriately placed air locks and doors to maintain the desired level of facility air pressurization relationships, a level animal sanitation and security. Placement of airlocks must be discussed with users. Doors should be powered operated should have controlled access where necessary.

Dual Corridor System:
Contamination control is the primary rational for choosing a dual corridor system. The dual corridor system has animal holding rooms leading to two separate corridors that are dedicated clean and dirty corridors for the movement of cages. The flow of cages is unidirectional and may involve two single loaded corridors in a small facility, one double loaded and two single loaded corridors in a larger facility. Dual corridors are not an efficient use of space and will increase the gross to net ratio.
Corridor Width: Corridor width should be dependent on the flow of traffic within the animal facility and the amount of storage that will be available in or near the facility. The Guide recommends a corridor width of 1 825 mm (6’-0”) – 2 450 mm (8’-0”) but 3 050 mm (10’-0”) - 3 650 mm (12’-0”) wide corridors allow for more flexibility in circulation in larger facilities. Two animal cage racks or pieces of the largest mobile equipment must be able to pass each other without restriction in the corridor. Sufficient storage must be designed in or near the facility so that equipment does not have to be stored in the corridors. Marshalling alcoves for racks and carts should be provided so that corridors are kept free of this equipment. The corridor corners should be rounded. Wall and corners shall have physical protection.

H.8 Vertical Circulation-Elevators:
In multilevel facilities, dedicated clean and dirty animal elevators are required. The elevator for transporting clean material should be located near the clean side of the cage wash area, while the elevator used for soiled material should be in close proximity to the soiled side of the cage wash area. The elevator size and location must accommodate the volume of materials to be handled in the cage wash, animal and material receiving, and waste removal areas. Elevators that will be used for transport of animals and animal facility equipment must be constructed of highly durable and cleanable materials. The elevator cab floor material must be of the same material as the floor in the animal facility. The elevator car interior should have guardrails at appropriate heights for the typical racks and carts that will be used in the facility. Elevator doors must be of sufficient height to accommodate the tallest racks that will be used in the facility. Consideration should be given to an elevator door width that can accommodate at least two racks side by side. At least one elevator should have the capacity to handle extremely heavy loads if, for instance, an irradiator is planned in the facility on a level below the loading dock level of the building. There should be adequate redundancy in the number of elevators to handle freight, staff and animals in the case of an equipment breakdown.

H.9 Security:
The objective of security in an animal research facility is to ensure the safety of the animals, staff, equipment, and data. At NIH owned or leased facilities; the site is the first level of security. The site may be open to the public or it may have controlled access depending on the location. The second level of security is the building. Access to the building must be managed. Air intakes and any central utilities must be safeguarded from intruders. The third level of security is the access to the animal research facility. Administrative staff, research and veterinary staff, maintenance staff and vendors will require access to the animal research facility. A controlled point of entry is required prior to entering the vivarium.

Security features must also be provided for the loading docks and service entries for the animal facility. Finally, the fourth level of security is the specific animal rooms, containment suites, surgical suites, pharmacy, or other areas within the animal facility with a higher level of controlled access and surveillance. Design an internal facility system to limit/control access to animal holding rooms and other areas. The A/E shall coordinate security requirements with DPSM.

H.10 Vivarium Loading Docks:
Refer to Section 3-3-10-C: Loading Docks, Delivery and Service Areas: The loading dock that services a building with an animal facility should include a dedicated bay for animal and material receiving and waste removal. The animal care loading dock must be viewed as an extension of the animal care facility. Excluding pests and creating conditions that promote proper sanitation, at this location, are imperative to maintaining a pest free facility that meets or exceeds AAALAC Guidelines. To achieve these desired goals of pest exclusion and good sanitation, the dock facility must be: properly sited, constructed of durable; cleanable materials; sized to meet current and future program needs; allow for some flexibility in use; and create an effective barrier between the outside and the clean environment of the animal care facility. The animal receiving loading dock should include:

• A dedicated animal facility bay that is visually protected for security. The dock must be physically segregated form other dock space and dock functions. This includes vehicle docking and material/supplies staging space.
• A receiving vestibule that is temperature and humidity controlled to protect valuable research animals. Overhead doors should be fitted with proper sweeps, gaskets, and brushes to exclude insects and rodent pests around the perimeter of the entire door. These doors and doorframes must provide an effective seal, when closed, to exclude insect and rodent pests. The loading dock doors should be equipped with air curtains or other similar devices to exclude flying insects and to create a dust and dirt barrier when the receiving or personnel doors are opened.
• A dedicated route of transportation into the animal facility if possible
• A large pass through autoclave if bedding is to be sterilized at the loading dock
• An area to decontaminate the animal containers before they enter the animal facility. The decontamination area can be at the loading dock or at the point of entry to the animal facility. The interior surfaces should be covered with materials that facilitate proper sanitation and ease of cleaning as is necessary in an animal care facility. These materials must be durable enough to withstand regular cleaning and disinfection. Facilities must be available for loading dock wash down and cleanup. Floor drains should not be designed into the receiving area of the loading dock.
• A cold storage room for animal carcasses.
• The dock entry points, e.g., materials receiving or personnel must be isolated from solid waste compacting, handling and storage operations. Solid waste operation can be attractive to pest species that are invasive to the facility.
• Recycling containers should not be sited on or near an animal facility loading dock. Waste should not be staged for removal inside the receiving area of the loading dock.
• There should be no exposed conduit, piping, ledges, wall mounted lights, etc. These provide perching and nesting sites for nuisance birds and are difficult to clean.
• Wall, corner and door guards should be of a type used inside the animal care facility, i.e., stainless steel, sealed at installation.
• An animal receiving room.
• Electrical service should be provided on all walls of the receiving area and the elevator lobby to power electric light traps for pest exclusion.
• Empty conduit and back box system for an audio visual communication device at the animal receiving area with a minimum of two remote points within the vivarium.
• Electric pest control devices.
• Lighting should be indirect to the loading dock to reduce attraction of flying insects. Do not use wall mounted lighting. Do not install lights directly above receiving or personnel doors.
• Provide a dedicated animal loading dock manager’s office
• Bulk chemical storage
• Gas cylinder storage

If animal bedding exits the building via a chute system, the loading dock configuration shall accommodate a front end container. Provide a container (compactor or dumpster) with an ability to be connected by a chute. On the “dirty” side of the loading dock, provide a concrete pad and guardrails matching up to the dumpsters, and provide a water source 10 meters away from the loading dock. Space shall be provided for a dedicated compactor for vacuum bedding disposal system.

End of Report