GBRMC

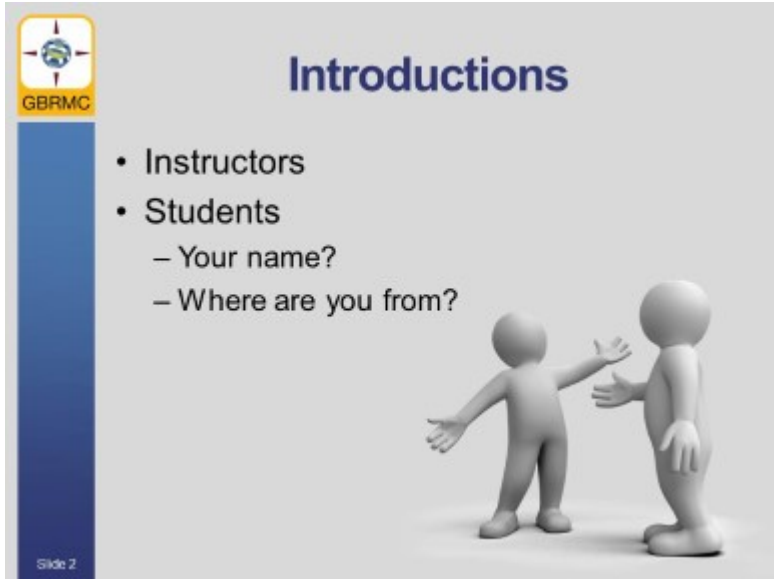
Laboratory Design Best Practices

Student Guide

2013

GLOBAL BIORISK MANAGEMENT CURRICULUM


Laboratory Design Best Practices
GLOBAL BIORISK MANAGEMENT
CURRICULUM
GBRMC


GBRMC
Introductions
• Instructors
• Students
– Your name?
– Where are you from?
Slide 2

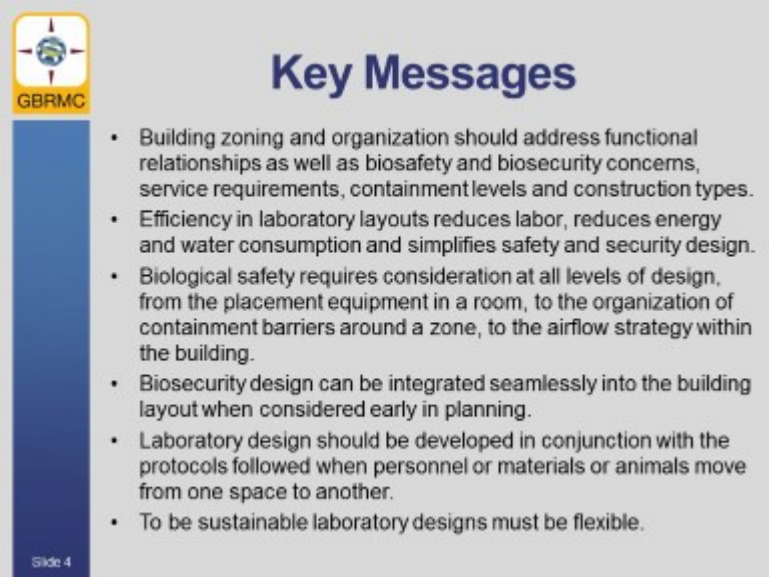
Action Plan

By the end of this lesson, I would like to:					
KNOW		FEEL		BE ABLE TO DO	

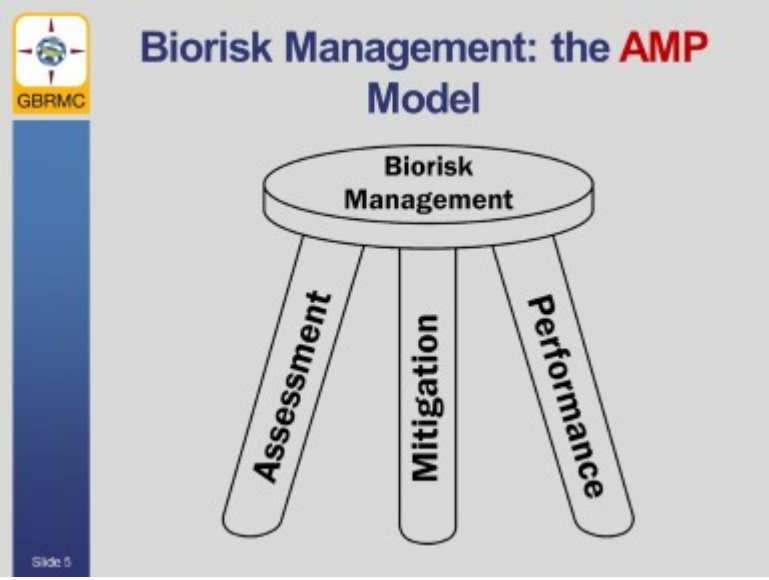
Your learning doesn't stop with this lesson. Use this space to think about what else you need to do or learn to put the information from this lesson into practice.

What more do I need to know or do?	How will I acquire the knowledge or skills?	How will I know that I've succeeded?	How will I use this new learning in my job?

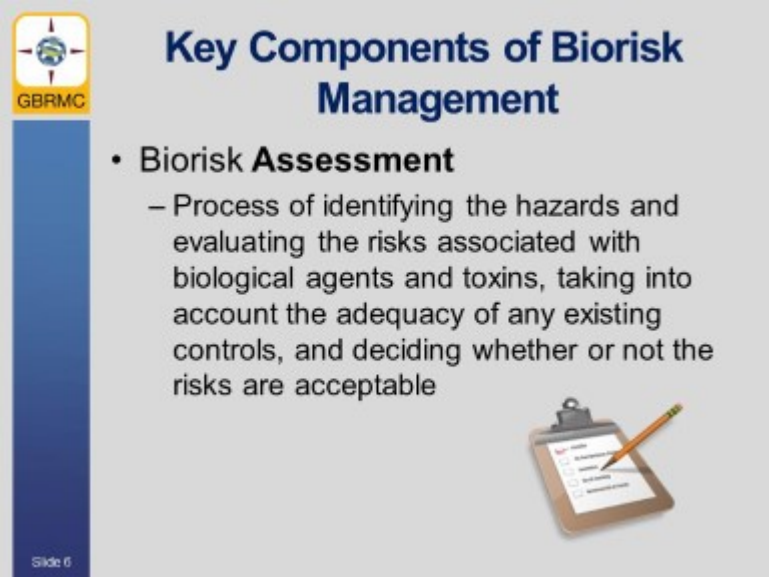
Use space on back, if needed


GBRMC
Key Messages
• Building zoning and organization should address functional relationships as well as biosafety and biosecurity concerns, service requirements, containment levels and construction types.
• Efficiency in laboratory layouts reduces labor, reduces energy and water consumption and simplifies safety and security design.
• Biological safety requires consideration at all levels of design, from the placement equipment in a room, to the organization of containment barriers around a zone, to the airflow strategy within the building.
• Biosecurity design can be integrated seamlessly into the building layout when considered early in planning.
• Laboratory design should be developed in conjunction with the protocols followed when personnel or materials or animals move from one space to another.
• To be sustainable laboratory designs must be flexible.
Slide 4

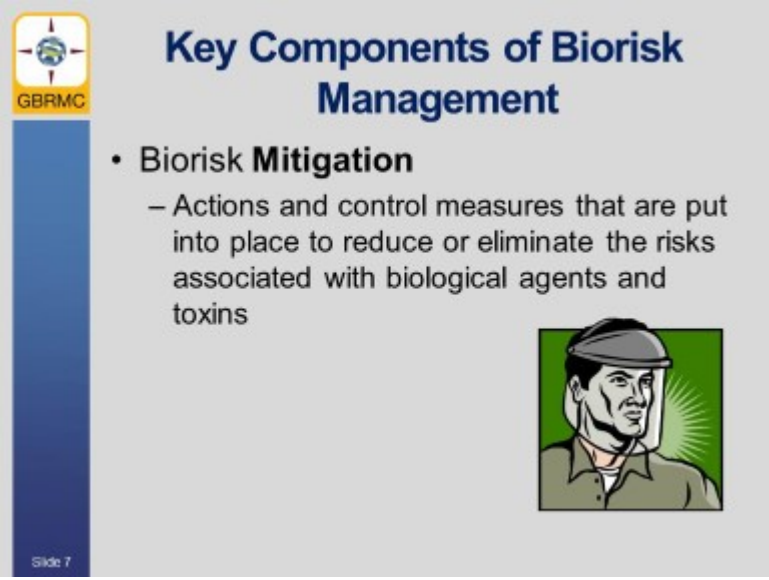
Notes:


GBRMC
Biorisk Management: the AMP Model
Biorisk Management
Assessment
Mitigation
Performance
Slide 5

Notes:


GBRMC
Key Components of Biorisk Management
• Biorisk **Assessment**
– Process of identifying the hazards and evaluating the risks associated with biological agents and toxins, taking into account the adequacy of any existing controls, and deciding whether or not the risks are acceptable
Slide 6

Notes:


GBRMC
Key Components of Biorisk Management
• Biorisk **Mitigation**
– Actions and control measures that are put into place to reduce or eliminate the risks associated with biological agents and toxins
Slide 7

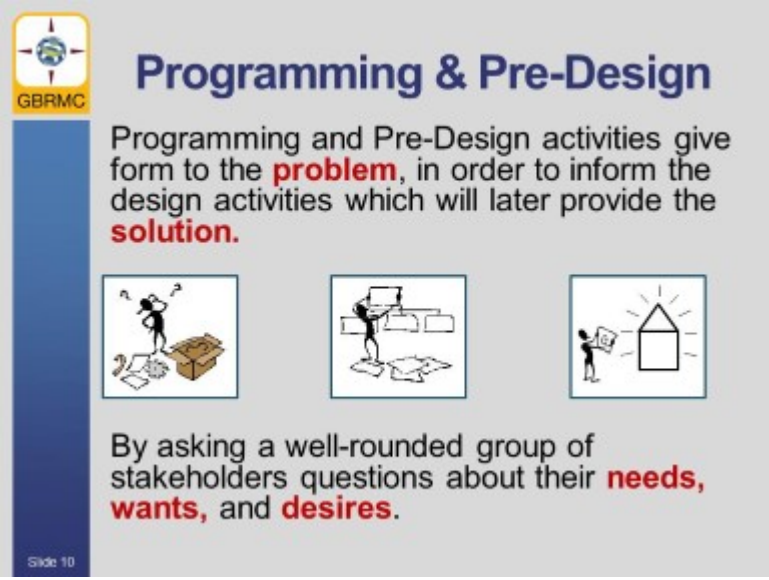
Notes:


GBRMC
Key Components of Biorisk Management
• Biorisk **Performance**
– Improving biorisk management by recording, measuring, and evaluating organizational actions and outcomes to reduce biorisk.

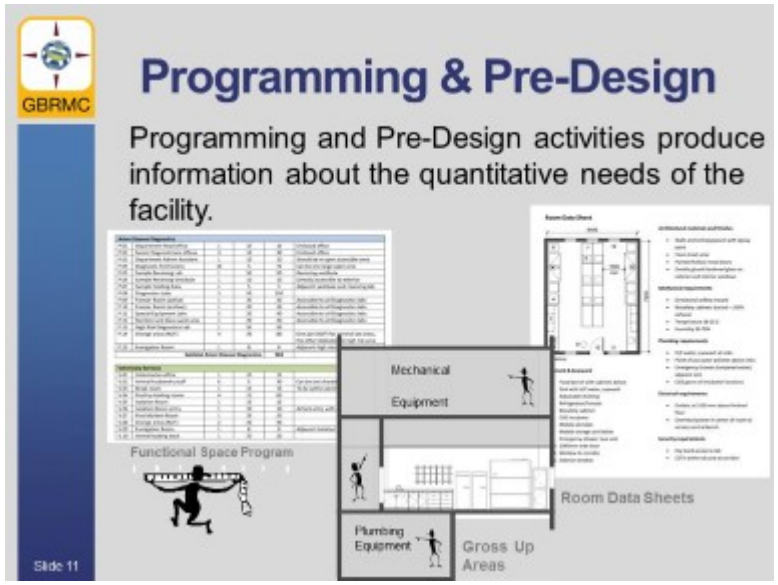
Notes:


GBRMC
Laboratory Design Best Practices
This course is designed to aid in Biorisk Management by promoting good bioscience lab design practices.
Slide 9

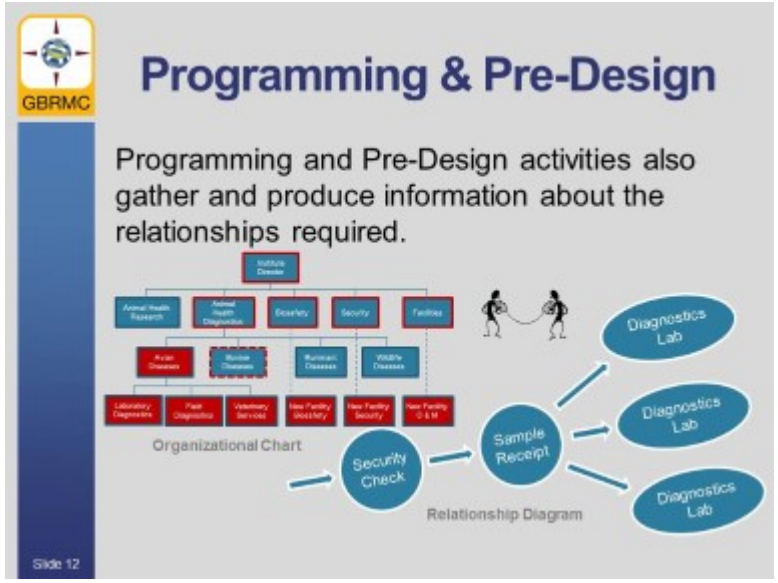
Notes:


GBRMC
Programming & Pre-Design
Programming and Pre-Design activities give form to the problem, in order to inform the design activities which will later provide the solution.
By asking a well-rounded group of stakeholders questions about their needs, wants, and desires.
Slide 10

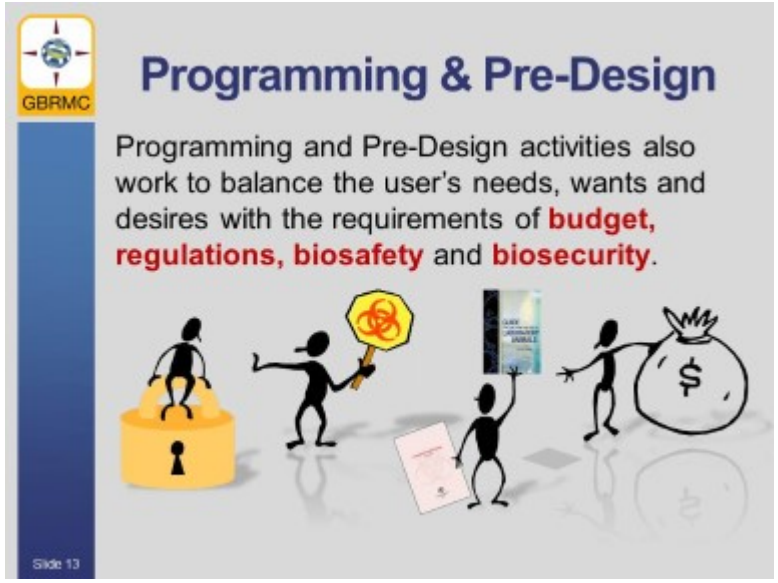
Notes:


GBRMC
Programming & Pre-Design
Programming and Pre-Design activities produce information about the quantitative needs of the facility.
Functional Space Program
Mechanical Equipment
Room Data Sheets
Plumbing Equipment
Gross Up Areas
Slide 11

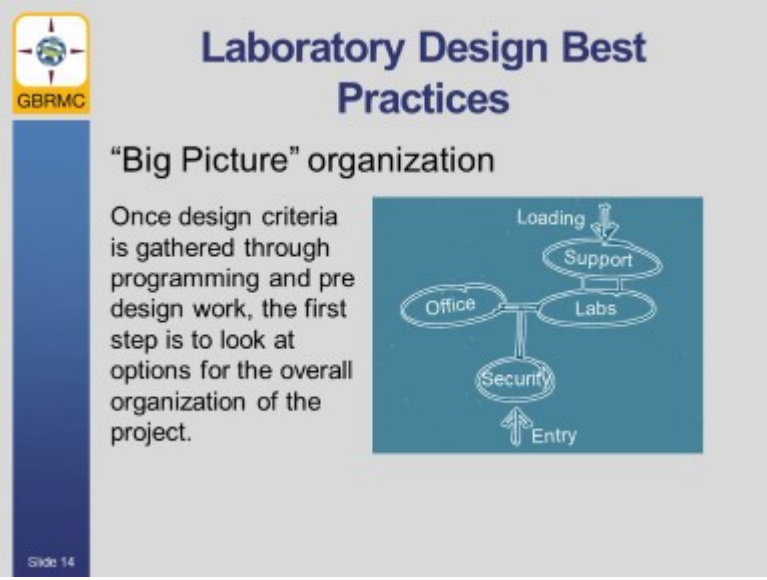
Notes:


GBRMC
Programming & Pre-Design
Programming and Pre-Design activities also gather and produce information about the relationships required.
Organizational Chart
Security Check
Sample Receipt
Diagnostics Lab
Diagnostics Lab
Diagnostics Lab
Relationship Diagram
Slide 12

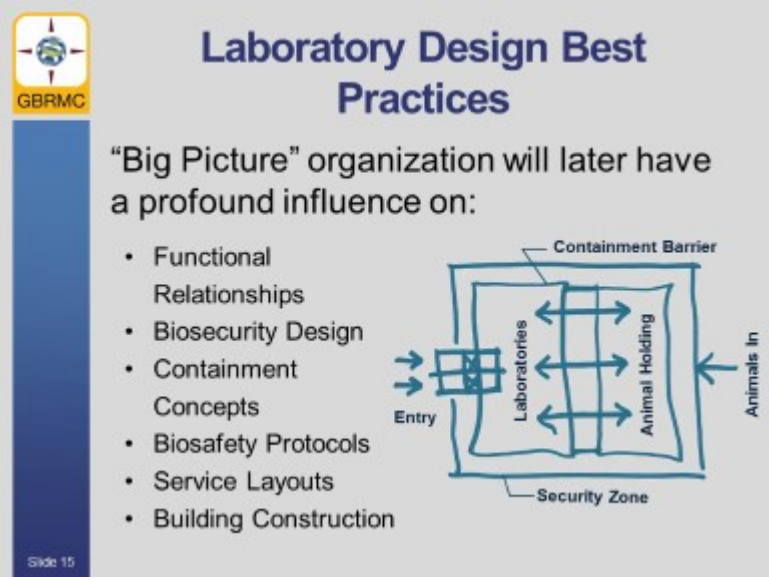
Notes:


GBRMC
Programming & Pre-Design
Programming and Pre-Design activities also work to balance the user's needs, wants and desires with the requirements of budget, regulations, biosafety and biosecurity.
Slide 13

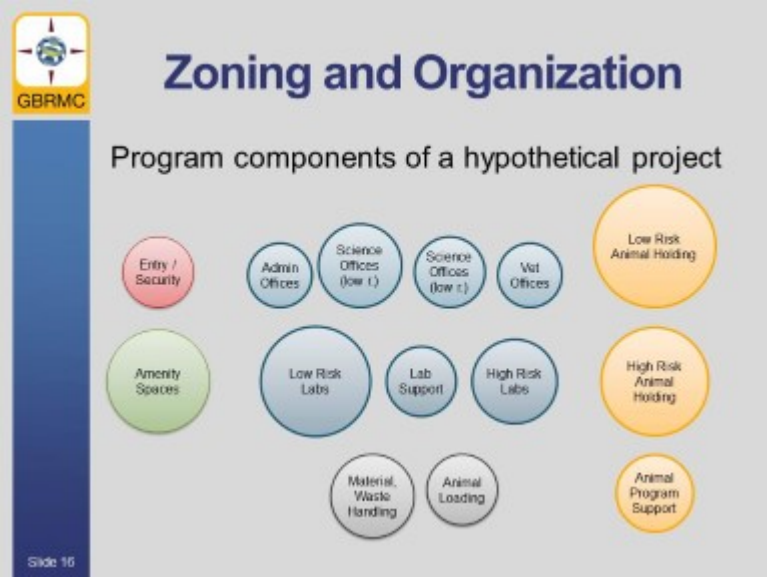
Notes:

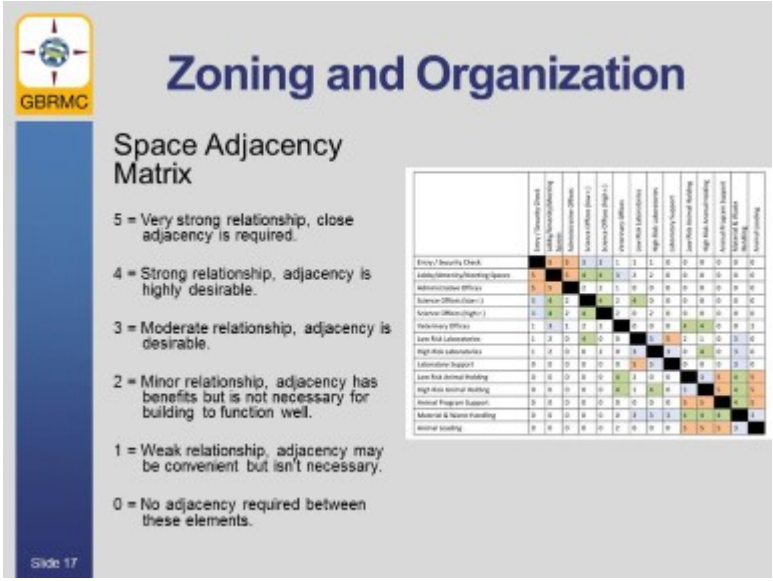

GBRMC
Laboratory Design Best Practices
"Big Picture" organization
Once design criteria is gathered through programming and pre design work, the first step is to look at options for the overall organization of the project.
Loading
Support
Office
Labs
Security
Entry
Slide 14

Notes:


GBRMC
Laboratory Design Best Practices
"Big Picture" organization will later have a profound influence on:
• Functional Relationships
• Biosecurity Design
• Containment Concepts
• Biosafety Protocols
• Service Layouts
• Building Construction
Containment Barrier
Entry
Laboratories
Animal Holding
Animals In
Security Zone
Slide 15

Notes:


GBRMC
Zoning and Organization
Program components of a hypothetical project
Entry / Security
Admin Offices
Science Offices (low r.)
Science Offices (low r.)
Vet Offices
Low Risk Animal Holding
Amenity Spaces
Low Risk Labs
Lab Support
High Risk Labs
High Risk Animal Holding
Material, Waste Handling
Animal Loading
Animal Program Support
Slide 16


GBRMC
Zoning and Organization
Space Adjacency Matrix
5 = Very strong relationship, close adjacency is required.
4 = Strong relationship, adjacency is highly desirable.
3 = Moderate relationship, adjacency is desirable.
2 = Minor relationship, adjacency has benefits but is not necessary for building to function well.
1 = Weak relationship, adjacency may be convenient but isn't necessary.
0 = No adjacency required between these elements.
Slide 17

GBRMC

Zoning & Organization Exercise

Group Exercise:

We will now see **3 organizational diagrams** based upon the program components and the desired adjacencies we have been given.

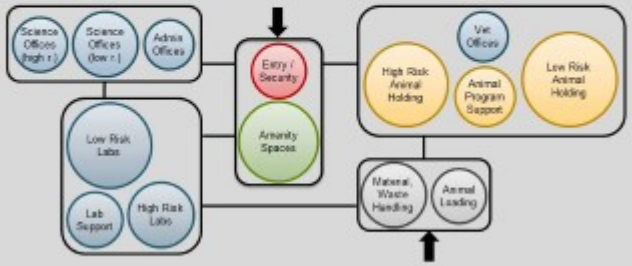
Your group will then analyze these and discuss what you think are the most **important criteria** for judging their **success or failure**.

Slide 18

GBRMC

Zoning and Organization

Zoning Diagram 1 -Lab and animal areas grouped separately

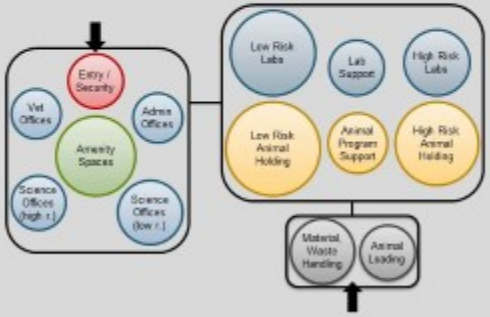


Slide 19

GBRMC

Zoning and Organization

Zoning Diagram 2 - Bioscience spaces consolidated

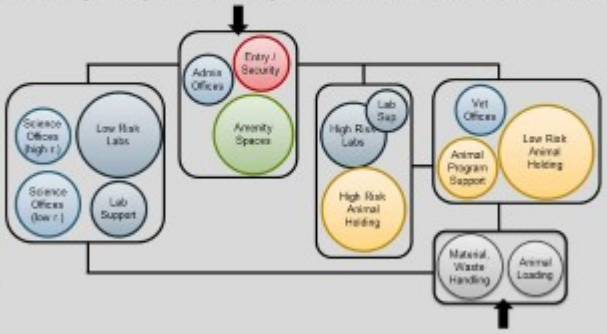


Slide 20

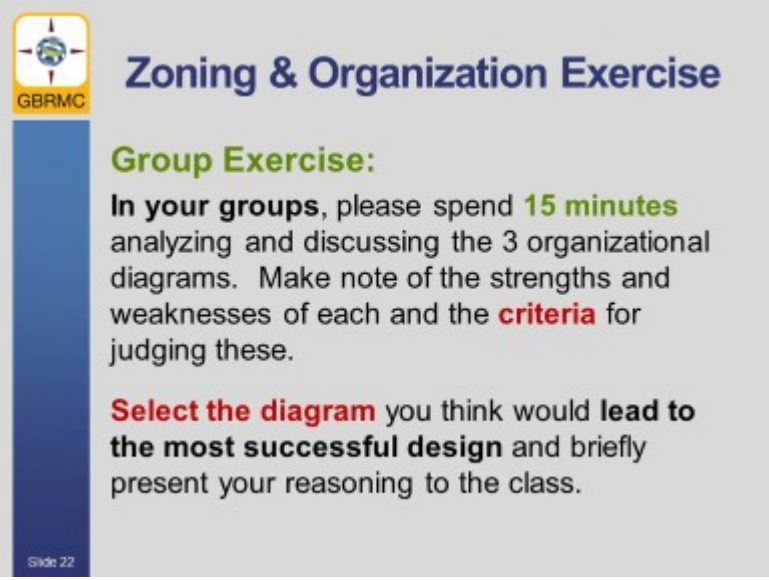
GBRMC

Zoning and Organization

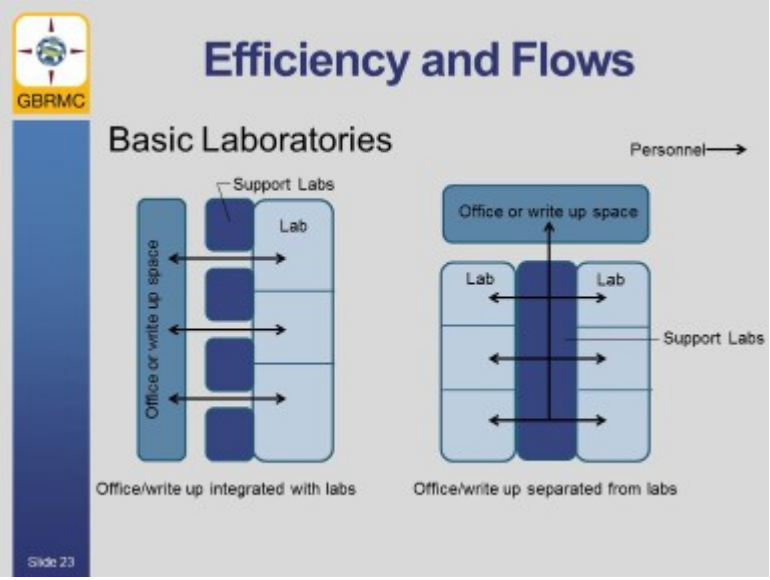
Zoning Diagram 3 - Higher Risk Areas Consolidated



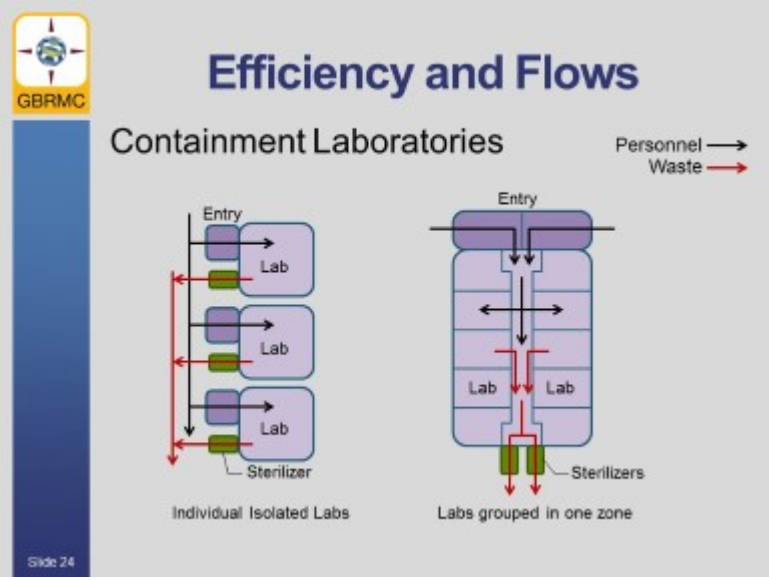
Slide 21



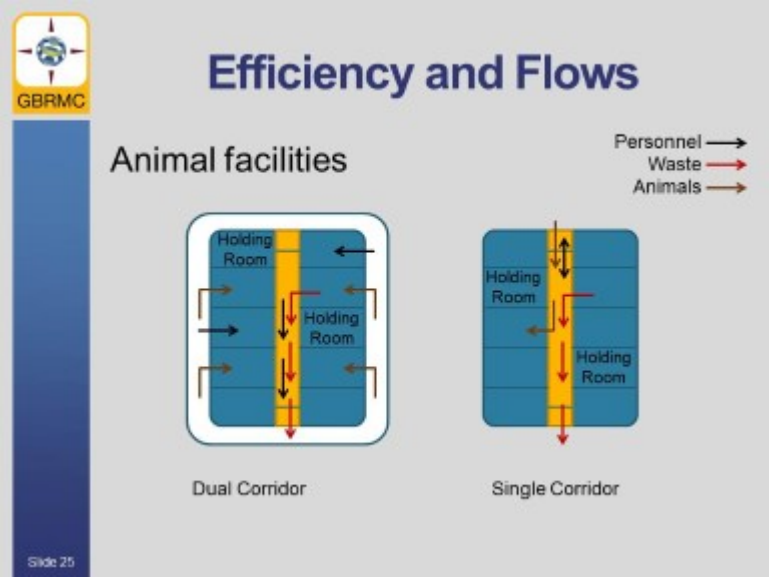
Make note of the criteria you use for judging the strengths and weaknesses of the organizational diagrams.


GBRMC
Efficiency and Flows
Basic Laboratories
Personnel
Support Labs
Lab
Office or write up space
Office or write up space
Lab
Lab
Support Labs
Office/write up integrated with labs
Office/write up separated from labs
Slide 23

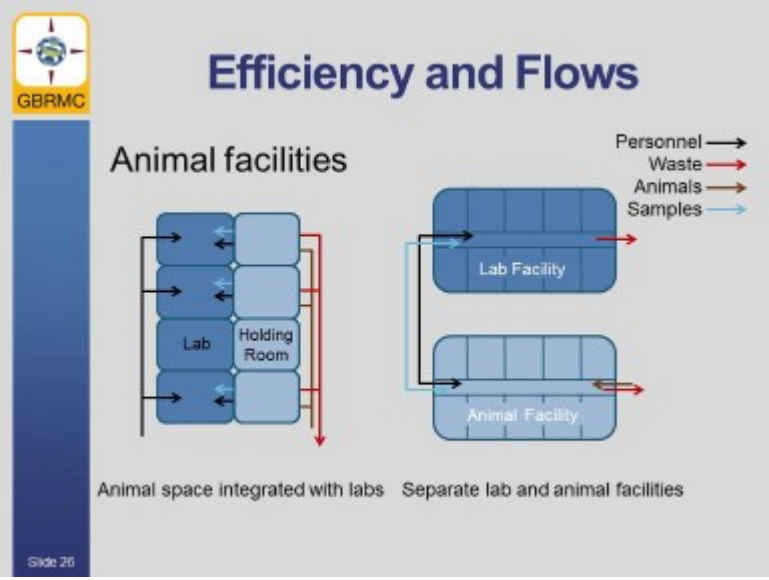
Notes:


GBRMC
Efficiency and Flows
Containment Laboratories
Personnel
Waste
Entry
Lab
Lab
Lab
Sterilizer
Individual Isolated Labs
Entry
Lab
Lab
Sterilizers
Labs grouped in one zone
Slide 24

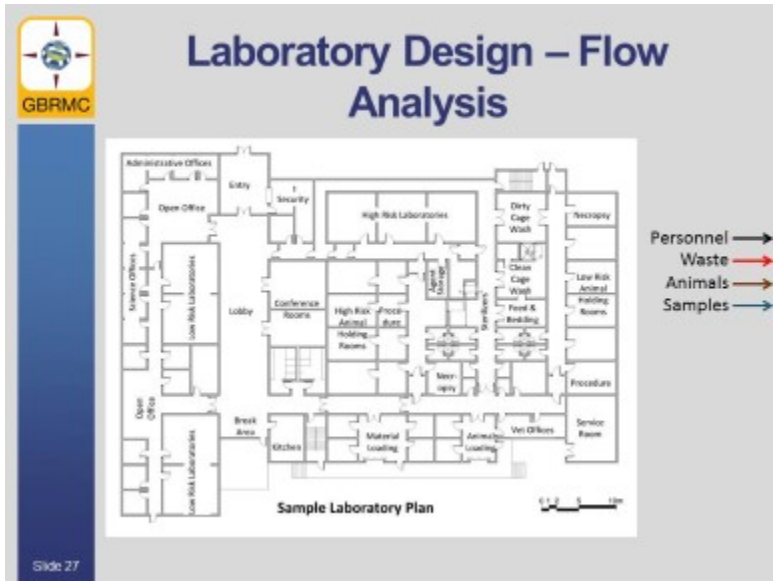
Notes:

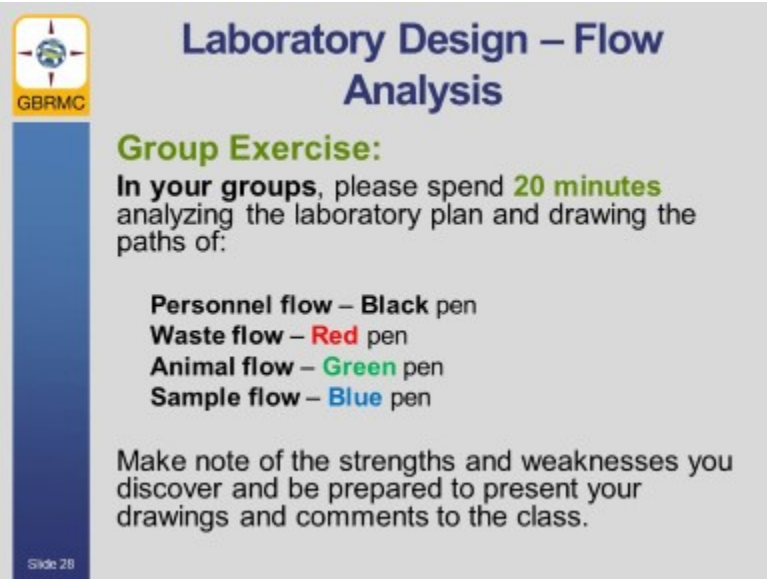

GBRMC
Efficiency and Flows
Animal facilities
Personnel
Waste
Animals
Holding Room
Holding Room
Holding Room
Holding Room
Dual Corridor
Single Corridor
Slide 25

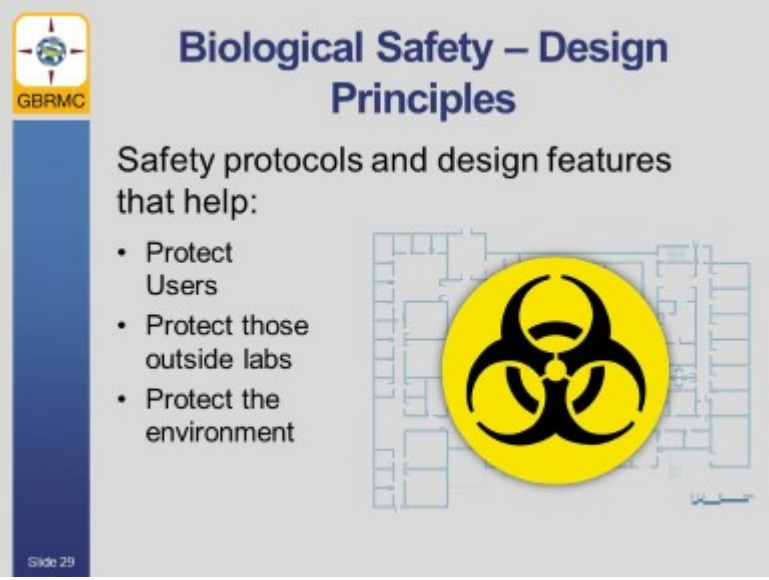
Notes:


GBRMC
Efficiency and Flows
Animal facilities
Personnel
Waste
Animals
Samples
Lab
Holding Room
Lab Facility
Animal Facility
Animal space integrated with labs
Separate lab and animal facilities
Slide 26

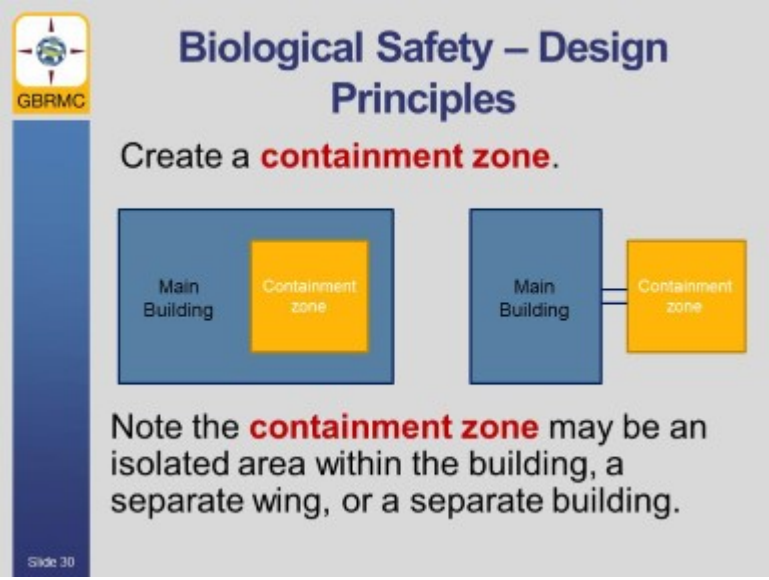
Notes:


GBRMC
Laboratory Design – Flow Analysis
Personnel
Waste
Animals
Samples
Sample Laboratory Plan
Slide 27


GBRMC
Laboratory Design – Flow Analysis
Group Exercise:
In your groups, please spend 20 minutes analyzing the laboratory plan and drawing the paths of:
Personnel flow – Black pen
Waste flow – Red pen
Animal flow – Green pen
Sample flow – Blue pen
Make note of the strengths and weaknesses you discover and be prepared to present your drawings and comments to the class.
Slide 28


GBRMC
Biological Safety – Design Principles
Safety protocols and design features that help:
• Protect Users
• Protect those outside labs
• Protect the environment
Slide 29

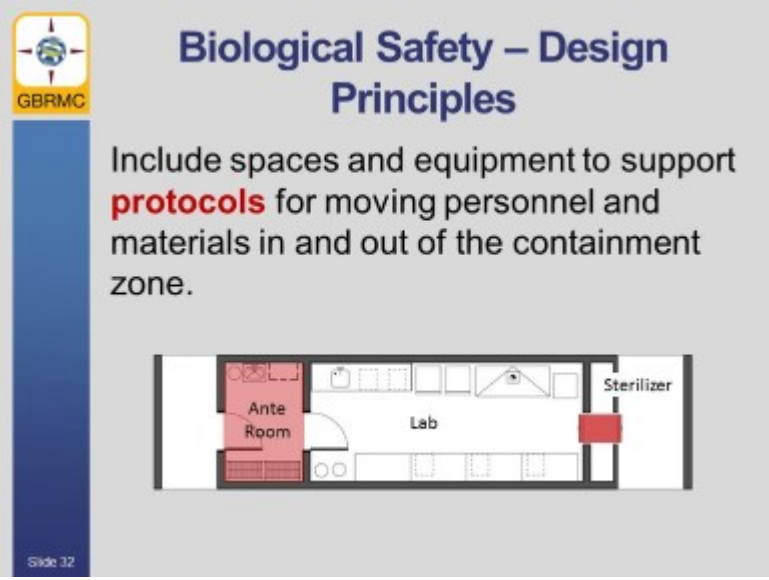
Notes:


GBRMC
Biological Safety – Design Principles
Create a containment zone.
Main Building
Containment zone
Main Building
Containment zone
Note the containment zone may be an isolated area within the building, a separate wing, or a separate building.
Slide 30

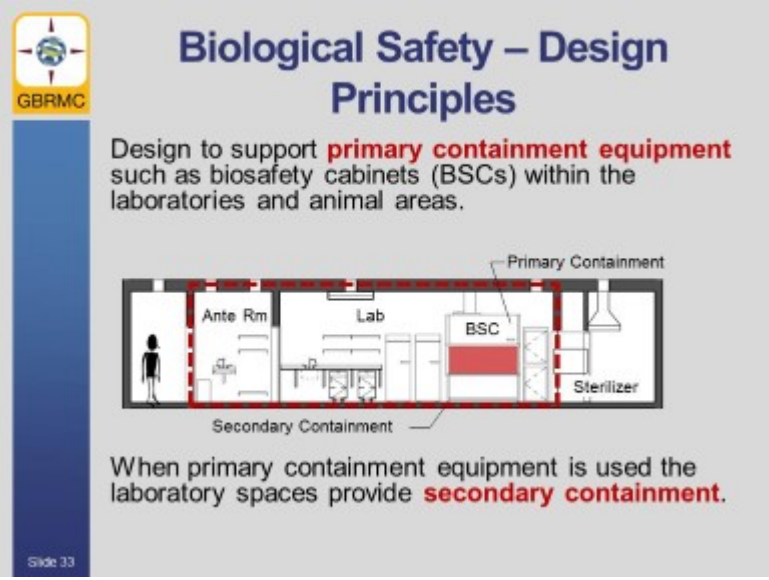
Notes:


GBRMC
Biological Safety – Design Principles
Clearly identify and Restrict access to the containment zone.
Use signage, door locks and other access control measures to ensure only trained and authorized personnel enter the containment zone.
WARNING
BIOHAZARD
AUTHORIZED
PERSONNEL ONLY
Slide 31

Notes:


GBRMC
Biological Safety – Design Principles
Include spaces and equipment to support protocols for moving personnel and materials in and out of the containment zone.
Ante Room
Lab
Sterilizer
Slide 32

Notes:


GBRMC
Biological Safety – Design Principles
Design to support primary containment equipment such as biosafety cabinets (BSCs) within the laboratories and animal areas.
Primary Containment
Ante Rm
Lab
BSC
Sterilizer
Secondary Containment
When primary containment equipment is used the laboratory spaces provide secondary containment.
Slide 33

Notes:

GBRMC

Biological Safety – Design Principles

- Create clearly defined containment barriers.
- A **containment barrier** is the wall (and any doors or equipment built into that wall), as well as the floor and ceiling, surrounding the containment zone.
- Containment barriers may also be created between spaces **within** a containment zone.

Slide 34

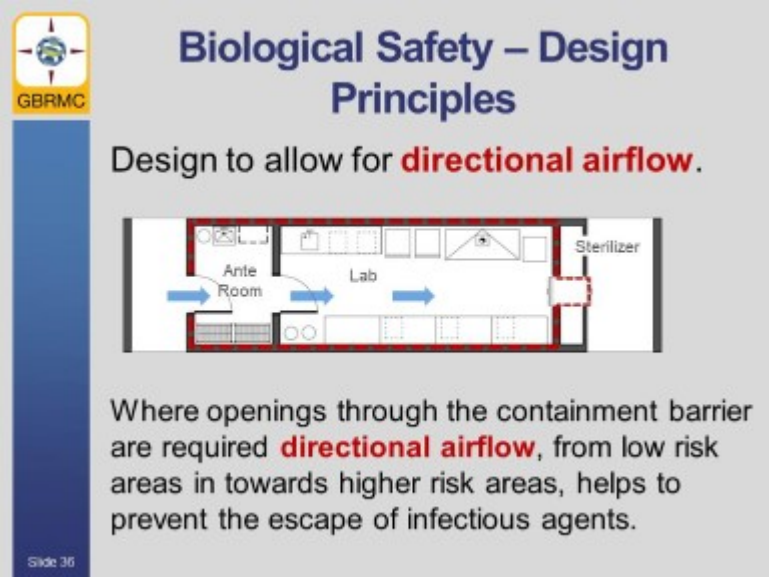
GBRMC

Biological Safety – Design Principles

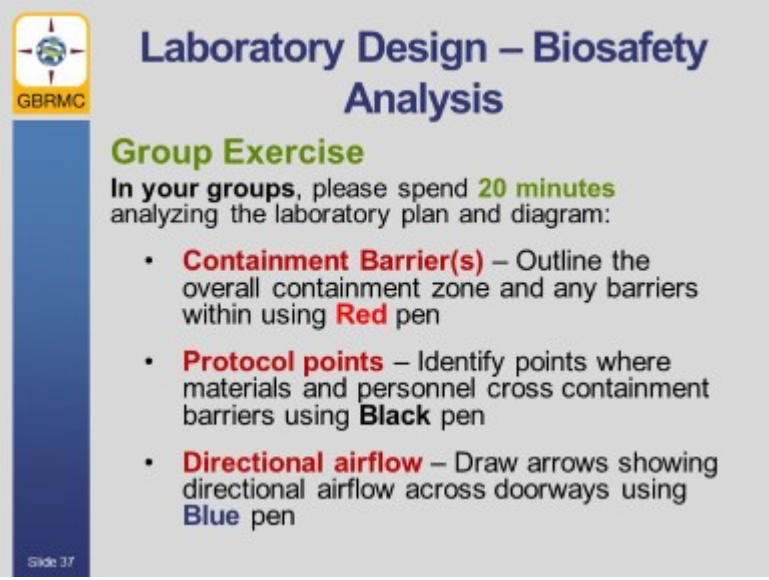
Equipment that is built into the containment barrier, and any services that penetrate the containment barrier, become a part of the barrier as well.

- HEPA Filters
- Sterilizers
- Dunk tanks, pass boxes
- Doors and windows
- Plumbing penetrations
- Electrical penetrations

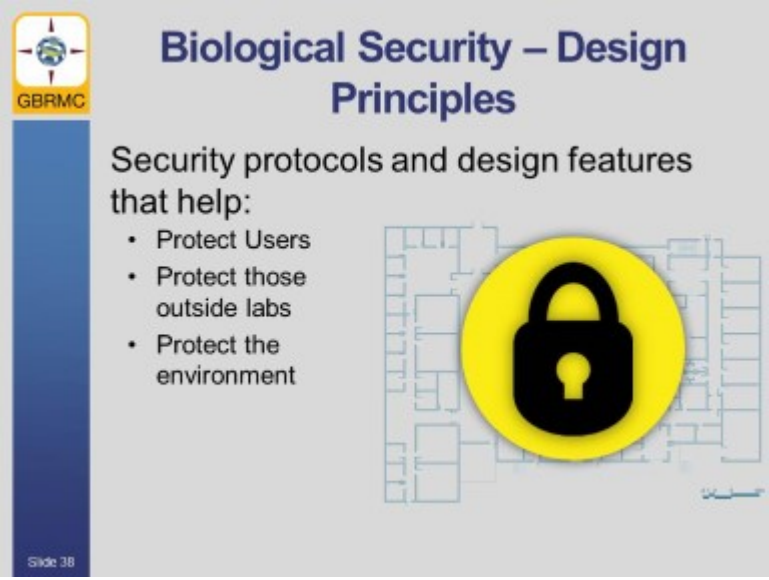
Slide 35


GBRMC
Biological Safety – Design Principles
Design to allow for directional airflow.
Ante Room
Lab
Sterilizer
Where openings through the containment barrier are required directional airflow, from low risk areas in towards higher risk areas, helps to prevent the escape of infectious agents.
Slide 36

Notes:


GBRMC
Laboratory Design – Biosafety Analysis
Group Exercise
In your groups, please spend 20 minutes analyzing the laboratory plan and diagram:
Containment Barrier(s) – Outline the overall containment zone and any barriers within using Red pen
Protocol points – Identify points where materials and personnel cross containment barriers using Black pen
Directional airflow – Draw arrows showing directional airflow across doorways using Blue pen
Slide 37

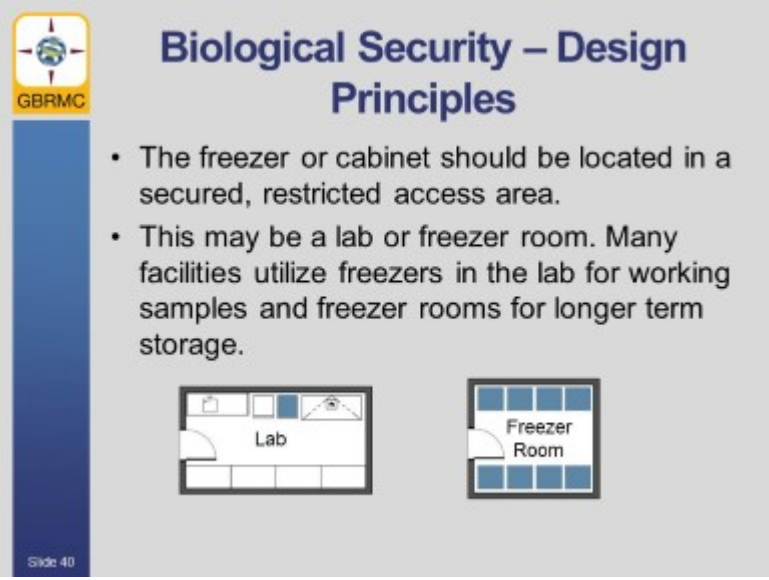
Notes:


GBRMC
Biological Security – Design Principles
Security protocols and design features that help:
• Protect Users
• Protect those outside labs
• Protect the environment
Slide 38

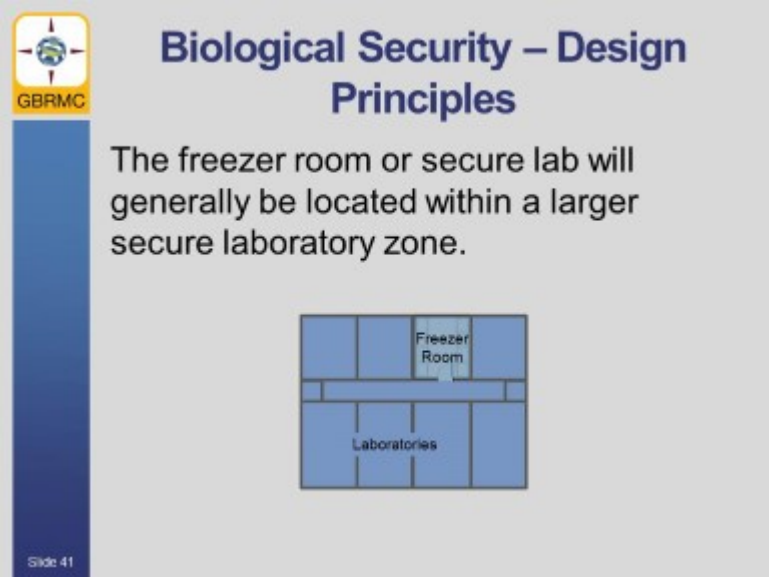
Notes:


GBRMC
Biological Security – Design Principles
• Biological agents or toxins should be secured in locked and monitored freezers or cabinets as appropriate to the material.
• Access should be restricted to only those who need the material to carry out their work.
Slide 39

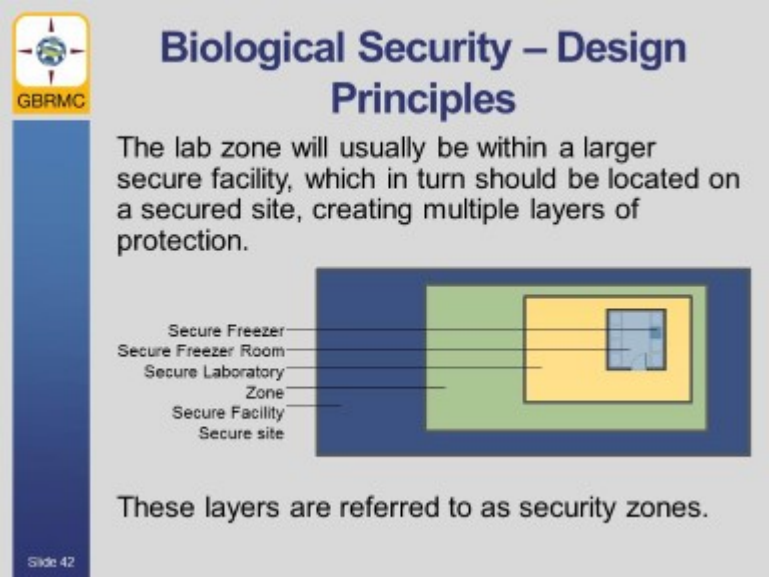
Notes:


GBRMC
Biological Security – Design Principles
• The freezer or cabinet should be located in a secured, restricted access area.
• This may be a lab or freezer room. Many facilities utilize freezers in the lab for working samples and freezer rooms for longer term storage.
Lab
Freezer Room
Slide 40

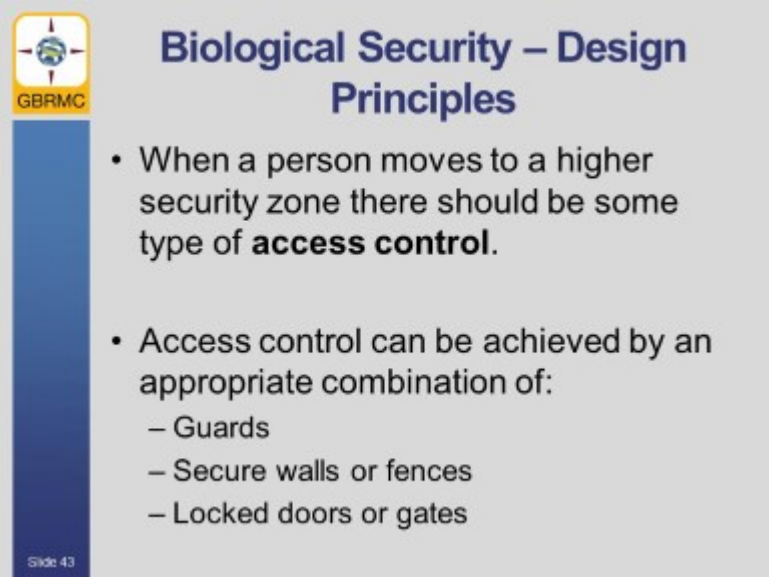
Notes:


GBRMC
Biological Security – Design Principles
The freezer room or secure lab will generally be located within a larger secure laboratory zone.
Freezer Room
Laboratories
Slide 41

Notes:


GBRMC
Biological Security – Design Principles
The lab zone will usually be within a larger secure facility, which in turn should be located on a secured site, creating multiple layers of protection.
Secure Freezer
Secure Freezer Room
Secure Laboratory
Zone
Secure Facility
Secure site
These layers are referred to as security zones.
Slide 42

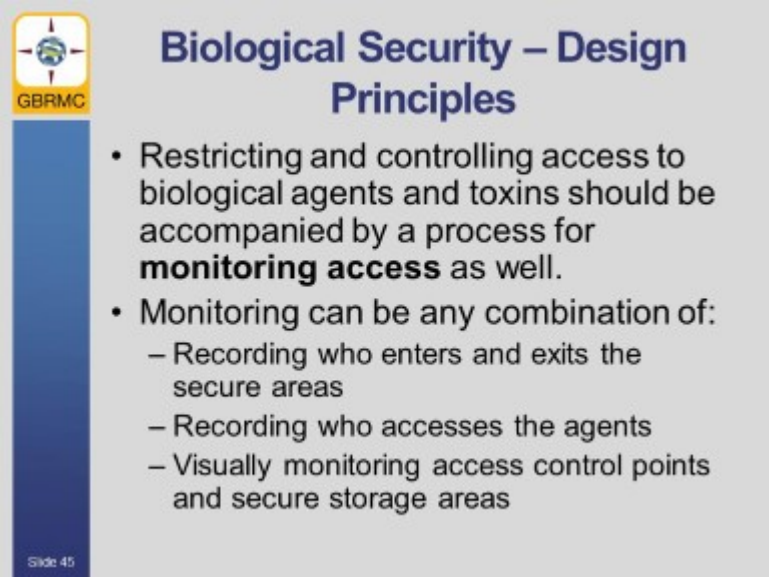
Notes:


GBRMC
Biological Security – Design Principles
• When a person moves to a higher security zone there should be some type of **access control**.
• Access control can be achieved by an appropriate combination of:
– Guards
– Secure walls or fences
– Locked doors or gates
Slide 43

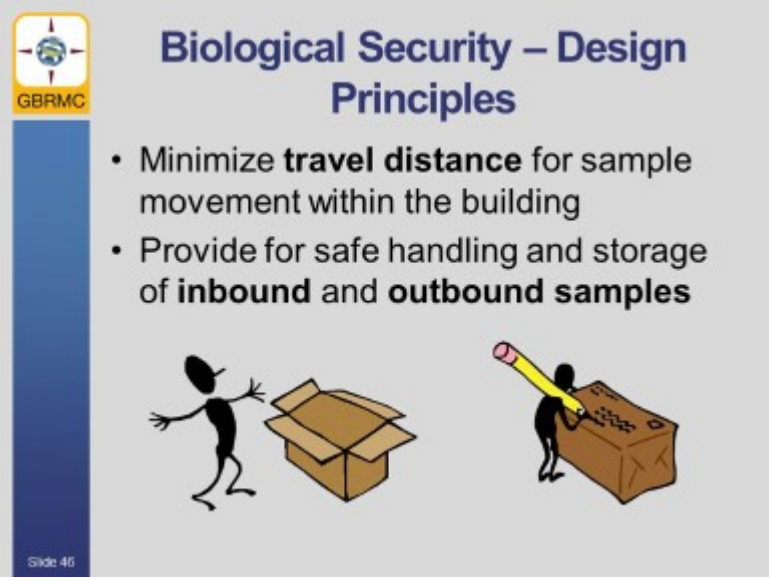
Notes:


GBRMC
Biological Security – Design Principles
Access control devices can be as simple as a guard opening a gate or as complex as an iris scanning or finger print reading device opening an electronic lock on a door.
Slide 44

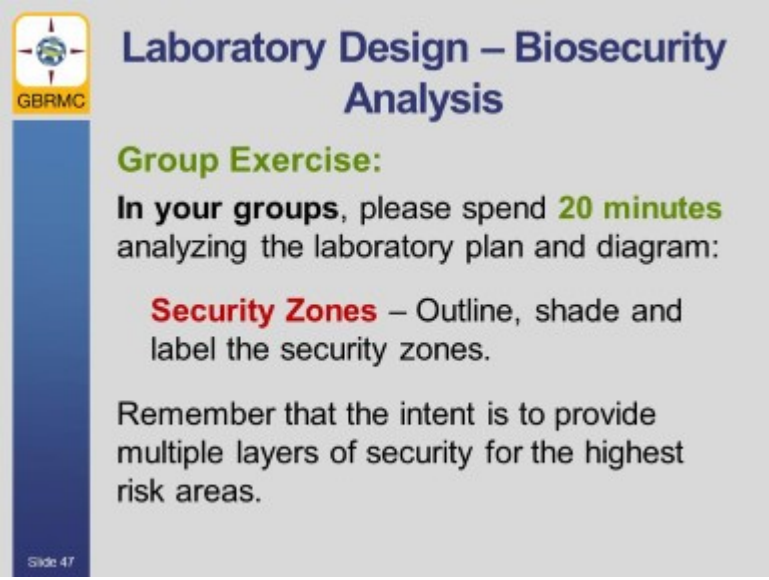
Notes:


GBRMC
Biological Security – Design Principles
• Restricting and controlling access to biological agents and toxins should be accompanied by a process for **monitoring access** as well.
• Monitoring can be any combination of:
– Recording who enters and exits the secure areas
– Recording who accesses the agents
– Visually monitoring access control points and secure storage areas
Slide 45

Notes:


GBRMC
Biological Security – Design Principles
• Minimize travel distance for sample movement within the building
• Provide for safe handling and storage of inbound and outbound samples
Slide 46

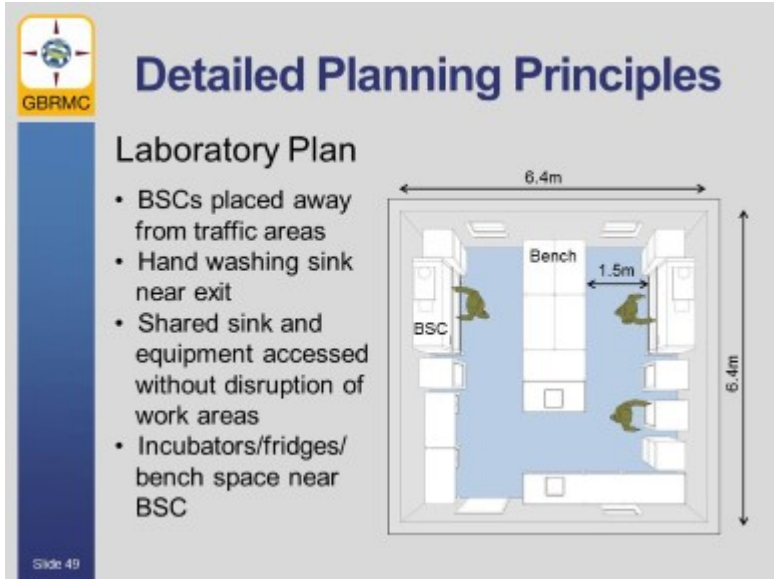
Notes:


GBRMC
Laboratory Design – Biosecurity Analysis
Group Exercise:
In your groups, please spend 20 minutes analyzing the laboratory plan and diagram:
Security Zones – Outline, shade and label the security zones.
Remember that the intent is to provide multiple layers of security for the highest risk areas.
Slide 47

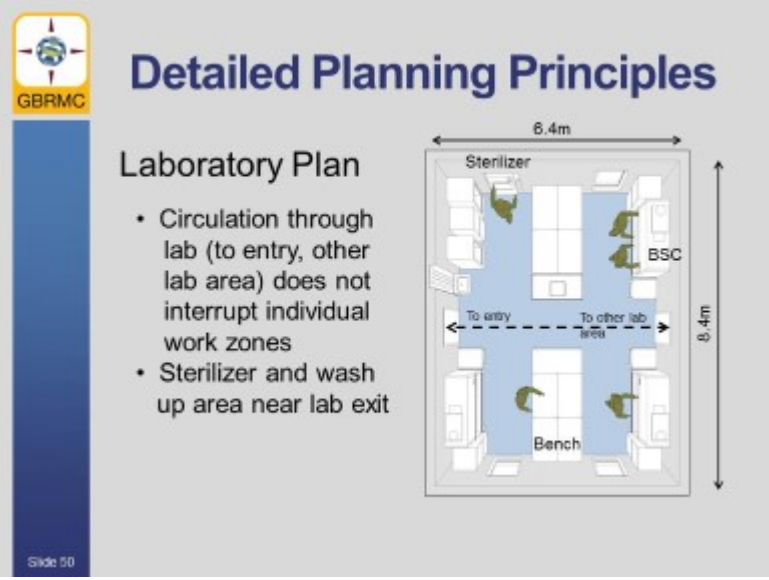
Notes:


GBRMC
Safety and Security Discussion
Class Exercise:
Each group will have 5 minutes to present to the class:
Biosafety Features & Shortcomings – Describe to the class at least 2 positive features and 2 areas for improvement.
Biosecurity Features & Shortcomings – Describe to the class at least 2 positive features and 2 areas for improvement.
Slide 48

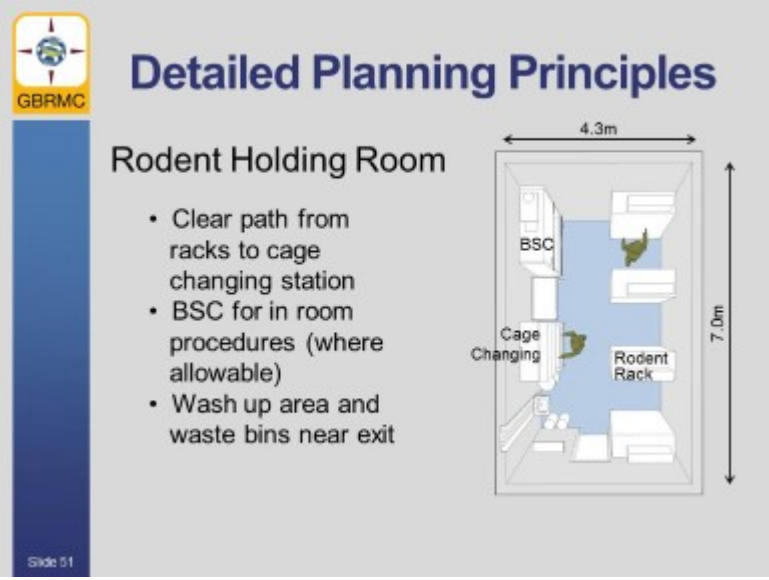
Notes:


GBRMC
Detailed Planning Principles
Laboratory Plan
• BSCs placed away from traffic areas
• Hand washing sink near exit
• Shared sink and equipment accessed without disruption of work areas
• Incubators/fridges/ bench space near BSC
6.4m
Bench
1.5m
BSC
6.4m
Slide 49

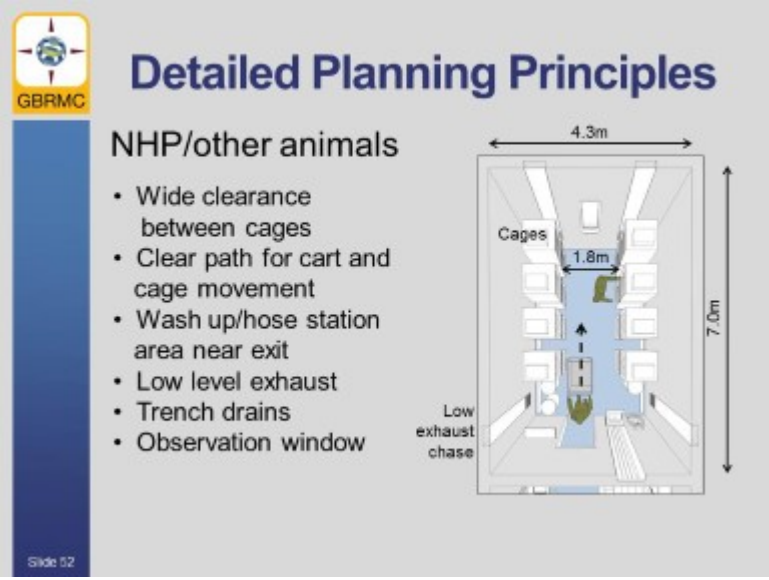
Notes:


GBRMC
Detailed Planning Principles
Laboratory Plan
• Circulation through lab (to entry, other lab area) does not interrupt individual work zones
• Sterilizer and wash up area near lab exit
6.4m
Sterilizer
BSC
To entry
To other lab area
8.4m
Bench
Slide 50

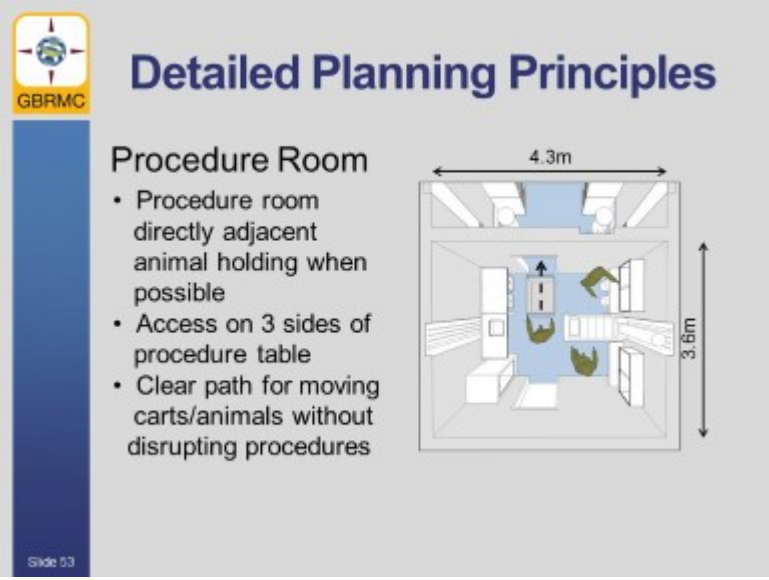
Notes:


GBRMC
Detailed Planning Principles
Rodent Holding Room
• Clear path from racks to cage changing station
• BSC for in room procedures (where allowable)
• Wash up area and waste bins near exit
4.3m
7.0m
BSC
Cage Changing
Rodent Rack
Slide 51

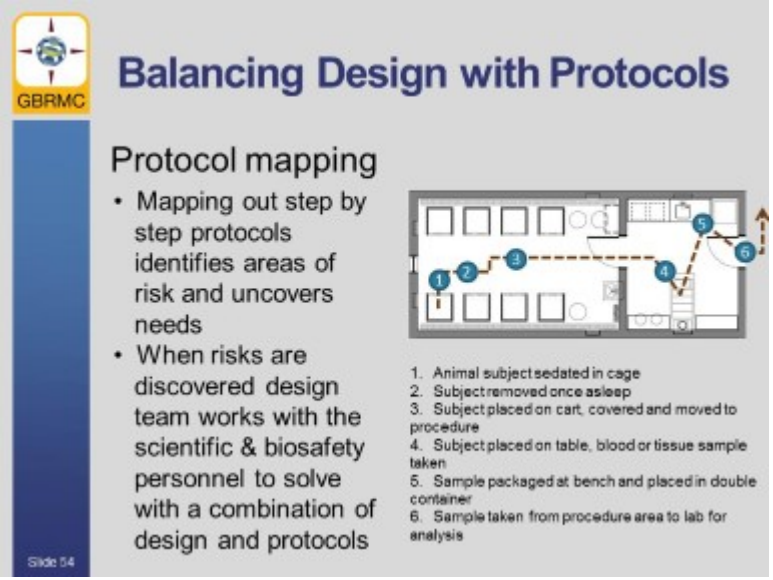
Notes:


GBRMC
Detailed Planning Principles
NHP/other animals
• Wide clearance between cages
• Clear path for cart and cage movement
• Wash up/hose station area near exit
• Low level exhaust
• Trench drains
• Observation window
4.3m
Cages
1.8m
7.0m
Low exhaust chase
Slide 52

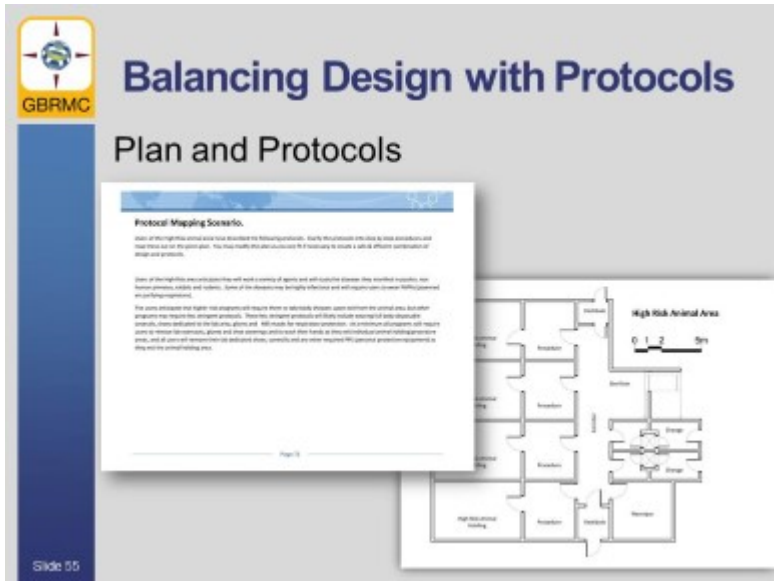
Notes:

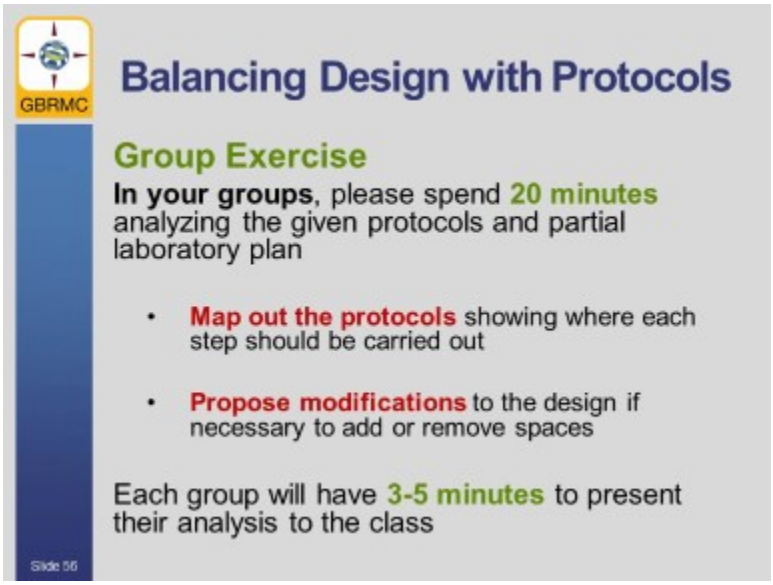

GBRMC
Detailed Planning Principles
Procedure Room
• Procedure room directly adjacent animal holding when possible
• Access on 3 sides of procedure table
• Clear path for moving carts/animals without disrupting procedures
4.3m
3.6m
Slide 53

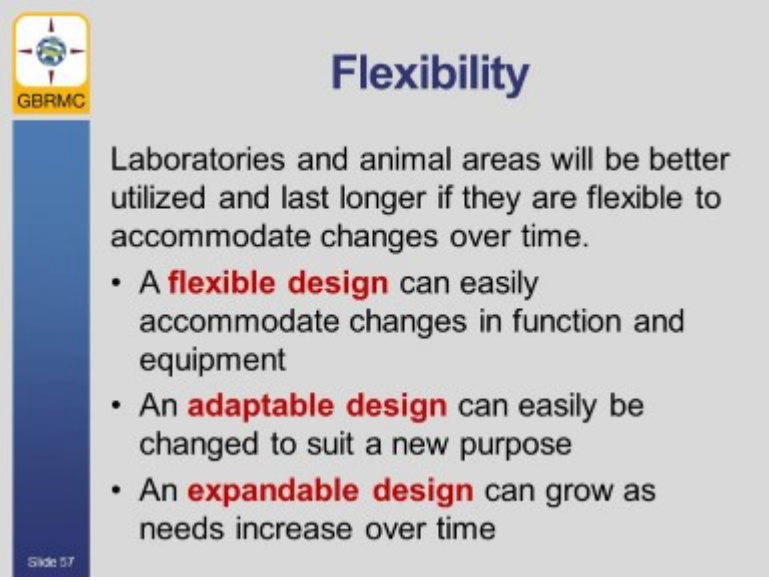
Notes:


GBRMC
Balancing Design with Protocols
Protocol mapping
• Mapping out step by step protocols identifies areas of risk and uncovers needs
• When risks are discovered design team works with the scientific & biosafety personnel to solve with a combination of design and protocols
1. Animal subject sedated in cage
2. Subject removed once asleep
3. Subject placed on cart, covered and moved to procedure
4. Subject placed on table, blood or tissue sample taken
5. Sample packaged at bench and placed in double container
6. Sample taken from procedure area to lab for analysis
Slide 54

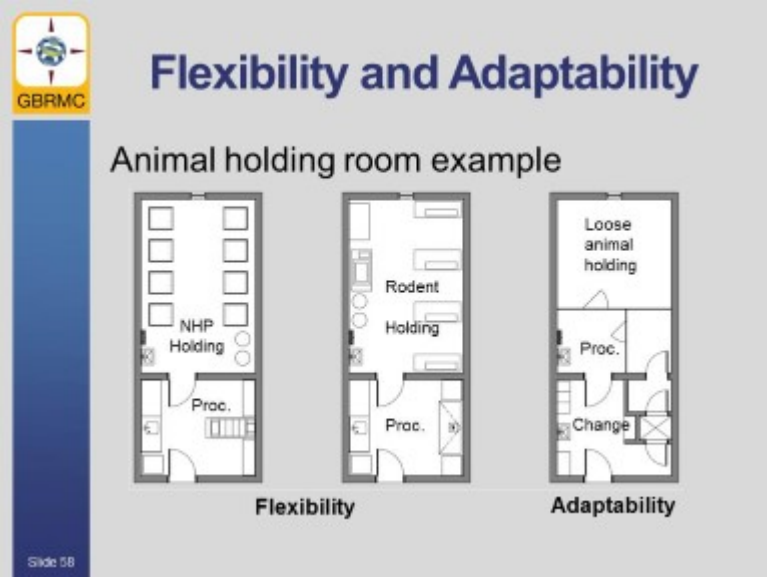
Notes:


GBRMC
Balancing Design with Protocols
Plan and Protocols
Protocol Mapping Scenario.
High Risk Animal Area
Slide 55

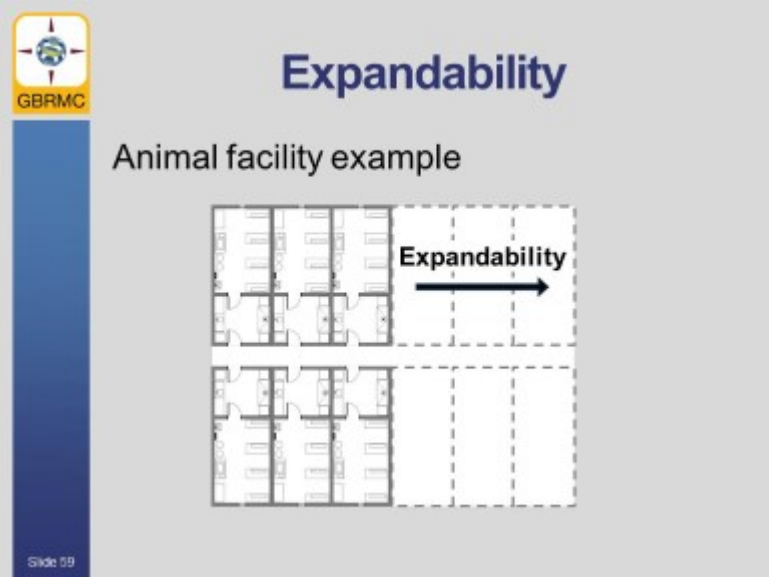

GBRMC
Balancing Design with Protocols
Group Exercise
In your groups, please spend 20 minutes analyzing the given protocols and partial laboratory plan
Map out the protocols showing where each step should be carried out
Propose modifications to the design if necessary to add or remove spaces
Each group will have 3-5 minutes to present their analysis to the class
Slide 56


GBRMC
Flexibility
Laboratories and animal areas will be better utilized and last longer if they are flexible to accommodate changes over time.
• A flexible design can easily accommodate changes in function and equipment
• An adaptable design can easily be changed to suit a new purpose
• An expandable design can grow as needs increase over time
Slide 57

Notes:


GBRMC
Flexibility and Adaptability
Animal holding room example
NHP Holding
Proc.
Rodent Holding
Proc.
Loose animal holding
Proc.
Change
Flexibility
Adaptability
Slide 58

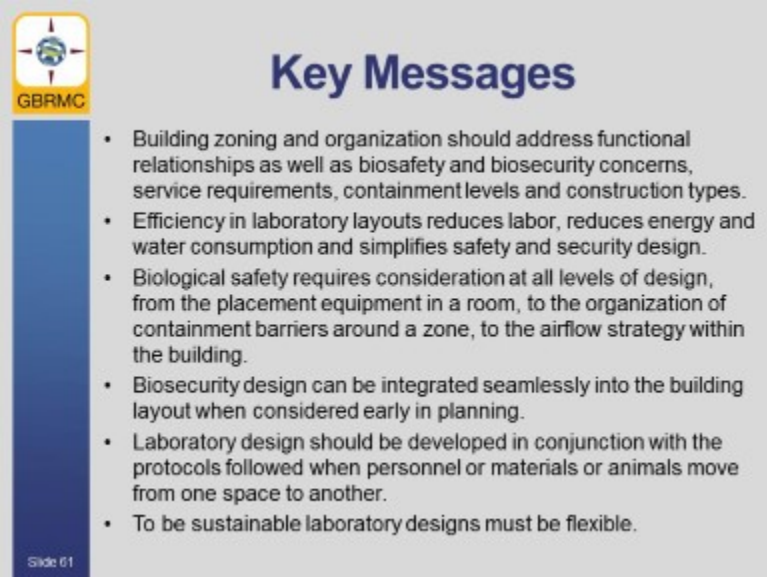
Notes:


GBRMC
Expandability
Animal facility example
Expandability
Slide 59

Notes:


GBRMC
Review
To wrap-up, let's discuss what we learned about Laboratory Design Best Practices.
What did we learn?
What does it mean?
Where do we go from here?
Slide 60

Notes:



Key Messages

- Building zoning and organization should address functional relationships as well as biosafety and biosecurity concerns, service requirements, containment levels and construction types.
- Efficiency in laboratory layouts reduces labor, reduces energy and water consumption and simplifies safety and security design.
- Biological safety requires consideration at all levels of design, from the placement equipment in a room, to the organization of containment barriers around a zone, to the airflow strategy within the building.
- Biosecurity design can be integrated seamlessly into the building layout when considered early in planning.
- Laboratory design should be developed in conjunction with the protocols followed when personnel or materials or animals move from one space to another.
- To be sustainable laboratory designs must be flexible.

Remember your action plan!

Action Plan

By the end of this lesson, I would like to:					
KNOW		FEEL		BE ABLE TO DO	

Your learning doesn't stop with this lesson. Use this space to think about what else you need to do or learn to put the information from this lesson into practice.

What more do I need to know or do?	How will I acquire the knowledge or skills?	How will I know that I've succeeded?	How will I use this new learning in my job?

Use space on back, if needed

Reference Materials for Further Study

A Design Guide for Energy Efficient Research Laboratories. Website. http://ateam.lbl.gov/Design-Guide/

ASHRAE Laboratory Design Guide. 2002. Ian B.D. McIntosh, Chad B. Dorgan, Charles E. Dorgan. American Society of Heating, Refrigerating and Air Conditioning Engineers.

Biosafety in Microbiological and Biomedical Laboratories (BMBL) 5th Edition, 2009. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institutes of Health. Available online at: http://www.cdc.gov/biosafety/publications/bmbl5/

Building Type Basics for Research Laboratories. 2nd Edition, 2001. Daniel D. Watch, Stephen A. Kliment, Perkins & Will. John Wiley & Sons, Inc.

CWA 15793, CEN Workshop Agreement, Laboratory Biorisk Management. 2011. European Committee for Standardization. Available online at:
ftp://ftp.cenorm.be/CEN/Sectors/TCandWorkshops/Workshops/CWA15793_September2011.pdf

Guide for the Care and Use of Laboratory Animals. 8th Edition, 2011. Institute for Laboratory Animal Research, National Research Council of the National Academies. The National Academies Press.

International Building Code. 2006 International Code Council. Available online at:
http://publicecodes.cyberregs.com/icod/ibc/2006f2/index.htm

Laboratory Biosafety Manual. 3rd Edition, 2004. World Health Organization. Available in multiple languages online at:
http://www.who.int/csr/resources/publications/biosafety/WHO_CDS_CSR_LYO_2004_11/en/

Laboratory Biosecurity Handbook. 2007. Reynolds Mathewson Salerno, Jennifer Marie Guadioso. CRC Press.

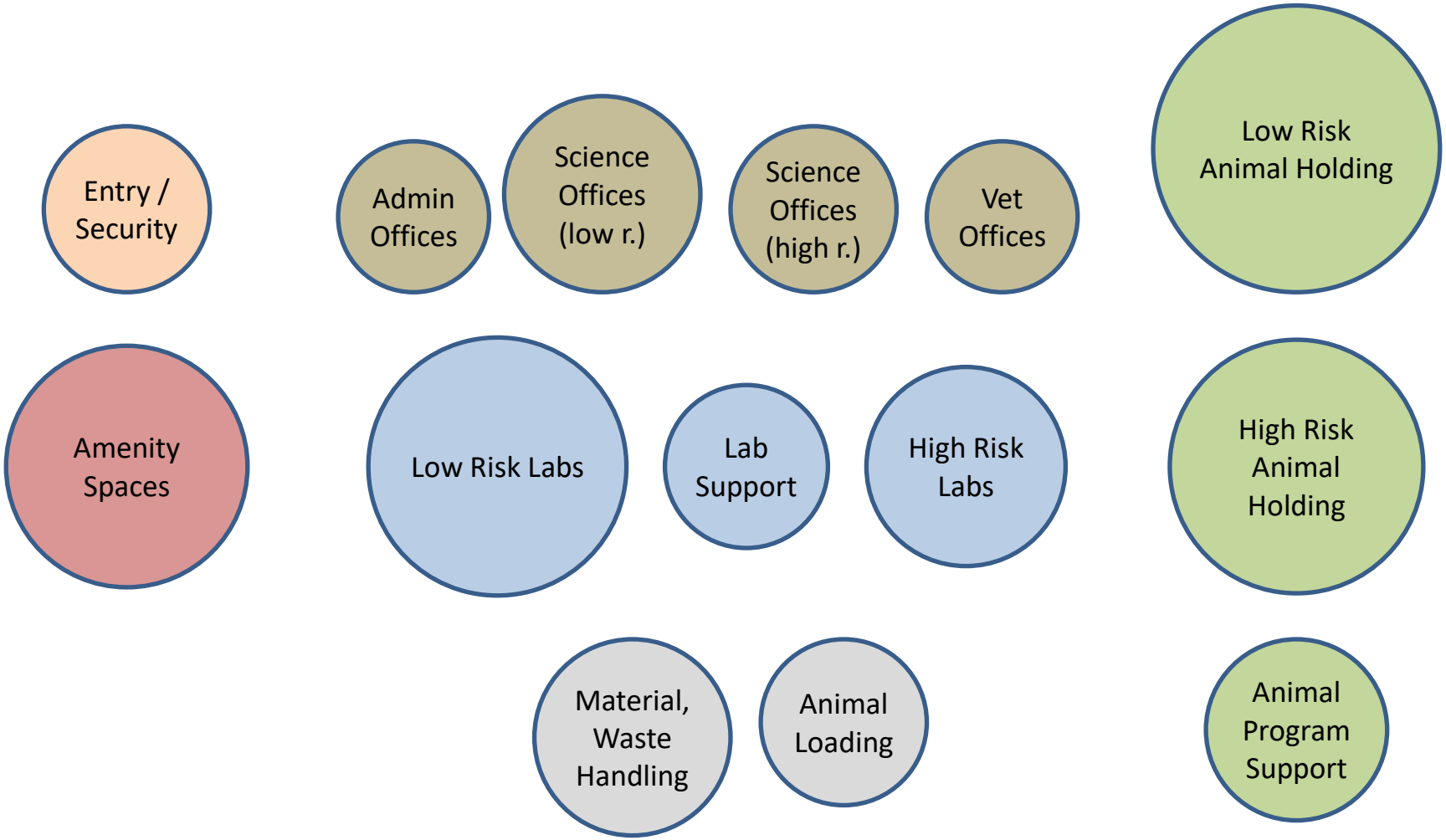
Laboratory Design Guide. 3rd Edition, 2005. Brian Griffin. Architectural Press, Elsevier.

NFPA 45: Standard on Fire Protection for Laboratories Using Chemicals. 2011. National Fire Protection Association. Available online at: http://www.nfpa.org/

Problem Seeking: An Architectural Programming Primer. 5th Edition, 2012. William M. Peña, Steven A. Parshall. John Wiley & Sons, Inc.

Whole Building Design Guide. Website. http://www.wbdg.org/

Program components of a hypothetical project



Space Adjacency Matrix

	Entry / Security Check	Lobby/Amenity/Meeting Spaces	Administrative Offices	Science Offices (low r.)	Science Offices (high r.)	Veterinary Offices	Low Risk Laboratories	High Risk Laboratories	Laboratory Support	Low Risk Animal Holding	High Risk Animal Holding	Animal Program Support	Material & Waste Handling	Animal Loading
Entry / Security Check		5	5	3	3	1	1	1	0	0	0	0	0	0
Lobby/Amenity/Meeting Spaces	5		5	4	4	3	2	2	0	0	0	0	0	0
Administrative Offices	5	5		2	2	1	0	0	0	0	0	0	0	0
Science Offices (low r.)	3	4	2		4	2	4	0	0	0	0	0	0	0
Science Offices (high r.)	3	4	2	4		2	0	2	0	0	0	0	0	0
Veterinary Offices	1	3	1	2	2		0	0	0	4	4	0	0	2
Low Risk Laboratories	1	2	0	4	0	0		3	5	2	1	0	3	0
High Risk Laboratories	1	2	0	0	2	0	3		3	0	4	0	3	0
Laboratory Support	0	0	0	0	0	0	5	3		0	0	0	3	0
Low Risk Animal Holding	0	0	0	0	0	4	2	0	0		3	5	4	5
High Risk Animal Holding	0	0	0	0	0	4	1	4	0	3		5	4	5
Animal Program Support	0	0	0	0	0	0	0	0	0	5	5		4	5
Material & Waste Handling	0	0	0	0	0	0	3	3	3	4	4	4		3
Animal Loading	0	0	0	0	0	2	0	0	0	5	5	5	3	

5 = Very strong relationship, close adjacency is required.

4 = Strong relationship, adjacency is highly desirable.

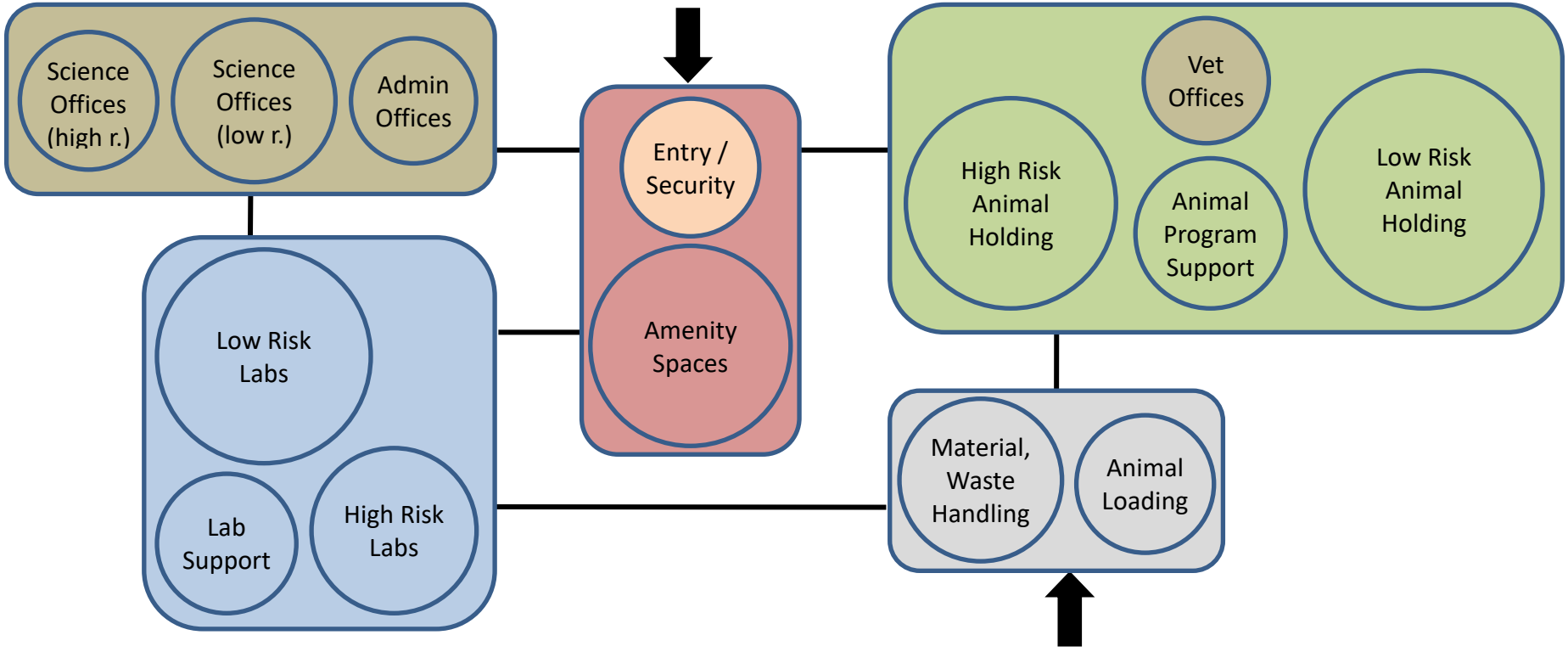
3 = Moderate relationship, adjacency is desirable.

2 = Minor relationship, adjacency has benefits but is not necessary for building to function well.

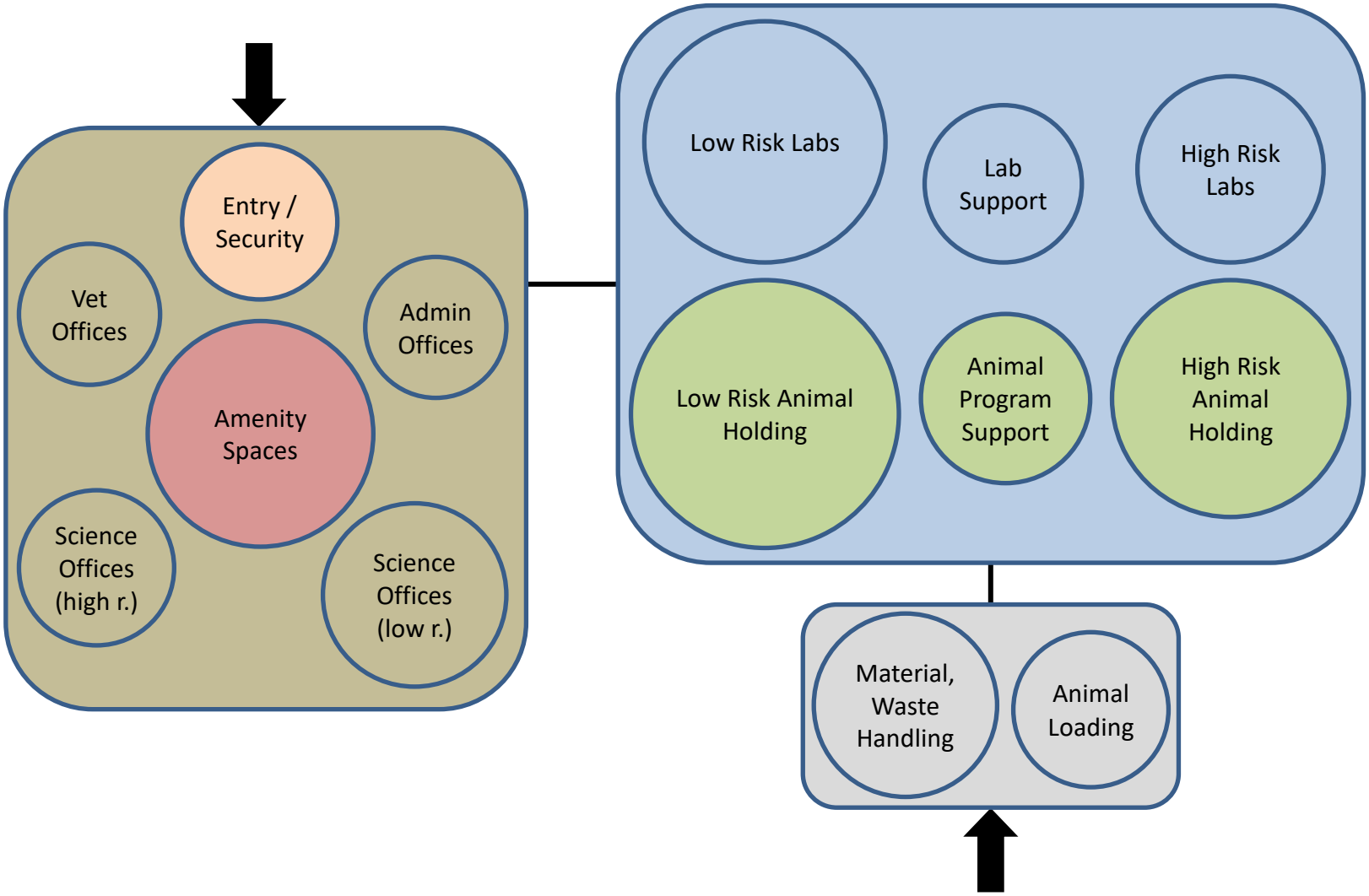
1 = Weak relationship, adjacency may be convenient but isn’t necessary.

0 = No adjacency required between these elements.

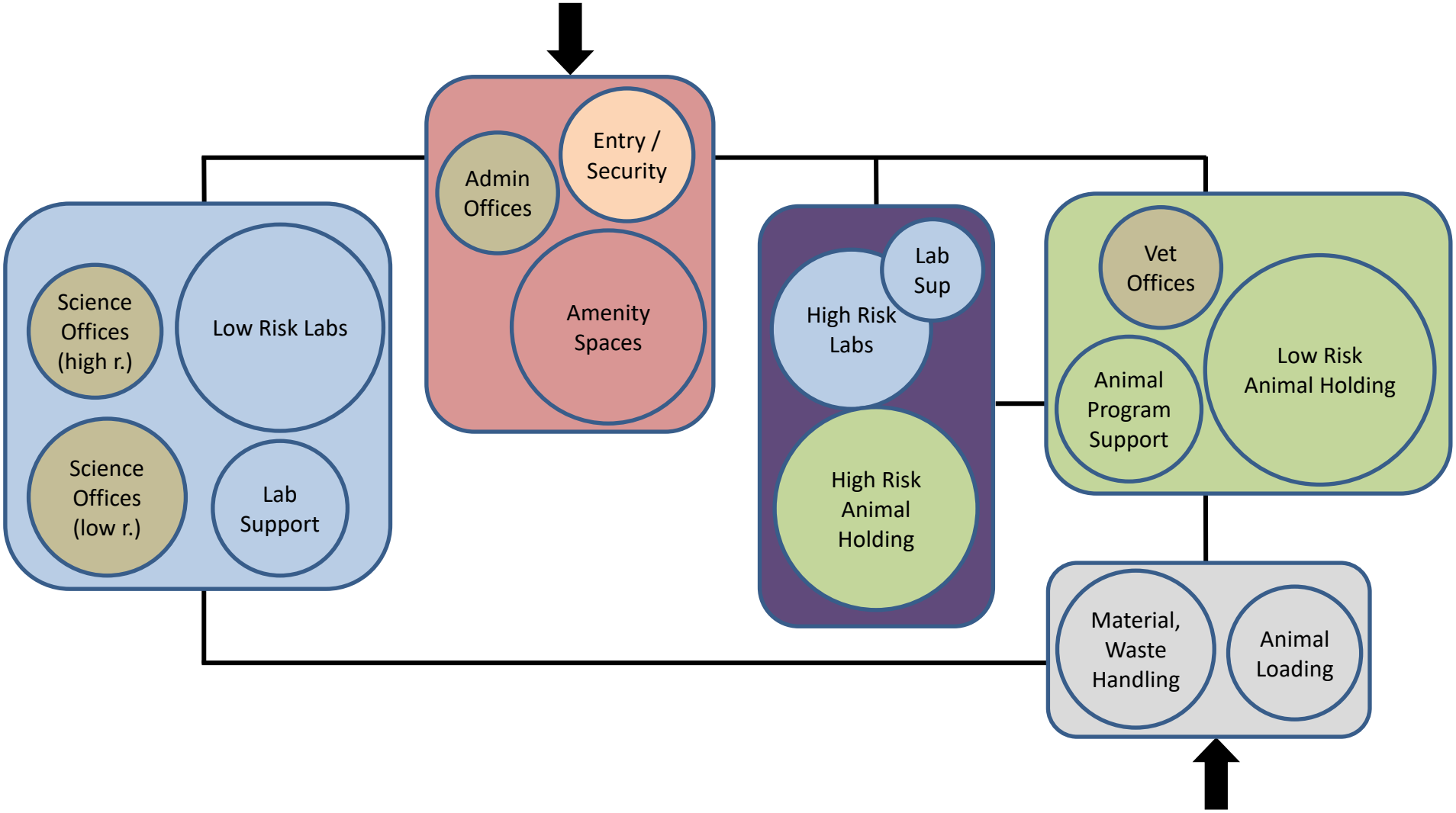
Zoning Diagram 1 – Lab and animal areas grouped separately

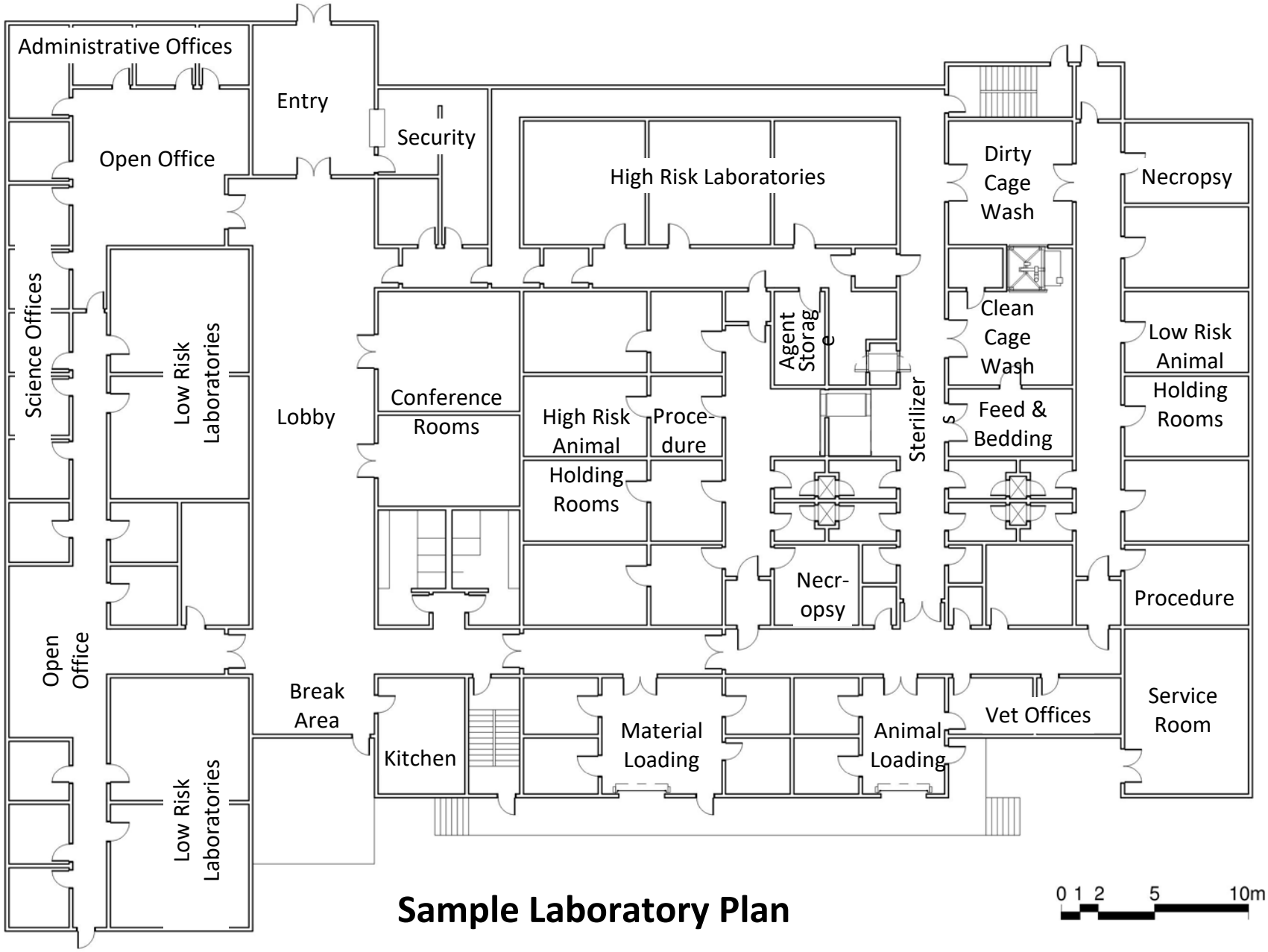


Zoning Diagram 2 – Bioscience spaces consolidated



Zoning Diagram 3 – Higher Risk Areas Consolidated





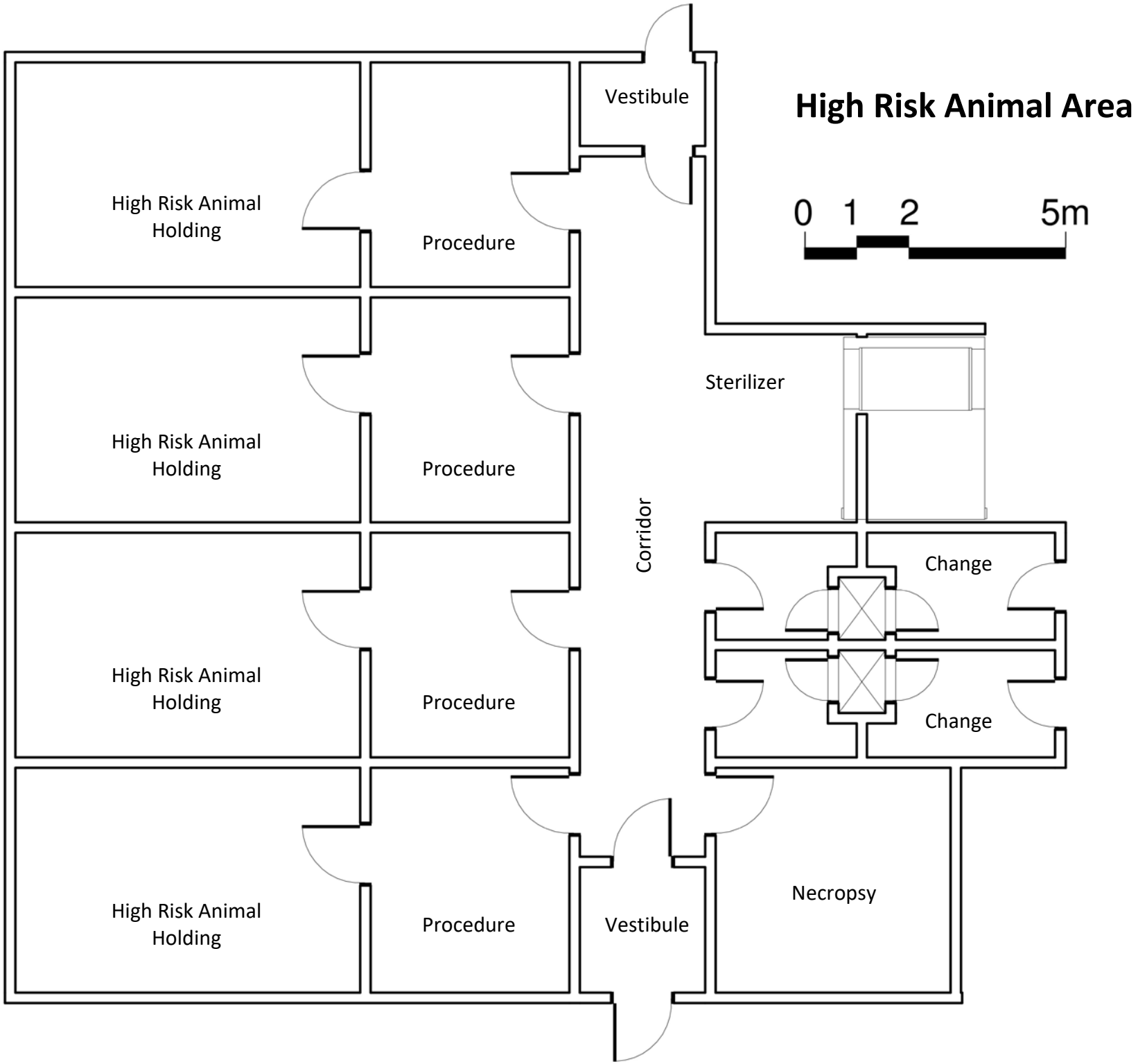
Sample Laboratory Plan

Protocol Mapping Scenario.

Users of the High Risk animal area have described the following protocols. Clarify the protocols into step by step procedures and map these out on the given plan. You may modify the plan as you see fit if necessary to create a safe & efficient combination of design and protocols.

Users of the High Risk area anticipate they will work a variety of agents and will study the diseases they manifest in poultry, non human primates, rabbits and rodents. Some of the diseases may be highly infectious and will require users to wear PAPRs (powered air purifying respirators).

The users anticipate that higher risk programs will require them to take body showers upon exit from the animal area, but other programs may require less stringent protocols. These less stringent protocols will likely include wearing full body disposable coveralls, shoes dedicated to the lab area, gloves and N95 masks for respiratory protection. At a minimum all programs will require users to remove lab overcoats, gloves and shoe coverings and to wash their hands as they exit individual animal holding/procedure areas, and all users will remove their lab dedicated shoes, coveralls and any other required PPE (personal protective equipment) as they exit the animal holding area.


High Risk Animal Area
0 1 2 5m
Vestibule
High Risk Animal Holding
Procedure
High Risk Animal Holding
Procedure
High Risk Animal Holding
Procedure
High Risk Animal Holding
Procedure
Vestibule
Corridor
Sterilizer
Change
Change
Necropsy