PRE-DESIGN REPORT

UNIVERSITY OF WISCONSIN, MILWAUKEE

CHEMISTRY BUILDING & CENTRAL UTILITIES EXTENSION

PREPARED FOR:

Wisconsin Division of Facilities Development and Management

DFDM PROJECT NO:

18H3D

FEBRUARY 17, 2020

Kahler Slater | CANNONDESIGN

UNIVERSITY of WISCONSIN

UWMILWAUKEE

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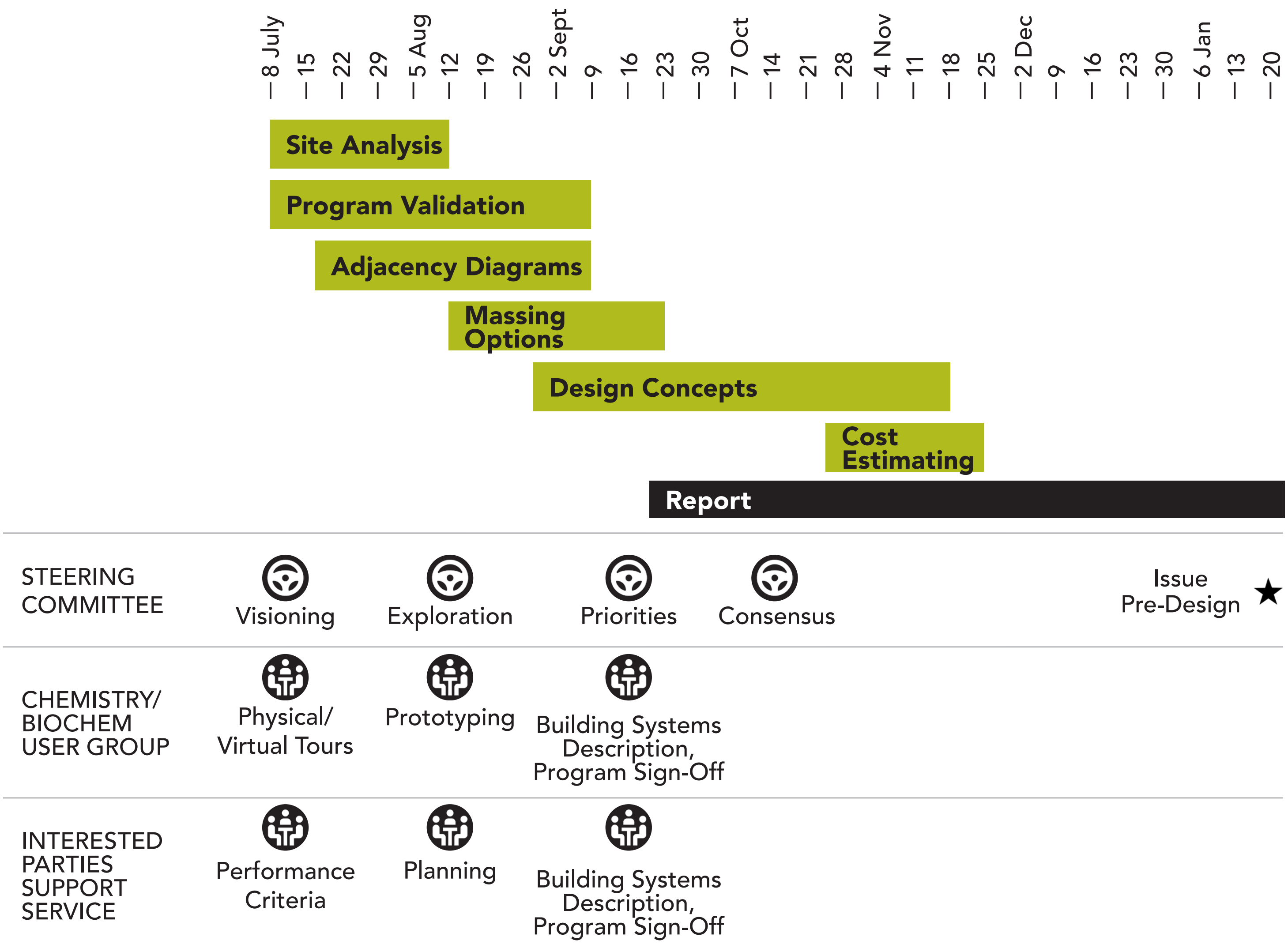
0 PREFACE

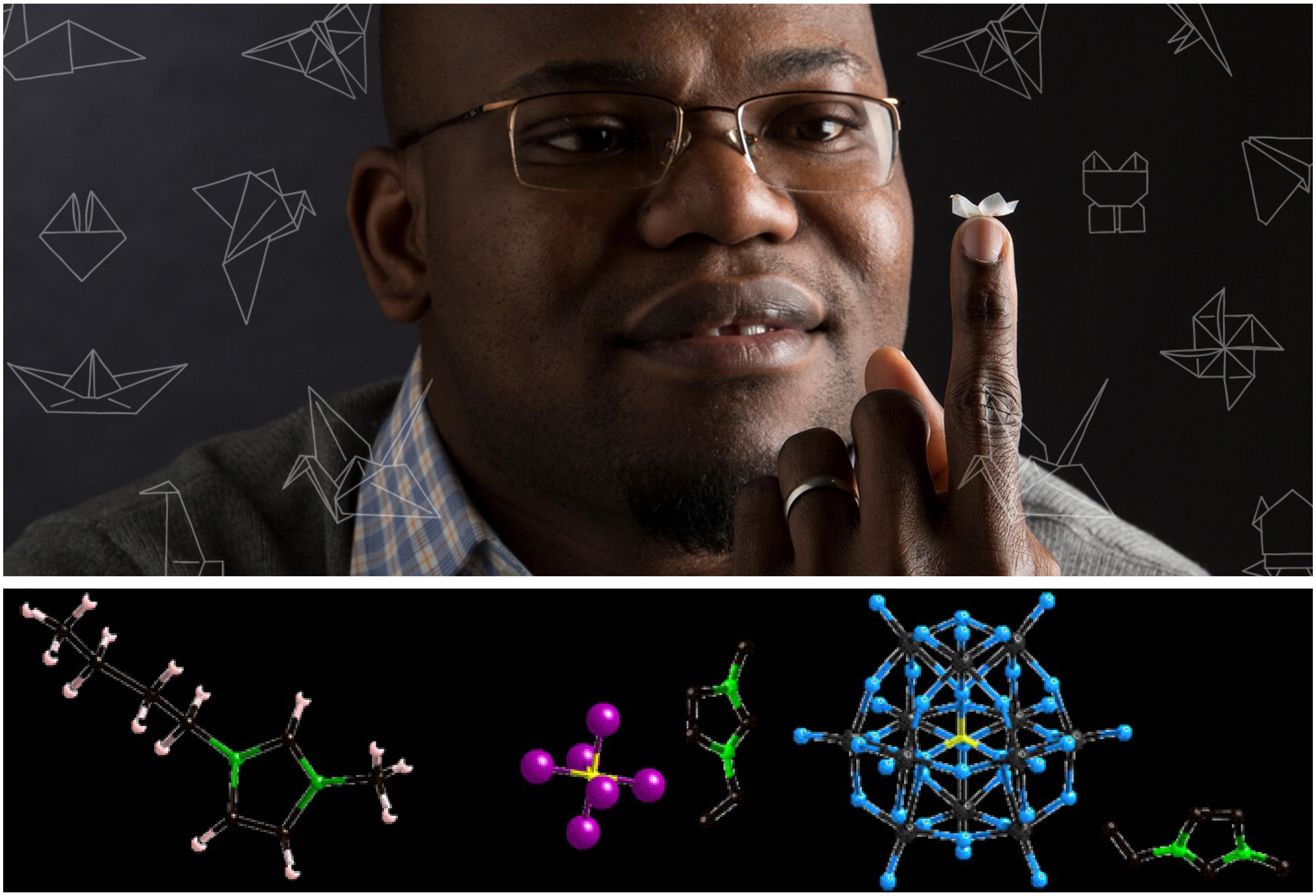
2019-2020 PRE-DESIGN UPDATE PROCESS



Process Summary

The Pre-Design process for the new Chemistry Building sought to update the cope and budget of the Chemistry building and utility extension using the capital project request and the 2015 Pre-Design Study, based upon four rounds of stakeholder meetings, precedent facility tours at other regional institutions, and existing facility walkthroughs. The process began with exercises to capture the mission and vision for the facility that would drive the programming and design concept for the building. A series of massing options and design concepts were explored with the preferred scheme developed in more detail to inform the cost estimate outlined in this report.

Stakeholders included Letters and Sciences Department of Chemistry and Biochemistry, faculty, administrative leaders, campus planning, physical environment committee representative and support services representatives, and UW System Capital Planning & Budget, and DFDM Wisconsin leadership.



Examples of research conducted by the UWM Chemistry and Biochemistry department.
SOURCE: https://uwm.edu/chemistry

The Chemistry building will…

… provide a state-of-the-art building for modern instruction to support students at all levels.

… support and enhance fundamental research and scientific innovation.

… connect researchers, students, and the community through science.

Vision Statement for the new Chemistry Building

THE NEW CHEMISTRY BUILDING WILL ...

… PROVIDE A STATE OF THE ART BUILDING FOR MODERN INSTRUCTION TO SUPPORT STUDENTS AT ALL LEVELS,

… SUPPORT AND ENHANCE FUNDAMENTAL RESEARCH AND SCIENTIFIC INNOVATION,

… CONNECT RESEARCHERS, STUDENTS, AND THE COMMUNITY THROUGH SCIENCE.

1 EXECUTIVE SUMMARY

GENERAL PROJECT SCOPE & DESCRIPTION

New Chemistry Building massing, view from E Kenwood Ave.

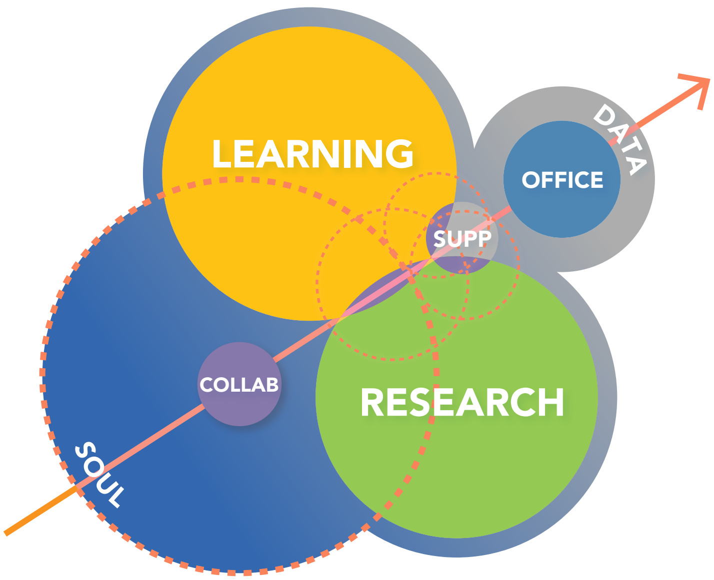
Project Description

This project will develop a chemistry and bio-chemistry building, south of the existing Chemistry Building that it is replacing, to provide instructional and research laboratories and associated support spaces, offices, and shared collaboration/informal learning space. This project will also extend and connect the required central campus utility services to the new building site. The new facility will be connected with an underground corridor to the Kenwood Interdisciplinary Research Center (KIRC) for campus utilities and support services.

Campus Utilities Extension

The project will require the extension of campus utilities to the site to support the building. Thermal and power services will be routed to the site in the space between EMS and the existing Chemistry Building. Steam and chilled water will be tied into the tunnel just north of the existing Chemistry building. See the site utility diagrams in Chapter 7 for detailed routing strategies.

SUMMARIZED SPACE TABULATION



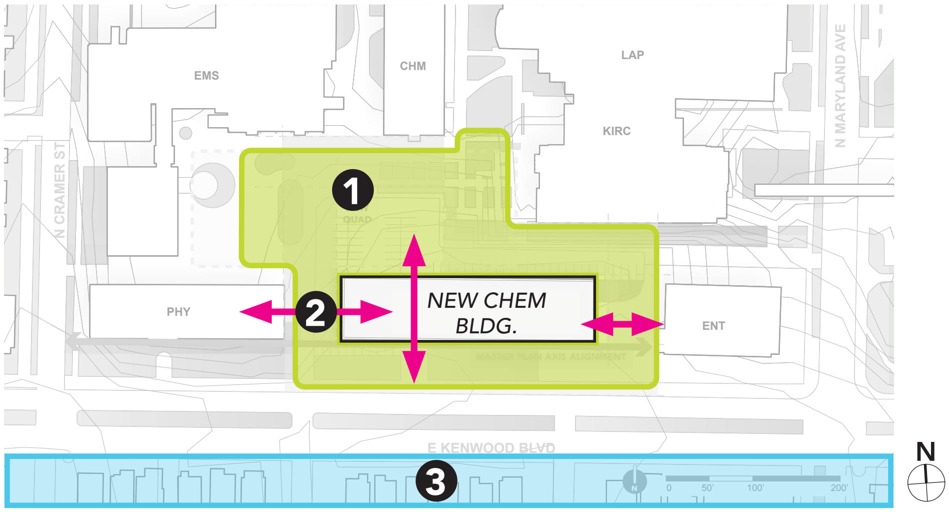
Conceptual program diagram depicting the major functional space typologies and their relationship to one another across a spectrum of quantitative needs, "data", and qualitative experience, "soul".

	TARGET PROGRAM (12.04.2019)
INSTRUCTIONAL LABS	32,148 ASF
RESEARCH	29,950 ASF
OFFICE	7,458 ASF
COLLABORATION	5,676 ASF
STORAGE	1,820 ASF
GENERAL CLASSROOMS	12,260 ASF
TOTAL	89,312 ASF
	159,220 GSF

Space Program

The total size of the building proposed is 159,220 GSF of new, mixed-use program. The spaces included represent the mix of functions required to fulfill the vision of the new Chemistry Building. Approximately equal quantities of learning and research space are tied together and supported by collaboration space and office space. Learning space includes introductory Instructional Labs, through advanced Chemistry. In addition, a series of General Assignment Classrooms (both small seminar rooms and large lecture halls) are included in this building for campus-wide use. Research space includes labs for multiple research typologies from the fume hood and exhaust intensive, to specialty support and equipment intensive, to dry labs. Based on a series of precedent tours, additional collaboration space has been requested by the University, to be added to the architectural concept and space planning during Preliminary Design.

SPECIFIC CHALLENGES & OBJECTIVES



Redevelopment Plan Context (NTS)
1. Proposed location and area of sitework as established in the 2015 Southwest Quad Redevelopment Plan
2. Arrows indicating pedestrian connection
3. Contextual scale across the site

Chemistry & Biochemistry

The Chemistry & Biochemistry Department has a wide range of research typologies including analytical, biochemistry, inorganic, organic, and physical focuses. The Department is currently housed in a building first occupied in 1974 that has exceeded its useful life from a physical infrastructure viewpoint. It requires repairs multiple times a day and doesn't always support the modern pedagogies and research methods that faculty have put into practice. There are also safety and visibility concerns within teaching labs and classrooms are too small for group work.

The new Chemistry Building will be a 4-story academic facility with a basement and a mechanical penthouse, that will accommodate instructional and research laboratories, classrooms, lecture halls, offices, collaboration spaces and other supporting program. The design team researched the different programs that the Department of Chemistry and Biochemistry offers and used that data to inform how the building is shaped and how the program elements interact with one another. This academic building will front the campus along E Kenwood Blvd. The blocking strategy is to break the scale down, making the building appear smaller. The building mass has two bars angling away from each other and large opaque masses on the ground floor. To minimize the impact of the scale of the building, the more massive block associated with the 2nd, 3rd, and 4th levels is lifted, creating a semi-transparent plinth that allows views from Kenwood Avenue to the improved outdoor spaces in the quad to the north of the building.

Site Analysis

The analysis of the site for the new Chemistry Building in the context of the SWQ Redevelopment Plan reveals several key drivers of the building massing and site design. One of the drivers is the creation of a green campus quad to the north of the Chemistry Building that invites people to linger and engage with this STEM centered region of campus.

The Chemistry Building is an essential component of the Southwest Quadrant Redevelopment. This plan provides new and renovated STEM facilities to support excellence in instruction, research and outreach. Located on the edge

The Chemistry building will…

… provide a state-of-the-art building for modern instruction to support students at all levels.

… support and enhance fundamental research and scientific innovation.

… connect researchers, students, and the community through science.

Vision Statement for the new Chemistry Building

of campus, the Chemistry Building is a centrally located entrance to the quadrant. Its form, massing and internal space configuration will form essential relationships with the buildings in proximity on the new green quad - Kenwood Interdisciplinary Research Complex, Lapham Hall and Engineering and Mathematical Sciences on the north, Lubar Entrepreneurship Center and UWM Welcome Center on the east, and future Engineering building that will replace the existing Physics building.

This building highlights the important relationship between the fabric of the campus and the residential neighborhood to the south.

University Vision

Through its design and programming, the new Chemistry Building will support the UWM Vision: "We will be a top-tier research university that is the best place to learn and work for students, faculty and staff, and that is a leading driver for sustainable prosperity. We will accomplish this through a commitment to excellence, powerful ideas, community and global engagement, and collaborative partnerships." *Source: Chancellor's Strategic Directions, https://uwm.edu/chancellor/*

During the Pre-Design process, several key attributes of the Chemistry program were identified that support the goals set forth by the University's vision and the vision for the new Chemistry Building. A state-of-the-art building needs to allow for flexibility and adaptability to support teaching innovation. Research excellence must be supported and enhanced by providing a highly collaborative environment with the spaces and tools researchers need. The new building will be welcoming to connect researchers, students, and the community.

1.3 Specific Challenges & Objectives

Welcoming

The prominent site provides the opportunity for the new building to be a gateway to STEM for the SWQ. It should provide spaces that invite users to stay and put science on display to celebrate the work being done within the Chemistry and Biochemistry Department.

Flexible & Adaptable

Programmed spaces throughout the new facility should be flexible, to accommodate multiple layouts in the same space, reconfiguration of equipment and furniture, and opportunities for collaboration both locally and internationally throughout. The space should be adaptable, allowing for changing pedagogical methods and implementation of future technologies through layout modularity and building systems that allow for future expansion and change.

Research Excellence

UW-Milwaukee earned "R1" (Research 1) status in 2015, and has since maintained that classification as one of the top research universities in the country. This research excellence is a core part of the Chemistry and Biochemistry Department and the new building should provide research spaces that support current and future research activities, while removing barriers between undergraduates and research, to encourage student ambition within the field.

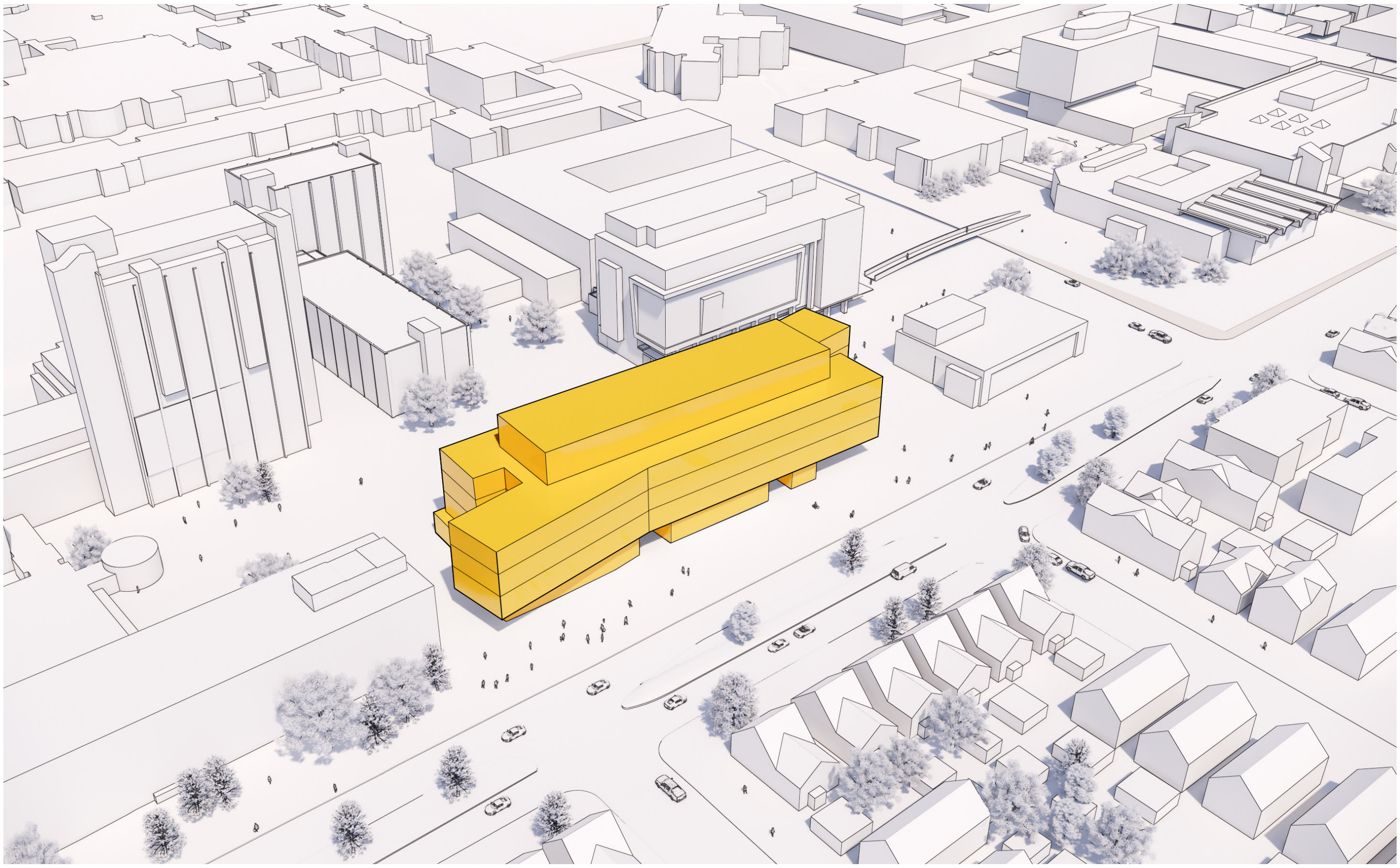
Teaching Innovation

12%-15% of the UW-Milwaukee student body takes chemistry coursework at any given point during the academic year. 35-44% of all students take at least one chemistry course throughout their time at the University. All faculty members teach at all levels of coursework and seek to reach students on a 1-on-1 basis. This project provides a unique opportunity to create learning spaces where faculty and students can engage with one another from introductory to advanced chemistry in a state of the art facility that accommodated and encourages new teaching and learning modalities.

Collaboration

Collaboration within the new Chemistry Building would include a wide variety of stakeholders; from students interacting and learning from one another, to faculty and industry partners collaborating on transformative research projects. The new facility should provide space throughout the building for these interactions to occur, in formal and informal ways.

SUMMARIZED RECOMMENDATIONS



Architectural Concept Aerial View

- Space Program: 159,220 GSF
- Architectural Concept: 4-story plus basement and mechanical penthous
- Semi-transparent plinth to encourage connection to the new green campus quad
- STEM gateway building
- Flexible and adaptable spaces
- State of the art research spaces
- 21st century teaching methods
- Collaborative environment
- Placemaking features

RELATIONSHIP TO REDEVELOPMENT PLAN

Aerial toward northwest of proposed SWQ.
SOURCE: Southwest Quadrant Redevelopment Plan 10.22.15

Southwest Quad Redevelopment Plan

The new Chemistry Building will be one piece of a comprehensive redeveloped Science, Technology, Engineering, and Mathematics (STEM), and Health Science focused portion of the UW-Milwaukee Kenwood Campus. The vision for this region of campus was set in 2014 to renovate this collection of aging facilities and support the future of research and enrollment growth in the STEM fields at UWM. Also, in 2015, an initial Academic /Research Building Pre-Design study was completed to define the needs of the Chemistry and Biochemistry Department. The recommendations outlined in this report use this study as a starting point for the development of a program, budget, and design direction for a new Chemistry Building.

UWM envisions an interdisciplinary STEM community with a strong research focus and enhanced relationships to local industrial and institutional partners.

SOURCE: Southwest Quadrant Redevelopment Plan 10.22.15

BUDGET SUMMARY

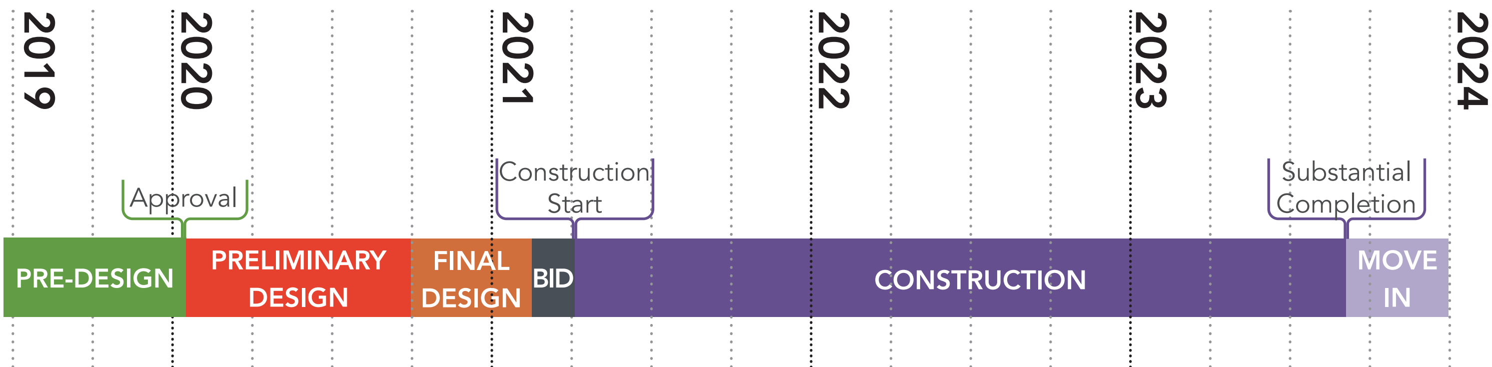
	CURRENT ESTIMATE		COMMENTS
	$/SF	TOTAL	
CONSTRUCTION COST TOTAL	**$582**	**$90,342,440**	
PROJECT CONTINGENCY (10%)		$9,035,000	
FF & E		$6,430,000	Cost carried forward from budget to estimate.
DESIGN FEES TOTAL		**$8,306,700**	
DFDM FEE		$3,975,100	
PROJECT TOTAL	**$760**	**$118,089,240**	

*NOTE: Numbers shown in this table represent costs for the 159,220 GSF building detailed in this report, based on the budget in Section 11.4. The cost estimate detailed in Section 11.4 is based on a 155,340 GSF building and will be updated in subsequent design phases.

Project Estimate

The above table outlines the summary cost estimate. A more detailed summary of this estimate is contained within Section 9 and the detailed breakdown included in Appendix 11.4. The total estimated construction cost for the Chemistry Building, including escalation taken through an estimated 24-month long construction period beginning in Spring 2021, is $90,342,440. Including project contingency, Furniture, Fixtures, and Equipment, and Architectural and Engineering Fees, the total project cost is estimated to be $118,089,240.

SCHEDULE SUMMARY

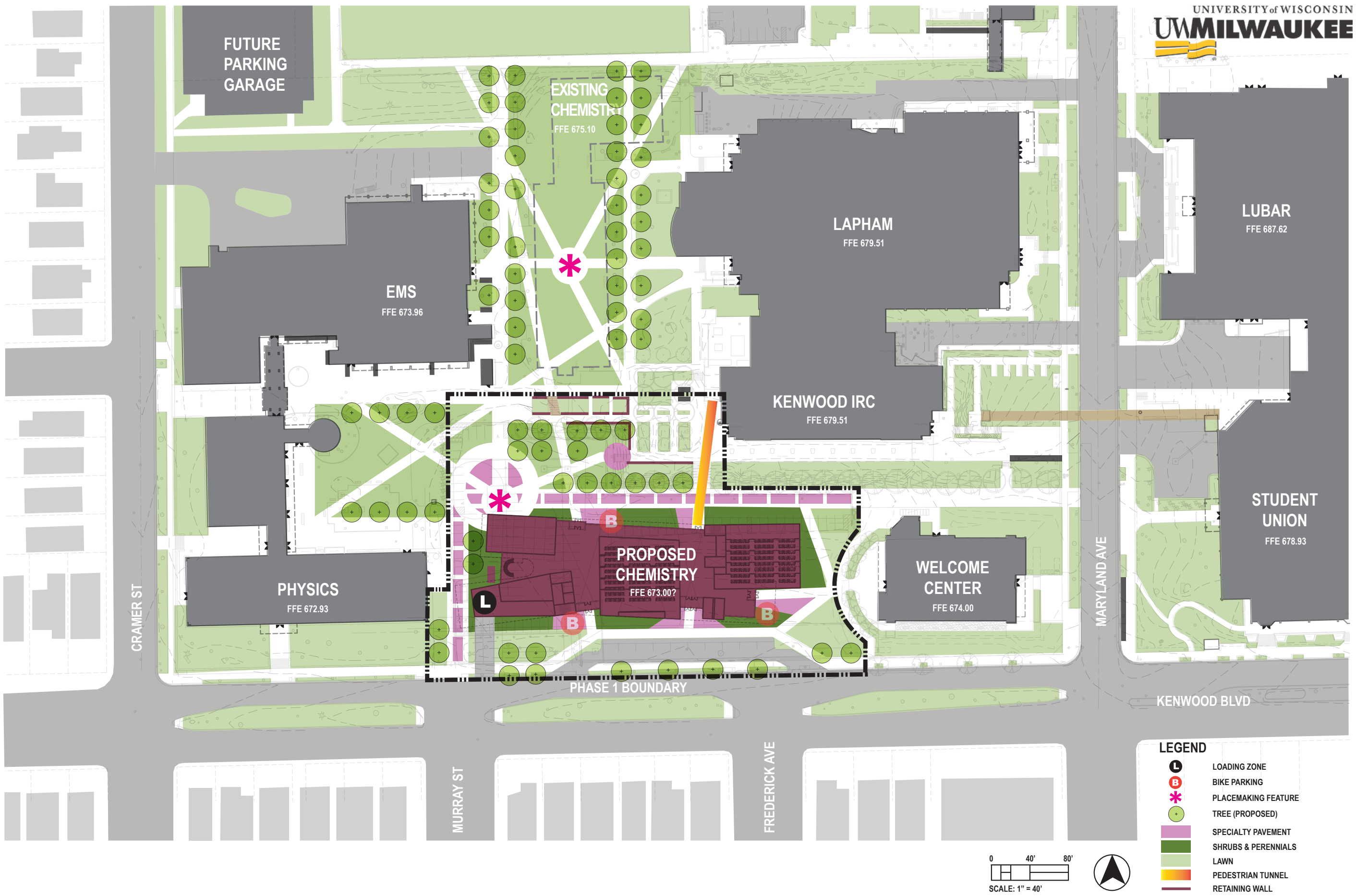


Project Schedule

The new Chemistry Building is the first project to be implemented from the SWQ Redevelopment Plan, and the process will move forward as shown above. Upon completion of the Pre-Design report the project team will immediately proceed into Preliminary Design with a target construction start date of Spring 2021. The project is anticipated to reach substantial completion two years later in Spring 2023.

Project Implementation Schedule

SITE PLAN



Site Concept

Goals for the New Chemistry Building site as identified by this design team suggest that the site should be integral to the campus fabric, STEM-focused, flexible, social, providing a place of respite, allowing a flow between the indoor and outdoor environments, accessible, and maintainable. The following site program elements: large-scale gathering space(s), small scale gathering spaces, open turf, placemaking features, pedestrian pathways, fire lanes, bicycle parking, vehicular parking, stormwater management, ten short term parking stalls along a drop off road, and a loading dock shared with the future STEM building that replaces the Physics building.

These site diagrams extend beyond the New Chemistry Building project site in order to look at the new quad greenspaces more holistically. The first phase to be implemented will be associated with the New Chemistry Building which will include the southern front entrance to the new building along Kenwood Boulevard, westward to the edge of the Physics Building, north to the edge of the Existing Chemistry Building, and east to Lubar Entrepreneurship Center and UWM Welcome Center.

Future phases will extend the campus quad greenspace west and north of the New Chemistry Building. The most significant area of the quad green open space will extend northward, replacing the existing Chemistry Building after its demolition. The location of the existing Chemistry Building will be a valuable extension of the quad given its central location within the STEM buildings and solar orientation within this block of campus.

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2 PROJECT OVERVIEW

PROJECT HISTORY

New Chemistry Building site and associated site work boundary (NTS)
SOURCE: Academic/Research Building Pre-Design Study

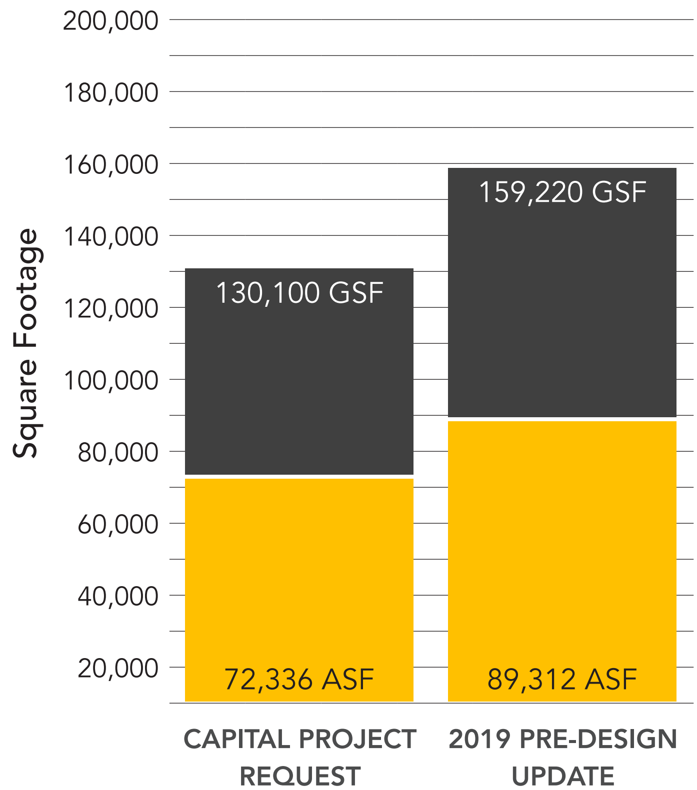
Southwest Quad Redevelopment Plan

The comprehensive Southwest Quad Redevelopment Plan (completed in 2015) broadly reviewed space needs for the seventeen academic departments and schools housed on the Southwest Quad. The first priority identified in that study was for a replacement facility for Chemistry and Biochemistry, due to two factors. First, the existing building is obsolete and at the end of it useful life. Secondly, Chemistry is a foundation course for all STEM and Healthcare disciplines, thus a core need on the SWQ.

Academic/Research Building Pre-Design Study

The 2015 Pre-Design study established the need for a new facility within the context of the condition of the existing facility and the future of the site as part of the STEM-focused SWQ. This study defined a series of goals for the project, summarized here:

- New and modern instructional laboratories to support and expand offerings for core curriculum for students across all STEM and health science related majors.
- New and modern research laboratories to support and expand a dynamic and successful research program.
- New and modern outreach facility to broaden relationships between UW-Milwaukee and the local primary and secondary education community.
- New and modern facilities for tutoring, mentoring and informal learning.



Summary of history of space program to be included in the new Chemistry Building.

The 2015 Pre-Design study for the new facility performed an even more detailed programmatic facility needs assessment including population projections and space utilization analysis.

Capital Project Request

The 2015 Pre-Design study was the basis of the Capital Project Request for a new 130,100 GSF Chemistry Building. The Capital Project Request removed Flex and Collaborative research components and added the extension and completion of the campus utilities loop in the Southwest Quad to the scope of the new Chemistry Building project.

2019 Pre-Design Study

The Kahler Slater / CannonDesign team was tasked with completing a PreDesign for the Chemistry building to develop the scope schedule and budget based on the enumerated project description and using the 12L2Y Predesign. The space program developed in 2015 was the starting point for the program outlined in this report. The primary deviations from the Capital Project Request program included the addition of General Assignment Classrooms and Instructional Lab collaboration space to the new Chemistry Building. These additions were made due to the recommendation of the existing facility conditions assessment to divest form the existing facility completely, requiring the relocation of classrooms into the new building.

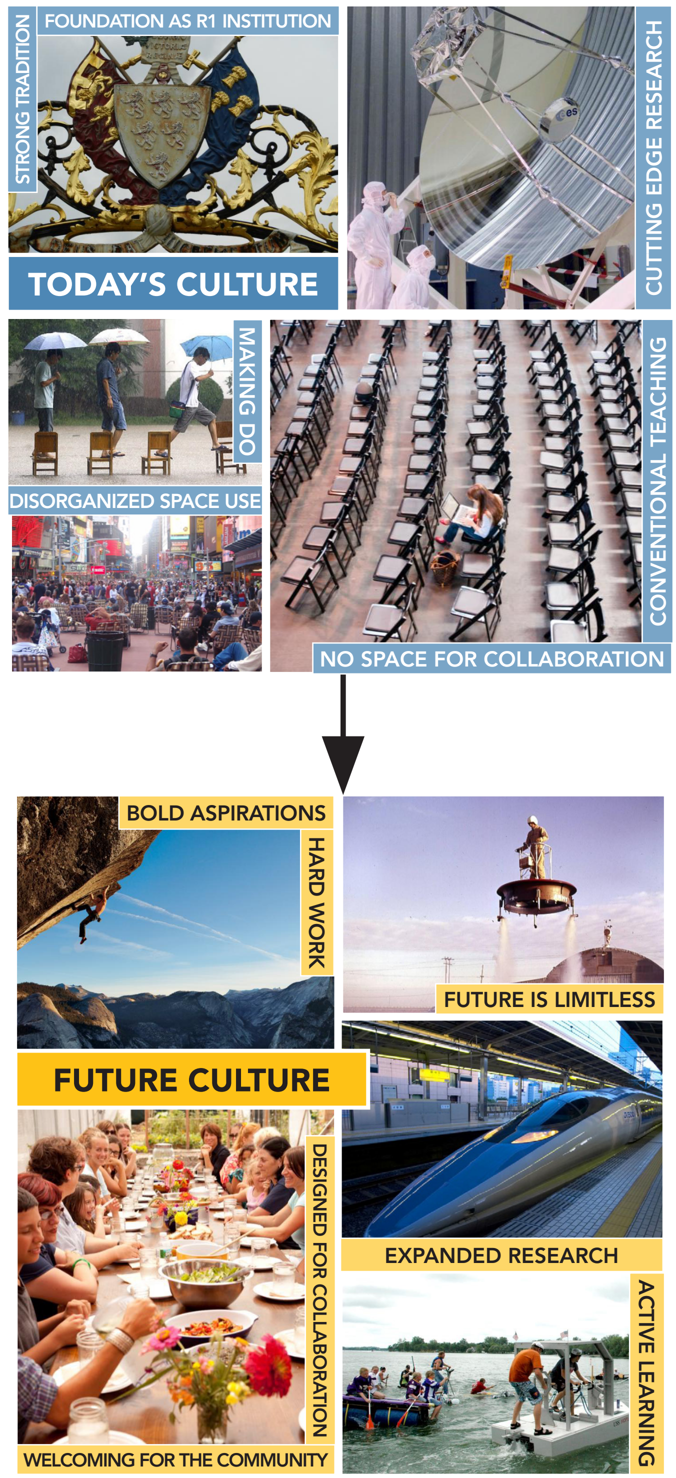
VISION, GOALS, & OBJECTIVES

UWM Chemistry & Biochemistry Culture

To begin to understand the qualitative goals and aspirations for a new Chemistry Building, the design team engaged the project stakeholders in an exercise that asked them to select a series of images that reflect the departmental culture today and what images reflect the desired future state for the Department.

Stakeholders identified that in the current state, the Department has a very strong foundation and history of cutting edge research, but that innovative thinking is not reflected in their current space. The existing Chemistry Building is a qualitatively poor space due to its ad hoc and disorganized space configuration, lack of space for collaboration and limitations of conventional spaces for instruction.

By contrast, stakeholders identified that their future culture should be designed for a high level of collaboration, welcoming in the wider community. The spaces should allow for an expansion of research activities and teaching methods that focus on active learning. The new building should inspire students and researchers to feel that their future is limitless and allow them to aspire to bold discoveries.



Outcomes of departmental culture exercise defining the future state of the Department.

Faculty responses to: What will be critical to helping you achieve your mission over the next 5 to 10 years?

Long Term Priorities

The design team also asked stakeholders to prioritize critical factors that they anticipate will help them achieve their mission for the new Chemistry Building in the next 5 to 10 years. Similarly to the culture conversation, responses between stakeholder groups consistently addressed themes of flexibility and agility to adapt to unknown future research focuses through increased collaboration and space efficiency. Again, the desire to continuously improve and support and already strong research foundation was important to the group. In addition, students were highlighted as the focus critical to achieving the mission. This is ensured with the program providing distinct offerings that attract students to UWM and to Chemistry & Biochemistry at the beginning of their education, and continues to offer them a good value for their investment.

PROJECT DRIVERS:

WELCOMING

FLEXIBLE & ADAPTABLE

TEACHING INNOVATION

TENETS OF FLEXIBILITY

- Pedagogical Methods
- Layout Modularity
- Future Technology
- Global PI Research
- Equipment and Furniture Movement

COLLABORATIVE

TENETS OF COLLABORATION

- Peer to peer learning
- Virtual Communication
- Inside / Outside of Classroom
- Physical Space (transparency, choice)
- Culture & Operations

Project Drivers

The engagement activities described previously resulted in the articulation of the five project drivers listed above. Two of these drivers, flexibility and collaboration, were further investigated to ensure the design team had clarity around what these items truly meant for the UWM Chemistry and Biochemistry Department in particular.

- **Welcoming**

  The prominent site provides the opportunity for the new building to be a gateway to STEM for the SWQ. It should provide spaces that invite users to stay and put science on display to celebrate the work being done within the Chemistry and Biochemistry Department.

- **Flexible & Adaptable**

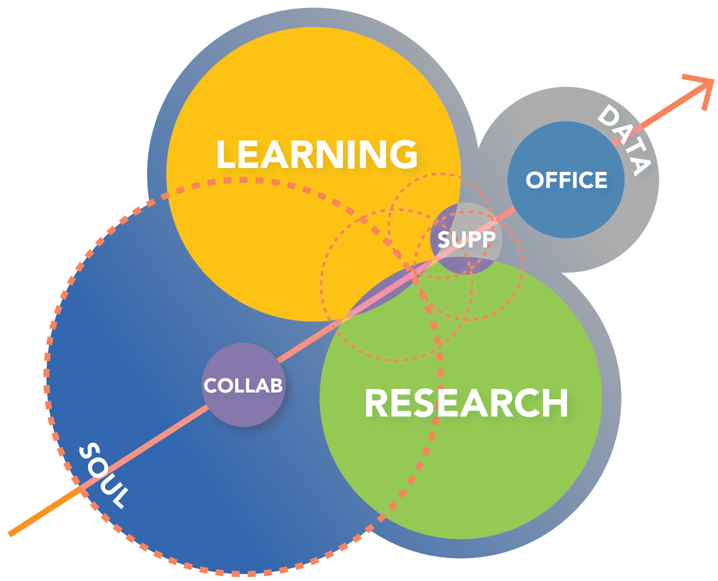
  Programmed spaces throughout the new facility should be flexible, to accommodate multiple layouts in the same space, reconfiguration of equipment and furniture, and opportunities for collaboration both locally and internationally throughout. The space should be adaptable, allowing for changing pedagogical methods and implementation of unknown future technologies through layout modularity and building systems that allow for future expansion and change.

- **Research Excellence**

  UW Milwaukee first earned "R1" (Research 1) status in 2015, and has since maintained that classification as one of the top research universities in the country. This strong tradition of research excellence is a core part of the Chemistry and Biochemistry Department. The new building should provide research spaces that support current and future research activities, while removing barriers between undergraduates and research, to encourage ambitions within the field.

- **Teaching Innovation**

  The second pillar of tradition within this Department is teaching innovation. 12%-15% of the UW-Milwaukee student body takes chemistry coursework at any given point during the academic year. 35-44% of all students take at least one chemistry course throughout their time at the University. All faculty members teach all levels of coursework and seek to reach students on a 1-on-1 basis. With this project



Conceptual program diagram depicting the major functional space typologies and their relationship to one another across a spectrum of quantitative needs, "data", and qualitative experience, "soul".

comes a unique opportunity to create learning spaces where faculty and students can engage with one another from introductory coursework through more advanced chemistry in a state of the art facility that accommodated and encourages new teaching and learning modalities.

- **Collaboration**

  Collaboration within the new Chemistry Building would include a wide variety of stakeholders; from students interacting and learning from one another, to faculty and industry partners collaborating on transformative research projects. The new facility should provide space throughout the building for these interactions to occur, both in formal and informal ways, ensuring that the user has choice in how they engage with others.

Space Typologies

Within the context of the mixed use space program a few key items immediately arose that would be explored in detail during this pre-design engagement and throughout the building design process.

- General Building Organization: Traditional lab buildings are zoned by function (research, office, classroom). The new Chemistry Building's organization should embrace increasingly collaborative and interdisciplinary ways of working and/or learning by exploring options to cluster activities and allow flexibility through a modular planning strategy.

- Classroom Typologies: Although active learning is the current trend in all academia, the design team developed prototypes that would support group based learning and collaboration inside and outside the classroom and laboratory specific to Chemistry.

- Teaching Labs: In order to expose undergraduates to advanced research in the early days of their education, as well as to take advantage of potential shared equipment and other efficiencies, the new Chemistry Building should establish key adjacencies between teaching labs and research labs.

- Research Labs: Contemporary research labs are increasingly more open and flexible, with limited divisions, as opposed to their traditional counterparts. Due to requirements of certain research activities, whether sensitive in nature and/or requiring highly skilled and trained researchers, some UWM Chemistry research is seen as challenging to be accommodated within a more open lab environment. The exploration of configuration and divisions between research labs will be an ongoing discussion through the design process.

- Workplace: The location of workspaces, whether faculty or student, in relationship to the research labs is very important for the day-to-day operations of the department. The University and Department prefer all workspace to be physically separated from the research labs, while maintaining the adequate adjacencies for student support and access.

Functional Requirements

Additional functional considerations were outlined during this Pre-Design process as detailed below.

- Accessibility: The University requested that the design of the new building go beyond minimum ADA standards and to include Universal Design features and provide inclusive restrooms that meet UWM's policy.

- Sustainability: The American Institute of Architects' (AIA) Framework for Design Excellence (formerly the COTE Top 10) provides excellent guidance for the built environment that not only focuses on building performance, but also promotes a comprehensive, integrated design perspective that focuses on people first through whole building design. Promotion and integration of the ten principles will be studied deeply throughout the design of the new Chemistry Building. Working in tandem with the users, the campus, the University, and the State, the design team will explore energy usage, user wellness, community integration, resources, and impact of the new building on its larger community and environs. Additionally, synergies with the AIA's framework will be studied in tandem with the LEED and WELL building systems as the entire team focuses on the most achievable, beneficial, and desired outcomes.

- Safety & Security: Ongoing conversation regarding safety and security features will occur as design progresses. It was acknowledge that the ability to secure individual spaces can be a challenge in an open, flexible, and collaborative environment.

- Hazardous Materials: The quantity and location of hazardous materials within the building may dictate where certain spaces can be located. Recent changes in the 2018 International Building Code have removed some limitations and will be adopted for this project.

- Loading/Receiving: The new loading dock to the west of the site is located adjacent to the next project in the SWQ to be implemented, a new Engineering Building. The design team will consider how the design of the loading dock for the Chemistry Building can be expanded or connected to a future adjacent loading area for the engineering building.

- Infrastructure: The design team was tasked with validating the recommended approach for extending and completing the campus utility loop for SWQ.

PURPOSE & SCOPE

New Chemistry Building site and associated site work boundary (NTS)

Architectural Scope

The new Chemistry Building will be a 159,220 GSF, 4-story building, with a basement and penthouse. It will house the Chemistry and Biochemistry Department, including workspaces for faculty and graduate students, Instructional Labs, Research Labs, and General Assignment Classrooms.

Site Scope

The site work for this project extends beyond the immediate area of the footprint of the new Chemistry Building to set up implementation of a master plan for the new STEM quad for the SWQ. The sitework also includes areas disturbed by the pedestrian access tunnel between this building and the existing KIRC and an utility work.

Utility Scope

This project includes extending the campus utility loop in the SWQ area for future developments in this area of campus. In addition, a pedestrian access and utility service tunnel is included in the project to connect the new Chemistry Building to high-value resources existing in KIRC and Lapham Hall beyond. In the long term, all buildings within the SWQ will be connected in this manner.

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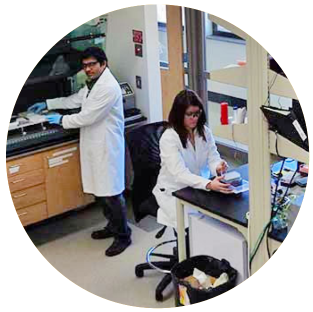
3 STAKEHOLDER ANALYSIS

OCCUPANTS

UNDERGRADUATES



GRADUATES

FACULTY/STAFF

CAMPUS & EXTERNAL PARTNERS

The new Chemistry Building will be comprised of a variety of spaces for a range of activities including instruction and research activities and special events and symposia. The building will be welcoming.

Undergraduates

12%-15% of the UW-Milwaukee student body takes chemistry coursework at any given point during the academic year. 35-44% of all students take at least one chemistry course throughout their time at the University.

Since the 2015 Pre-Design study was completed, although the quantity of Bachelor Degrees in Chemistry & Biochemistry has decreased, over time the overall trend has been an increase in degrees granted. In addition, the number of fall credit hours has increased over time. Even given the historical trends toward an increase in enrollment and degrees granted, based on data from 2018 and 2019, it is expected that a leveling will occur in future years.

Graduate Students

UWM Chemistry graduate students serve many roles within the Chemistry Department. First year students support faculty as Teaching Assistants, while graduate students in their later years support faculty research in the lab. In addition to these roles, graduate students provide tutoring for undergraduates in their courses. These students use a variety of spaces within the building including a mix of shared and dedicated workspaces and offices.

Since the 2015 Pre-Design Study was completed the number of graduate degrees in Chemistry has increased, signaling a demand for future research expansion in the department.

Faculty / Staff

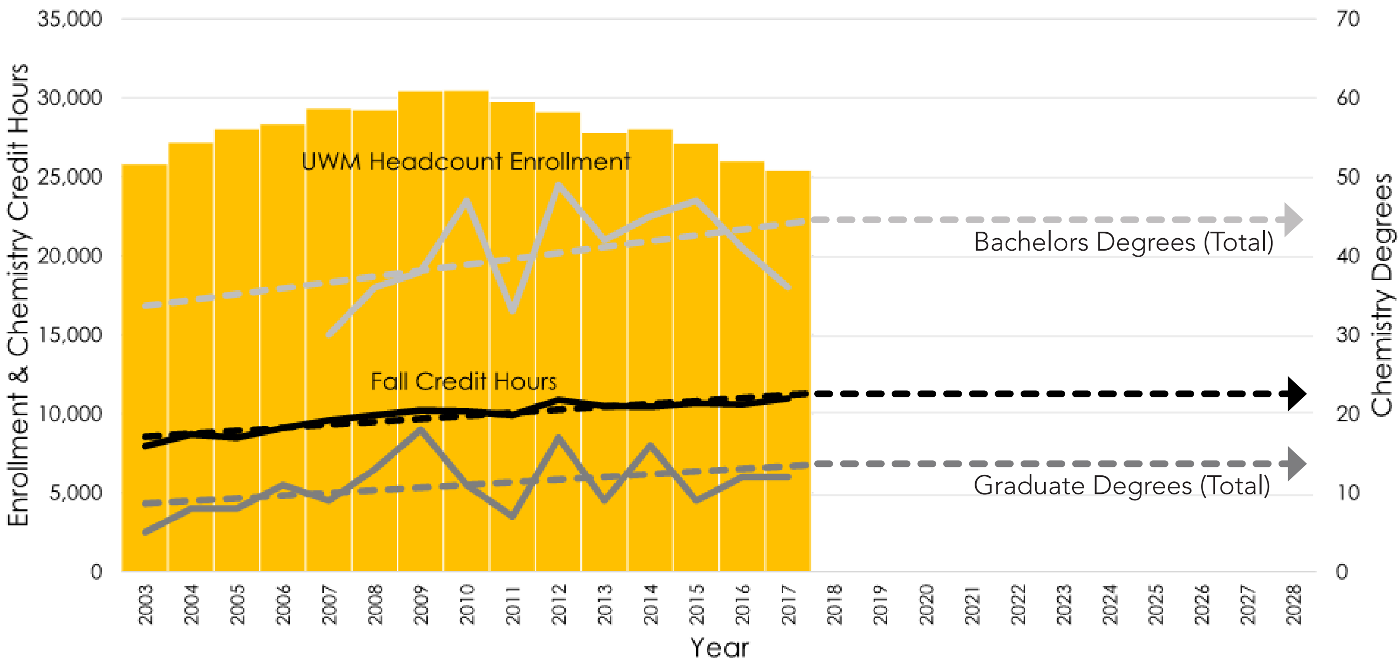
UWM Chemistry and Biochemistry Faculty conduct individual and collaborative research as well as teaching at all levels of Chemistry. Faculty work with undergraduate and graduate students as well as external partners. It is anticipated that quantity of faculty and staff will increase from a total of 38 to 49 to accommodate increased research activities.

Campus & External Partners

The inclusion of General Assignment classrooms in the space program of the new Chemistry Building creates an important opportunity to expose students to advanced research activities so that they are connected to Chemistry & Biochemistry early on in their academic careers and can aspire to be a part of that culture.

In addition, the new Chemistry Building will provide an opportunity for expanding the K-12 partnerships the Department already has established, by providing an Outreach Lab and Classroom for external engagement.

WHAT HAS CHANGED SINCE 2015?



Enrollment and Credit Hour Trends since 2015.
SOURCE: Data is from the UW-Milwaukee 2017-2018 Fact Book

	EXISTING	PROPOSED
	2019	**2029**
FACULTY	20	25
FACULTY/TEACHING	0	3
EMERITUS FACULTY	1	1
TEACHING ACADEMIC STAFF	5	6
GRAD/POST-DOC RESEARCHERS	63	100
GRAD: TA FIRST YEAR	15	15
NON TEACHING ACADEMIC STAFF	6	6
CLASSIFIED	6	8
TOTAL	**116**	**164**

Anticipated headcount for primary building occupants

CURRENT CHALLENGES

Left to Right: research lab, teaching lab, small classroom

Existing Chemistry Building

As documented in the updated Facility Assessment Report, the existing Chemistry Building was originally built in 1974 and its building systems and spaces are quickly approaching the end of their useful lives. Refer to Part 3 of this report for a detailed Existing Conditions report.

Beyond the poor condition of the physical infrastructure, spatially the qualities and experiences within the spaces of the existing building are not conducive to, and often inhibit, contemporary research methods, collaborations, and pedagogical methods.

Current research labs are configured with graduate student workstations within the lab, which is a safety concern and makes it difficult for graduate researchers to engage with one another. Research labs are also configured into smaller, subdivided spaces, some of which have been combined over time to accommodate growth in the number of researchers within a lab. This has required ad-hoc reconfigurations of the space, which should be avoided in the future.

Teaching labs are similarly inflexible and not adaptable to changes in enrollment, technology, or pedagogy. They also have poor sitelines, necessitating decreased class sizes, resulting in inefficient space use. Existing office spaces are scattered throughout the building, again not intentionally configured for access to research labs and collaboration.

Classroom spaces allow for very limited flexibility for collaborative group work and teaching innovation due to station sizes significantly below contemporary metrics as shown below. Additionally, there is limited collaboration space associated with the instructional spaces and students are often found seated in the narrow corridors between classes. The inclusion of this type of informal space should be a key part of the new facility.

Classroom Metrics		
	Existing Station Size	**Recommended Station Size**
Lecture (150+ seats)	10 SF/Student	20 SF/Student
Medium Classroom (50-80 Seats)	13 SF/Student	30 SF/Student
Small Classroom (0-50 Seats)	17 SF/Student	30 SF/Student

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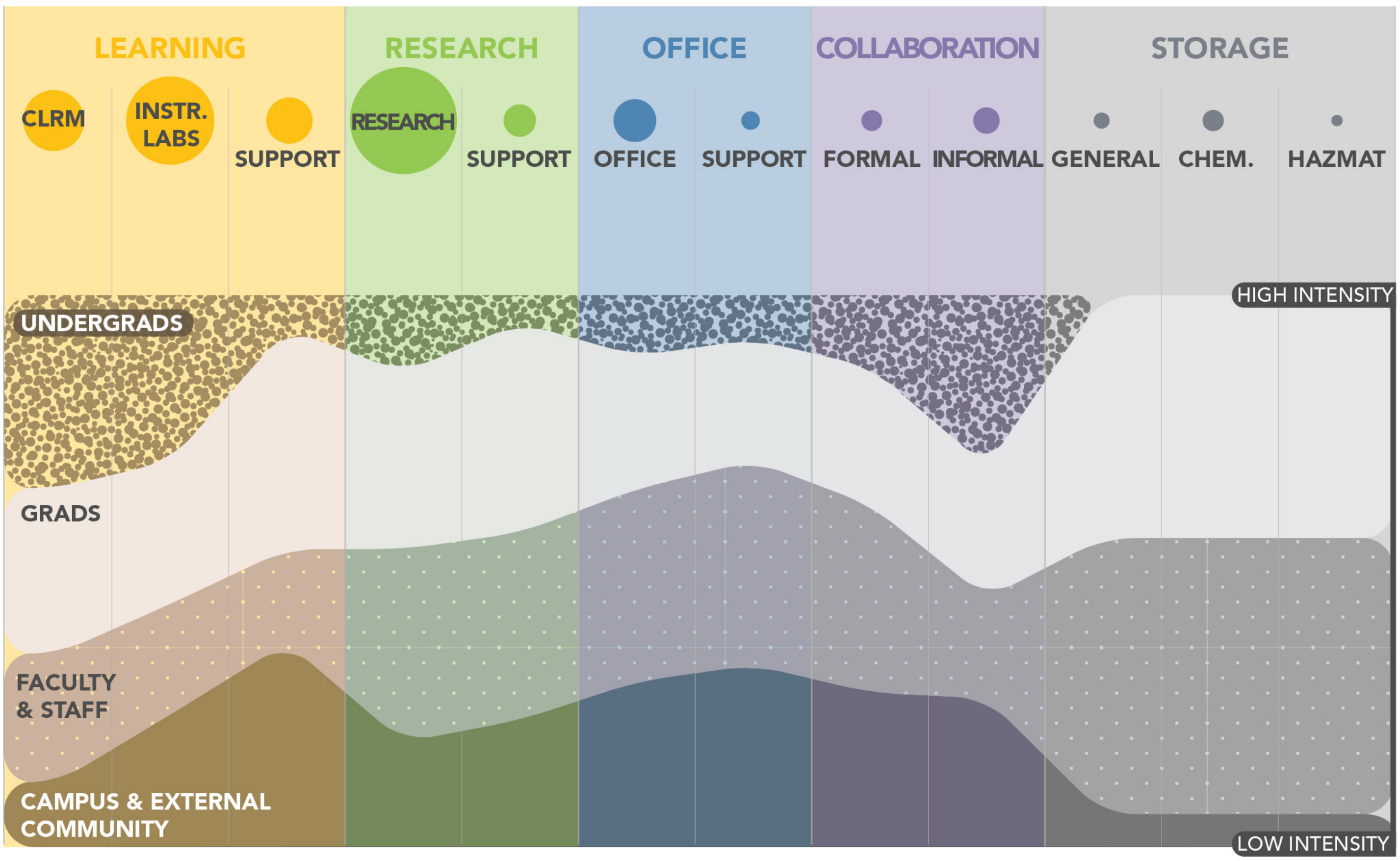
FUTURE SPACE USE



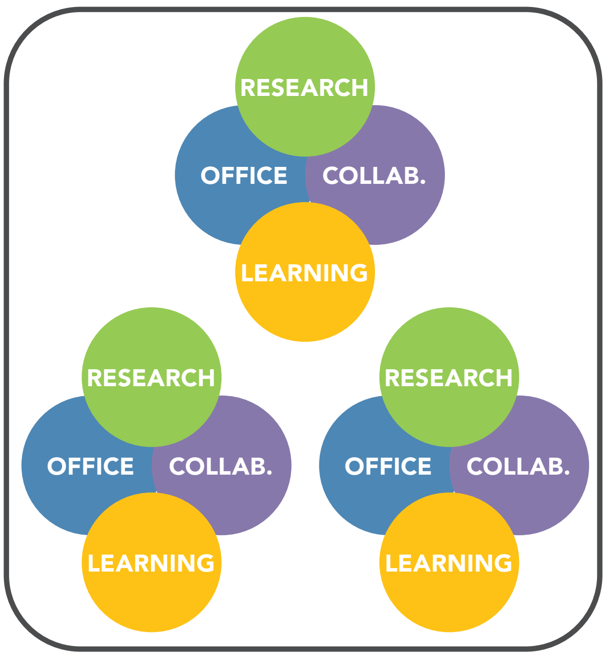
Space use intensity chart showing the day-to-day spaces that each building occupant uses.

Building Planning Strategy

During the visioning process the design team developed an understanding of how the primary occupants of the new Chemistry Building will use the spaces throughout the building. An analysis of these patterns across space function groups (learning, research, office, collaboration, and storage) reveals disconnects between spaces used by different groups, signaling an opportunity to develop a space plan for the building that encourages increased interactions (outside of formal coursework) between groups such as faculty and undergraduates or graduate students and the external community through space adjacencies.

The Chemistry building will be a place where students, faculty, staff and partners will experience the innovative research and pedagogy of the UWM Chemistry and Biochemistry Department. Traditional lab building planning zones the facility based on categories of function, and contemporary research facilities benefit from clustering these activities throughout the building. Implementing a strategy for space planning based not on a building zoned by function, but instead one that balances the efficiencies of co-locating like activities and clustering mixed uses throughout the building to enhance collaboration across disciplines and research focuses. Clustering also yields efficiencies in how researchers and students work in the space; Allowing for heads down work at sensitive equipment to be coupled with nearby space for impromptu problem solving and consultation with fellow researchers. Students and instructors can continue their conversations beyond class time in adjacent spaces. Visitors to the building and those just passing through on a cold Milwaukee winter day are encouraged to spend time in the building and create a vibrant and lively gateway to this STEM focused zone of the UWM campus.

CONTEMPORARY PLANNING: MIXED USE CLUSTERS



Mixed Use Cluster Benefits

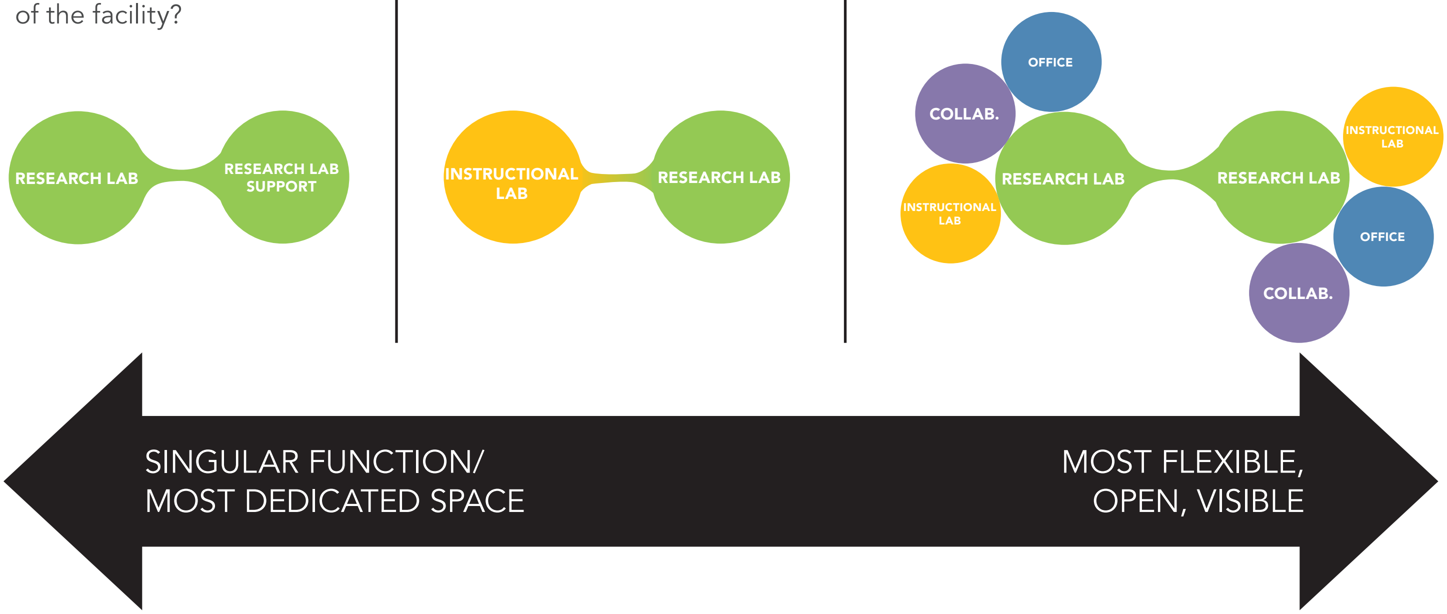
- Increased utilization of space
- Efficiencies of programming
- Impromptu collaboration in adjacent spaces
- Transparency of research
- Break down of silos
- Increased openness and flexibility
- Direct access to complementary functions

What are the necessary spatial relationships to support...

Function
...the day-to-day operations of the facility?

Experience
...the vision for the facility?

Research Focus
...Principal Investigator relationships?



Adjacency Strategies

There are multiple ways in which adjacencies within the new Chemistry Building should be addressed. Those range of adjacencies can be purely functional, or prioritize the qualitative experience. Each of the three strategies shown above are appropriate for different spaces in the program and will be layered and combined in the planning of the facility.

Function

Certain adjacencies between spaces in the facility are non-negotiable and must be prioritized. Highly specialized spaces with one specific function or spaces that need to be secure (whether due to safety and security issues or sensitivity of the research) would be laid out with this strategy in mind.

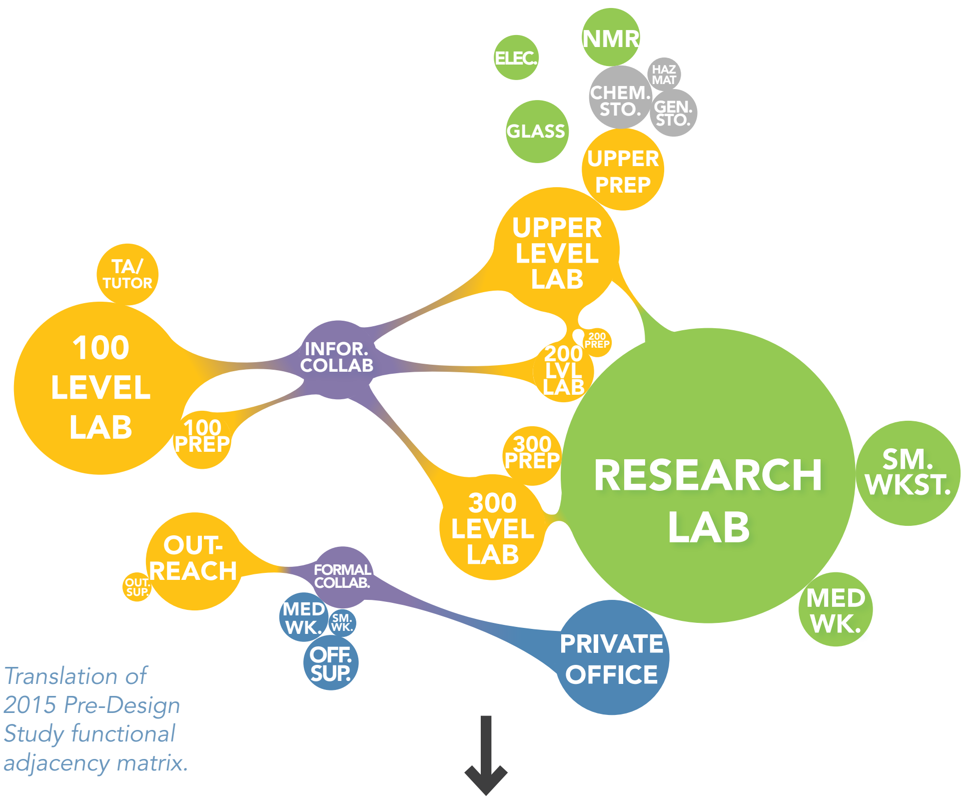
Experience

A second adjacency strategy is to consider the experience and vision for the facility. For example, (although not required functionally) co-locating research labs with classrooms or instructional labs would ensure that undergraduates beginning their educational path are encouraged to aspire to advanced research due to the visibility of that work in their day-to-day education.

Research Focus

To support the strategy of clustering program for a contemporary mixed use research facility another set of adjacencies to be considered is research focus. Researchers doing similar work, requiring similar equipment, support spaces, and building systems would be adjacent to one another. This strategy enhances future flexibility for research team sizes and creates efficiencies in building design, leading to more open and collaborative research environments.

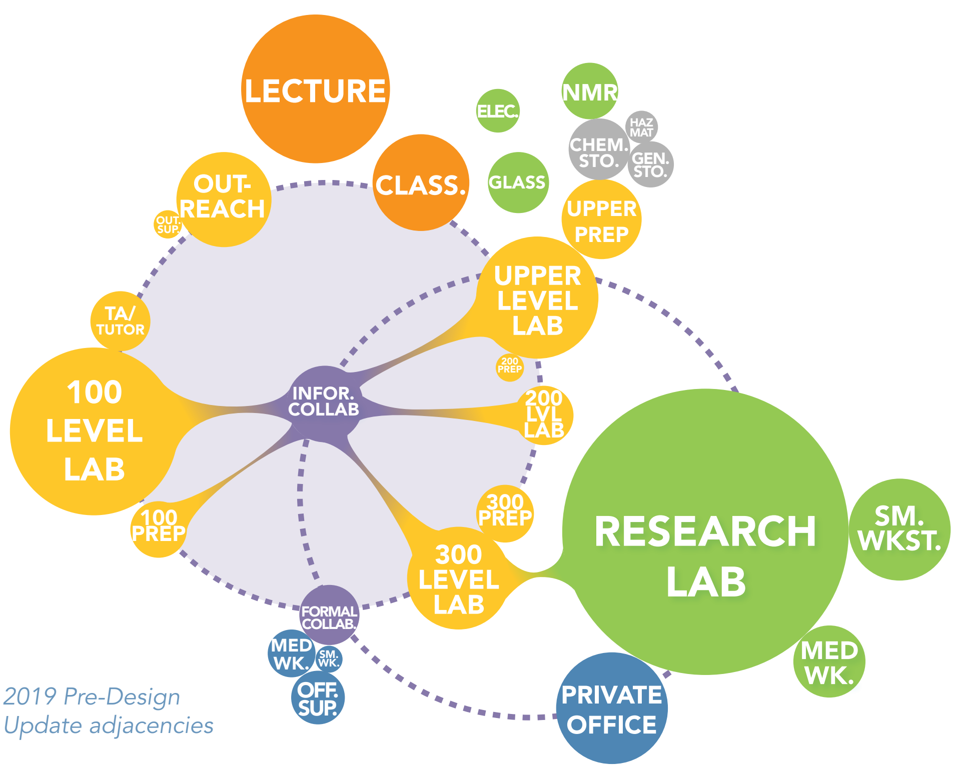
ADJACENCY DIAGRAMS



Translation of 2015 Pre-Design Study functional adjacency matrix.

2015 Functional Adjacencies

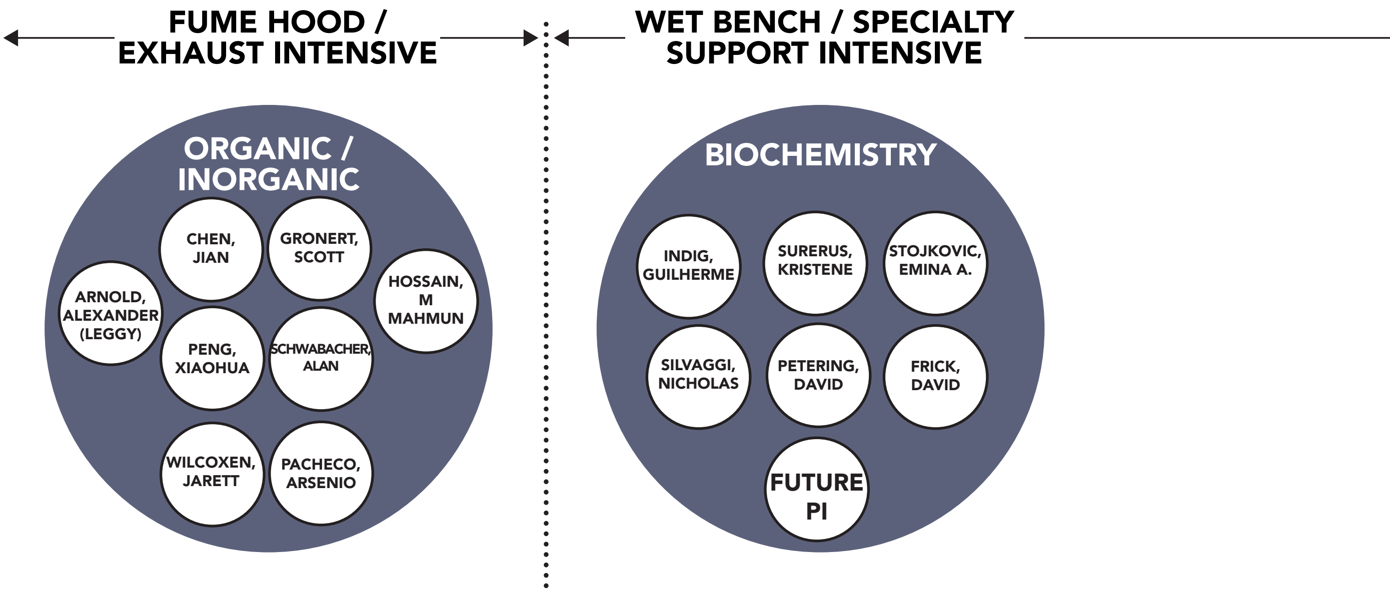
- Instructional labs adjacent to prep
- Research labs adjacent to researcher workspaces
- Faculty offices adjacent to formal collaboration and support workspaces
- Instructional labs adjacent to informal collaboration
- Classrooms not included



2019 Pre-Design Update adjacencies

2019 Functional + Experiential Adjacencies

- Informal collaboration as connector between other program spaces to increase interaction
- Small classrooms adjacent to upper level instructional labs to couple complementary functions
- Lecture adjacent to research labs to increase opportunity for research on display
- Formal collaboration adjacent to informal collaboration for increased utilization



Spectrum of research activities by PI

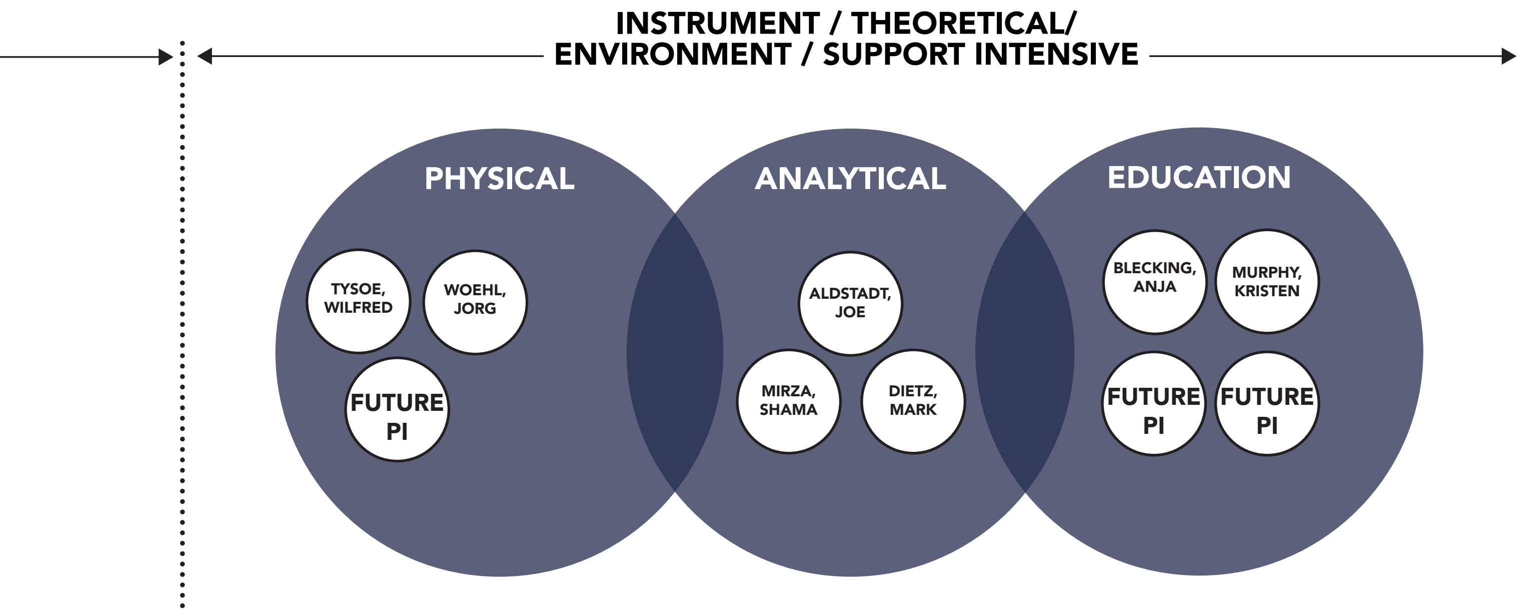
Research Lab Clusters

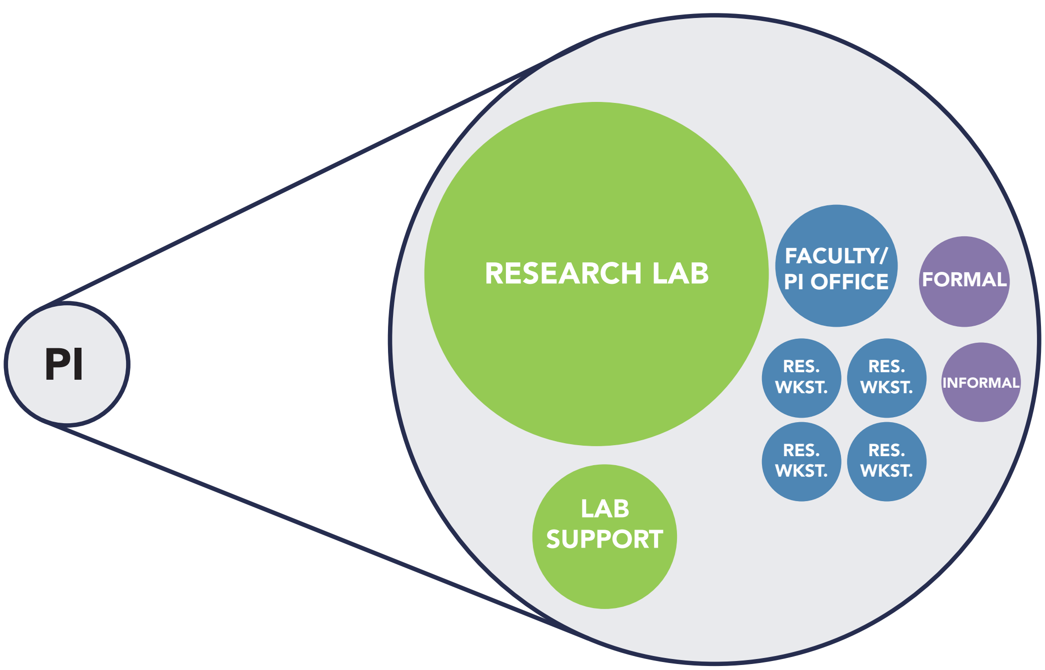
Contemporary research labs are more open and flexible creating spaces for multiple PIs to work with shared prep spaces and equipment. Given that Chemistry & Biochemistry research is a continually evolving field with a future that is difficult to predict, an open layout allows for flexibility in size of research groups over time.

The ten year research plan includes disciplines with different space needs forming neighborhoods for 2-6 PIs in the following categories.

- Fume Hood Intensive: Highest density of fume hoods and require the most intensive building systems to run. Typical type of lab for Organic and Inorganic chemistry.
- Wet Bench Intensive: Primarily wet benches and require significant support spaces to run. Typical type of lab for Biochemistry.
- Instrument Intensive Lab: Highly controlled environments with significant specialty equipment and support space needs. Typical lab for Physical and Analytical Chemistry and Chemistry Education.

Each PI represented in the diagram above uses a series of spaces within the space program to conduct their work, not only the research lab itself. Implementation of the research lab clustering model in the planning of the new Chemistry Building requires consideration of the lab space per research team as it relates to the researchers' workspaces and offices, and proportion of collaboration space required for a cohesive functional research cluster based on the day-to-day operations of each research lab.





Space program components that accompany each PI

Building Tours

The team conducted regional tours of existing research and teaching facilities in order to understand how contemporary lab spaces function from the first hand experience of the users. The following buildings were included in the tours, participants are noted in parentheses:

- University of Wisconsin, Madison's Chemistry Building (CannonDesign
- Wisconsin Institutes For Discovery (CannonDesign)
- Wisconsin Energy Institute (CannonDesign)
- Biochemical Sciences Complex (CannonDesign)
- William Eckhardt Research Center (UW-Milwaukee & CannonDesign)
- Mudd Building (UW-Milwaukee & CannonDesign)
- Northwestern Technological Institute (UW-Milwaukee & CannonDesign)

NOTE: All costs shown escalated to start of construction Spring 2021.

Chemistry Building

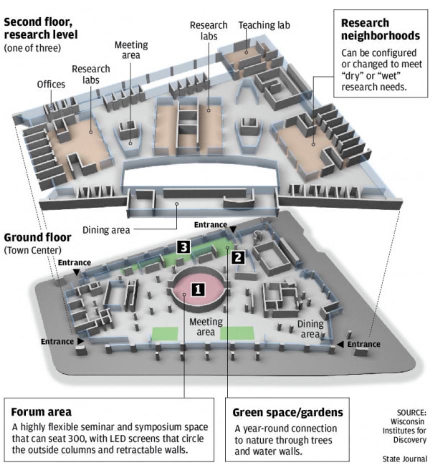
Chemistry Building Floor Plan (NTS)

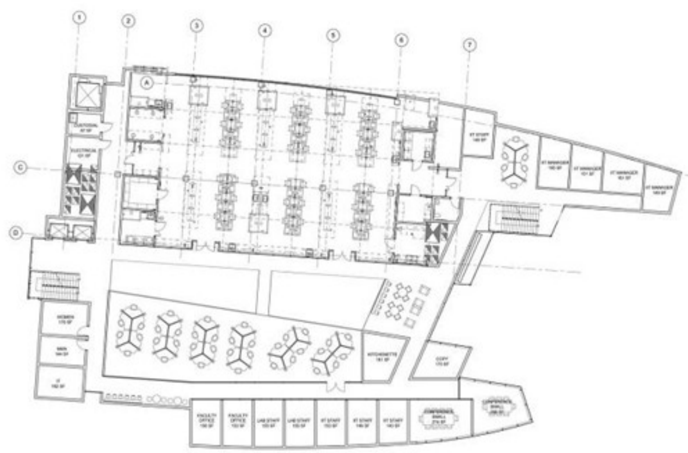
University of Wisconsin, Madison's Chemistry Building

- Architect: Flad Architects, Madison, WI
- Year: 2000
- Area: 225,000 GSF
- Project Cost: $247M ($1,099/GSF)
- Research labs only (teaching labs in the adjoining new addition under construction)
- Heavy fume hood use (mostly synthetic chemistry research)
- Research labs dedicated per PI
- Shared core facility space on 2nd Floor
- Grad student offices separated from labs and glazed on two sides (became more standard since this project)

Wisconsin Institutes For Discovery

Wisconsin Energy Institute





Wisconsin Institutes For Discovery Program (NTS)

Wisconsin Energy Institute Floor Plan (NTS)

Wisconsin Institutes For Discovery

- Architect: Ballinger, Philadelphia, PA
- Year: 2010
- Area: 330,000 GSF
- Project Cost: $295M ($893/GSF)
- LEED Gold & Lab of the Year Award winner
- Building is all research labs, no undergraduate teaching labs; however, it does have outreach teaching labs
- The building is more biomedical with moderate fume hood density
- Shared research space in an open lab concept with 2-5 PI's per lab area, 3 lab areas per floor
- No dedicated corridors and open office concept
- High priority placed on flexibility, plug & play, easier upfit as research directions change

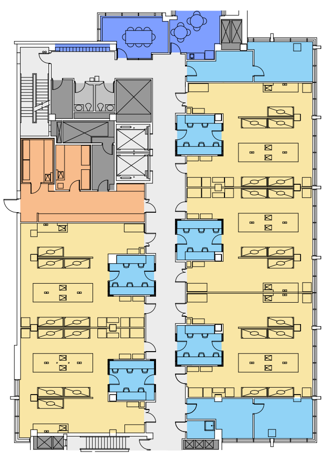
Wisconsin Energy Institute

- Architect: Potter Lawson, Madison, WI
- Year: 2012
- Area: 107,000 GSF
- Project Cost: $75M ($698/GSF)
- Second floor is mostly chemistry-based research, and as you move up to higher floors there are less fume hoods with more bio-based research
- Typically, one large open lab per floor with 3-4 PI's per floor
- Support labs on ends of open lab for good transparency though office/open
- Open grad student offices separated from labs, visually connected
- Private PI offices private on periphery

3.3 Future Space Use

Biochemical Sciences Complex

William Eckhardt Research Center



Biochemical Sciences Complex Lab Layout Plan (NTS)

William Eckhardt Research Center Site Plan (NTS)

Biochemical Sciences Complex

- Architect: Flad Architects, Madison, WI
- Year: 2012
- Area: 169,200 GSF
- Project Cost: $146M ($864/GSF)
- Conventional layout with fixed casework and dedicated single-PI labs
- Research labs have interconnecting doors/ghost corridors
- PI offices in corners
- Central core lab support area within racetrack corridor
- Transparency only at doors
- Open grad student offices separated from labs, visually connected.
- Private PI offices private on periphery

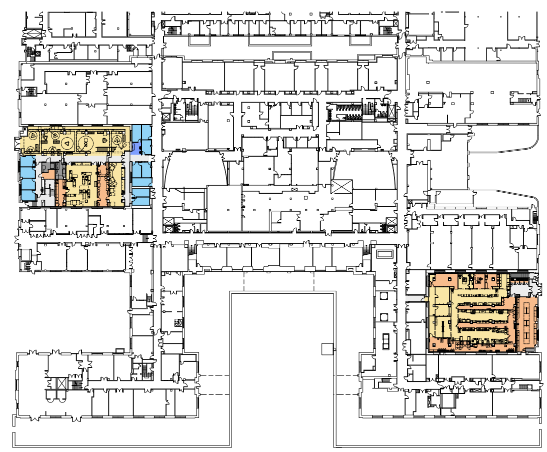
William Eckhardt Research Center

- Architect: HOK & James Carpenter Design Associates
- Year: 2005
- Area: 277,000 GSF
- Project Cost: $361M ($1,303/GSF)
- Each floor is considered a neighborhood, with a home base at the north end providing the largest gathering spaces
- Five above-grade floors accommodate lab types ranging from optics to chemistry
- Planned interaction spaces include a conference facility, pre- and post-event space, a café and corner collaboration areas
- On the top floor, an open balcony provides a view of Chicago's skyline

Mudd Building

Northwestern Technological Institute

Mudd Building Floor Plan (NTS)



Northwestern Technological Institute Floor Plan (NTS)

Mudd Building

- Architect: Flad Architects, Madison, WI
- Year: Addition & Renovation 2018
- Area: 125,000 GSF
- Project Cost: $93M ($743/GSF)
- Building is research labs only with no teaching in this building
- Provide collaborative student resources and much-needed growth space for state-of-the-art scientific research laboratories
- Climate-controlled space for sensitive instrumentation
- The second floor provides collaborative student and research consultation space
- The third, fourth and fifth floors have computational and wet laboratory research space

Northwestern Technological Institute

- Architect: Holabird & Root, Chicago, IL
- Year: 2008
- Area: 50,000 GSF each addition
- Design of the several additions and renovations addresses the building's research, instructional, and collaborative functions
- Large atrium in each addition that provides generous indoor public gathering space for use by all building occupants
- Natural lighting in existing building and additions
- Laboratory facilities are designed for adaptation to a wide range of uses, supporting multidisciplinary research as cutting-edge engineering intersects with biology, physics, mathematics, and chemistry.

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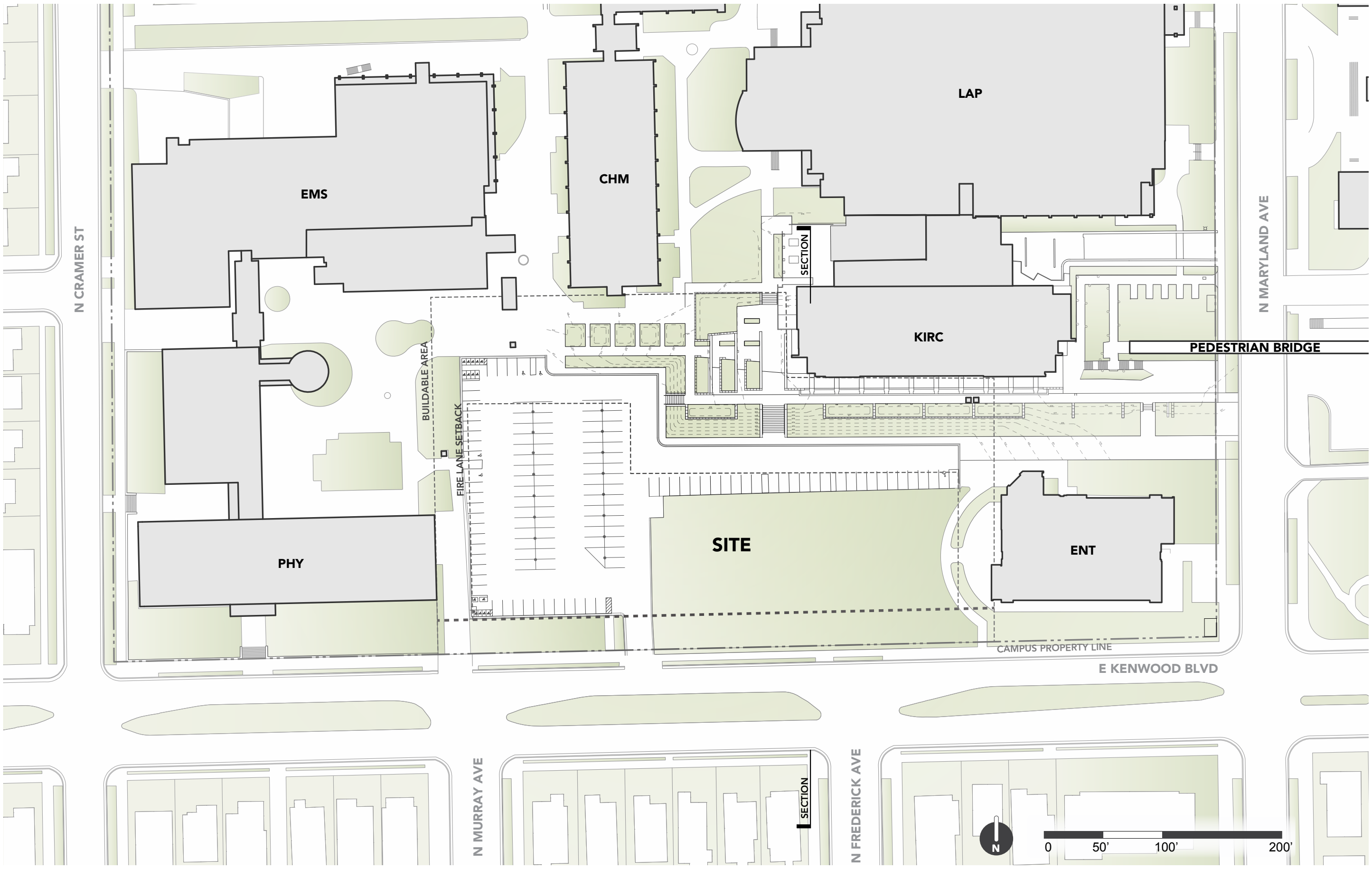
4 PHYSICAL PLANNING ISSUES

SITE/EXISTING CONDITIONS



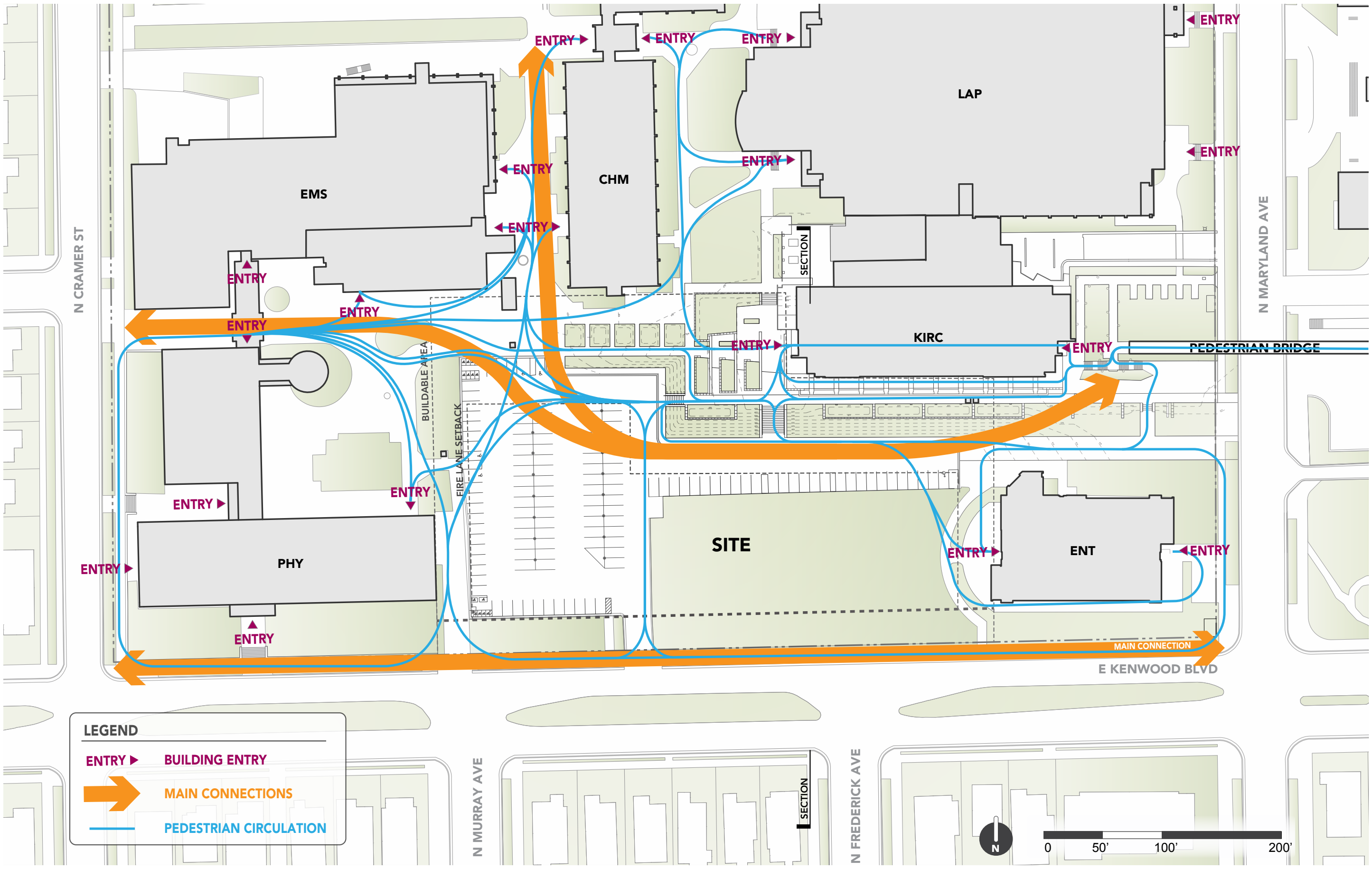
Existing Site Plan

Existing Conditions

The new Chemistry Building will be one piece of a redeveloped STEM and Health Science focused portion of the UW-Milwaukee Kenwood Campus. The vision for this region of campus was set in 2015 to renovate this collection of aging facilities and support the future of education and research in the STEM fields. Also in 2015, an initial Academic / Research Building Pre-Design study was completed to define the needs of the Chemistry and Biochemistry Department. The recommendations outlined in this report use this study as a starting point for the development of a program, budget, and design direction for a new Chemistry Building.

Chemistry & Biochemistry

The Chemistry and Biochemistry Department includes a wide range of research typologies including analytical, biochemistry, inorganic, organic, physical, and chemistry educations focuses. Researchers are currently housed in a building first occupied in 1974, but that building has exceeded its useful life from a physical infrastructure viewpoint, and cannot accommodate modern and efficient teaching and research methods.



Existing Site Analysis

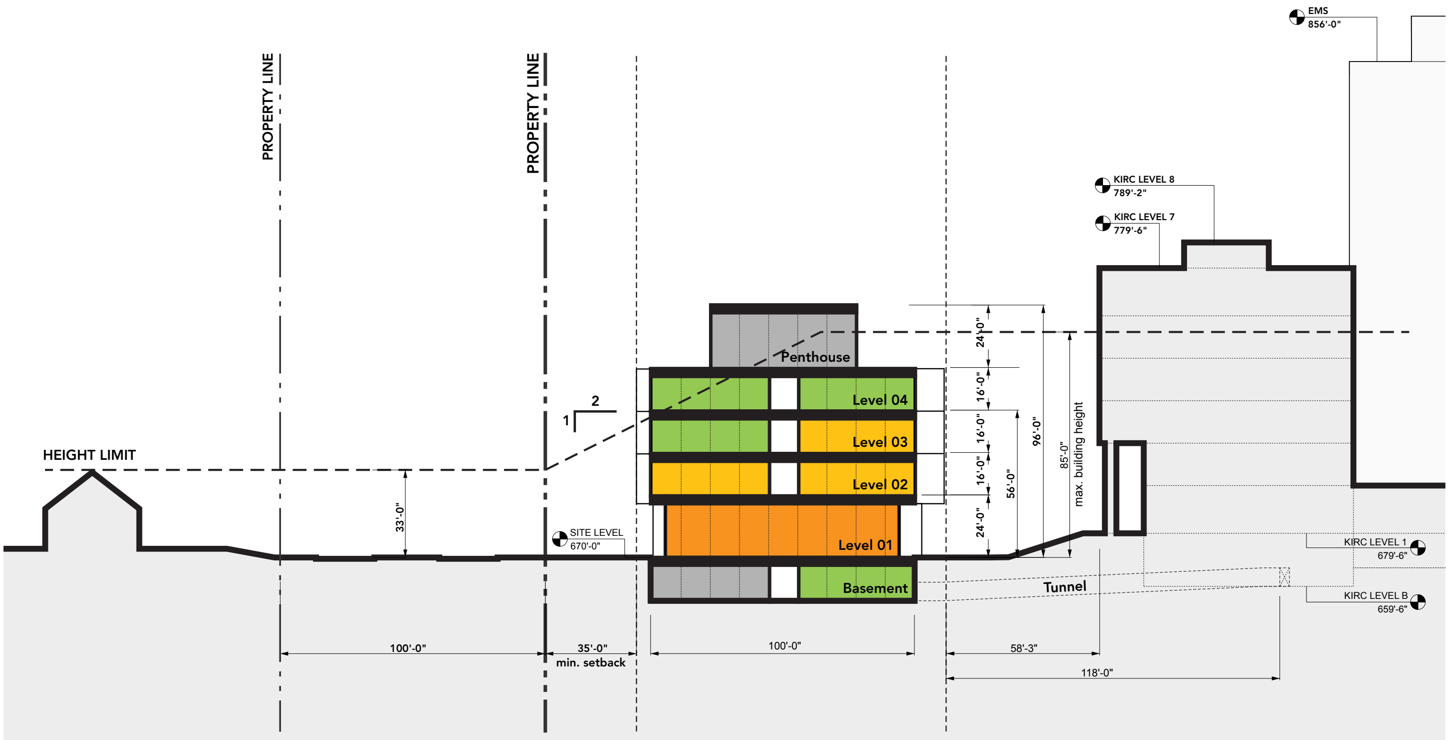
Site Analysis

The context of the Campus Master Plan and SWQ Redevelopment Plan revealed several key drivers of the building massing and site design.

First is the creation of a formal campus quad to the north of the project site. The UW-Milwaukee campus lacks green space, and this project has the opportunity to set the stage for a large central quad that invites people to linger and engage with this STEM centered region of campus.

Chemistry relates to all disciplines in the STEM quad making connections to all existing and proposed campus buildings a significant consideration. This building is also located on the edge of campus, highlighting the important relationship between the fabric of the campus and the residential neighborhood to the south.

ZONING / UTILITIES



Section 1: New Chemistry Building Section - Zoning Envelope (NTS)

Zoning

Setback and height requirements impact location and massing. To the south, a residential district with mainly two story, single-family homes face the campus across the wide Kenwood Ave. boulevard. Some larger multi-family appears as the block approaches Maryland Ave.

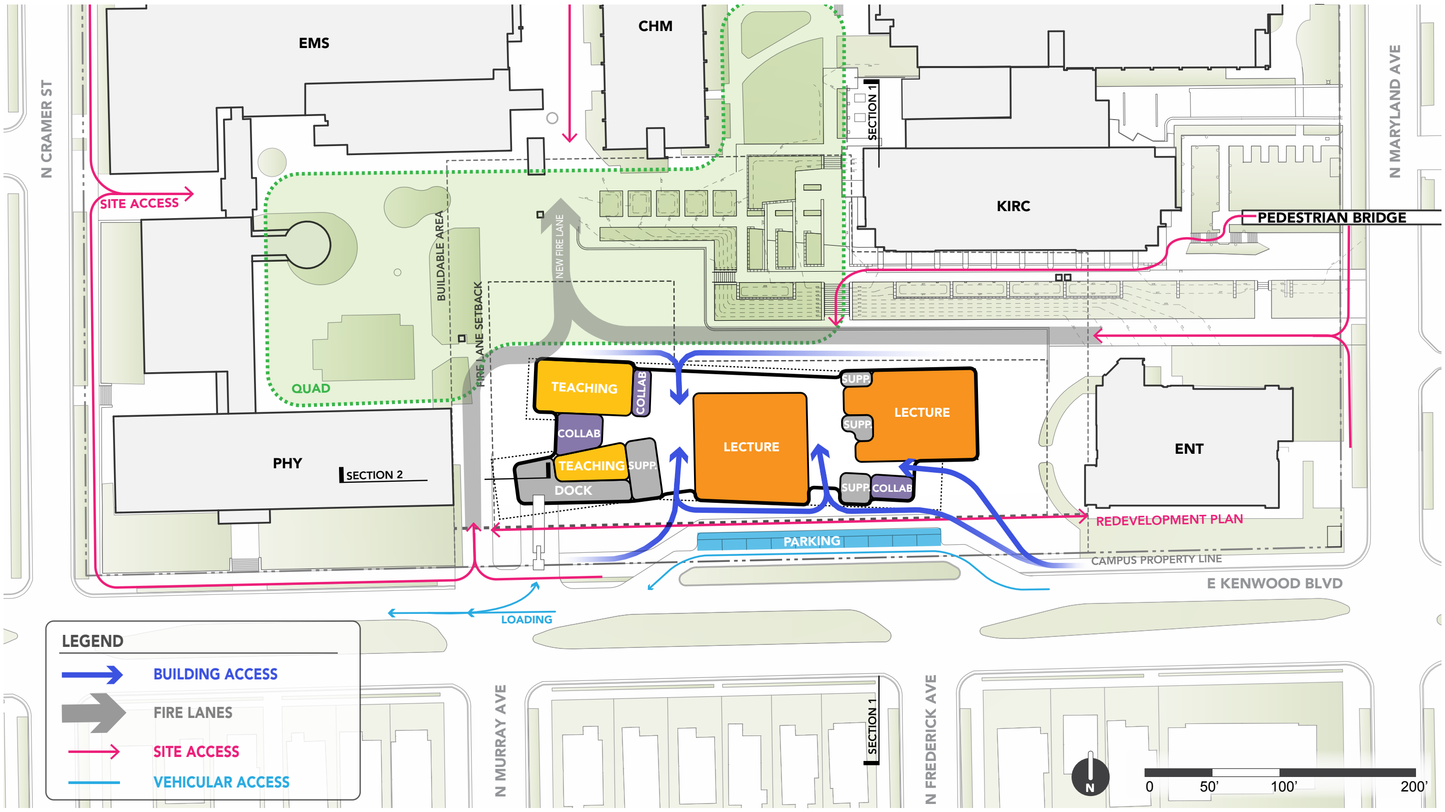
Existing buildings set farther into campus exceed current zoning minimum heights by approximately 35-feet at KIRC and over 100-feet at the EMS building. Due to the proximity of the proposed chemistry building to the street scape, we propose to adhere as closely to the zoning envelope as possible while fulfilling the required program. The project proposes a variance to the zoning requirements to allow a portion of the fourth-floor roof and the penthouse only to surpass the minimum height requirements. The highest occupied floor will remain below the height requirement of 85-feet. Preliminary discussions with zoning officials have begun and will be ongoing during preliminary design to confirm acceptance of the proposed variances.

Utilities

The project area is served by public utilities that run east-west along East Kenwood Boulevard as well as utilities that run north-south along North Maryland Avenue and North Cramer Street. The proposed new chemistry building footprint requires rerouting three 10-inch sanitary sewers and one water line. In addition, the building footprint requires one 18-inch storm sewer, one 8-inch storm sewer, and two storm sewer structures to be relocated or abandoned. The proposed electrical, chilled water, steam, and steam condensate mains will be routed through the north-south corridor between the EMS Building and the existing Chemistry Building. There are existing 8-inch diameter storm sewers located in this area that will require rerouting because this corridor will be densely packed with the new utilities and the existing storm sewer. Construction of the proposed electric, chilled water, and steam will necessitate installation of new storm.

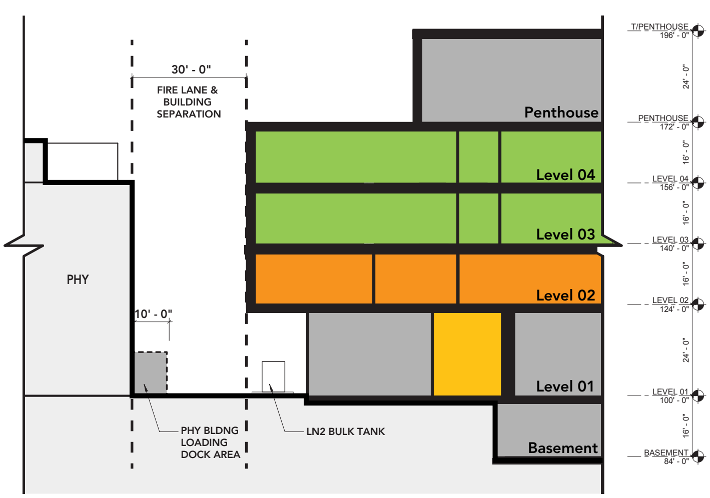
All utilities serving the new Chemistry Building and existing utility reroutes will connect to the existing public utilities in East Kenwood Boulevard between North Murray and Frederick Avenues. The sanitary sewers will be connected to the existing 18-inch sanitary sewer. The storm sewers

TRANSPORTATION / CIRCULATION



Site Circulation

will be connected to the existing 15-inch combined sewer. The water service lines will be connected the 12-inch water main. The proposed utility connections are pending City of Milwaukee review. Refer to section 7.6 for additional detail and diagrams detailing these connections.



Section 2: New Chemistry Building Section - Fire Lane & Building Separation (NTS)

Transportation & Circulation

The proposed building is fully integrated into existing transit infrastructure. Local and Campus transit options use the corridor along Maryland Ave. Local buses also run along Kenwood Blvd. Kenwood Blvd also maintains existing bicycle lanes. Bike parking around the site is abundant, located at Kenwood IRC and several places along the EMS building. The proposed building will also have additional bike parking at multiple entrances. Parking is a campus wide resource of parking garages and lots. Ten (10) additional accessible and short-term parking will be made via a drop-off lane from Kenwood Blvd. immediately adjacent the proposed Chemistry building. Pedestrian routes throughout the site will be maintained. Planned lobby spaces in the Chemistry building will allow pedestrian level porosity through the site from Kenwood north into the quad. New landscape features north of the building will create the proposed STEM quad, with abundant access, seating, and relaxing spaces. Improvements to the Kenwood streetscape along the building will also enhance the pedestrian experience.

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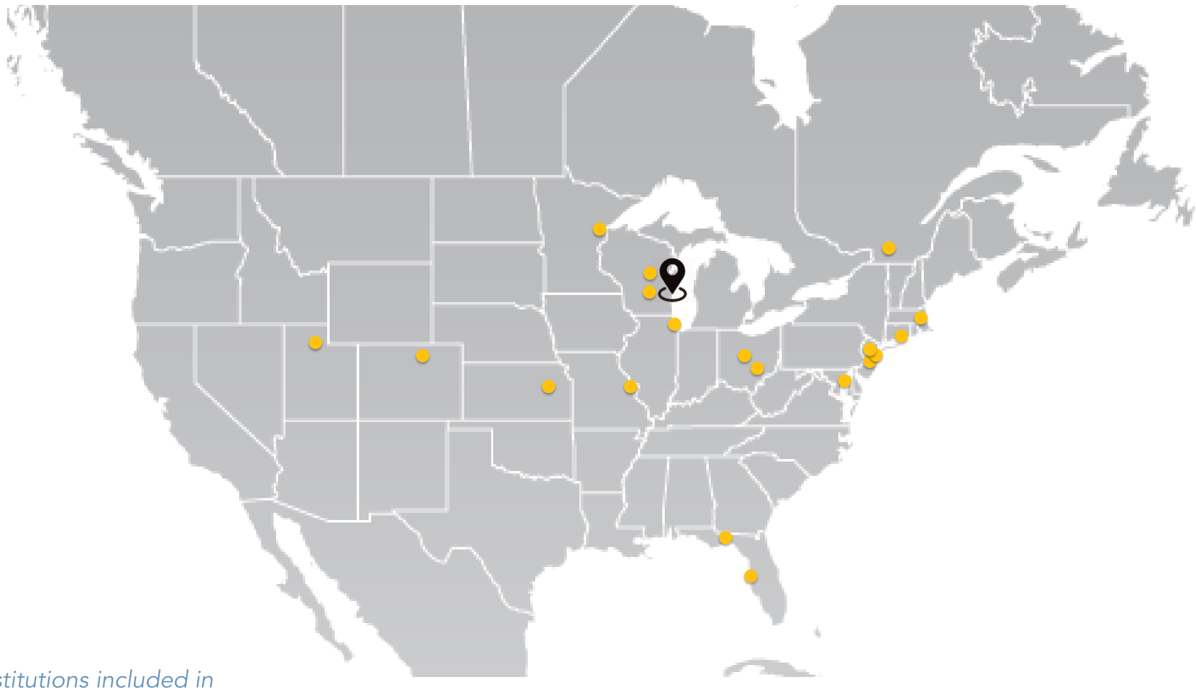
5 CHANGES & PROJECTIONS

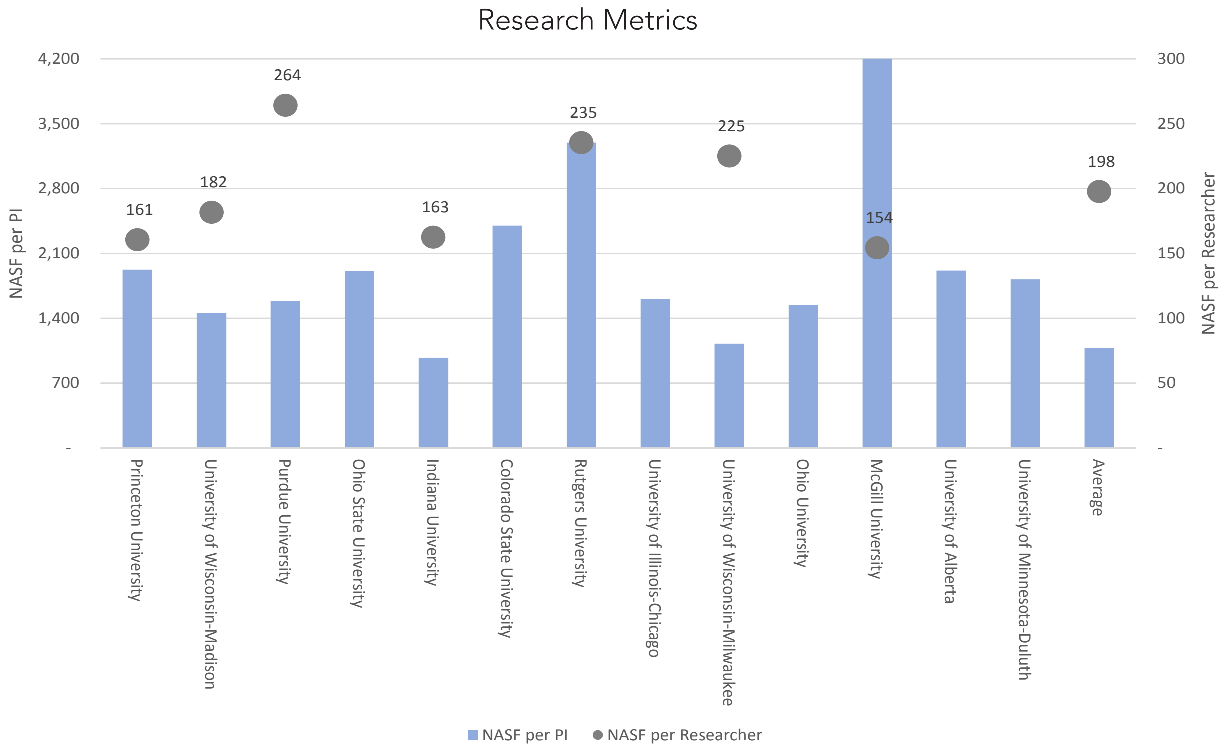
PROGRAM ANALYSIS



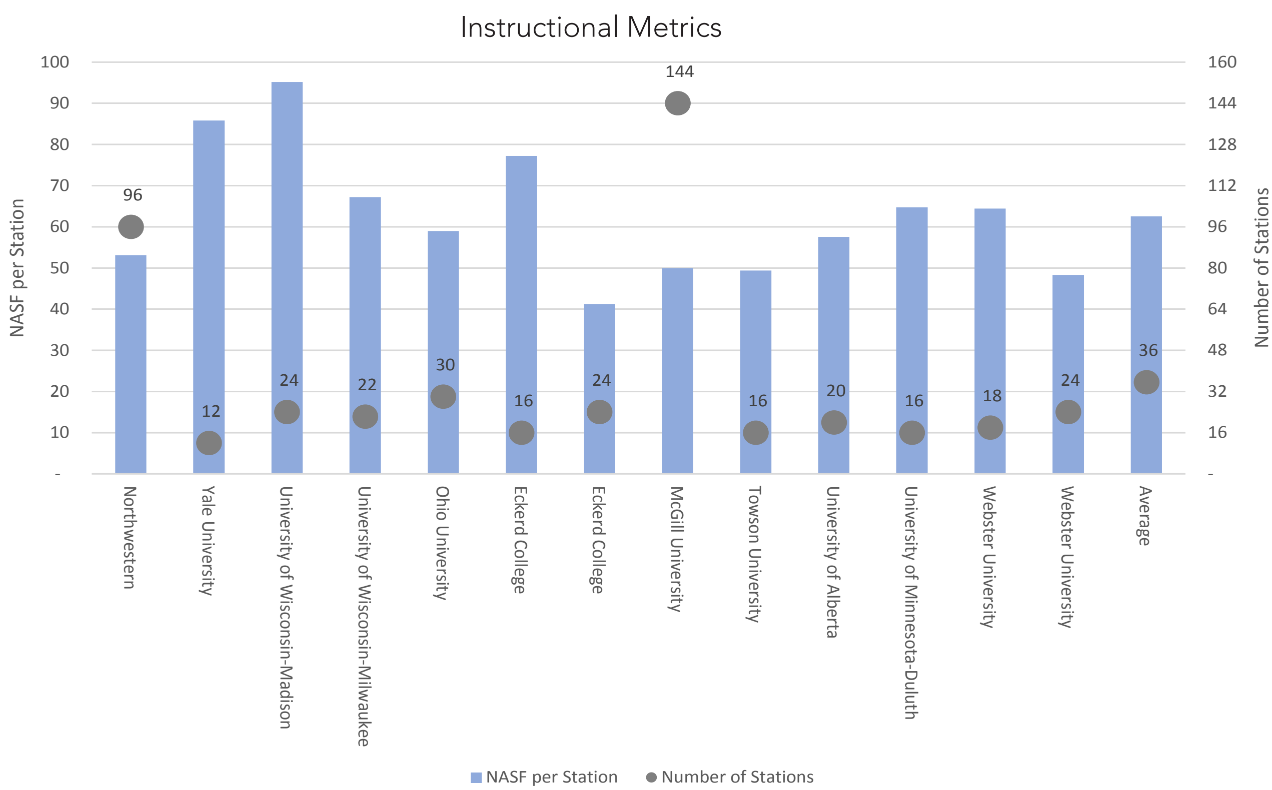
Map of institutions included in benchmarking analysis

Benchmarking

The design team conducted a benchmarking analysis for research lab space and instructional lab space to inform the confirmation of the space program that UWM Chemistry and Biochemistry would need to be on par with contemporary chemistry research facilities. The institutions included in this analysis were those requested by the University in addition to recent projects from the design team's experience. The study found that, on average, institutions provide 200 NASF per researcher (a researcher was defined as the PI, graduate assistant, or post-doc) in a research lab and 50-60 NASF per station in an instructional lab. The proposed program detailed in Section 6 provides 213 NASF per researcher and 58 NASF per station in 100 and 200 level labs and 86 NASF per station in 300 level and advanced labs.

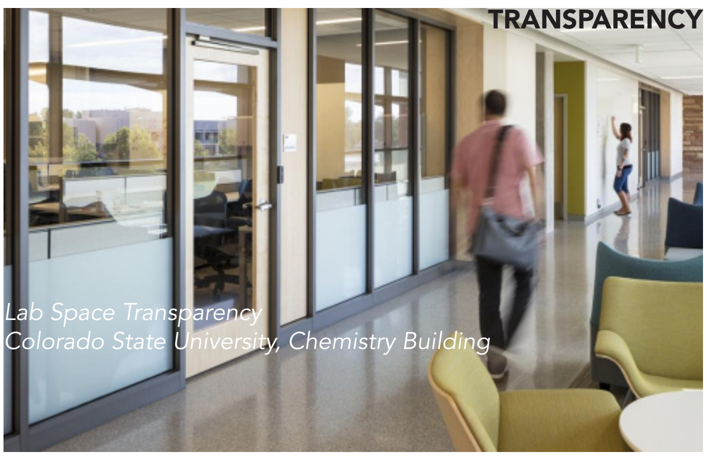


Benchmarks for NASF of research space

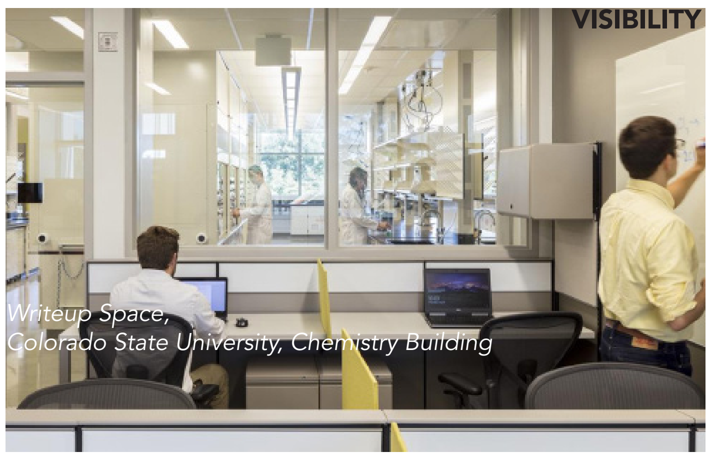


Benchmarks for NASF of instructional lab space

Research Lab
Webster University, Browning Hall –Interdisciplinary Science Building



Lab Space Transparency
Colorado State University, Chemistry Building



Writeup Space,
Colorado State University, Chemistry Building

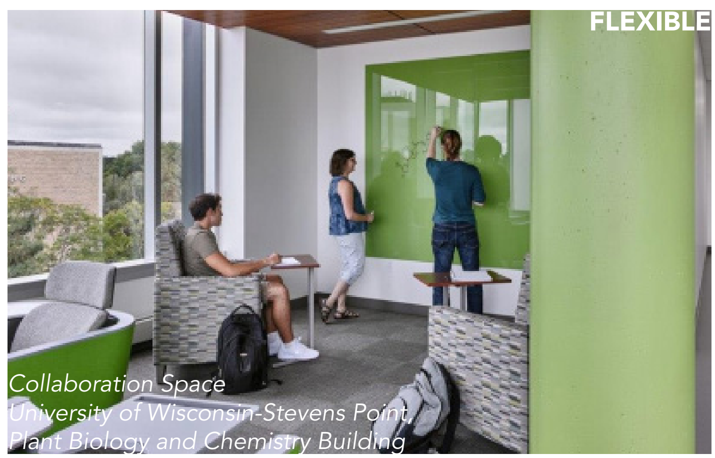
Qualitative Features

The space typologies included in the program for the new Chemistry Building should be associated with specific space qualities that will ensure the vision for the building outlined in this document is translated into the design. Features such as transparency, flexibility, and openness, balanced with the need for specialized research spaces will ensure that the new Chemistry Building meets both pragmatic and visionary design goals.

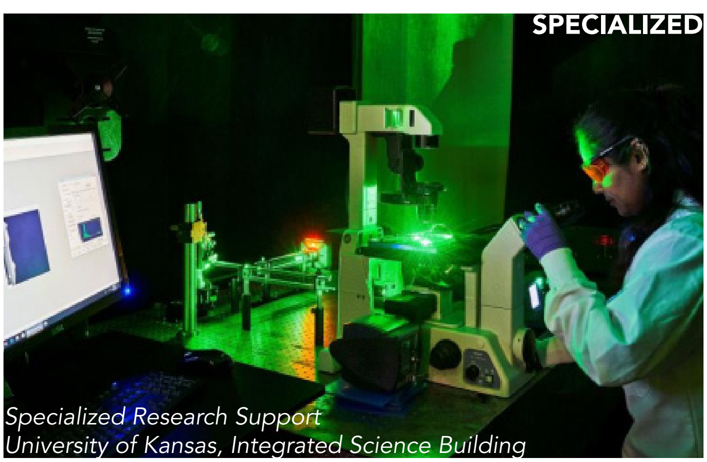
Chemistry Lab
Yale University, Sterling Chemistry Lab

Central Atrium,
University of Kansas, Integrated Science Building

Lecture Hall
University of Kansas, Integrated Science Building



Collaboration Space
University of Wisconsin-Stevens Point,
Plant Biology and Chemistry Building



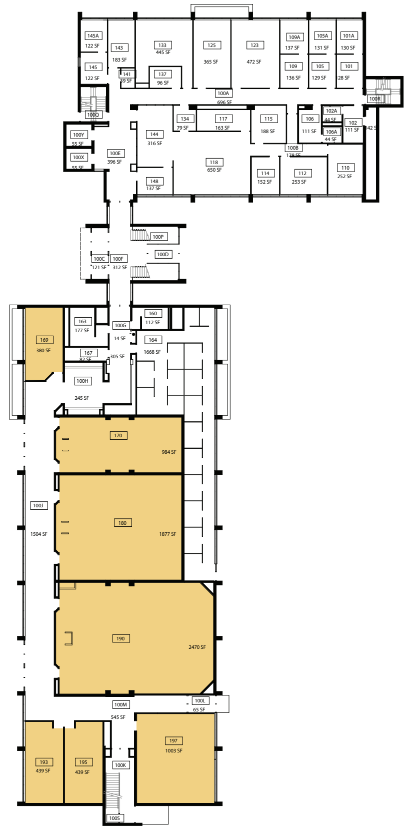
Specialized Research Support
University of Kansas, Integrated Science Building

Collaboration Space,
Colorado State University, Chemistry Building

5.1 Program Analysis

Room Number	Space Type	Space Capacity	Space Category
CHM193	Discussion	25	21-25
CHM195	Discussion	25	21-25
CHM197	Discussion	46	41-50
CHM169	Lecture	21	21-25
CHM170	Lecture	77	61-90
CHM180	Lecture	166	151-180
CHM190	Lecture	251	211+

Existing Chemistry Classrooms,
SOURCE: 2015 Pre-Design Report



Level 01

Existing Chemistry General Assignment Classrooms (NTS)
SOURCE: 2015 Pre-Design Report

General Assignment Classrooms

To understand and confirm the required General Assignment Classroom quantity and variety, the design team began analyzing the utilization of the existing classrooms within the Chemistry Building. The existing building has three small classrooms of 21-25 seats, one medium classroom of 45 seats, one large classroom of 77 seats, and two large classrooms of 166 seats and 251 seats respectively.

The utilization diagrams shown in Section 6.2 track seat utilization and room utilization for the three years preceding this study. The university has a target of 67% seat utilization for classrooms under 170 seats and a target room utilization of 32 out of 45 hours in a week. This study found that the majority of the small classrooms trend towards the desired room and seat utilization. The larger classrooms tend to have lower seat utilization signaling that some right-sizing is necessary. The two lecture halls meet the desired room utilization, but occasionally dip below the desired seat utilization. Stakeholders did note that large lecture halls are in high-demand on campus and would not be candidates for reduction in seat count in the new building.

The team also analyzed the seat alignment with existing classroom capacities per section assigned to each room.

Based on section enrollment caps and target seat utilization, the team found the following:

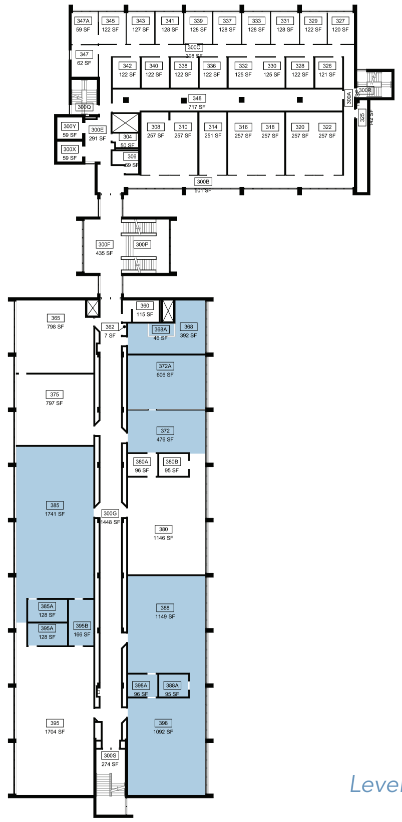
- Highest demand classrooms 26-30 seats (Fall ~52-60 sections / Spring ~73-80 sections)
- 7-8 sections per semester for 211+ classrooms
- 4-10 sections per semester for 121-150 classrooms
- ~6 sections per semester for 61-90 classrooms

Finally, the team projected the data based classroom demand and found based on past scheduled events, target utilization metrics, and excluding significant enrollment changes the following need, to be confirmed by the stakeholders in the development of the program:

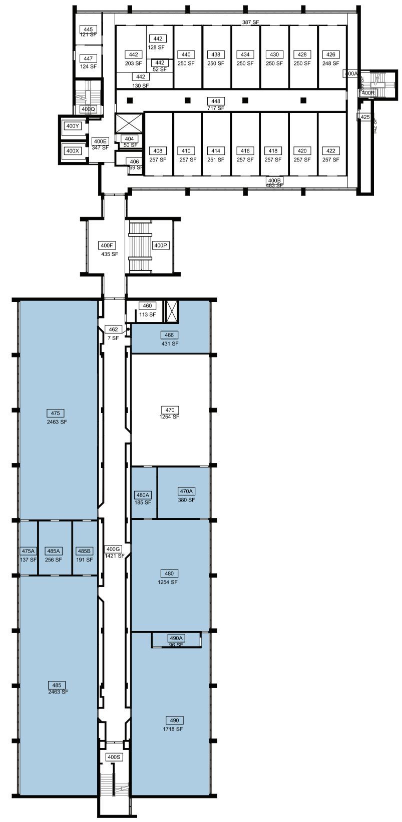
- 1 Lecture: 250 seats with lecture prep space
- 1 Lecture:180 seats with lecture prep space
- 1 Classroom:45 seats
- 3 Classrooms: 24 seats

Level 02

Level 03



Level 04



Existing Chemistry Instructional Labs (NTS)
SOURCE: 2015 Pre-Design Report

Instructional Labs

A utilization study was also conducted for the existing Instructional Labs. The team confirmed one unique feature of UWM labs that becomes an operational consideration; some instructional labs are dedicated to singular course, which results in some inefficiencies, but will be difficult to change due to current class scheduling practices. See Section 6.2.

The utilization diagrams shown found that seat utilization was very high in most of the spaces and there was a range of low, on target, and high room utilization semester-to-semester.

The team calculated the following projected instructional lab demand based on past scheduled events, target utilization metrics, and excluding significant enrollment changes the following need, to be confirmed by the stakeholders in the development of the program:

- 12 small instructional labs for 16-24 seats
- 1 medium studio lab for 41-50 seats

Room Number	Space Capacity
CHM271	12
CHM283	12
CHM284	18
CHM285	18
CHM286	18
CHM297	18
CHM298	18

Room Number	Space Capacity
CHM365	15
CHM385	15
CHM388	18
CHM395	15
CHM398	18
CHM470	18
CHM475N	14
CHM475S	14
CHM480	18
CHM485N	14
CHM485S	14
CHM490	18

Existing Instructional Labs

UTILIZATION ANALYSIS

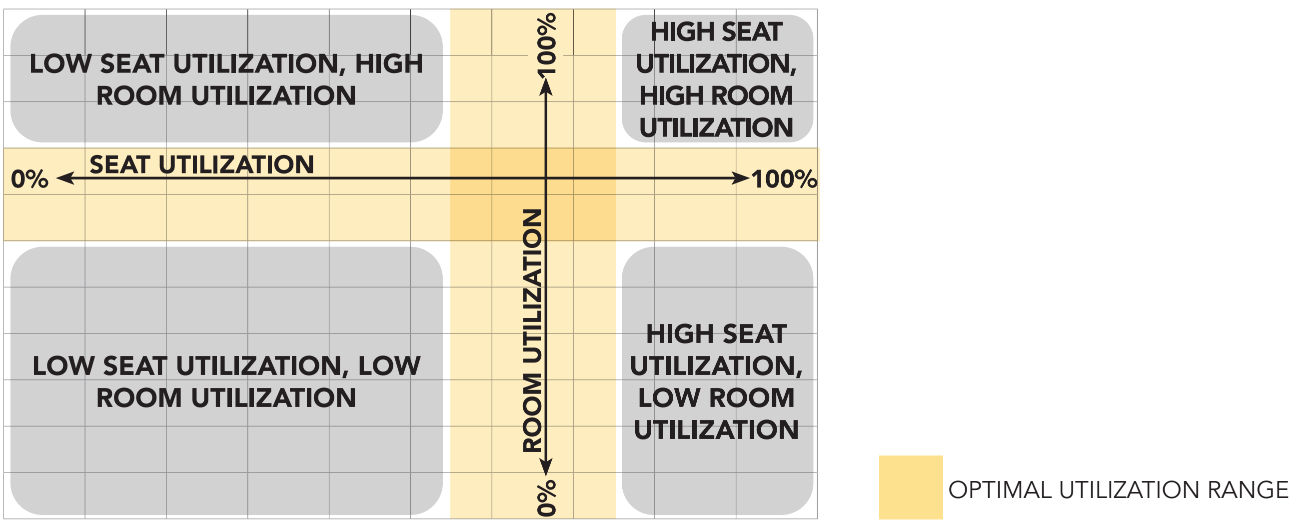
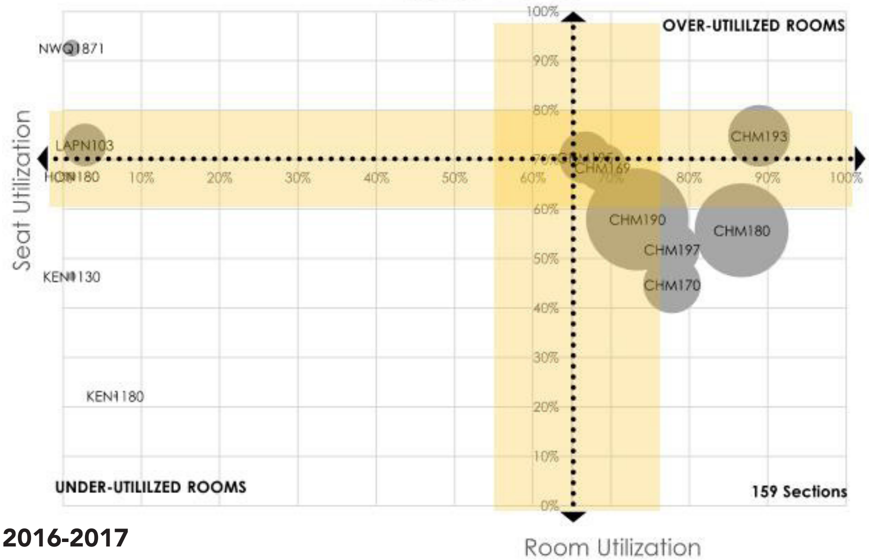


Diagram of utilization study chart, mapping current space utilization in four quadrants based on low/high seat utilization and low/high room utilization in comparison to University targets.

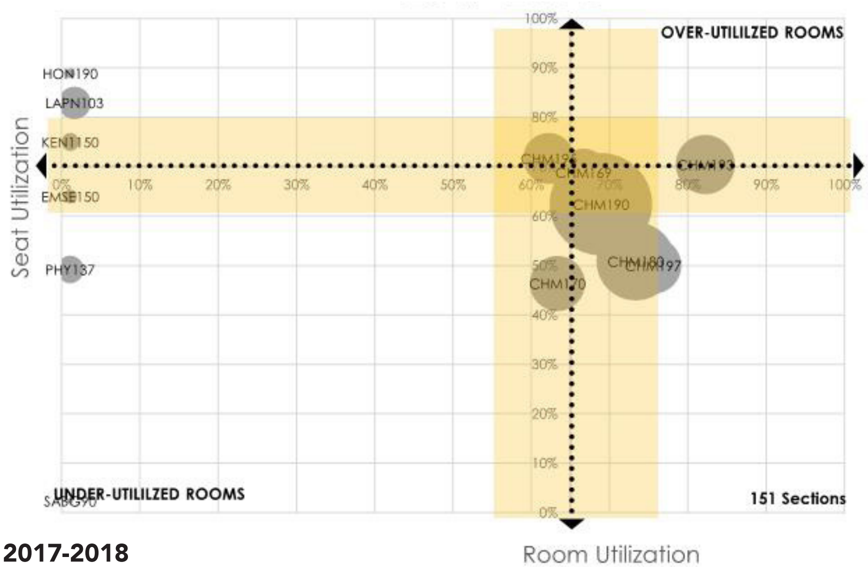
General Assignment Classrooms

The University provided data for the previous three academic years for analysis as part of the program confirmation process. The results of that analysis are outlined in Section 05 of this report and in the charts shown on the following pages. These diagrams map both seat utilization and room utilization. Seat utilization is the percent of seats in that are filled in a given classroom. The University has a seat utilization target of 65%, with an acceptable range of 55%-75%. Room utilization is the % of hours per week a room is used. The University target is 32 out of 45 hours. The following charts show the utilization of the General Assignment classrooms located in the existing Chemistry Building.

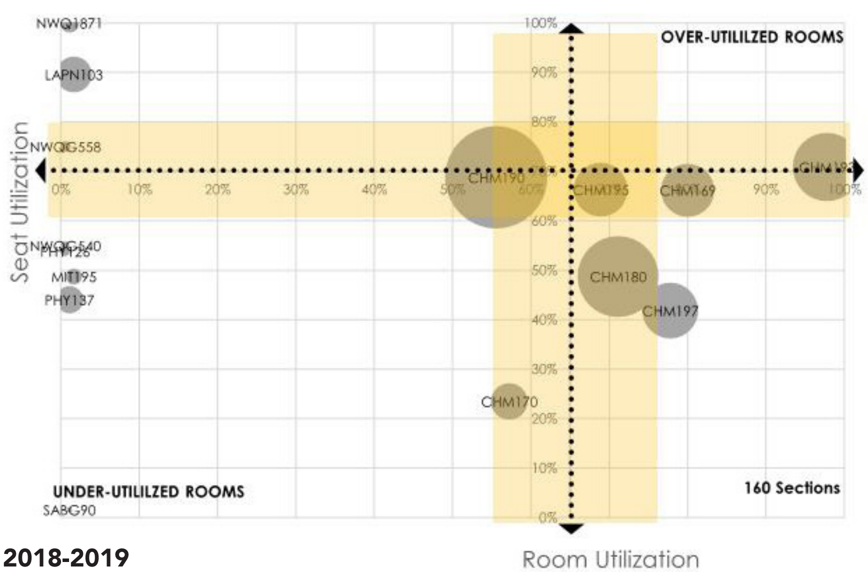
FALL SEMESTERS: GENERAL ASSIGNMENT CLASSROOM UTILIZATION ANALYSIS



2016-2017



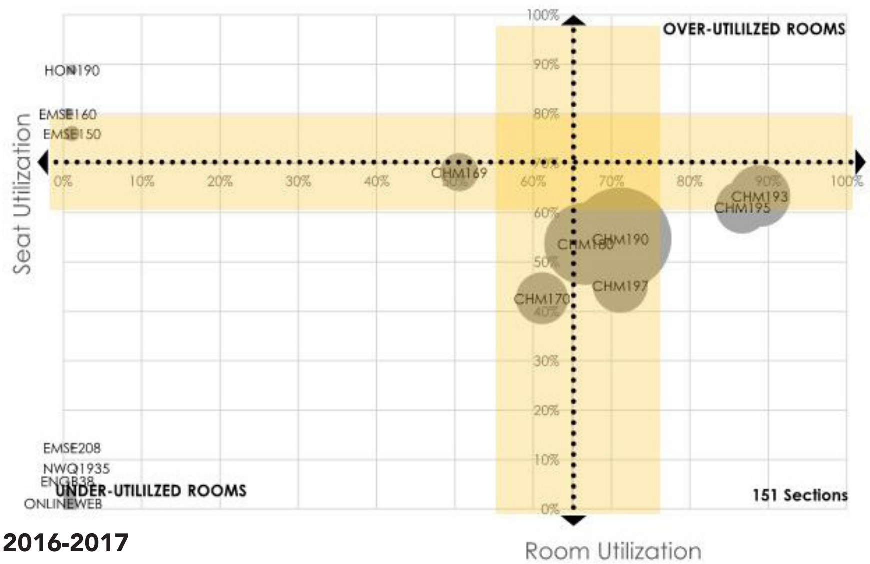
2017-2018



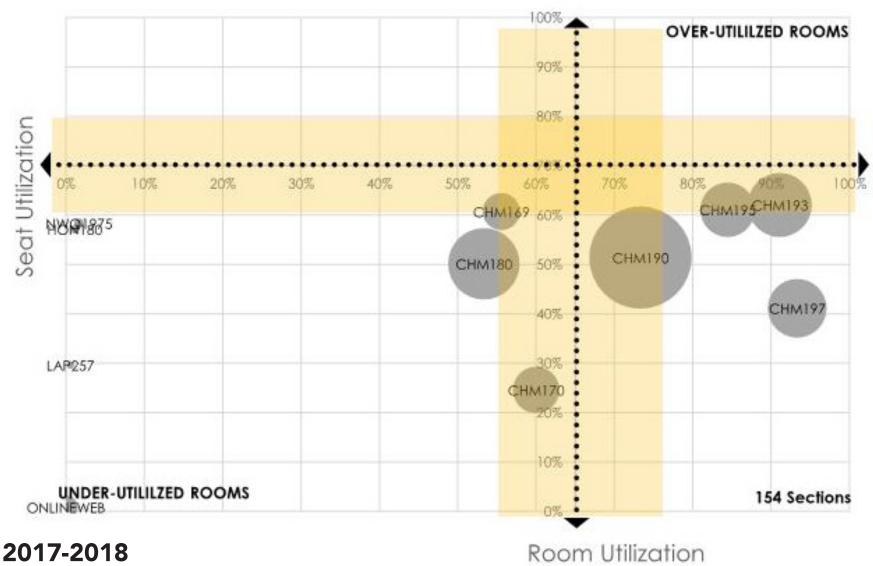
2018-2019

Chemistry Building General Assignment Classrooms, utilization study, fall semesters, academic years 2016-2017, 2018-2019, 2019-2020

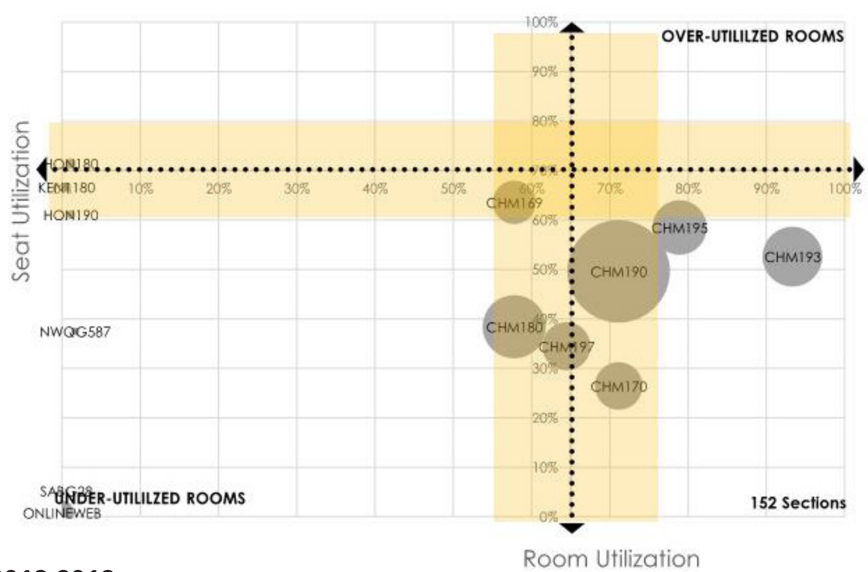
SPRING SEMESTERS:
GENERAL ASSIGNMENT CLASSROOM UTILIZATION ANALYSIS



2016-2017



2017-2018



2018-2019

Chemistry Building General Assignment Classrooms, utilization study, spring semesters, academic years 2016-2017, 2018-2019, 2019-2020

SECTIONS ENROLLMENT ALIGNS WITH SCHEDULED ROOM CAPACITY

SECTIONS ENROLLMENT WITHIN APPROPRIATE RANGE FOR SCHEDULED ROOM CAPACITY

SECTIONS ENROLLMENT TOO LOW OR TOO HIGH FOR SCHEDULED ROOM CAPACITY

ROOM ALIGNMENT (Max Enrollment)	MAX ENROLLMENT											
ROOM	0-10	11-20	21-25	26-30	31-40	41-50	51-60	61-90	91-120	121-150	211+	Grand Total
11-20	1	1	3	1								6
21-25	5	12	26	401	87							531
26-30		1		1	1							3
31-40			2			3						5
41-50	8	2	3	56	15	13	36	6				139
51-60								2				2
61-90		3	1	30	12		6	28	9			89
121-150								3		2		5
151-180		1			1			9	11	36	12	70
211+	4							2	4	17	50	77
Grand Total	18	20	35	489	116	16	42	50	24	55	62	927

Existing Classroom Utilization and Seat Alignment: Green indicates that the section sizes within the room align with the room's capacity. Yellow indicates that section sizes are slightly too small or too large for the room's designed capacity. Red indicates that rooms are not appropriate for that section size.

Sum of # HOURS PER WEEK	MAX ENROLLMENT											
ROOM	0-10	11-20	21-25	26-30	31-40	41-50	51-60	61-90	91-120	121-150	211+	Grand Total
11-20	1	0	4	0								5
21-25	13	27	48	425	108							621
26-30		0		0	1							1
31-40			1			1						2
41-50	19	4	6	59	30	31	44	14				207
51-60								1				1
61-90		7	1	39	24		15	66	25			177
121-150								4		1		4
151-180		3			2			23	30	97	29	184
211+	8							6	11	30	135	190
Grand Total	41	42	61	523	164	32	59	114	66	128	164	1,392
F2016	0.4	0.1	0.4	2.2	1.7	0.1	0.3	0.9	0.6	1.0	1.0	
F2017	0.2		0.4	2.5	1.0	0.1	0.5	0.6	0.7	0.6	1.1	
F2018	0.2	0.4	0.1	2.7	1.5		0.5	0.5	0.5	0.5	0.9	
S2017	0.3	0.3	0.5	3.1	0.3	0.4	0.1	0.8	0.1	0.9	0.9	
S2018	0.2	0.5	0.3	3.5	0.8	0.3	0.2	0.4	0.1	0.7	0.8	
S2019	0.2	0.2	0.3	3.8	0.3	0.2	0.2	0.6	0.2	0.6	0.9	
Demand	0.2	0.3	0.3	3.0	0.9	0.2	0.3	0.6	0.4	0.7	0.9	

Classroom demand model. Analysis based on past scheduled events, target utilization metrics, including seat fill ratios and weekly scheduled hours. Excludes significant enrollment changes in the future.

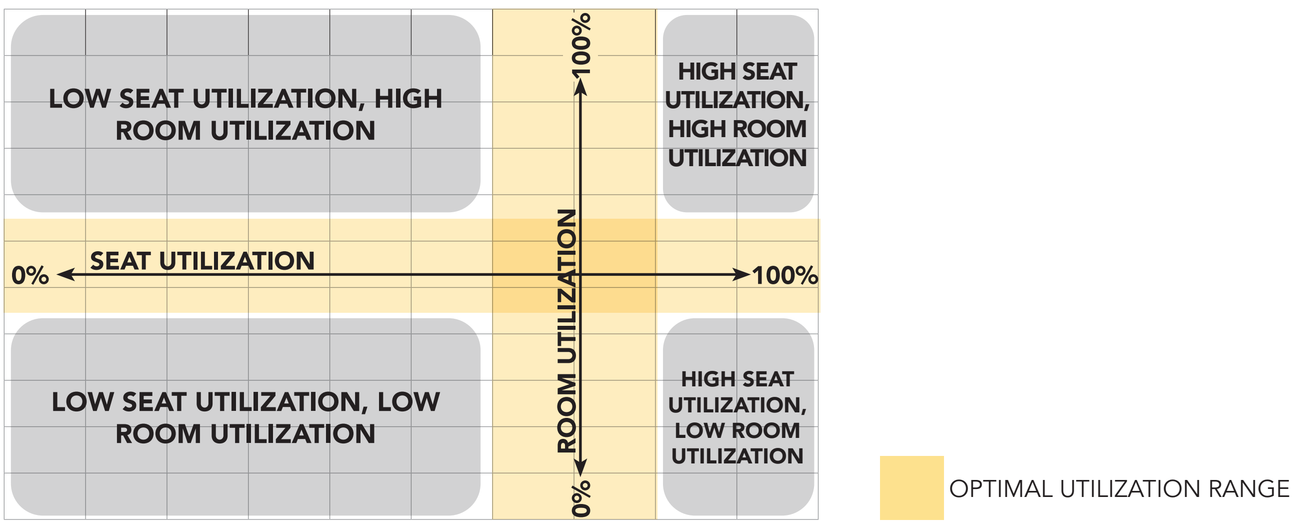


Diagram of utilization study chart, mapping current space utilization in four quadrants based on low/high seat utilization and low/high room utilization in comparison to University targets.

Instructional Labs

The University has a seat utilization target of 70% for instructional labs, with an acceptable range of 60%-80%. The University target for room utilization is 25 out of 45 hours. The following charts show the utilization of the Chemistry and Biochemistry Instructional Labs located in the existing Chemistry Building.

Room Number	Space Capacity	No. of Sections	No. of Hours	
CHM271	12	15	41.0	Spring (106, 543)
CHM283	12	24	72.0	Fall/Spring (603)
CHM284	18	33	96.0	Fall/Spring (102, 185/104)
CHM285	18	30	90.0	Fall/Spring (102/104)
CHM286	18	58	174.0	Fall/Spring (102)
CHM297	18	41	123.0	Fall (104)
CHM298	18	47	135.0	Fall/Spring (185/102)

- 19 instructional labs scheduled in past 3 years
- 3 instructional labs dedicated in Fall and 2 in Spring
- 7 instructional labs dedicated to a single course

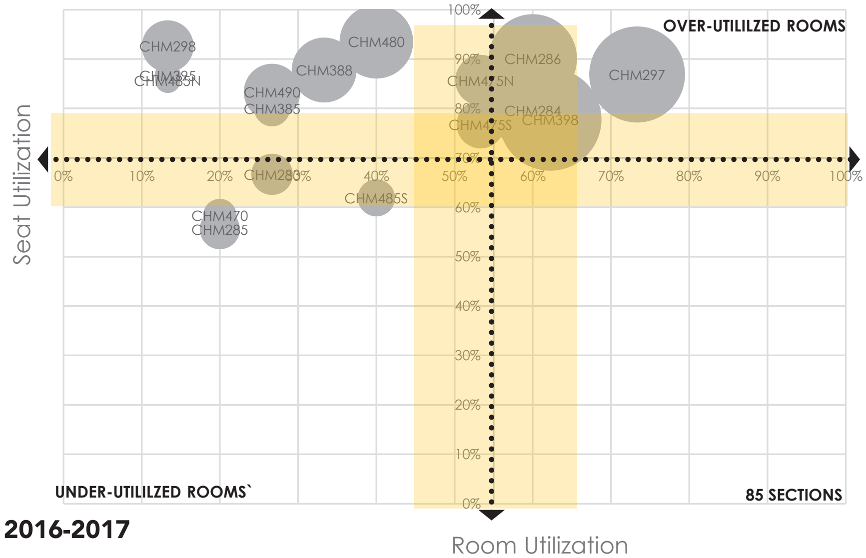
Room Number	Space Capacity	No. of Sections	No. of Hours	
CHM365	15	3	18.0	Spring (584)
CHM385	15	19	114.0	Fall/Spring (221)
CHM388	18	36	108.0	Fall/Spring (103)
CHM395	15	49	116.0	Fall/Spring (101,221)
CHM398	18	47	116.0	Fall/Spring (101,103)
CHM470	18	5	27.0	Fall (194, 563)
CHM475N	14	24	144.0	Fall/Spring (344)
CHM475S	14	22	132.0	Fall/Spring (344)
CHM480	18	43	129.0	Fall/Spring (105)
CHM485N	14	5	30.0	Fall/Spring (582/342, 344)
CHM485S	14	14	84.0	Fall/Spring (342/344)
CHM490	18	7	24.0	Fall (105, 582)

Existing Instructional Lab space use

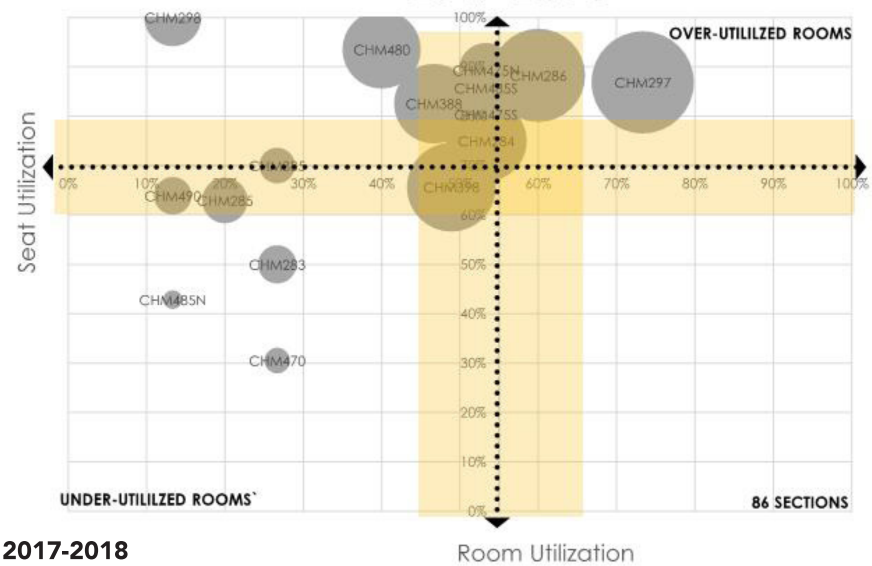
Sum of # HOURS PER	MAX ENI LLMENT					
ROOM	0-10	11-20	21-25	26-30	41-50	Grand Total
11-20	36	641	36	1,034	24	1,771
26-30			0			0
Grand Total	36	641	36	1,034	24	1,771
F2016	0.3	4.4		6.9		
F2017	0.1	4.8	0.4	6.8		
F2018		3.9		6.8		
S2017	1.1	4.4	0.5	6.7	0.3	
S2018		4.6	0.4	6.9	0.3	
S2019		3.9	0.2	7.6	0.3	
Demand	0.5	4.3	0.4	7.0	0.3	

Instructional lab demand model. Analysis based on past scheduled events, target utilization metrics, including 70% seat fill ratio and 55% room utilization. Excludes significant enrollment changes in the future.

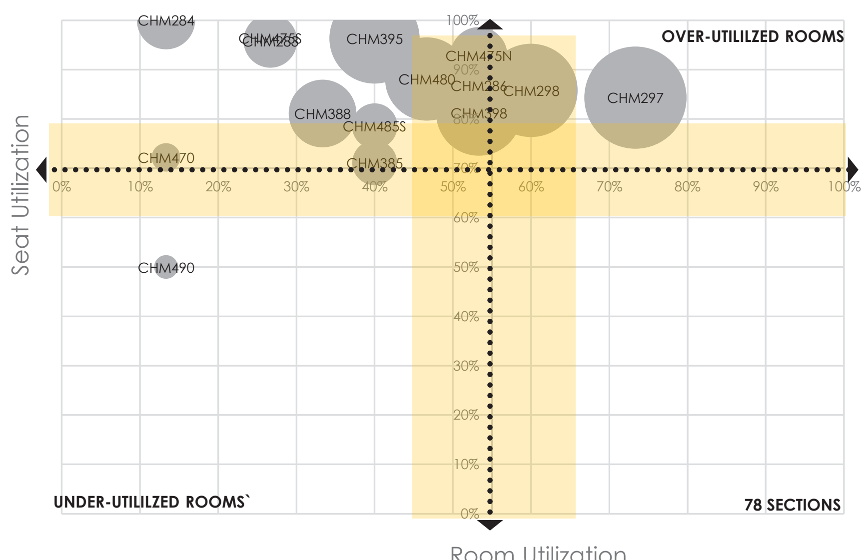
**FALL SEMESTERS:
INSTRUCTIONAL LAB UTILIZATION ANALYSIS**



2016-2017



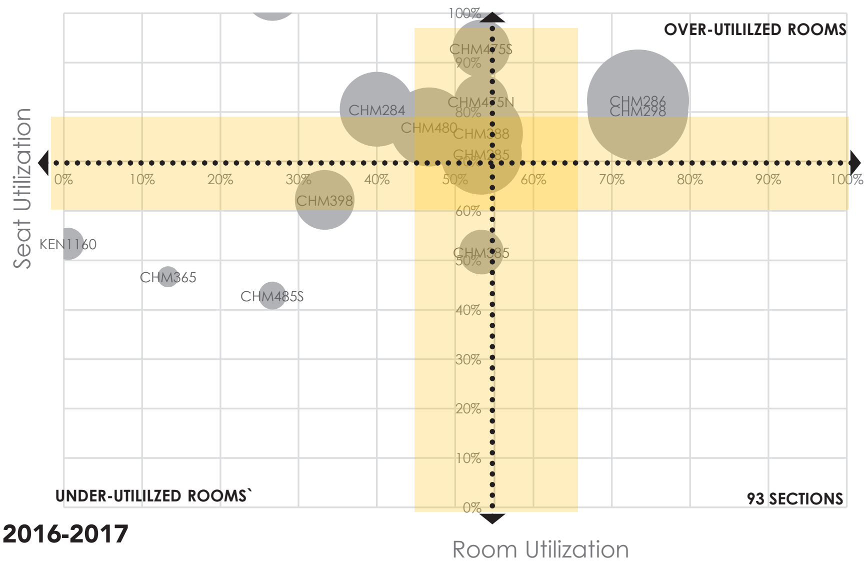
2017-2018



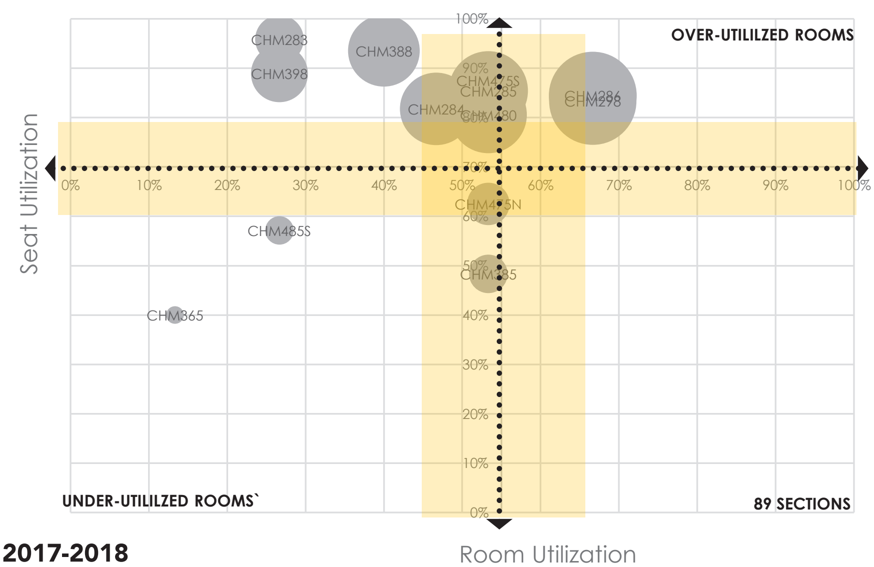
2018-2019

Chemistry Building Instructional Labs, utilization study, fall semesters, academic years 2016-2017, 2018-2019, 2019-2020

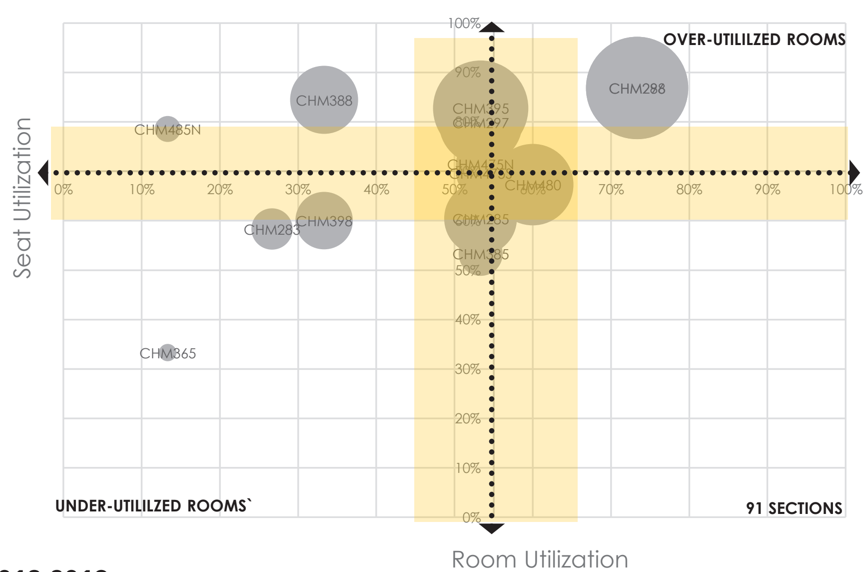
SPRING SEMESTERS: INSTRUCTIONAL LAB UTILIZATION ANALYSIS



2016-2017



2017-2018



2018-2019

Chemistry Building Instructional Labs, utilization study, spring semesters, academic years 2016-2017, 2018-2019, 2019-2020

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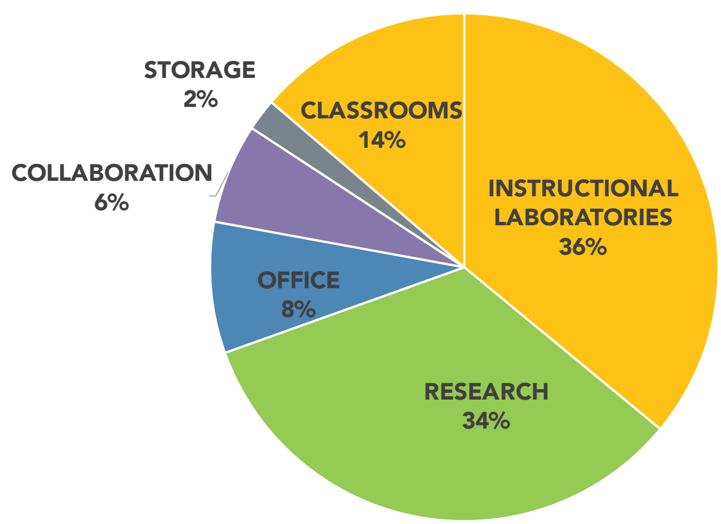
6 SPACE PROGRAM

SPACE PROGRAM

	EXISTING (10.02.2015)	CAPITAL PROJECT REQUEST (10.01.2018)	TARGET PROGRAM (12.06.2019)
INSTRUCTIONAL LABS	30,523	32,032	32,148
RESEARCH	28,982	29,252	29,950
OFFICE	8,371	7,476	7,458
COLLABORATION	2,560	1,356	5,676
STORAGE	2,677	2,220	1,820
GENERAL CLASSROOMS	7,563	-	12,260
TOTAL	80,676 ASF	72,336 ASF	89,312 ASF
	130,315 GSF	130,100 GSF	159,220 GSF

Program Summary

The program chart shown above reflects the history of the Chemistry Building, both in its existing form and the evolution of program development from the existing state at the time of the 2015 Pre-Design Study to the target program outlined in detail in the following pages. The Pre-Design space tabulation was used as the starting point for this program update and new considerations including evolving programs, space organization, modular design strategies, and added space needs informed the Target Program.



New Chemistry Building program breakdown by space functions

FCIM	SPACE	TARGET PROGRAM NO. OF OCCUPANTS/ AREA2	ASF/ OCCUPANT3	ASF/ AREA	NO. OF ROOMS4	TOTAL OCCUPANTS	TOTAL ASF	SUBTOTAL5	COMMENTS
TEACHING						-			
	INSTRUCTIONAL LABORATORIES					-		**25,298**	
210	100 Level Lab	24	58	1,380	8	192	11,040		
210	200 Level Lab	24	58	1,380	1	24	1,380		
210	300 Level Lab	16	86	1,380	3	48	4,140		
210	Biochemistry	12	115	1,380	1	12	1,380		
210	Pchem Lab	16	86	1,380	1	16	1,380		
210	Advanced Lab 1	10	184	1,838	1	10	1,838		
110	Advanced Lab Classrooms	16	43	680	2	32	1,360		
220	Studio Lab / Outreach	54	51	2,780	1	54	2,780		
220	Outreach Lab						-		combined into Studio Lab
110	Outreach Classroom						-		combined into Studio Lab
	INSTRUCTIONAL SUPPORT					-		**6,850**	
215	100 Level Prep Including Manager Desk	1	600	600	1	1	600		
215	100 Level Prep			300		-	-		low priority pending layout, can there be small closet storage for bulk mateirals accessible from inside the lab
215	200 Level Prep			300	1	-	300		can serve advanced analytical lab
215	300 Level Prep Including Tech Desk	1	600	600	1	1	600		can serve organic advanced lab, priority is direct adjacency to 300 level
255	300 Instruments			650	1	-	650		requires student access, adjacent to lab
215	Organic Prep and Storage			300		-	-		low priority pending layout if accessible to 200 and 300 level prep
255	Biochem Equipment			900	1	-	900		
255	Pchem Instrument			600	1	-	600		
215	Adv. Lab Prep Including Tech Desk	1	600	600	1	1	600		
215	Prep and Storage					-			
225	Outreach Support			300	1	-	300		
210	Computer Lab	30	40	1,200	1	30	1,200		potential for future testing needs, supplemental instruction taught here
410	Tutoring	25	20	500	1	25	500		20-25 students at a time max
310	TA Office Areas	20	30	600	1	20	600		

6.1 Space Program

FCIM	SPACE	NO. OF OCCUPANTS/ AREA2	ASF/ OCCUPANT3	ASF/ AREA	NO. OF ROOMS4	TOTAL OCCUPANTS	TOTAL ASF	SUBTOTAL5	COMMENTS
		TARGET PROGRAM							
RESEARCH						-			
	RESEARCH					-		**26,640**	
310	Postdoc Workstation Area	1	60	78	-	-	-		
310	Research Assistant Area	1	30	39	100	100	3,900		
250	Departmental Lab Space								See Typology Below
250	Fume Hood Intensive Lab Space			940	8	-	7,520		
250	Wet Bench Intensive Lab Space			940	7	-	6,580		
250	Instrument Intensive Lab Space			940	6	-	5,640		
250	Instrument Intensive Lab Space			600	4	-	2,400		Revised lab type, previously noted as dry lab (11/25 per UWM Faculty Lab Type Verification)
310	ACS Exams Institute Staff Offices	1	120	120	3	3	360		
310	ACS Exams Institute Reception			240	1	-	240		
	RESEARCH SUPPORT					-		**3,310**	
225	NMR Facility			1,080	1	-	1,080		
720	Glass Shop and Classroom	17	64	1,080	1	17	1,080		
725	Glass Shop Storage			180	1	-	180		
720	Electronics Shop	2	277	554	1	2	554		
725	Electronics Shop Storage			90	1	-	90		
250	Autoclave			100	1	-	100		2 autoclaves in one space
720	Machine Shop					-			
225	Computer Cluster					-			
250	Cold Room					-			
250	Hydrogenation Room			226	1	-	226		
225	Shimadzu					-	-		

FCIM	SPACE	TARGET PROGRAM NO. OF OCCUPANTS/ AREA2	ASF/ OCCUPANT3	ASF/ AREA	NO. OF ROOMS4	TOTAL OCCUPANTS	TOTAL ASF	SUBTOTAL5	COMMENTS
OFFICE									
	OFFICE					-		**5,538**	
310	Faculty and Scientist's Offices	1	120	156	28	28	4,368		
310	Teaching Academic Staff Offices	1	120	156	4	4	624		
310	Teaching Academic Staff Workstations	1	60	78	2	2	156		
310	Non-Teaching Academic Staff Workstations	1	60	78	4	4	312		
310	Flex Lab Post Doc	1	60	78	-	-	-		Flex lab removed from program
310	Graduate Assistant Workstations	1	30	39	2	2	78		refer to instructional and research themes for additional space
310	Flex Lab Research Assistants	1	30	39	-	-	-		Flex lab removed from program
	DEPARTMENTAL OFFICE SUITE					-		**1,620**	
310	Department Chair Office	1	120	156	1	1	156		
350	Department Chair Meeting Room	6	20	120	1	6	120		
310	Non-Teaching Academic Staff Offices	1	120	156	2	2	312		
310	Classified and Other Workstations	1	30	39	8	8	312		
310	Office Area			240	1	-	240		4 workstations and a waiting area
315	Storage			240	1	-	240		area can be split between dept. office and basement
315	Mail Room			120	1	-	120		cubbies for each person with a workspace (151 total)
315	Kitchenette			60	1	-	60		Area for sink and refrig.
315	Copier			60	1	-	60		
	DEPARTMENT OFFICE SUPPORT					-		**300**	
315	Copier			60	1	-	60		
315	Kitchenette			120	2	-	240		1 for grad, 1 for faculty

6.1 Space Program

FCIM	SPACE	TARGET PROGRAM							
		NO. OF OCCUPANTS/ AREA2	ASF/ OCCUPANT3	ASF/ AREA	NO. OF ROOMS4	TOTAL OCCUPANTS	TOTAL ASF	SUBTOTAL5	COMMENTS
COLLABORATION									
	INTERACTION					-		**3,516**	
350	Conference	30	20	600	1	30	600		
350	Conference	12	17	200	3	36	600		
350	Meeting Room	8	20	156	1	8	156		
650	Alcove Seating	3	33	100	10	30	1,000		
650	Small Group Lounge	6	20	120	6	36	720		
350	Focus / Team Rooms	6	20	110	4	24	440		reduced to 110, but more flexible if same size as office depending on location within the building
BUILDING SUPPORT									
	STORAGE					-		**1,820**	
730	General Storage			800	1	-	800		
760	Solvent Storage			200	2	-	400		
760	Dry Ice Storage			100	1	-	100		adjacent to dock
760	Cryogen Storage			120	1	-	120		
760	Gas Cyliner Storage			200	2	-	400		code required separation exterior
	Bulk LN2								
	Haz Mat Waste			1,000	-	-	-		Stays in Lapham
TOTAL CHEMISTRY ASF						**809**	**74,892**	**74,892**	
		TOTAL SWQ 1 BUILDING						**74,892**	
		EFFICIENCY RATIO						**55.5%**	
		TOTAL GROSS SQUARE FEET						**134,906**	68,187
PROGRAM ADDED CAPITAL PROJECT REQUEST									
LEARNING								**12,260**	
	CLASSROOMS							**12,110**	
110	Lecture	250	20	5,000	1	5,000	5,000		
110	Lecture	180	20	3,600	1	3,600	3,600		
110	Classroom	45	30	1,350	1	1,350	1,350		
110	Classroom	24	30	720	3	2,160	2,160		
	INSTRUCTIONAL SUPPORT							**150**	
115	Lecture Prep			150	1	150	150		AV Support, confirm reduction from 300
		EFFICIENCY RATIO						**60%**	
		TOTAL GROSS SQUARE FEET					**20,433**		
COLLABORATION									
	INTERACTION							**2,160**	
650	Instructional Lab Breakout Spaces	12	20	240	9	2,160	2,160		adjacent to 100 and 200 level instructional labs
		EFFICIENCY RATIO						**56%**	
		TOTAL GROSS SQUARE FEET					**3,880**		

FCIM	SPACE	TARGET PROGRAM NO. OF OCCUPANTS/ AREA2	ASF/ OCCUPANT3	ASF/ AREA	NO. OF ROOMS4	TOTAL OCCUPANTS	TOTAL ASF	SUBTOTAL5	COMMENTS
NON-ASSIGNABLE (included in Building GSF unless SF noted)									
	CIRCULATION								
W06	Vestibule						-		
W06	Lobby				1	4,000	4,000		
W06	Corridor				1	15,000	15,000		
W07	Stairs				10	320	3,200		2 per floor
W02	Passenger Elevator				5	121	605		1 per floor
W02	Service Elevator				5	121	605		1 per floor
	BUILDING SUPPORT								
X03	Toilet Room (men / women)				10	200	2,000		
X03	Toilet Room (unisex)				1		-		
X03	Lactation Room			100	1		100		
X01	Housekeeping Closet						-		1 per floor
X01	Housekeeping Storage						-		
X01	Housekeeping Equipment						-		
W04	Loading / Receiving				1		-		Service Yard
X04	Recycling / Trash						-		Service Yard
	BUILDING SYSTEMS								
Y04	Generator Room			1,000	1		1,000		Ideally, single indoor generator located at grade level. Requires fuel truck access. Could be located outside building if UW-M accepts aesthetics/maintenance. Could also be basement. 25x40
Y05	Main Electrical Room (Normal)			1,200	1		1,200		Building location close to one of the existing electrical entrances (seems to be several). Locate at building perimeter for transformer removal access. Requires two exits from room. 20x60
Y06	Main Electrical Room (Emergency)			320	1		320		Located adjacent to normal power electrical room. Includes emergency distribution equipment and automatic transfer switches. 16x20
Y07	UPS Room			120	1		120		TBD if central battery system is required
Y08	Electrical Room Rooftop/Penthouse			200			-		One room above one of the stacked electrical riser closets. 10x20
Y09	Electrical Room Riser Closets			140	5		700		Three stacked riser closets near building center (1 per floor). 10x14
Y10	Electrical Room Riser Closets			100	5		500		Three stacked riser closets near building center (1 per floor). 10x10
Y11	Chilled Water Distribution			400	1		400		Grade level near south side site CHW entrance. 20x20
Y12	Process Chiller Equipment Room			800	1		800		Penthouse, basement or grade. 40x20
Y13	Steam Equipment Room			1,000	1		1,000		Grade/basement level preferred, but PH level could work. 50x20
Y14	Hot Water Pump Room			400	1		400		Penthouse, basement or grade. 15x25
Y04	AHUs			15,000			-		Air Handlers and Exhaust Heat Recovery Units. Some flex in length/width. Some AHU's could go at grade/basement if intake extended up above 1st floor. 50x300

6.1 Space Program

FCIM	SPACE	TARGET PROGRAM							
		NO. OF OCCUPANTS/ AREA2	ASF/ OCCUPANT3	ASF/ AREA	NO. OF ROOMS4	TOTAL OCCUPANTS	TOTAL ASF	SUBTOTAL5	COMMENTS
Y04	Exhaust Fants			1,200			-		Equipment located within roof screen. 30x40
Y04	Cooling Towers			1,200			-		For process cooling, campus CHW not always available 30x40
Y03	Air Shafts			800	4		3,200		Equal amount at 1/3 or 1/4 points of building length. Need at least one shaft per control area stack. Perhaps more depending on ceiling space available for large horizontal ducts. To be further evaluated upon selection of architectural scheme. SF required at all floors except first, includes room for piping. If occupied basement is programmed, then need some shafts through 1st floor. 800 sf/floor
Y04	Gas Meter - Outdoors			75			-		Service Yard
Y04	Domestic Water and RO/DI Equipment			600	1		600		Could be split to two rooms, 20x30
Y04	LCW/PCW HX and Pumps			200	1		200		
Y04	Lab Air Compressors			300	1		300		PH or grade level location could be discussed. 15x30
Y04	Lab Vacuum Pump			300	1		300		could be penthouse
Y04	Waste Pipe Risers			10	30		300		Multiple riser locations about every 2 column bays, 15"x6"
Y04	Sewage Ejector Pumps			1	100		100		lowest level, required? 10x10
Y04	Subsoil Drainage Pumps			1	100		100		lowest level, required? 10x10
Y04	Plumbing Closets			24	10		240		Fire rated shaft on corridor with double doors for valve access, perhaps two per floor will be required 4x6
Y04	Fire Protection Service Entrance			20	1		20		Backflow preventer is often located within the Fire Pump Room, assuming that the lead-in can be located there
Y04	Fire Pump Room			200	1		200		Room must have at least 10' in the least dimension, may require direct exterior access per the AHJ's discretion, and needs a 6' wide door that swings out of the room
Y04	Telecom Entrance			150	1		150		ground floor or basement, 10x15
Y04	Telecom Building Distribution			180	1		180		Primary distribution point for all backbone terminations, patching and networking. Located adjacent to the Entrance 10x18
Y04	Server Room						-		Further programming required to confirm if this space is needed, confirm size. Probably ASF and not MEP GSF.
Y04	Telecom Room			150	5		750		Three stacked riser closets near building center (1 per floor) 10x15
Y04	Telecom DAS								unlikely any additional space will be required for this equipment
TOTAL GROSS SF							**38,590**	**29,597**	**Delta with grossing factor**

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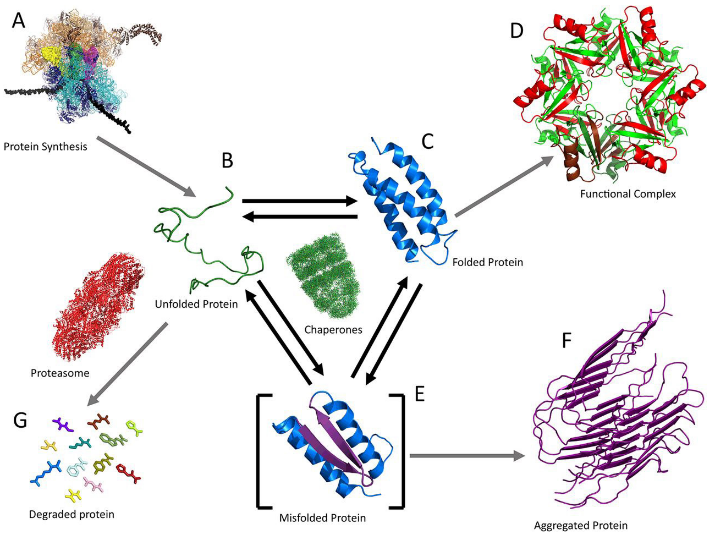
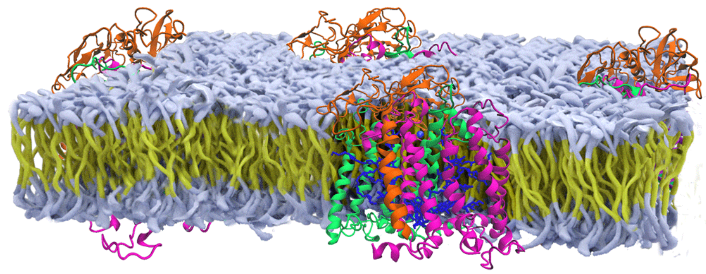
7 DESIGN RECOMMENDATIONS

VISION



Folding and stabilization of life proteins.
Source: Progress In Inorganic Chemistry, Volume 56.



Model of the bacterial reaction center buried within a membrane.
Source: Allen JP., Recent Innovations In Membrane-Protein Structural Biology.

Chemistry first. Chemistry front-and-center.

All aspects of the design proposal of the new facility intend to share, enhance, visualize, and promote the profound research and dedicated academics of the department while fostering a cross-disciplinary and collaborative environment. The design process begins with a comprehensive study of the research areas and academic program. This is a dense building that will be built for efficiency and completely focused on the laboratory spaces within. This focus on research and academics is the priority.

The design intends to celebrate that priority and infuse it with the collaborative spirit of the department. The result of this is an inside-out approach. The facade will express the interior environment and organization. While the dense upper floors are filled with labs, the ground level has a distinct purpose. This level will be inviting and connected, removing barriers to entry and the campus beyond with wide open spaces and view corridors through the building. The interior spaces will provide flowing and easy circulation paired with intimate, informal gathering spaces. This is where chemistry meets the world and these spaces intend to be welcoming and accessible to all.

The Chemistry building will…

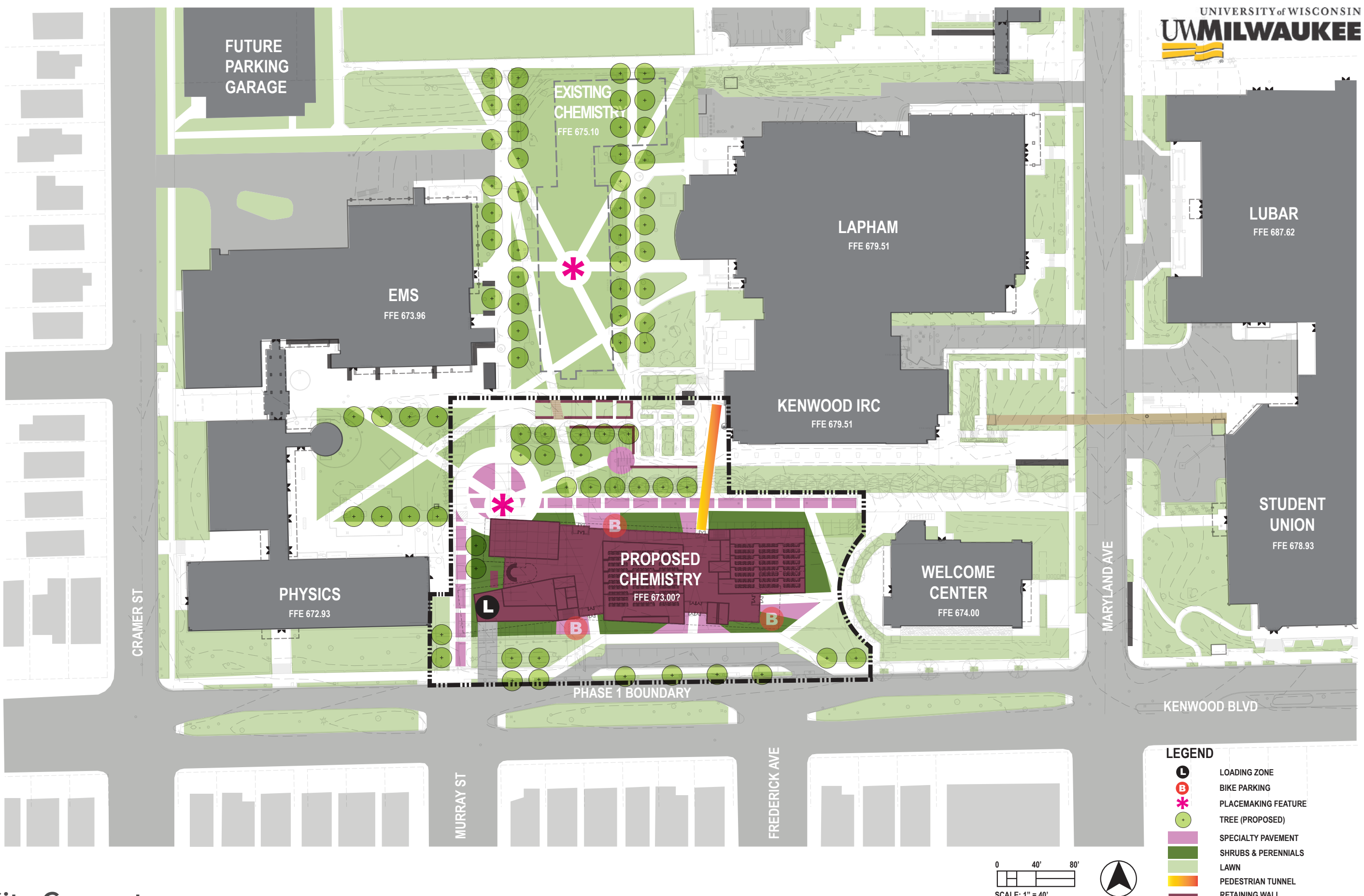
… provide a state-of-the-art building for modern instruction to support students at all levels.

… support and enhance fundamental research and scientific innovation.

… connect researchers, students, and the community through science.

Vision Statement for the new Chemistry Building

SITE CONCEPT



Site Concept

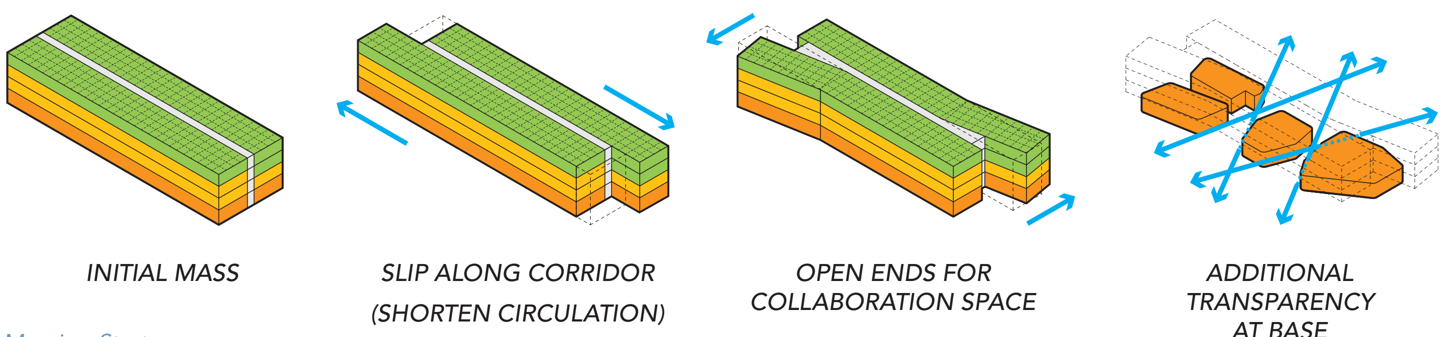
Goals for the New Chemistry Building site as identified by this design team suggest that the site should be integral to the campus fabric, STEM-focused, flexible, social, providing a place of respite, allowing a flow between the indoor and outdoor environments, accessible, and maintainable. The following site program elements: large-scale gathering space(s), small scale gathering spaces, open turf, placemaking features, pedestrian pathways, fire lanes, bicycle parking, vehicular parking, stormwater management, ten short term parking stalls along a drop off road, and a loading dock shared with the future STEM building that replaces the Physics building.

These site diagrams extend beyond the New Chemistry Building project site in order to look at the new quad greenspaces more holistically. The first phase to be implemented will be associated with the New Chemistry Building which will include the southern front entrance to the new building along Kenwood Boulevard, westward to the edge of the Physics Building, north to the edge of the Existing Chemistry Building, and east to Lubar Entrepreneurship Center and UWM Welcome Center.

Future phases will extend the campus quad greenspace west and north of the New Chemistry Building. The most significant area of the quad green open space will extend northward, replacing the existing Chemistry Building after its demolition. The location of the existing Chemistry Building will be a valuable extension of the quad given its central location within the STEM buildings and solar orientation within this block of campus.

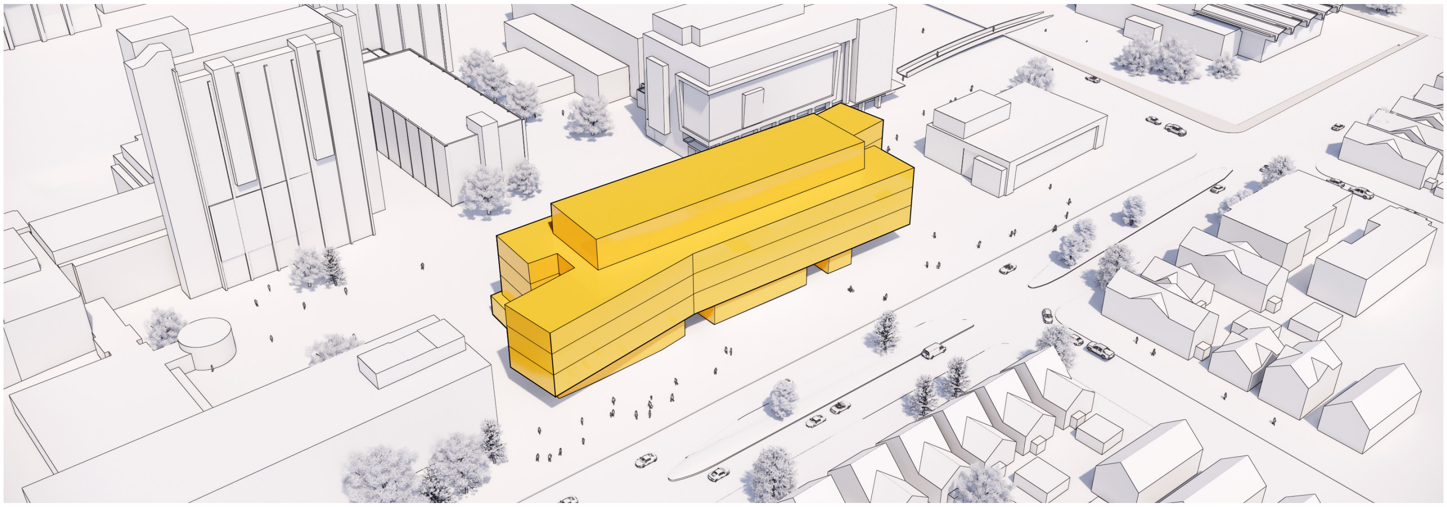
BUILDING MASSING

View from E Kenwood Blvd



Massing Strategy

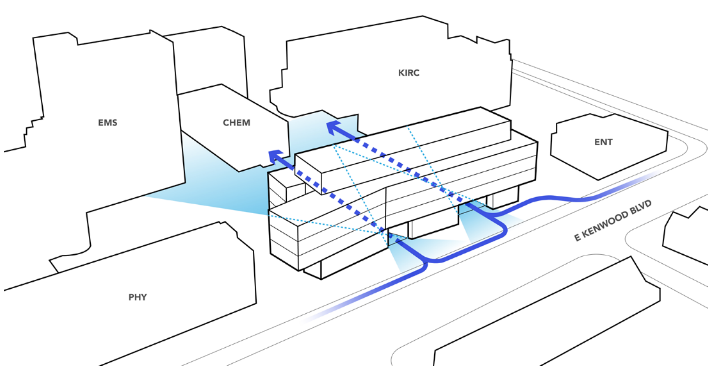
The project, in concert with the zoning requirements, has a massing scheme that promotes an efficient layout for the laboratories within while maintaining sensitivity to the neighborhood immediately south of campus. The basic linear scheme allows for an efficient circulation in both distribution systems and building users. In order to further delineate the long bar massing, a slip between the north and south halves provides an even more efficient circulation while breaking down the bulk of the building. An additional layer, a slight bend in the mass, provides additional visual definition. These moves help provide a richness to the basic program stacking scheme from all angles, including approaches from Kenwood and Maryland Avenues. Lastly, the teaching and research laboratory programs are lifted from the ground plane. The first floor accommodates the general assignment lecture halls. Around those halls, a welcoming lobby, pre-function area, collaboration hubs, and outreach labs form remainder of the floor. The transparency between these zones, from north to south, allows the pedestrian and residential level street scape to have viewsheds through the mass – creating a porous experience that helps alleviate the "bulk" of the building on the street at a human-scale. The remainder of the program stacks vertically to aid efficiencies in laboratory service requirements and provide for flexible future planning as needs change.



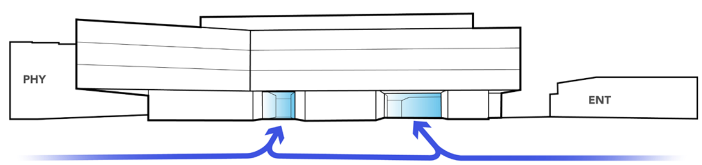
Aerial View

Facade View from E Kenwood Ave

Quad View



Visibility and Porosity



Visibility In Elevation

ADJACENCIES AND STACKING

The proposed Chemistry Building has three major programmatic elements: classrooms, teaching laboratories, and research laboratories. These spaces are threaded with ancillary spaces: offices, collaboration, and support. While several adjacency strategies were reviewed, the team determined a vertical stacking approach best serves the mission of the new facility.

Generally, the upper levels house research labs to the north and teaching labs to the south. PI. offices are co-located to promote and enhance collaboration between researchers. The length of the corridor is broken by collaboration zones which will house small rooms and informal teaching spaces. Teaching labs at lower levels house the more populated 100- and 200-level spaces. The more focused 300- and 400-level labs for senior students are located on the upper floors.

The mix of Research and Teaching labs is functional and purposeful. Visibility and access to research spaces and faculty will enhance the student experience and expose students, visitors, and colleagues to the rigorous, interesting, and profound work performed within the laboratories. This mix is intended to facilitate the department's mission and collaborative spirit.

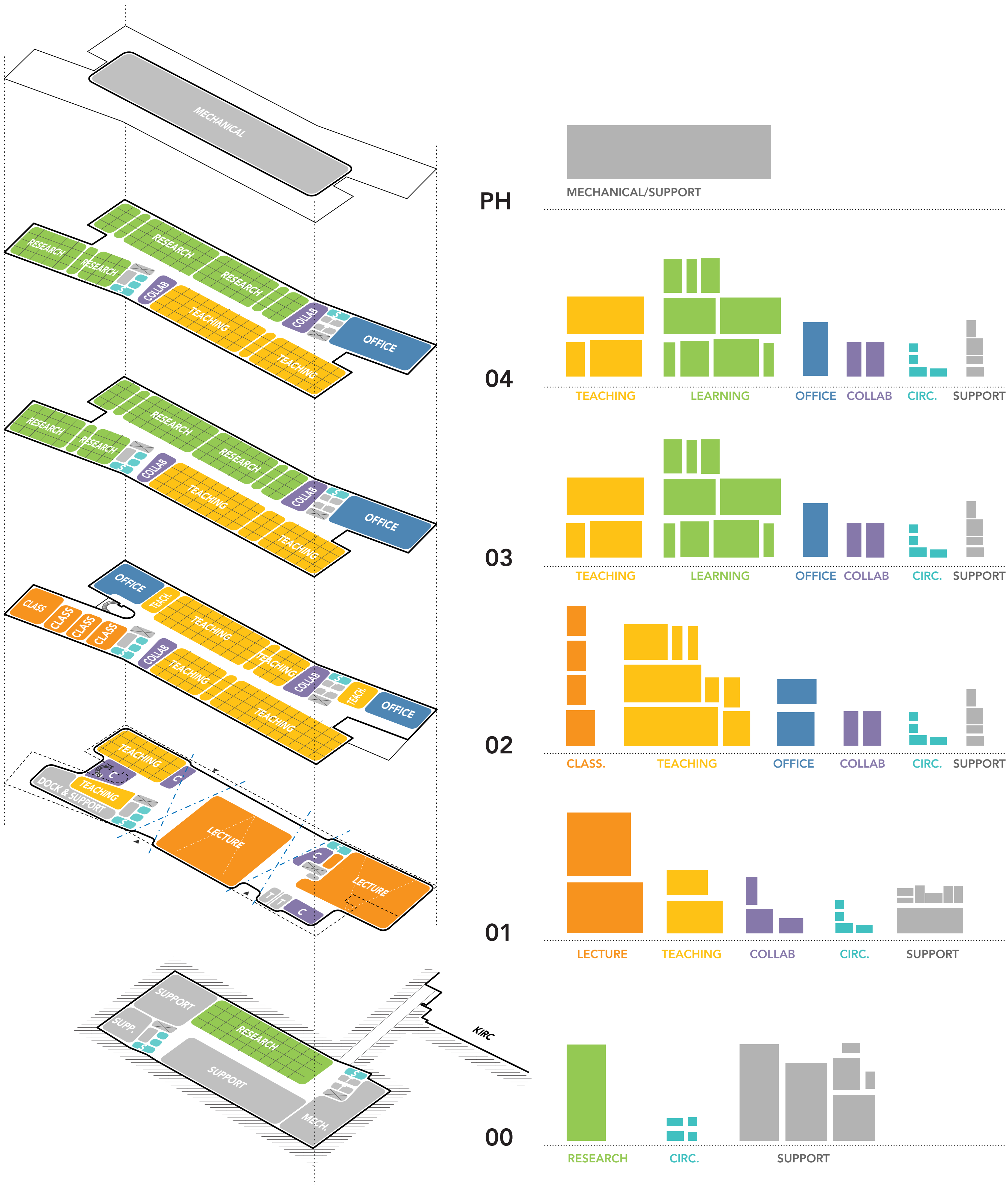
Classrooms are located on the first and second level. Larger lecture halls on the ground floor allow ease of access and general-purpose use. Smaller seminar rooms are located on the quieter second floor for a more intimate experience, while maintaining a connection to the ground level with an open communicating stair. The lecture halls split the main lobby space into two zones. They share one half which will provide a distinct pre-function space while also being used for arrival and dismissal from regular classes. This separates the lecture hall traffic from the traffic of the upper floors of the building in order to resolve bottlenecks.

The second floor also contains teaching assistant offices and departmental offices, allowing immediate access from the stair while providing a degree of focus and quiet from the busy main lobby.

The remainder of the first floor houses loading dock and storage functions but is otherwise dedicated to chemistry outreach and secondary teaching spaces. Centered around the main stair and facing the new quad are the chemistry outreach studio lab and computer lab spaces intended to promote the program and be used in conjunction with the Lubar Center and KIRC.

The basement houses the majority of the support spaces alongside two research labs for specialized, sensitive functions. Additionally, this level provides below grade corridor access to KIRC.

Lastly, all of the program is arranged along a central east-west circulation axis. Stair and elevator cores are under from the building ends and paired with the collaboration zones in order to be conducive to informal interaction while efficiently serving the building.

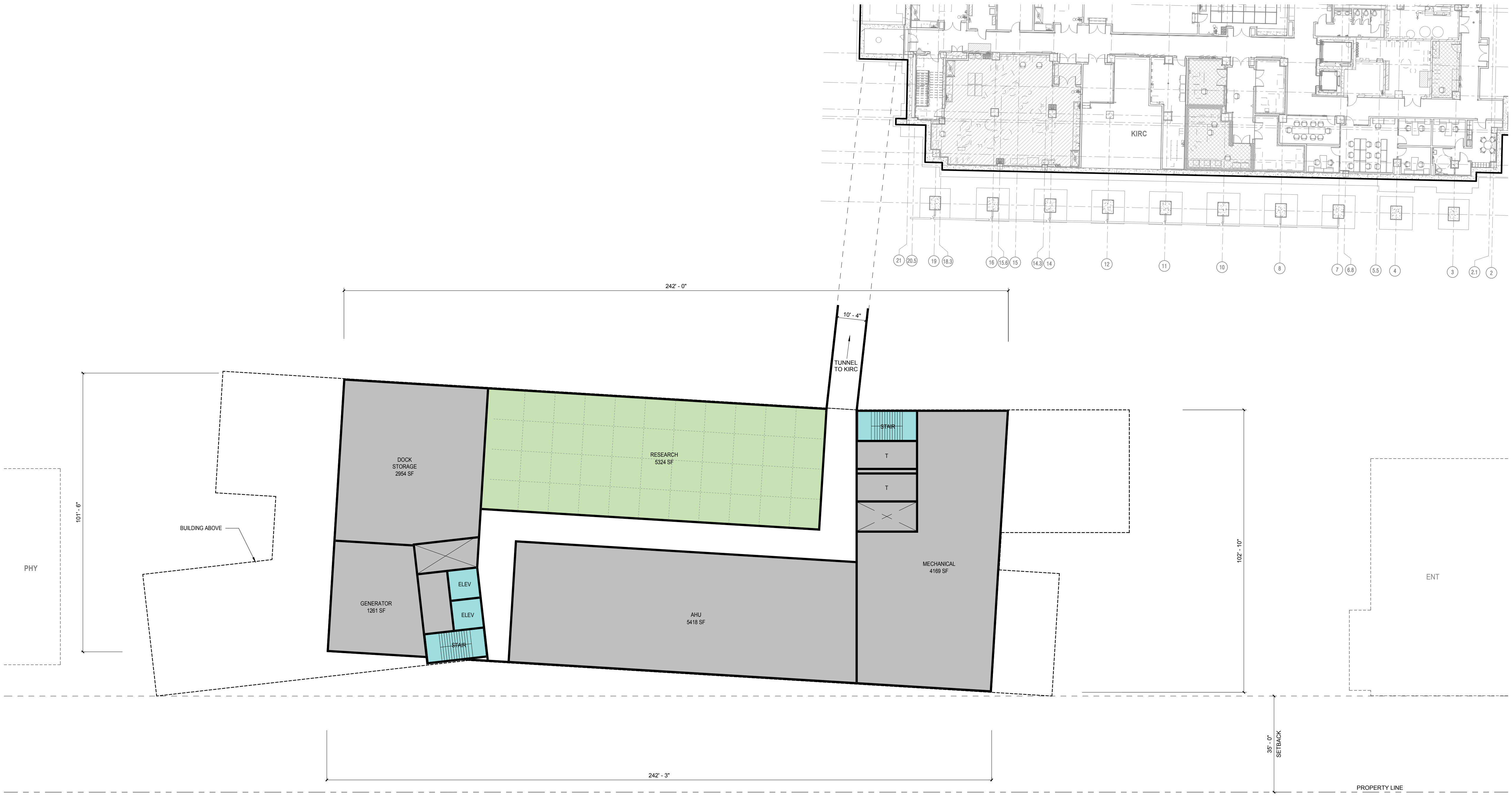


Proposed Program Breakdown (NTS)

FLOOR PLANS

Level B

The basement level contains a pedestrian connection to the KIRC facility. With a slight slope, the different in finished floor levels is mitigated. Two research labs are contained in this level. The remainder of the space houses facility requirements such as air handler, electrical, and storage space.



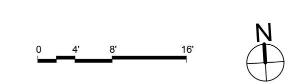
LEVEL B FLOOR PLAN

PROGRAM BREAKDOWN

BASEMENT AREAS	
DEPARMENT	AREA
CIRCULATION	2403 SF
RESEARCH	5324 SF
SUPPORT	14897 SF
VERTICAL CIRCULATION	647 SF
TOTAL GROSS PER LEVEL	23270 SF

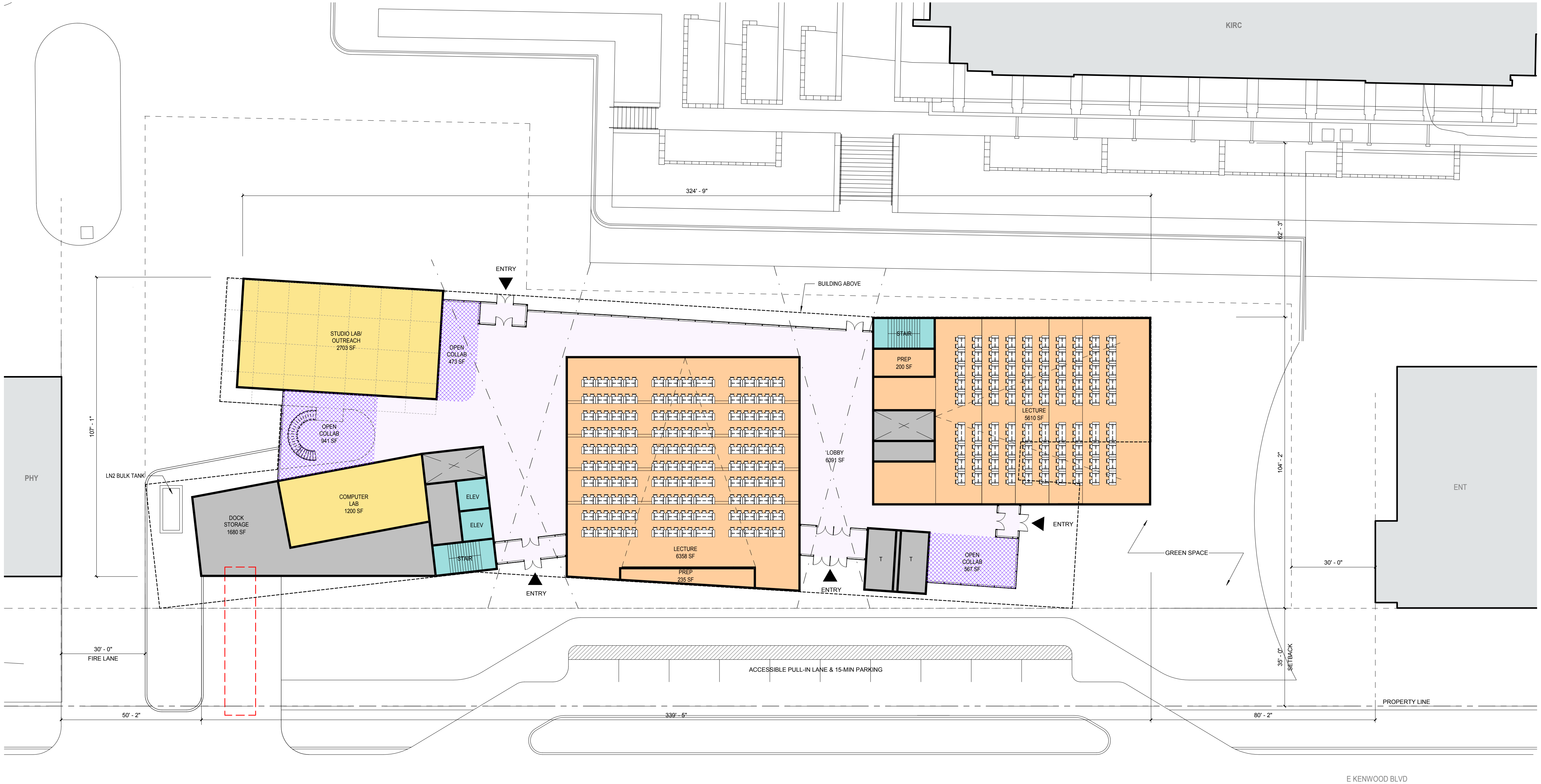
PROGRAM LEGEND

- RESEARCH
- SUPPORT
- VERTICAL CIRCULATION



Level 1

The first floor is imagined as a series of program pavilions. Between the pavilions, view sheds are maintained from Kenwood Ave through to the new STEM quad to the north. Additionally, the Outreach Lab and the computer labs, dock, storage, and lecture halls round out he program. Throughout the lobby, informal collaboration and waiting zones create space for students and faculty to meet, study, or relax. An open communicating stair connects the main lobby level to the smaller seminar classrooms on the second floor, along with the Chemistry Department Office and 100-level teaching labs.



LEVEL 1 FLOOR PLAN

PROGRAM BREAKDOWN

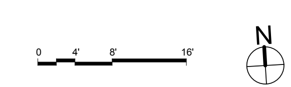
LOBBY: 6,279 SF @ 5 OCC/SF = 1,256 OCC
LECTURE HALLS: 11,670 @ 1 OCC PER SEAT = 434 OCC

LEVEL 01 AREAS

DEPARMENT	AREA
CLASSROOM / LECTURE	12403 SF
COLLABORATION	1981 SF
LOBBY	7089 SF
SUPPORT	2909 SF
TEACHING	3904 SF
VERTICAL CIRCULATION	653 SF
TOTAL GROSS PER LEVEL	28939 SF

PROGRAM LEGEND

- CLASSROOM / LECTURE
- TEACHING
- COLLABORATION
- SUPPORT
- VERTICAL CIRCULATION
- LOBBY



Level 2

The second floor is home to the first set of teaching labs, companion offices, and the departmental office. Additionally, tutoring and teaching assistant spaces are located on this level adjacent the seminar classrooms. The open communicating stair and double-height space provides an immediate connection to the lobby level.

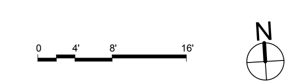
LEVEL 2 FLOOR PLAN

PROGRAM BREAKDOWN

LEVEL 02 AREAS	
DEPARMENT	AREA
CIRCULATION	4581 SF
CLASSROOM / LECTURE	3745 SF
COLLABORATION	1662 SF
OFFICE	3503 SF
SUPPORT	1087 SF
TEACHING	15432 SF
VERTICAL CIRCULATION	653 SF
TOTAL GROSS PER LEVEL	30664 SF

PROGRAM LEGEND

- CLASSROOM / LECTURE
- TEACHING
- OFFICE
- COLLABORATION
- SUPPORT
- VERTICAL CIRCULATION



Level 3

Level 3 and 4 provide the bulk of the laboratory space. Typically, the north and west sides house the research labs while the south side is home to the teaching labs. The eastern wing is the location of the PI offices and related shared functions. Open zones with glazing cap the ends of corridors allowing light to penetrate the spine and provide a waypoint and visual relief. Through these floors, further collaboration program is defined near the main circulation points and provide breaks in the experience of the circulation spaces.

LEVEL 3 FLOOR PLAN

PROGRAM BREAKDOWN

LEVEL 03 AREAS	
DEPARMENT	AREA
CIRCULATION	4491 SF
COLLABORATION	1698 SF
OFFICE	2261 SF
RESEARCH	13071 SF
SUPPORT	1087 SF
TEACHING	8017 SF
VERTICAL CIRCULATION	653 SF
TOTAL GROSS PER LEVEL	31279 SF

PROGRAM LEGEND

- TEACHING
- RESEARCH
- OFFICE
- COLLABORATION
- SUPPORT
- VERTICAL CIRCULATION

Level 4

Level 3 and 4 provide the bulk of the laboratory space. Typically, the north and west sides house the research labs while the south side is home to the teaching labs. The eastern wing is the location of the PI offices and related shared functions. Open zones with glazing cap the ends of corridors allowing light to penetrate the spine and provide a waypoint and visual relief. Through these floors, further collaboration program is defined near the main circulation points and provide breaks in the experience of the circulation spaces.

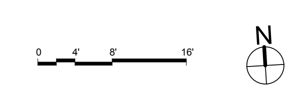
LEVEL 4 FLOOR PLAN

PROGRAM BREAKDOWN

LEVEL 04 AREAS	
DEPARMENT	AREA
CIRCULATION	4491 SF
COLLABORATION	1698 SF
OFFICE	2261 SF
RESEARCH	13071 SF
SUPPORT	1087 SF
TEACHING	8017 SF
VERTICAL CIRCULATION	653 SF
TOTAL GROSS PER LEVEL	31279 SF

PROGRAM LEGEND

- TEACHING
- RESEARCH
- OFFICE
- COLLABORATION
- SUPPORT
- VERTICAL CIRCULATION



Level 5

The penthouse serves the remainder of the laboratory exhaust and HVAC systems, along with the companion electrical service and other minor mechanical roles.

LEVEL 5 FLOOR PLAN

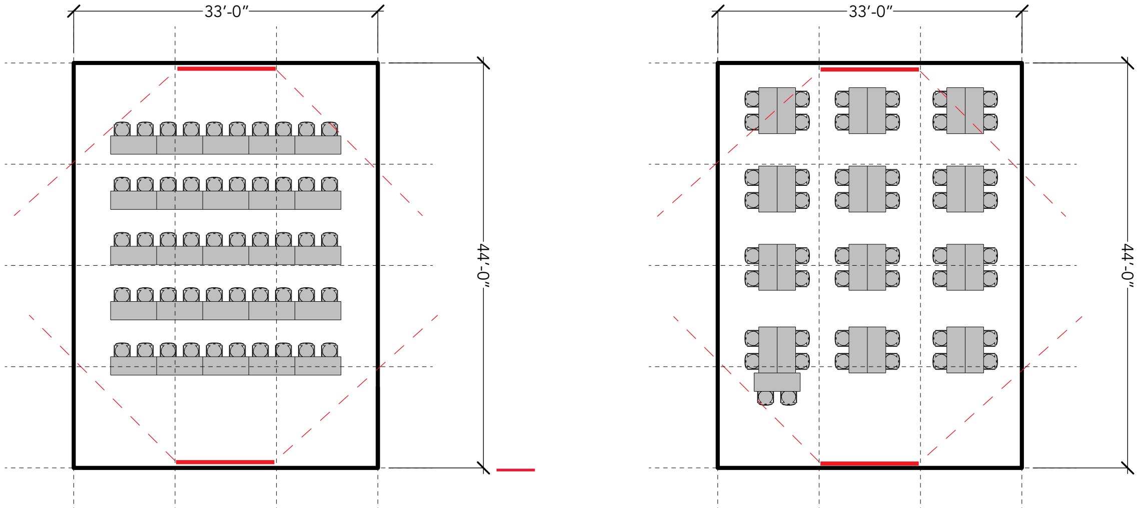
PROGRAM BREAKDOWN

PENTHOUSE AREAS	
DEPARMENT	AREA
SUPPORT	14305 SF
TOTAL GROSS PER LEVEL	14305 SF

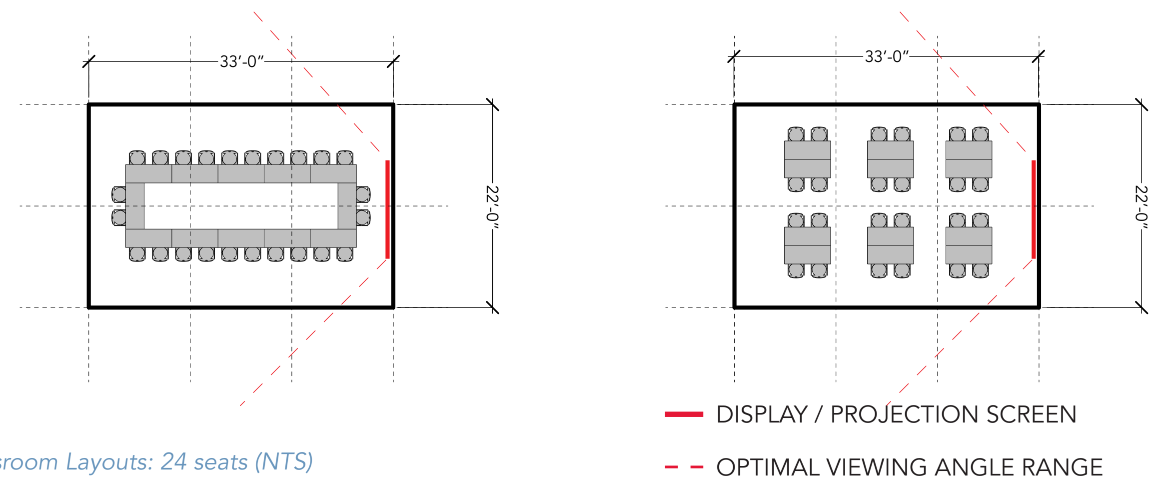
PROGRAM LEGEND

SUPPORT

TYPICAL LAYOUTS



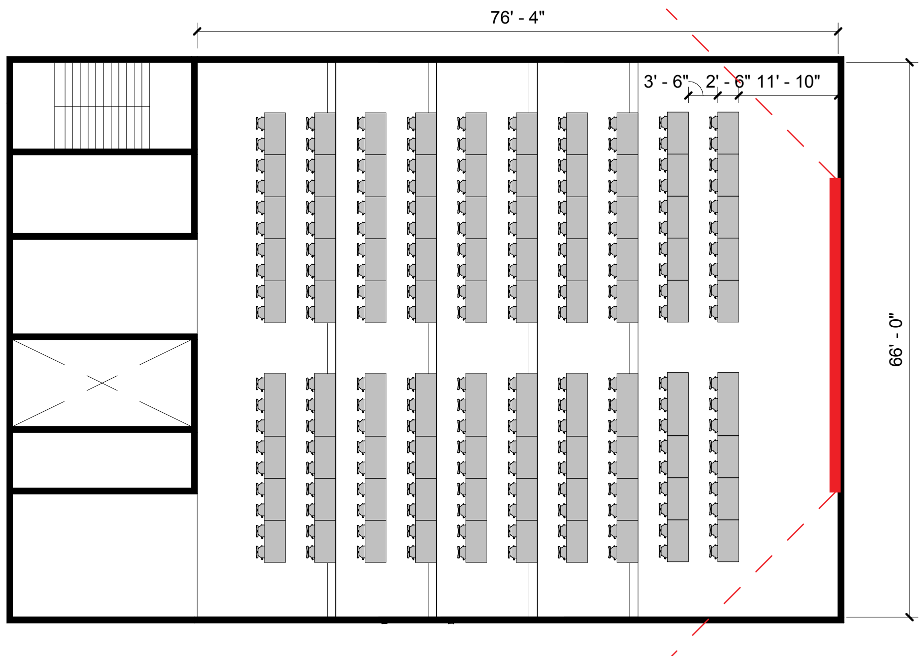
Typical Classroom Layouts: 45 seats (NTS)



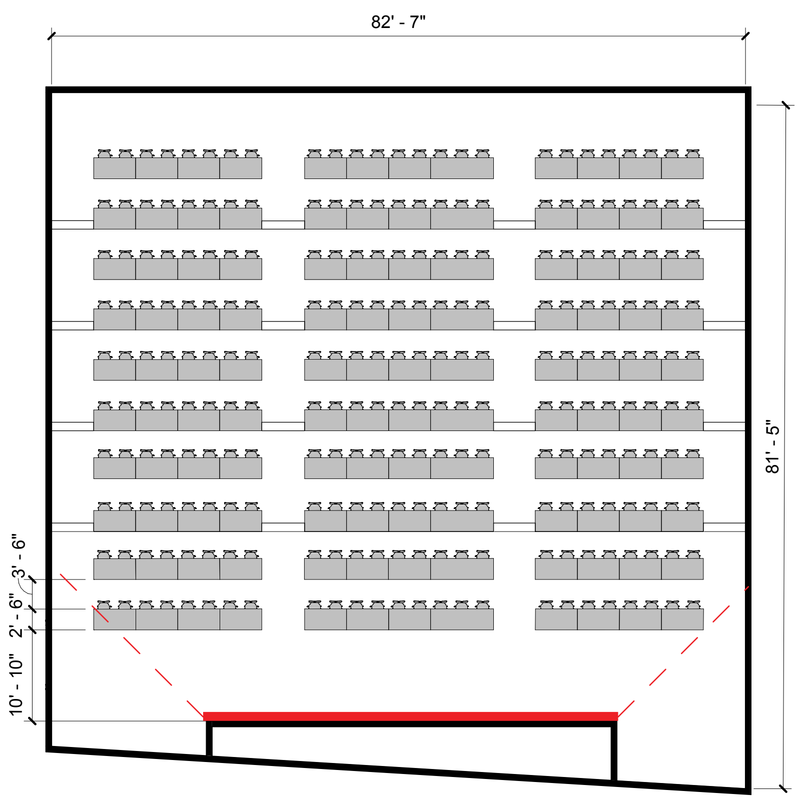
Typical Classroom Layouts: 24 seats (NTS)

Classrooms

General Assignment classrooms include small and medium flat floor classrooms accommodating 24 and 45 students respectively, and two large lecture halls for 180 and 250 students. The small classrooms are intended for use for discussion sections as well as group work. The furniture in the room will consist of moveable tables and chairs that can be quickly reconfigured for multiple pedagogical methods; from traditional lecture to group work for 4-6 students. One primary teaching wall will include a projection screen and adjacent wall will have a series of white boards for presentation and collaborative work. The medium classroom will function similarly but have two projectors on opposite ends of the room to enhance the flexibility of the room. The large lecture halls are both designed with deep tiers that each accommodate two rows of seating with fixed tables and moveable chairs. This configuration allows for student to "turn and talk", breaking up into groups on each tier level for collaborative learning activities. The front of the room will include continuous white boards within the reach range of the instructor, with large projection screens above, allowing for simultaneous presentation and problem-solving modes. An adjacent lecture prep room will provide A/V support for each lecture hall.



Typical Classroom Layouts: 180 Seat Lecture (NTS)

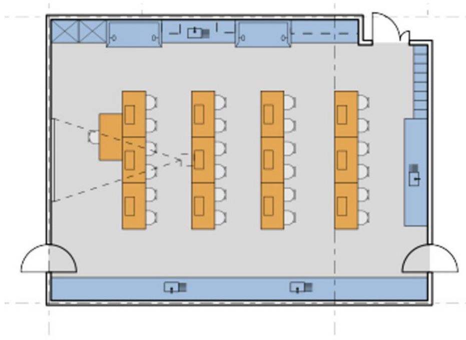


Typical Classroom Layouts: 250 Seat Lecture (NTS)

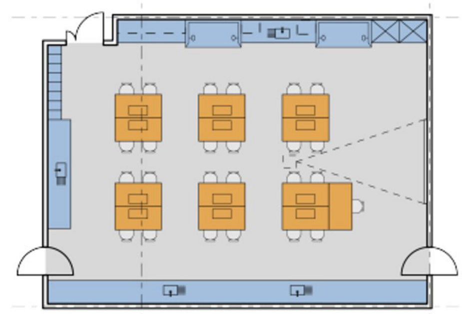
DISPLAY / PROJECTION SCREEN

OPTIMAL VIEWING ANGLE RANGE

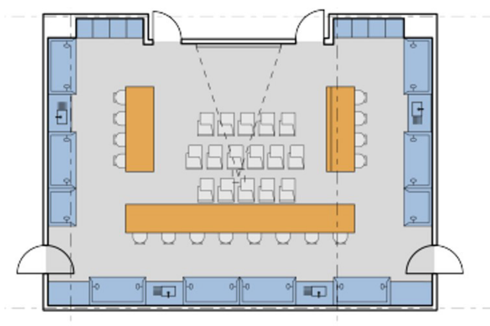
2015 PRE-DESIGN REPORT INSTRUCTIUONAL LAB LAYOUTS



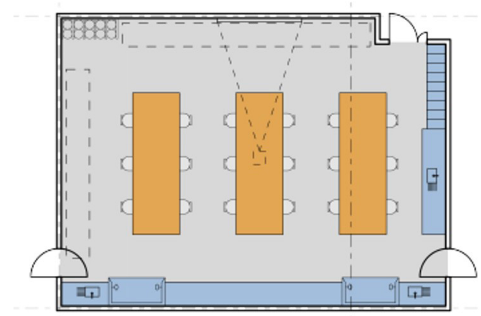
Option 1: Typical 100/200 Level Instructional Lab (NTS)



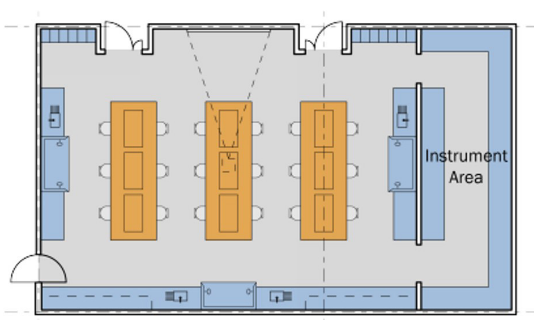
Option 2: Typical 100/200 Level Instructional Lab (NTS)



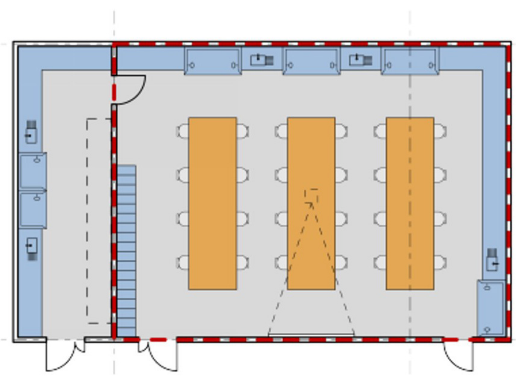
Typical 300 Level Instructional Lab (NTS)



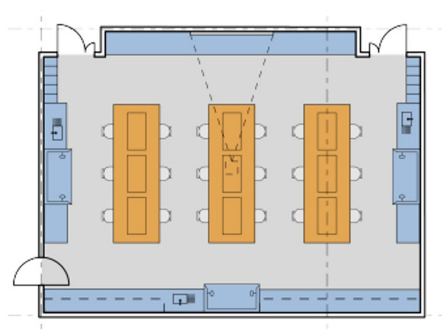
Physical Chemistry Instructional Lab (NTS)



Advanced Chemistry Instructional Lab (NTS)

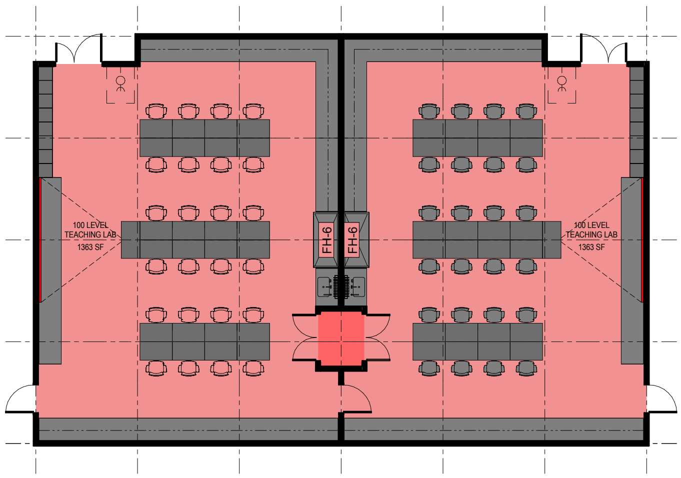


Studio/Outreach Instructional Lab (NTS)

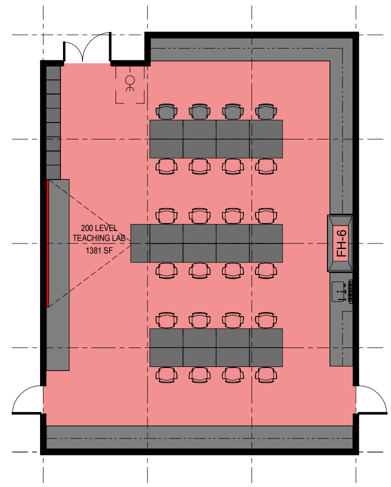


Biochemistry Instructional Lab (NTS)

PROPOSED INSTRUCTIONAL LAB LAYOUTS



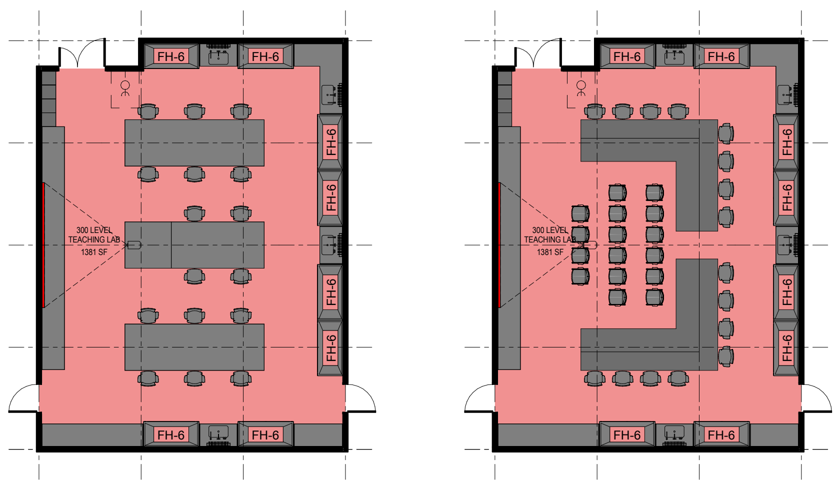
Typical 100 Level Instructional Lab (NTS)



Typical 200 Level Instructional Lab (NTS)

Space Function

- LAB
- LAB SUPPORT
- OFFICE
- TEACHING LAB
- TEACHING LAB SUPPORT



Typical 300 Level Instructional Lab (NTS)

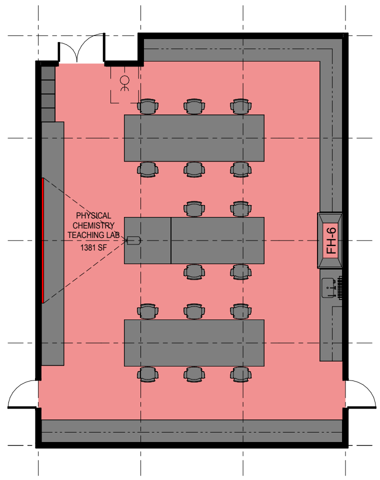
Instructional Lab

The proposed Instructional Laboratories build upon the Instructional Laboratory layouts that were developed for the 2015 Pre-Design Report. However, the proposed Instructional Laboratories depart from the 2015 Report with regards to room orientation and minor casework/ equipment layout. The adjustment to the orientation of the proposed Instructional Laboratory Layouts provide a better connection to adjacent instructional spaces, an improved presentation wall, less disruptive student entrance, as well as providing more opportunities for transparency along the public corridor(s). Additionally, the proposed Instructional Laboratories modified the 2015 Report Instructional Laboratory Layouts in attempt to standardize casework and equipment across the various instructional lab typologies to allow the Department greater flexibility in scheduling/ utilization of the instructional laboratories.

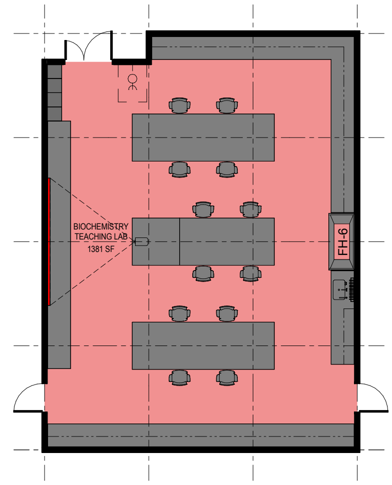
The proposed Instructional Laboratories are teaching facilities that vary in size, from sections of 10 to 24 students (plus Instructor), as well as a large Outreach/Studio Instructional Laboratory with capacity for 54 students and the ability to divide the space into two groups of 27 students. The proposed Instructional Laboratory Layouts are designed with clear sightlines for instructional and safety purposes. Group or individual experimentation will occur at either mobile or fixed laboratory casework

Space Function

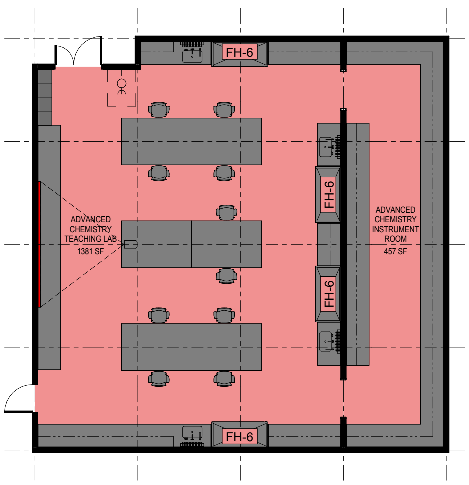
- LAB
- LAB SUPPORT
- OFFICE
- TEACHING LAB
- TEACHING LAB SUPPORT



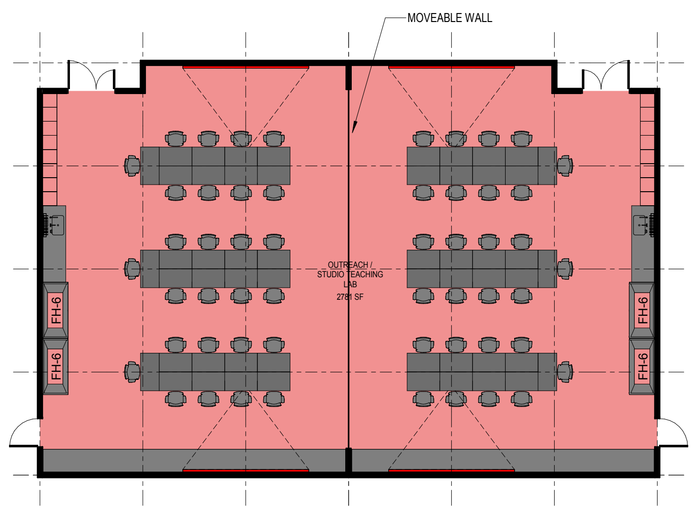
Typical Physical Chemistry Instructional Lab (NTS)



Typical Biochemistry Instructional Lab (NTS)

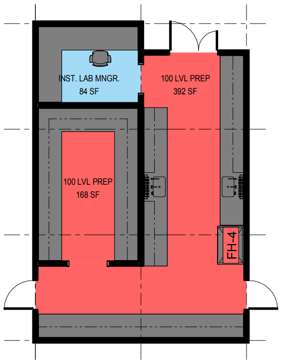


Typical Advanced Chemistry Instructional Lab (NTS)

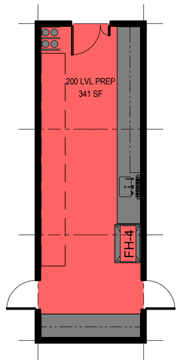


Typical Outreach/Studio Instructional Lab (NTS)

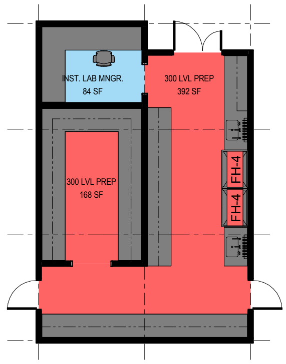
within the given Instructional Laboratory. The Outreach/ Studio Instructional Laboratory is designed with multiple presentation locations to provide a multifocal instructional laboratory for dynamic instruction with large groups. Fixed laboratory casework with sinks, fume hood(s) and other utilities are located along the perimeter walls, and either fixed or flexible casework is in the middle of the instructional laboratory as required by the specific instructional laboratory requirements. Each instructional laboratory will be designed and fit out based on the specific needs of the instructional laboratory course that will be taught in the respective space, but forethought for adaptability and flexibility of the overall Instructional Laboratories will be given for the Department to have the ability to locate different instructional courses in a given space over time. The main presentation wall in the various Instructional Laboratories will have a writable surface (i.e. magnetic glass, whiteboard, etc.) and integral AV (i.e. overhead projector, large flat screen TV, etc.) for presentations. Instructional Laboratories will have support, prep, or instrumentation spaces either immediately adjacent or located nearby so that storage/prep of chemicals and instrumentation does not take place in the instructional laboratory. Additional requirements and information are in respective Room Data Sheets located in the Appendix.



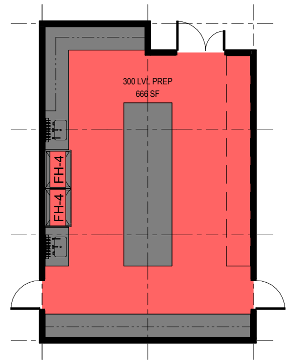
100 Level Prep (NTS)



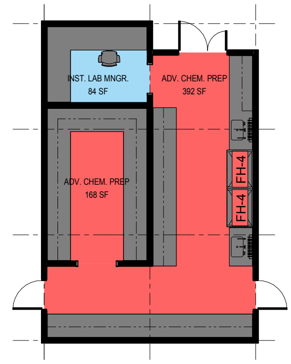
200 Level Prep (NTS)



300 Level Prep (NTS)



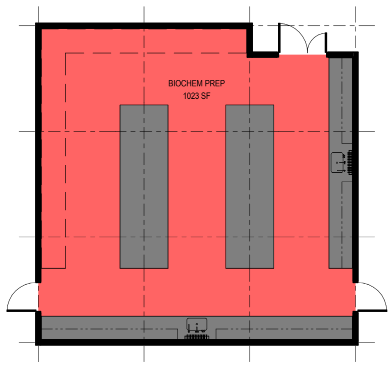
300 Level Prep (Inst.) (NTS)



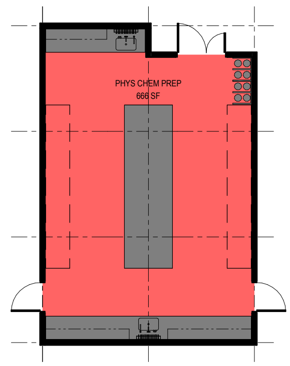
Adv. Chem Prep (Inst.) (NTS)

Space Function

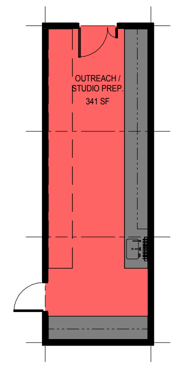
- LAB
- LAB SUPPORT
- OFFICE
- TEACHING LAB
- TEACHING LAB SUPPORT



Biochemistry Prep (NTS)



Phys Chem Prep (NTS)

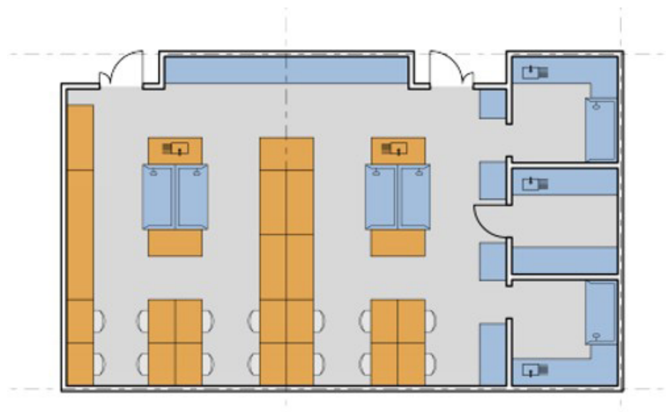


Studio/Outreach Prep (NTS)

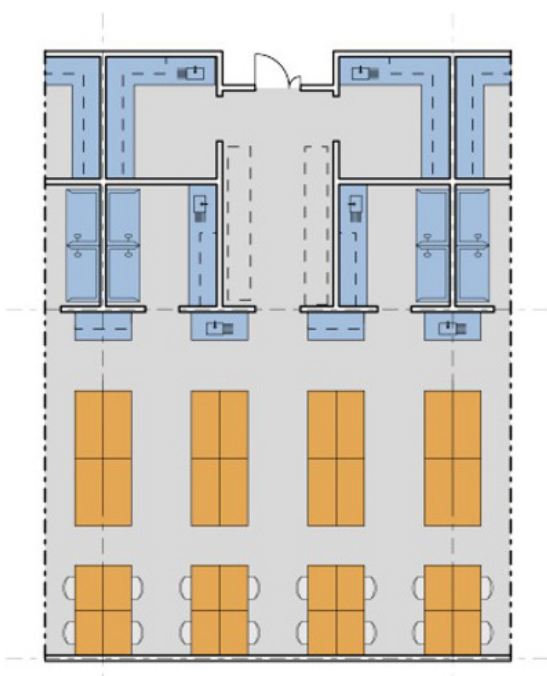
Instructional Laboratory Support

Instructional Support spaces (i.e. chemical storage, prep, instrumentation, etc.) will be located either immediately adjacent or located close to the Instructional Laboratories so that storage/prep of chemicals and instrumentation does not take place in the instructional laboratory. Some of these rooms will have desks for lab managers or technicians to help prepare the instructional laboratories for use and manage distribution of materials and equipment for students. Additional requirements and information are in respective Room Data Sheets located in the Appendix.

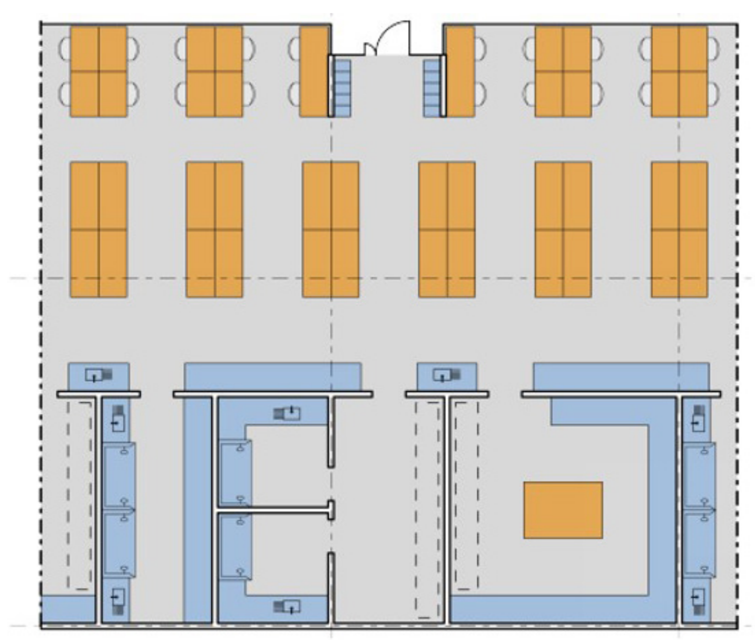
2015 PRE-DESIGN REPORT RESEARCH LAB LAYOUTS



Research Laboratory Type I (NTS)

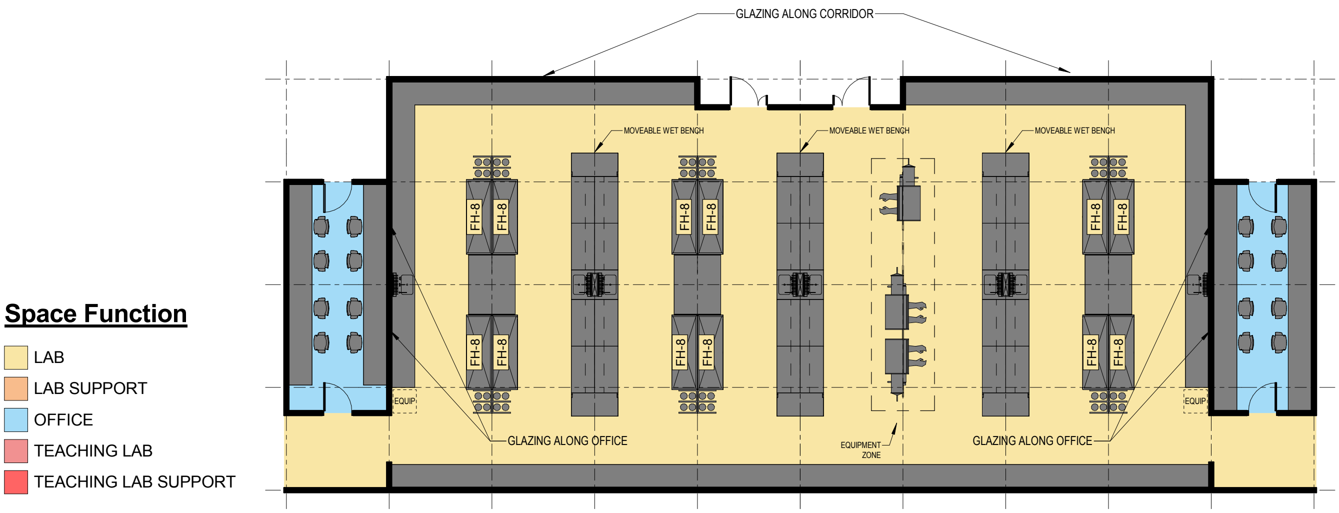


Research Laboratory Type II (NTS)



Research Laboratory Type III (NTS)

PROPOSED RESEARCH LAB LAYOUTS



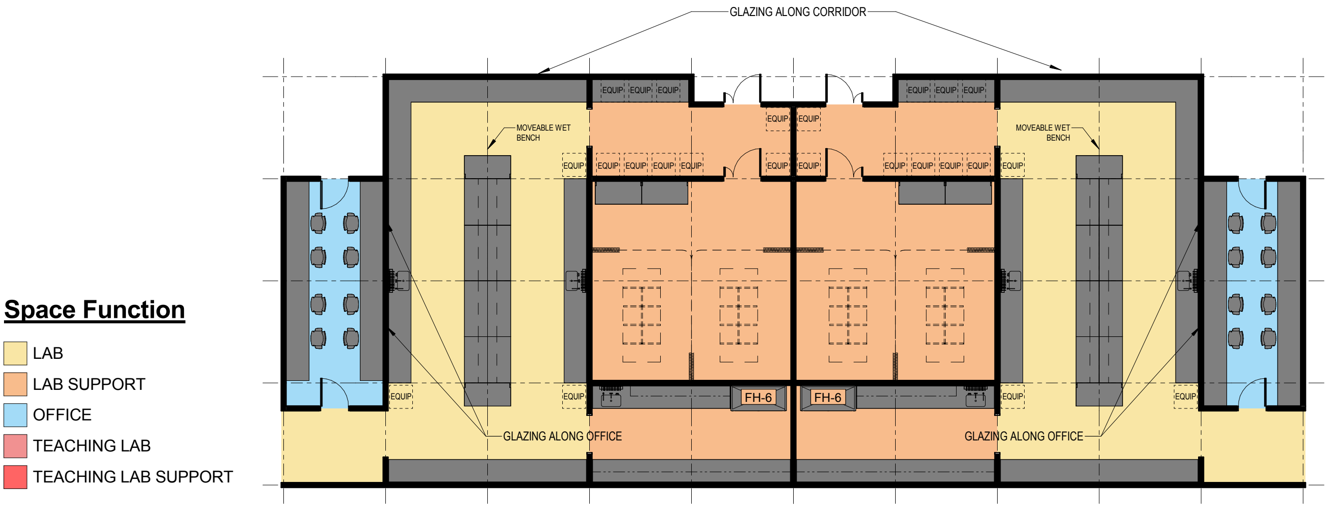
Typical Fume Hood Intensive Research Neighborhood (NTS)

Research Laboratories

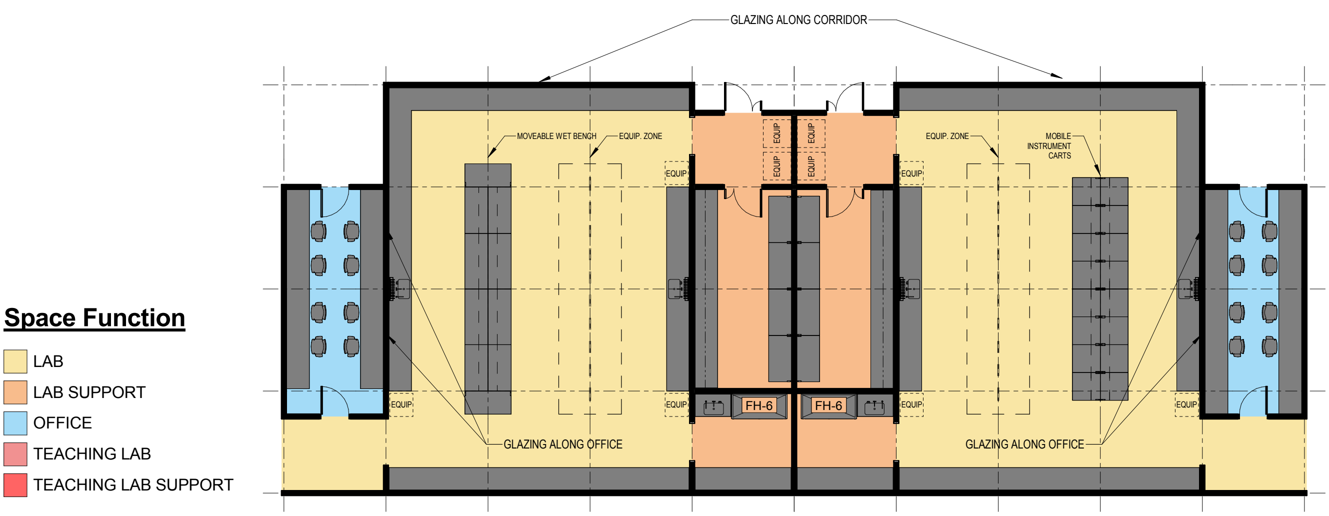
The proposed Research Laboratories build upon the Research Laboratory layouts that were developed for the 2015 Pre-Design Report. However, the proposed Research Laboratories depart from the 2015 Report by defining prototypical Research Laboratory Typologies which respond to the general nature of the research and equipment that will be utilized in those spaces. The Research Laboratory Typologies that were defined are: Fume Hood Intensive Laboratory, Wet Bench Intensive Laboratory, and Instrument Intensive Laboratory.

The proposed Research Laboratories Typologies are organized and designed in clusters, or "Research Neighborhoods". The Research Neighborhoods consist of open wet laboratories of various sizes (2-4 Faculty and 8-32 Research Assistants) which respond to the different chemistry and biochemistry research typologies, and their respective research and support requirements. Co-locating multiple research groups in collective Research Neighborhoods is useful in promoting collaborative research and makes boundaries between faculty and research groups easier to shift over time in response to changes in group size and/or funding. In addition to open wet laboratories, a series of enclosed laboratory support rooms will be defined for such things as fume hood alcoves, tissue culture, equipment rooms, imaging and microscopy, and any other specialized research or equipment functions that may require a more controlled environment. Lab benches throughout open lab areas will be movable table-based laboratory casework wherever possible fed by overhead utility carriers and/or ceiling interface panels. Fixed laboratory casework will be used at perimeter locations with space for floor mounted equipment. Research Assistant write up spaces will be located outside of the research laboratory environment and will be located adjacent to the research laboratories, primarily for safety and environmental control. Additionally, the location of the researcher write-up spaces outside (but adjacent to) the research laboratory will allow views into the research laboratory as well as provide access to daylight for the researchers while maintaining a direct connection to the research environment. Additional requirements and information are in respective Room Data Sheets located in the Appendix.

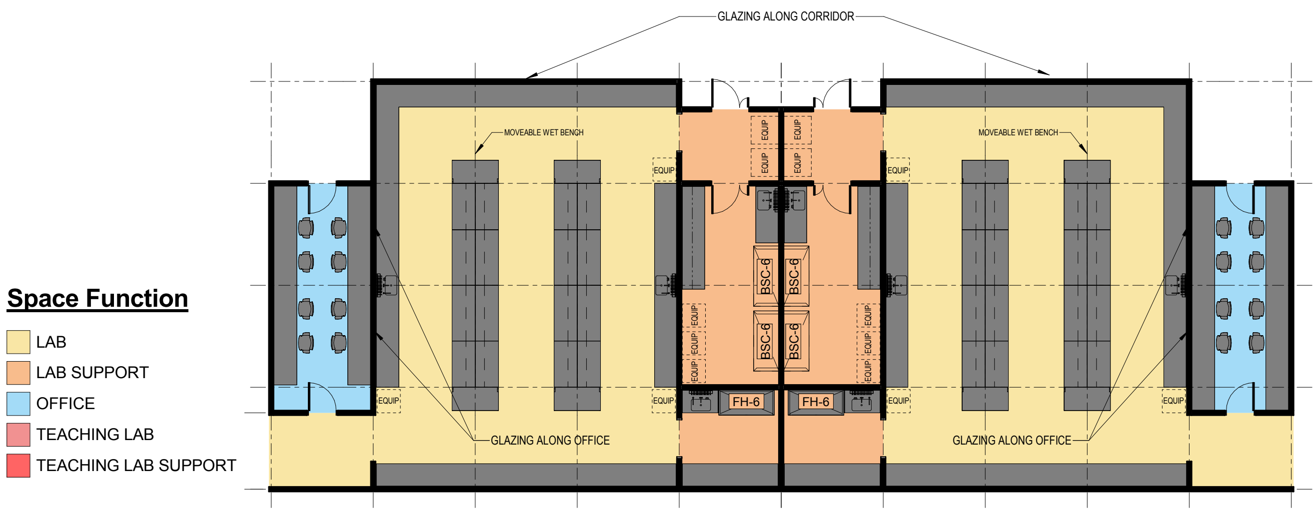
7.6 Typical Layouts



Typical Instrument Intensive Research Neighborhood (NTS)



Typical Instrument Intensive Research Neighborhood (NTS)

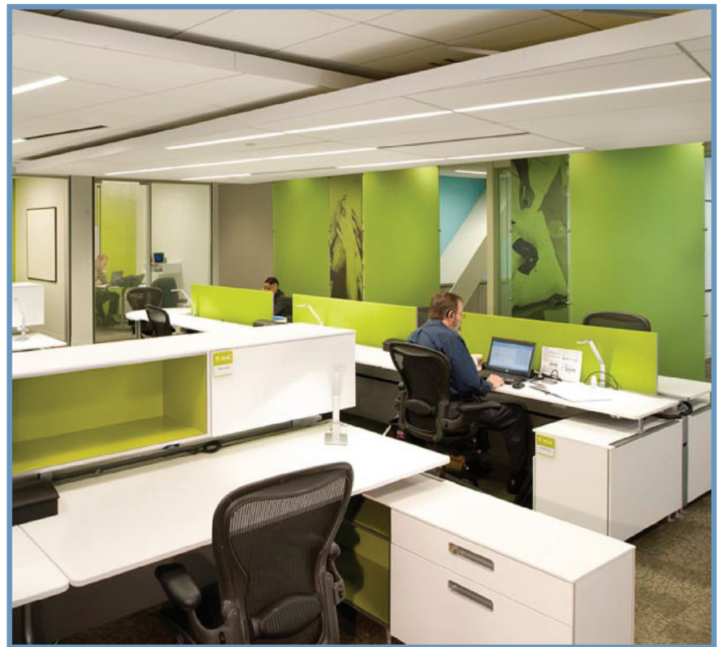


Typical Wet Bench Intensive Research Neighborhood (NTS)

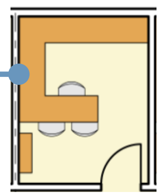
Research Support

The Research Support spaces area a series of highly specialized areas which will support the research and instructional missions of the Chemistry and Biochemistry Department. The Research and Support spaces include an NMR Facility, Scientific Glass Shop and Classroom, Electronic Instrumentation Shop, Hydrogenation Room, and Autoclave. Each of these spaces has its own distinct set of requirements, and additional requirements and/or information are in respective Room Data Sheets located in the Appendix.

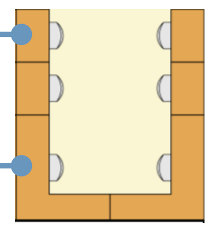
Private Office



Small Workstation



Typical Private Office Layout (NTS)
SOURCE: Academic/Research Building Pre-Design 10.02.15



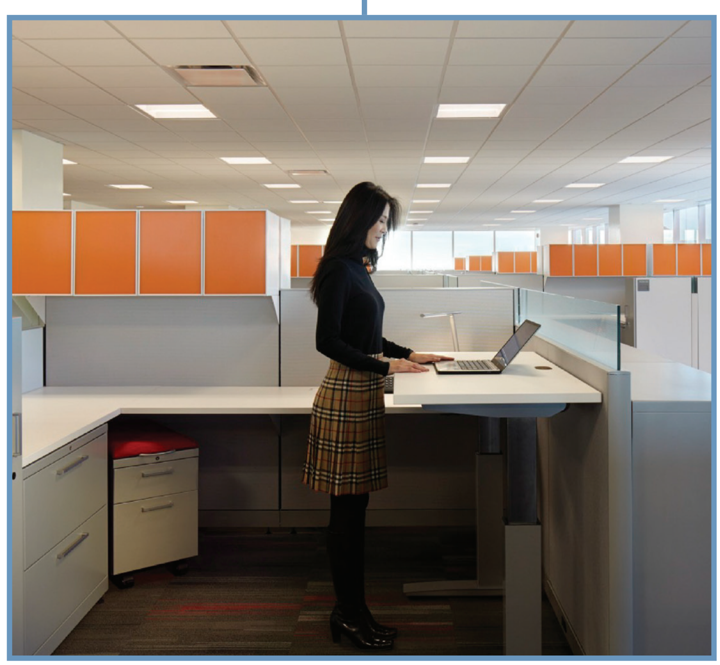
Typical Workstation Layouts (NTS)
SOURCE: Academic/Research Building Pre-Design 10.02.15

Offices and Workstations

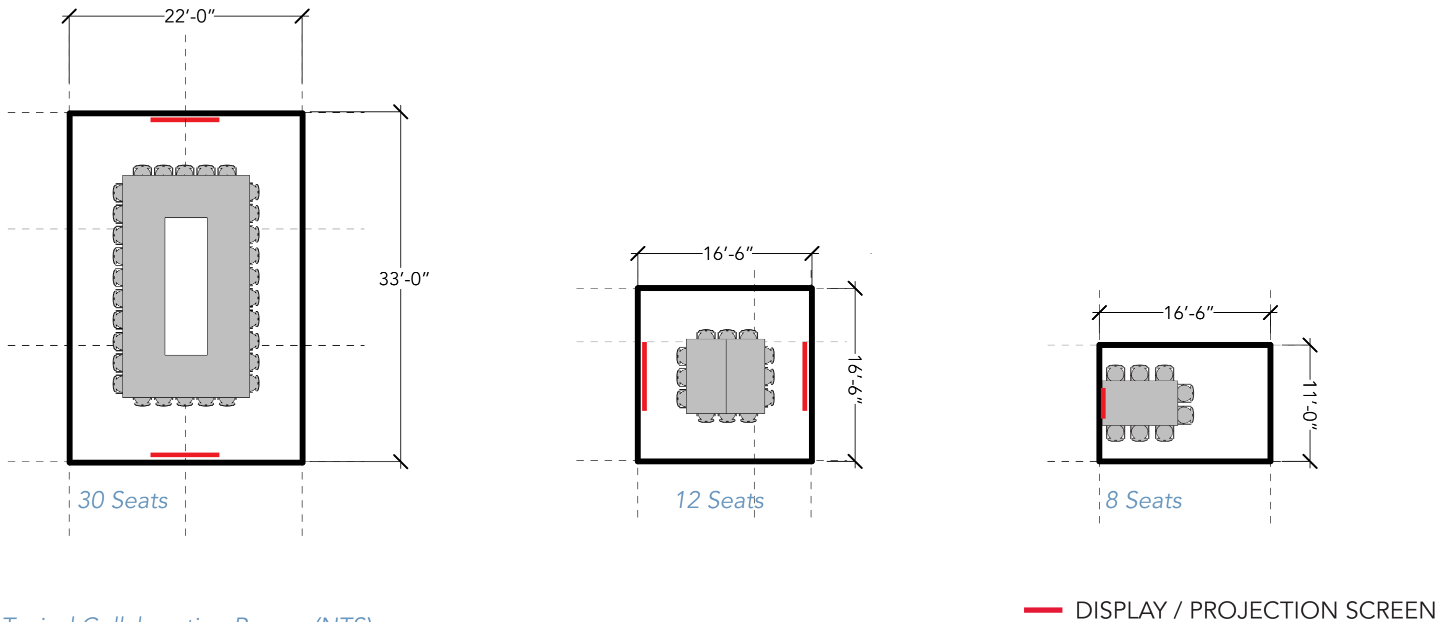
Offices spaces include private offices and large and small workstations. The private offices are reserved for faculty, scientists, and teaching and non-teaching staff that require privacy for their day-to-day work and accommodate a desk with two guest chairs with larger group meetings to be accommodated in formal collaboration spaces. Large workstations are provided for the remaining teaching and non-teaching academic staff as well as post docs. These stations accommodate height adjustable desk surfaces, adjacent additional work surfaces, and 3-4 storage units. Smaller, open workstations are intended for graduate assistants and accommodate height adjustable desk surfaces, one additional adjacent work surface, and 1-2 storage units.

Office Support Areas

Office support areas are a series of shared resources directly adjacent to and accessed from office and workspace areas. These include storage, mail room, kitchenettes, and copiers to assist in the day-to-day functions of administrative and research faculty, staff, and graduate students.



Large Workstation



Typical Collaboration Rooms (NTS)

Collaboration Spaces

Collaboration spaces will be distributed throughout the building and include both formal and informal configurations. Formal spaces include small and medium conference rooms and focus rooms accommodation 6-30 people. Informal spaces that are not intended to be scheduled include alcove seating and small group lounges. The small conference rooms of 8-12 seats are intended for day to day use for faculty and student meetings, while the large is intended for all staff meetings. The informal spaces will range in size and configuration and will largely be open, flexible spaces for students to meet with one another between classes.

Storage and Service Spaces

Storage space in the new Chemistry Building is comprised of a series of spaces for different materials used by the teaching and research labs, and for general building service. These include general storage, solvent storage, dry ice storage, cryogen storage, and gas cylinder storage, all located inside of the building. Bulk liquid nitrogen will be housed on the exterior of the building. These spaces all have differing code requirements for separation from adjacent uses that will be met.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: CIVIL

Civil Utilities

The project area is served by public utilities that run east-west along East Kenwood Boulevard as well as utilities that run north-south along North Maryland Avenue and North Cramer Street. The proposed new Chemistry Building footprint requires rerouting three 10-inch sanitary sewers and one water line. In addition, the building footprint requires one 18-inch storm sewer, one 8-inch storm sewer, and two storm sewer structures to be relocated or abandoned. The proposed electrical, chilled water, steam, and steam condensate mains will be routed through the north-south corridor between the EMS Building and the existing Chemistry Building. There are existing 8-inch diameter storm sewers located in this area that will require rerouting because this corridor will be densely packed with the new utilities and the existing storm sewer. Construction of the proposed electric, chilled water, and steam will necessitate installation of new storm.

All utilities serving the new Chemistry Building and existing utility reroutes will connect to the existing public utilities in East Kenwood Boulevard between North Murray and Frederick Avenues. The sanitary sewers will be connected to the existing 18-inch sanitary sewer. The storm sewers will be connected to the existing 15-inch combined sewer. The water service lines will be connected the 12-inch water main. The proposed utility connections are pending City of Milwaukee review.

Alternative utility connections were considered as follows:

- The sanitary sewer which collects waste north of the new Chemistry Building could be connected to the 12-inch sanitary sewer in North Cramer Street if the invert elevations allow. This alternative should only be considered if rerouting the sanitary sewer directly to East Kenwood Boulevard presents significant challenges. This alternative may provide some hydraulic relief to the 18-inch sanitary sewer in East Kenwood Boulevard. However, all sanitary flows on East Kenwood Boulevard combine with the flows from North Cramer Street before heading south, and it is yet to be determined if the 12-inch sanitary sewer in North Cramer Street can handle the additional flow.
- The storm sewers could be connected to either the 12-inch combined sewer between North Murray and Cramer Avenues or the 42-inch combined sewer between North Maryland and Frederick Avenues. This alternative should be considered if it is determined that the 15-inch combined sewer between N Frederick and Murray Avenues cannot handle the additional diverted storm sewer flow.

Utility connections to North Maryland Avenue were also considered. However, the tunnel between the new

Chemistry Building and KIRC would present design challenges for the existing utility reroutes, and there are no apparent additional benefits to connecting the new utilities to this location.

Stormwater

MMSD Chapter 13 Surface Water and Stormwater rules apply to this project per sections 13.301 (2) and 13.302 (3). This requires that the stormwater runoff management plan achieve either the allowable runoff release rate or the allowable runoff volume. These requirements are detailed in section 13.302 (1) as follows:

- "Allowable runoff release rate" means a post-development peak outflow during the 1% probability (100-year) storm that is no more than 0.5 cubic feet per second multiplied by the area of the site in acres and a post-development peak outflow during the 50% probability (2-year) storm event that is no more than 0.15 cubic feet per second multiplied by the area of the site in acres.
- "Allowable runoff volume" means a post-development runoff volume that is no greater than the pre-development volume for both the 1% probability (100-year) and 50% probability (2-year) storm events during the critical time.

Water management strategies will be developed to meet these requirements.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: LANDSCAPE

Site Analysis

In order to understand the UW-Milwaukee New Chemistry Building project site, the design team studied circulation, access, topography, and placemaking. Kenwood Boulevard lines the southern edge of the project site, providing vehicular and regional bicycle access to the site, as well as defining the edge of campus. Pedestrians and bikers travel to campus from all sides, but it is important to note that many people arrive to the site from the residential neighborhood south of the site. At the northern edge of the project site, several pedestrian routes converge, creating the opportunity for gathering spaces at this intersection of activity. With the removal of surface parking from the project site, vehicles are deemphasized, and the pedestrian experience is able to be prioritized. Modifications to fire access lanes will be required to maintain safe access through the site, while also supporting pedestrian circulation day-to-day.

Looking at the greater UW-Milwaukee campus, this project site stands out as one of few areas on campus with considerable grade change. Southwest of the Kenwood IRC Building (KIRC), the site drops approximately 10' to the site of the New Chemistry Building, creating an opportunity to design a landscape that elegantly transitions and provides access between the two levels. A proposed access tunnel between KIRC and the New Chemistry Building will require the reconstruction of existing plaza spaces west of KIRC, providing the opportunity to modify those spaces to better integrate with the New Chemistry Building site. West of KIRC, edge conditions surrounding existing rain gardens have raised safety concerns because wheelchairs and maintenance vehicles are not protected from falling into these recessed areas. This project offers an opportunity to address these safety concerns and design a space that highlights the unique topography of the site.

The Southwest Quadrant carries a strong campus identity through its use of placemaking features such as branding and art. Banners and signage indicate a clear transition into campus and provide wayfinding features. Existing sculpture pieces located in this region of campus have integrated public art on campus and serve as landmarks for wayfinding. The development of the New Chemistry Building site should account for campus's branding and wayfinding standards, along with identifying the potential for additional public art. The analysis of the UW-Milwaukee New Chemistry Building project site and surrounding campus area is a critical first step in the design process to understand the space through different perspectives.

Landscape Design

The UW-Milwaukee New Chemistry Building project site and adjacent campus landscape is slated for major redevelopment as outlined in the 2015 Southwest Quadrant Redevelopment Plan and 2010 Campus Master Plan. Both plans envision a pedestrian-oriented open greenspace as a central focus for the entire interdisciplinary STEM community situated in this area of campus. Goals for the New Chemistry Building site as identified by this design team suggest that the site should be integral to the campus fabric, STEM-focused, flexible, social, providing a place of respite, allowing a flow between the indoor and outdoor environments, accessible, and maintainable. The following site program elements: large-scale gathering space(s), small scale gathering spaces, open turf, placemaking features, pedestrian pathways, fire lanes, bicycle parking, vehicular parking, stormwater management, ten short term parking stalls along a drop off road, and a loading dock shared with the future STEM building that replaces the Physics building

Phase 1

These site diagrams extend beyond the New Chemistry Building project site in order to look at the new quad greenspaces more holistically. The first phase to be implemented will be associated with the New Chemistry Building which will include the southern front entrance to the new building along Kenwood Boulevard, westward to the edge of the Physics Building, north to the edge of the Existing Chemistry Building, and east to Lubar Entrepreneurship Center and UWM Welcome Center. Construction extents of the proposed access tunnel connecting KIRC and the New Chemistry Building will determine the necessary removal, reconstruction, and potential redesign of the 2015 KIRC west plaza during this phase. The newly installed 2019 Welcome Center seating areas, walkways, and planting areas adjacent to the new Chemistry Building are to be preserved.

The +/- 10' grade change between KIRC and the new Chemistry Building provides an opportunity for a tiered amphitheater-like courtyard at the southern terminus of the quad greenspace that will serve as a focal point within the overall STEM quad. This area will provide smaller gathering spaces for students and create an opportunity for larger event venues at the lower level of the new Chemistry Building. There is also an opportunity to address campus accessibility concerns regarding the KIRC planters by adding a curb with curb cuts to the existing design as a part of this project.

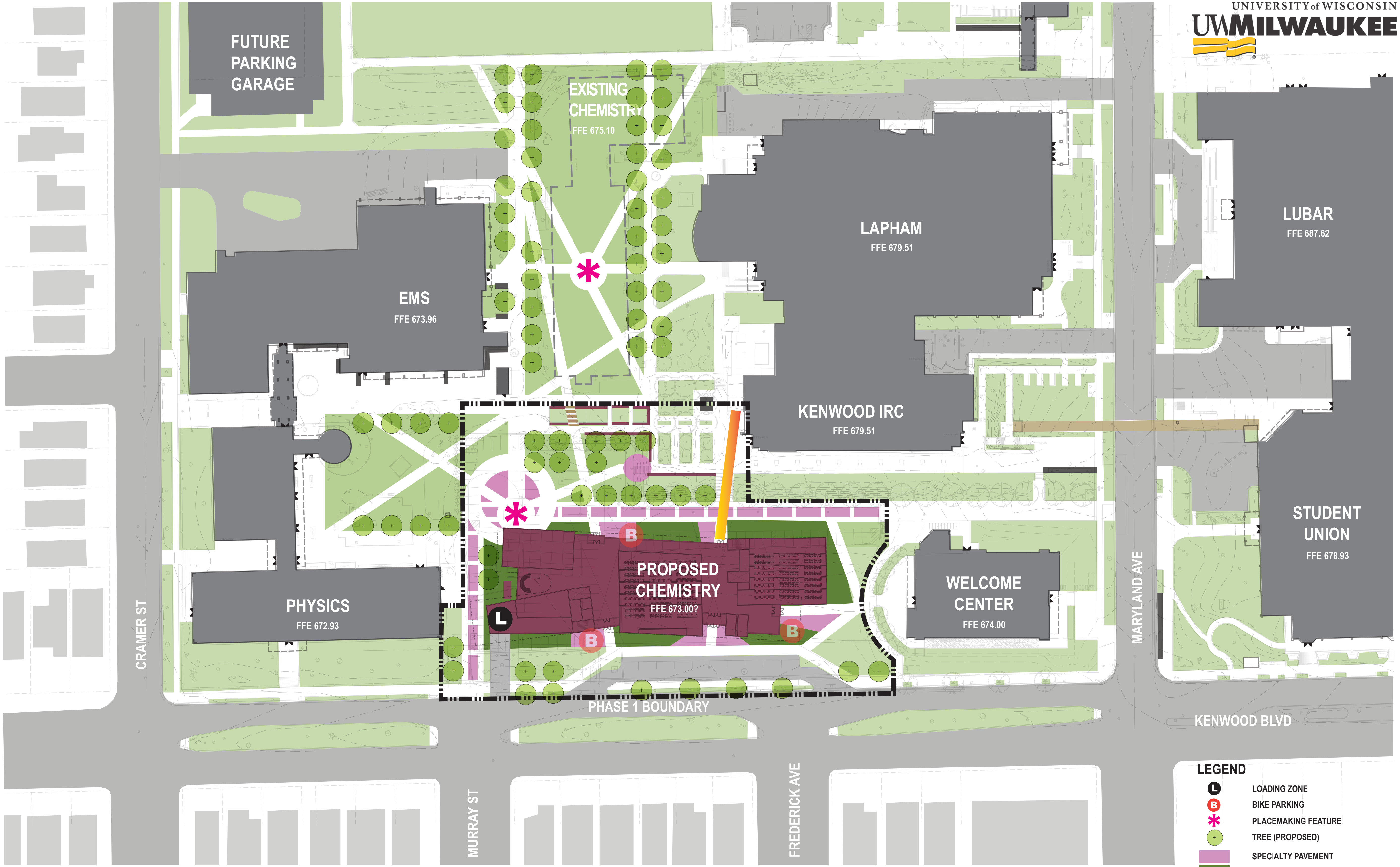
The New Chemistry Building will align with the Welcome Center's 35' setback from the property line, allowing for a one-way drive through drop-off with a few temporary and ADA accessible parallel parking stalls off of Kenwood Boulevard. Planting areas and an entry patio space will provide a welcoming face to the residential neighborhood to the south.

Bicycle parking will be provided at several locations near building entrances. Fire lanes must be maintained throughout the central quad greenspace. Specialty hardscape treatments throughout the site are being evaluated to further enhance wayfinding, soften the expanse of the fire lanes through the quad, aid in pedestrian safety, and manage stormwater. Site hardscapes will be designed in accordance with the UW Milwaukee Technical Guidelines and ADA Guidelines.

Open turf will occupy a portion of the available greenspaces with select areas of more intensive plantings. Lower maintenance and more environmentally sensitive turf options will be explored; however, traditional bluegrass turf may be utilized. Foundation plantings along the exterior walls of the new building will soften the structure's façade and add to the overall site aesthetic. Plantings will consist of a mix of trees, shrubs, ornamental grasses, and flowering perennials to provide multi-seasonal interest. Urban tolerant plants will be utilized for their ability to withstand periods of heat, drought, salt spray, and cold hardiness. Low-maintenance plantings will be utilized as much as possible to minimize water demand, perennial deadheading, pruning, etc. beyond the establishment period. Foundation plants will be selected in compliance with Crime Prevention Through Environmental Design (CPTED) principles to permit open sight lines to and from the building for safety and security purposes. Lawn and planting areas will not be permanently irrigated.

Future Phases

Future phases will extend the campus quad greenspace west and north of the New Chemistry Building. The most significant area of the quad green open space will extend northward, replacing the existing Chemistry Building after its demolition. The location of the existing Chemistry Building will be a valuable extension of the quad given its central location within the STEM buildings and solar orientation within this block of campus.



SITE CONCEPT

SITE DESIGN CONCEPT

SITE AND BUILDING SYSTEMS DESCRIPTIONS: ARCHITECTURE

Overview

The new Chemistry Building will be a 6-story facility that includes a basement; four levels broken down into offices, classrooms, laboratories, collaboration spaces and supporting program; and a mechanical penthouse. The team's intent is to follow the 2018 International Building Code (IBC) throughout the project.

Exterior Wall Assembly

Understanding the code requirements and its exceptions, the team's position is to use noncombustible materials to pursue Type IIB construction.

The ground floor's support and loading dock areas will consist of precast panels over stud wall assemblies, while for the rest of the program, we will be using a thermally broken, low iron 1" IGU, SSG Curtain Wall System. This will ensure the transparency that the vision and architectural concept for the building require.

The main wall assembly for levels 02-04 will be composed of ACM Panels with continuous insulation over cold-formed framing with 1" IGU, Aluminum Glazed Window Wall system. Based on the Wisconsin Department of Administration Division of Facilities Development, the window openings will follow the Daylighting Standard for State Facilities of a window-to-wall ratio of 30% maximum on the East, South, and West facades; and 70% on the North facade. We will be using a continuous vertical Curtain Wall System at the corridor ends and all exterior soffits will be comprised of ACM Panels.

Finally, Precast Panels and Metal Panels will be used for the Mechanical Penthouse.

Roof Assembly

All roofs will have drains with overflow and R30 tapered insulation, or the value required by the Energy Code.

Vapor Retarders

All walls, roofs and slabs will have vapor retarder.

Interior Finishes

Varies per program element. Refer to Room Data Sheets.

Floor

Varies per program element. Refer to Room Data Sheets.

Partitions

Most interior partition assemblies will be comprised of Gypsum Wall Board over cold-formed framing with insulation (where needed). Finishes range from paint, to mid-range porcelain tile in all public areas on ground floor and second level classrooms, to full-height tile at wet walls in toilet rooms. To allow maximum daylight, corridors will be 50% glazing into research and teaching labs.

Ceilings

All ceilings will be comprised of Gypsum Wall Board, Soffits and lighting coves in the main rooms with the potential of using ACT in the corridors. See Room Data Sheets for labs, classrooms and offices.

Refer to Room Data Sheets for a more specific breakdown of materials and finishes per program element.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: STRUCTURE

Foundation System:

A soils report has not been filed for this site, but based on the recent construction of the adjacent Lubar Center we can infer some rough estimates of expected soil conditions.

A presumptive allowable bearing capacity of 4,000 psf will be used for preliminary design. Based on the soil bearing capacity, the total post-construction settlements are estimated to be 1 inch or less with differential settlements of ½" or less. Groundwater elevations for the adjacent site were between elevations 645 and 664 feet above MSL. These presumptive values, as well as subsurface water and drainage recommendations will be confirmed by further investigation.

It is likely that drain tile will be recommended around the perimeter of the foundation base and under the basement slab.

Foundations for the heated structures will be set at a minimum of 48 inches below exposed grade for frost protection. Footings for unheated structures should be placed a minimum of 60 inches below finished grade.

A vapor barrier is recommended under all slabs that will receive floor coverings. It will be evaluated if this vapor barrier should be placed directly below the slab or under a sand layer.

The slab on grade will be 4 inches unless thicker slabs are needed for heavier loading. The slabs will be designed using a subgrade modulus of 250 pci. If basement rooms are to contain special sensitive equipment with vibrational concerns, slabs may require full isolation and heavy slabs to minimize transmission of transient vibration.

Seismic soil classification for this site is considered to be a Site Class D. The seismic acceleration parameters are SdS of 0.112 and Sd1 of 0.070.

We anticipate a shallow spread footing system will be used. Shear resisting elements such as stair cores and elevators will be placed on larger spread footing pads under their entire area.

Laboratory Vibration/Structural Consideration:

Vibration criteria for areas intended to accommodate sensitive equipment are based on Vibrational Velocity as measured in one-third octave bands of frequency over the range of 8-80 Hz for equipment without internal pneumatic isolation. For this facility, we will be designing the structural system to satisfy the limiting velocity of 2,000 in/sec per CRSI Publication No. 10-DG-VIBRATION Table 3.3 Acceptance Criteria for Sensitive Equipment.

Floor Framing – Laboratory:

The basic bay size module at this point seems most efficient at approximately 22' x 33'. A concrete system for this bay size is most likely to consist of a standard pan/joist system of approximately 27" in depth. Both beams and joists would be this depth. The concrete beams are assumed to be 30" wide in the center bays and 24" wide along the perimeter and will be post-tensioned to reduce the vibrational effects. The joist system would likely be 20" deep pans with a 7" slab. In the corridors within the lab modules, an 8" flat slab will be used. The concrete compressive strength to be specified for all floor framing and columns will be 5 ksi. The concrete system, while being inherently fire-proofed, also provides stiffness/mass for vibration control. As equipment vibrational requirements become more defined, due consideration will be made for the system design. There will likely be post tensioned transfer beams above the column free areas at locations where the building overhangs, or locations where columns do not stack vertically. Transfer beams could be as large as 60"x60" in cross section. Transfer beams would be post-tensioned and may require incremental stressing as upper floors are added.

At the large cantilever of the upper floors to the west, a multi-floor concrete flexural element would be provided at the north and south extent of the projection. This element could be implemented as a multistory truss or as a perforated wall with truss like reinforcing. Concrete secondary beams would span north-south between the trusses with either a flat slab or pan joists spanning east west between panels. Spacing between the secondary beams could be 25-35 feet with pan joists or 10-15 feet with a flat slab.

Roof Framing – Laboratory:

Roof framing would be a concrete system similar to floors. Reinforcing may be reduced due to decreased loads and vibration constraints.

Roof Framing – Penthouse:

The penthouse roof framing is proposed to be of steel-framed construction using wide flanged beams and steel roof deck. Fire-proofing will also be required on these system elements to achieve a rating if required Wide flanged beams provide much greater flexibility than open web joists for supported equipment and piping, as well as reducing steel surface area required to be fireproofed. Framing over the penthouse area will be sized to reflect increased mechanical loading requirements characteristic of this use.

Lateral Resistance

Lateral systems to resist the forces due to wind, seismic, and unbalanced earth pressure will likely consist of reinforced concrete shear walls. Shear walls will most likely be 12" thick to allow for higher capacity is easy constructability. These will be placed in areas such as stair and elevator shafts, mechanical shafts, restroom blocks, or other walls that likely remain unchanged over time. Resistance will be required in both north-south and east-west directions. The steel framed penthouse will have braced frames to resist lateral forces.

General Structural Design Parameters

- International Building Code (IBC), (2018)

  IBC 2018 is chosen by owner,. This is not the edition currently adopted by the State of WI. As such, all provisions of IBC 2018 (such as special inspections) will be required, without WI state exceptions granted for currently adopted IBC version.

- Wind and Seismic: per requirements of ASCE 7-10 (American Society of Civil Engineers).

- Snow loading: per requirements of ASCE 7-05. Both basic and drifted snow requirements. Milwaukee area ground snow load – 40 psf

Floor Loading

- First floor public areas and corridors - 100 psf Live
- Office areas – upper levels - 80 psf Live
- Corridors – upper levels - 80 psf Live
- Lab areas – all levels – 125 psf Live, as determined by equipment needs and future flexibility requirements.
- Mechanical – as required by equip. but not less than 100 ps

SITE AND BUILDING SYSTEMS DESCRIPTIONS: MECHANICAL

Outdoor Design Conditions

		Dry Bulb Temperature (°F)	Wet Bulb Temperature (°F)
Summer	System Design[1]	89°F	77°F
Winter	System Design[2]	-10°F	-

(1) Based on Wisconsin Administrative Code SPS 363.0302

(2) Based on Wisconsin Administrative Code SPS 363.0302

System Design Conditions

System	Design Temperature [1] (°F)	Differential Temperature [1] (°F)
High Pressure Steam	352°F at 125 psig saturated	-
Low Pressure Steam	240°F at 10 psig saturated	-
Chilled Water	45	14
Process Chilled Water	58	6
Heating Hot Water	130	20

(1) Refers to circulated fluid temperature unless otherwise indicated.

Terminal Device Design Conditions

System	Design Temperature [1] (°F)	Differential Temperature [1] (°F)
Cooling Coils	45	14
Preheat Coils	130	30
Reheat Coils	130	20
Perimeter/Misc. Heating	130	20
Humidifiers	240 (10 psig saturated)	N/A
Air Handling Unit Supply Air	55	N/A

(1) Refers to circulated fluid temperature unless otherwise indicated.

Indoor Design Conditions, Ventilation Rates and Pressure Relationships

Room	Space Criteria						
	Temperature (°F) (2)		Humidity (%RH) (3)		Minimum Ventilation (ACH) (4)		Pressure Relationship
	Min.	Max.	Min.	Max.	Occ.	Unoc.	
Office, Conference and Administrative Support Areas	68	76	25	50	(5)		Neutral or Positive
Teaching and Research Laboratory	72	72	25	50	6	4	Negative
Lab Support Space (shared Equipment Spaces)	72	72	25	50	6	4	Negative
Cold Rooms	40 (year round)		Non-condensing (controlled)		0.5 cfm per sq ft	0.5 cfm per sq ft	Neutral
Toilet rooms/Janitor Closets					(5)		Negative
Corridor					(5)		Positive to Laboratory
Telecommunication Rooms	72 (year round)		Mechanical humidification not planned		NR		Neutral
Mechanical and Electrical Rooms	60-10°F over summer outdoor design temperature1 04°F Maximum		Mechanical humidification not planned		NR		Positive
Elevator Machine Room	75 (year round)		Mechanical humidification not planned		NR		Neutral

(1) Minimum – Winter Heating
Maximum – Summer Cooling.
Occ. – Occupied Air Change Rate
Unoc. – Unoccupied Air Change Rate
NR – No requirement
N/A – Not applicable.

(2) Systems will be designed to meet the indicated temperature with a ± 2°F accuracy unless otherwise noted.

(3) Systems will be designed to meet the indicated relative humidity with a ± 5% accuracy unless otherwise noted.

(4) Total air changes per hour for supply air in positive pressure or neutral rooms,or return/exhaust air in negative pressure rooms.

(5) Based on Table 6-1 of ASHRAE 62.1 Standard 2013.

Assumed Heating and Cooling Loads

Internal Load Density					
Space	Lighting Density (W/sf) (1)	Equipment Density (W/sf) (1)	Occupant		
			Occupants per 1000sf (2)	Sensible BTUH (3)	Latent BTUH (3)
Offices, Conference, and Administrative Support Areas	1.0	3.0	5	250	200
Conference	1.0	2.0	100	250	200
Teaching Laboratory and Research Laboratory	1.8	8.0	25	250	200
Laboratory Support Spaces (shared Equipment Spaces)	1.8	16	25	250	200
Cold Rooms	1.5	2.0	-	-	-
Telecommunication Rooms	1.0	To be determined by actual equipment load	-	-	-
NMR facility	To be determined by actual lighting load, but not less than 1.5 W/sf	To be determined by actual equipment load, but not less than 8.0	5	250	200
Corridor	1.0	0			

(1) Actual load will be used where higher than the listed value.

(2) Occupant density in each space will be based on code adopted ASHRAE Standard 62.1-2010 or the actual occupant density listed in the facility program.

(3) The occupancy heat rejection will be based on ASHRAE Handbook of Fundamentals 2013.

Infiltration

The building heat loss calculations will include an infiltration load for building perimeter spaces.

Type	Airflow
Exterior Wall with Windows	0.11 cfm per square foot of wall
Exterior Walls without Windows	0.06 cfm per square foot of wall
Main Exterior Doors	200 cfm per door
Loading Dock Doors	5 cfm per square foot of door opening area

Building Envelope

Performance criteria for building envelope construction materials will be in accordance with the data provided by Architect]

Acoustic Criteria

Sound attenuation equipment will be provided based on standard design practice. Results are not guaranteed due to many items not under control of the design team and actual building usage.

Space Type	Initial Goals for NC Levels (1)
Laboratory with fume hoods	NC 50
Laboratory without fume hood	NC 45
Laboratory Support Spaces	NC 45
Open Office	NC 40
Private Office	NC 35
Conference Rooms	NC 35

(1) Based on 2015 ASHRAE Handbook – HVAC Applications.

(2) Measured dBA values will be approximately 5 points higher than average NC levels. A space with NC-40 will have an average sound level of 45 dBA.

(3) Sound attenuation equipment will be provided based on standard design practice and recommendations from acoustical consultant. Based on past experience, sound attenuation devices may be required for main air handling units and exhaust fans.

(4) Requirements and criteria will be further evaluated as design progresses

(5) The targeted noise levels assume an acoustical tile ceiling. If there is not acoustic tile ceiling, noise levels will be higher.

(6) The average noise level in laboratories, with fume hoods, shall be measured at three feet in front of a fume hood at five feet above finished floor level. The average noise level in all other spaces shall be measured in the middle of the room at five feet above finished floor level

(7) Fume hood manufacturers data indicates noise levels from a fume hood can be as high as NC=55, at a distance of 36" in front of the fume hood. Multiple fume hoods within the space can also increase noise levels above those of a single fume hood.

Systems Diversity

In conjunction with the variable flow systems serving the building, an HVAC equipment sizing diversity will be applied to the design supply air quantities for sizing the primary heating, and cooling system equipment. Diversity factors will be based on expected use factors and maximum building population.

System	Type	Diversity Factor
Terminal Systems	-	100%
Air Handling System	Occupant	85%
	Lighting	90%
	Equipment	85%
High Pressure Steam	-	85%
Low Pressure Steam		85%
Chilled Water		85%
Process Chilled Water		75%
Heating Hot Water		85%
Preheat Water		100%
Perimeter Heat Water		85%

Lab Equipment Exhaust

The exhaust air requirements for fume hoods will be based on maintaining a face velocity of 50 fpm through the open sash with the sash 100% open.

Acid, combustible, or flammable storage cabinets are not vented unless otherwise noted.

Hood Description/Exhaust Requirement:
6’-0” restricted sash (horizontal) bench hood: 615 cfm
4" point (snorkel) exhaust: 40 ~ 50 cfm

Executive Summary: Base Design Criteria

Steam and Condensate System

Distribution:

Steam will be generated by the boiler plant and distributed through campus system. Steam will be saturated. Steam and pumped condensate shall be extended from the existing distribution system in an adjacent steam tunnel and shall be routed to the new building. Steam distribution shall be provided to accommodate future services.

Refer to the Steam and Condensate Distribution Diagram. The preliminary calculated peak building steam load is estimated to be 27,100 PPH.

Steam pressure will be reduced by a pressure reducing station to service the project's low pressure steam (10 psig) requirements.

The steam will be used at the generated pressure and reduced appropriately as a source in the facility for the following applications:

- Steam to Hot Water Convertor
- Humidification
- Untreated Steam
- Domestic and Lab Hot Water Heaters

High pressure condensate will be flashed to low pressure condensate in flash tanks.

Steam condensate returned back to the boiler plant will be metered. Meter will be fitted with a pulse initiator and wiring connected to the Building Automation System (BAS).

System Warm-up Method

Supervised warm-up will be used instead of automatic warm-up. Steam main drip leg length and traps will be sized based on supervised warm-up method.

In addition to the pressure reducing valves, a manual bypass valve will be provided for redundancy.

Equipment and Components

Steam safety valve will be sized based on the capacity of the largest valve of the PRVs, not the total capacity of all PRVs. Safety valve vent pipes will be piped up through the roof to a minimum of 8 ft above roof.

Pressure reducing valves will be self-contained, pilot-operated type. Two pressure reducing valves per PRV station will be utilized and valves will be sized at 1/3 and 2/3 of the design load.

Chilled Water System

Distribution:

Chilled water will be generated by the existing chilled water plant and distributed from the existing secondary pumps in the Central Utility Plant (CUP). New chilled water shall be extended from the existing distribution system to new service.

Refer to the Chilled Water Distribution Concept Diagram. The preliminary calculated peak chilled water load is estimated to be 1,725 tons.

Chilled water is provided by CUP with the following conditions:

Supply temperature: 45°F

Building:

An automatic by-pass valve will be provided to by-pass the tertiary building pumps whenever there is sufficient pressure from the secondary pumps to serve the building.

Chilled water system will be variable volume system utilizing a modulating 2-way control valve at cooling coils of each cooling coil. Each secondary pump will be provided with variable frequency drive (VFD).

A differential pressure transmitter between the chilled water supply and return mains will be utilized to vary the speed of the pumps, via VFDs, to maintain a constant differential pressure between the piping mains.

Chilled water usage will be metered via automated BTU meter with flow rate, supply temperature and return temperature input. Data will be input to Building Automation System (BAS).

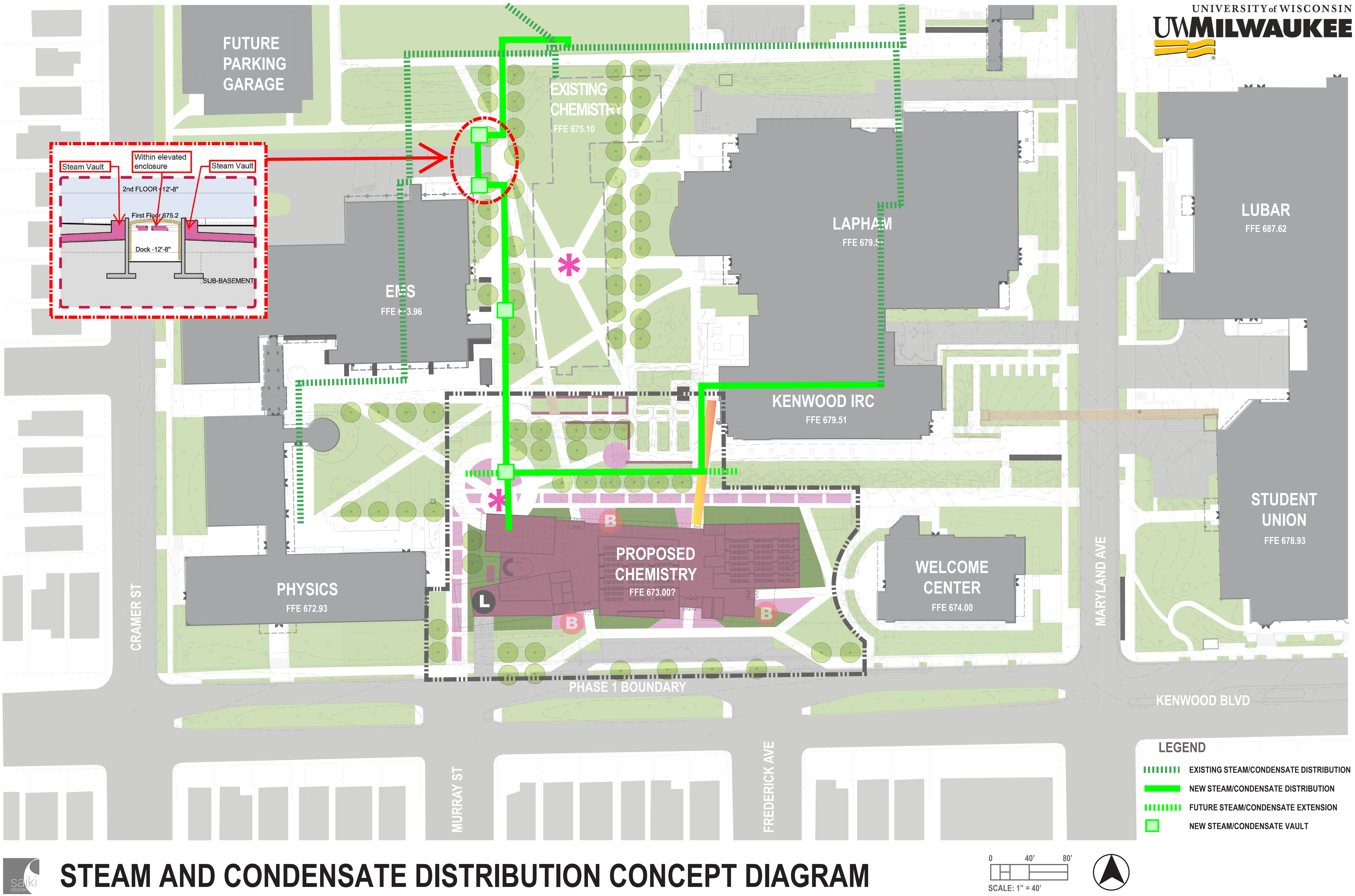
Equipment and Components

Chilled water secondary pumps will be double suction horizontal split case centrifugal type with a variable frequency drive.

The chilled water system will also include the following components:

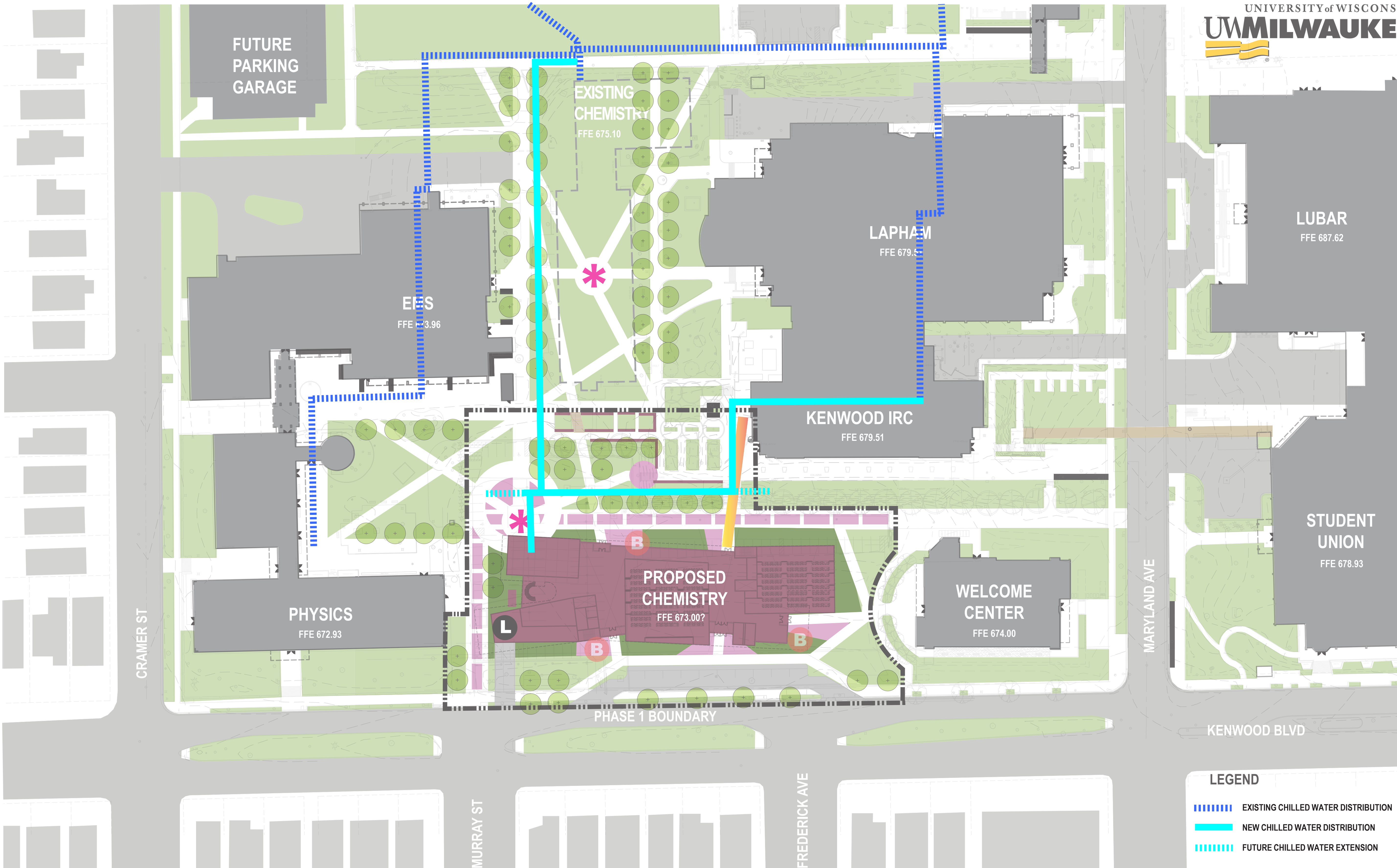
- Chemical pot feeder
- Air separator
- Bladder type expansion tank
- Make-up water assembly
- Cooling coils
- Appropriate valving and piping specialties

Subcircuits will be selected for linear control characteristics of the terminal device and control valve combination.



STEAM AND CONDENSATE DISTRIBUTION CONCEPT DIAGRAM

STEAM AND CONDENSATE DISTRIBUTION CONCEPT DIAGRAM



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CHILLED WATER DISTRIBUTION CONCEPT DIAGRAM

CHILLED WATER DISTRIBUTION CONCEPT DIAGRAM

Process Cooling System

System Description

Process cooling will be piped to various process equipment in the facility including cold rooms and laboratory equipment.

Process cooling water will be generated by utilizing chilled water supplied from the Central Utility Plant (CUP) through water-to-water heat exchangers. Associated drycooler and pumps shall be provided to provided process cooling water during periods when chillers are not operating at the plant.

Equipment and Components

Distribution pumps will be end suction type.

Heat exchangers will be plate and frame type.

The system will also include the following components:

- Chemical pot feeder
- Air separator
- Bladder type expansion tank
- Make-up water assembly
- Bag type water filter 10% side stream
- Drycoolers
- Drycooler pumps
- Appropriate valving and piping specialties

Process cooling water system will be variable volume system utilizing modulating 2-way control valves at a majority of the equipment served. Three way control valves will be provided at the most remote equipment served on each floor to maintain minimum flow in the process cooling water system. Each distribution pump will each be provided with a VFD.

Differential pressure transmitters between the process cooling water supply and return mains will be utilized to vary the speed of the secondary pumps, via the VFD's, to maintain a constant pressure differential between the piping mains.

Heating Hot Water System

System Description

Heating hot water system will serve AHU heating coils and terminal heating devices such as reheat coils, unit heaters, radiant panels, and cabinet unit heaters.

Heating hot water system will be variable volume system utilizing a modulating 2-way control valve at each terminal heating device. Distribution pumps will each be provided with VFD.

A differential pressure transmitter between the supply and return mains will be utilized to vary the speed of the pumps, via variable frequency drives, to maintain a constant pressure differential between the piping mains.

Each preheat coil will be served by a coil pump circuit which will maintain constant flow through the preheat coil. A modulating 2-way control valve will be provided at each preheat coil pump circuit to maintain the required water temperature in the pumped coil circuit

Equipment and Components

Distribution pumps will be base mounted end suction centrifugal type with VFDs. Boiler pumps will be in-line type.

The heating and reheat water system will also include the following components:

- Chemical pot feeder
- Air separator
- Bladder type expansion tank
- Make-up water assembly
- Reheat coils
- Unit heaters
- Cabinet unit heaters
- Appropriate valving and piping specialties

Piping Distribution Criteria			
System	Material	Size Criteria	Pipe and Fitting Insulation
High Pressure Steam (120), high pressure condensate (120), and pumped condensate in Existing Tunnels and Steam Pits/Vaults, and enclosed soffit areas	Carbon steel piping shall be provided with socket welded fittings for pipes 2" and smaller and welded fittings for pipes 2-1/2" and larger. High pressure steam piping shall be Standard Weight (STD) High pressure condensate and pumped condensate shall be extra strong (XS)	High pressure steam main distribution shall be 12" Pumped condensate main distribution shall be 4" High pressure condensate from drip traps shall be sized based on load and velocity. Building branch service to be sized per building sizing requirements.	high pressure steam main distribution or high pressure condensate shall be minimum 2.8" thick Aerogel or 5" mineral Wool with aluminum jacket. Pumped condensate main distribution shall be minimum 1.2" thick Aerogel or 2" thick mineral wool with aluminum jacket.
Steam Direct Buried Piping Distribution System	Steam shall be distributed through direct buried piping system consisting of a carrier pipe, insulation, air space, coated conduit, conduit polyurethane insulation and HDPE or FRP jacket. Carbon steel piping shall be provided with socket welded fittings for pipes 2" and smaller and welded fittings for pipes 2-1/2" and larger. Steam carrier piping will be Standard Weight (ST) Conduit shall be minimum 10 GA or as required by the manufacturer.	Subgrade steam carrier piping shall be 12" Building branch service to be sized per building sizing requirements.	Carrier piping insulation shall be minimum 2.8" thick Aerogel or 5" mineral Wool Conduit insulation shall be minimum 2" thick Polyeurethane

Piping Distribution Criteria			
System	Material	Size Criteria	Pipe and Fitting Insulation
Pumped Condensate Direct Buried Piping Distribution System	Pumped Condensate shall be distributed through direct buried piping system consisting of a carrier pipe, insulation, air space, coated conduit, conduit polyurethane insulation and HDPE or FRP jacket. Carbon steel piping shall be provided with socket welded fittings for pipes 2" and smaller and welded fittings for pipes 2-1/2" and larger. Pumped condensate carrier piping shall be extra strong (XS) Conduit shall be minimum 10 GA or as required by the manufacturer.	Subgrade pumped condensate carrier piping shall be 4" Building branch service to be sized per building sizing requirements.	Carrier piping insulation shall be minimum 1.2" thick Aerogel or 2" thick mineral wool. Conduit insulation shall be minimum 1" thick Polyeurethane.
Steam and Condensate System	Steam piping will be Standard Weight (ST) Condensate piping will be Extra Strong (XS). Plant steam and condensate will be distributed through carbon steel piping with threaded fittings for pipes 2" and smaller and welded fittings for pipes 2-1/2" and larger.	Steam piping for steam pressures equal to or less than 15 psig will be sized for a maximum pressure drop of 3/4 psi/100 ft of pipe and a maximum velocity of 6,000 fpm. Steam piping for steam pressures greater than 15 psig will be sized for a maximum pressure drop of 2 psi/100 ft of pipe and a maximum velocity of 8000 fpm. For gravity condensate return piping, sizing criteria on Table 21 of ASHRAE Handbook of Fundamentals – 2013 Chapter 22 will be used. The capacity of Table 21 which is based on ST steel pipe will be adjusted to XS steel pipe.	Rigid glass fiber insulation with appropriate insulation jacket
Steam Condensate Pumped Discharge	Condensate piping will be Extra Strong (XS). Condensate will be returned through carbon steel piping with threaded fittings for pipes 2" and smaller and welded fittings for pipes 2-1/2" and larger.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 1" and larger. 2 fps minimum velocity to 8 fps maximum velocity.	Rigid glass fiber insulation with appropriate insulation jacket

Piping Distribution Criteria			
System	Material	Size Criteria	Pipe and Fitting Insulation
Humidification	Piping will be carbon steel with threaded fittings for piping 2" and smaller and with welded fittings for piping 2-1/2" and larger.	For steam pressure equal to or less than 15 psig will be sized for a maximum pressure drop of 3/4 psi/100 feet of pipe and a maximum velocity of 6000 fpm.	Rigid glass fiber insulation with appropriate insulation jacket
Chilled Water	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger. Unions will not be provided at terminal heating devices in copper piping.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Polyicocyanurate type insulation with appropriate insulation jacket.
Chilled Water (Main distribution Below Ground direct buried)	PE4710 IPS or DIPS DR-11 HDPE piping.	30" outside diameter supply and return piping for main distribution. Building branch supply sized per building requirements.	none
Chilled Water (Main distribution above grade within enclosures)	PE4710 IPS or DIPS DR-11 HDPE piping or STD weight carbon steel piping with welded fittings for pipes 2-1/2" and larger	30" outside diameter supply and return piping for HDPE. 24" carbon steel	2" Polyisocyanurate with saran vapor retarder and PVC jacket.
Heating Hot Water	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger. Unions will not be provided at terminal heating devices in copper piping.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Rigid glass fiber insulation with appropriate insulation jacket
Preheat Water	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Rigid glass fiber insulation with appropriate insulation jacket

Piping Distribution Criteria			
System	Material	Size Criteria	Pipe and Fitting Insulation
Glycol Water Heat Recovery	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Rigid glass fiber insulation with appropriate insulation jacket
Process Cooling	Type L copper piping with soldered fittings for pipes 2" and smaller and ST carbon steel piping with welded fittings for pipes 2-1/2" and larger. Unions will not be provided at terminal heating devices in copper piping.	Maximum pressure drop of 4 ft of water/100 ft of pipe for piping 6" or smaller. 10 fps maximum velocity for piping 8" and larger.	Rigid glass fiber insulation with appropriate insulation jacket

Glycol Water Heat Recovery System

System Description

Glycol water heat recovery system pumps will circulate glycol water to heat recovery coils located in laboratory air handling units and to heat recovery coils located in exhaust systems to recover waste heat. Glycol heat recovery system will utilize a 45% ethylene glycol/water solution.

Equipment and Components

Distribution pumps will be end suction centrifugal type.

The system will consist of the following additional components:

- Bladder type expansion tank
- Air separator
- Glycol water make-up system
- Appropriate valving and piping specialties

HVAC Air Systems Descriptions

This section includes general descriptions for HVAC air systems. Refer to Duct Distribution Criteria and Equipment and Reliability Matrix for more detail.

Air Handling Systems

System Description

General / Lecture

Factory fabricated custom air handling unit serves the lecture and general office areas,

System will be a single duct variable air volume reheat system, providing heating, cooling, and humidification control to the spaces.

Air will be supplied to all appropriate spaces and a portion of this air will be returned to the air handling unit or relieved to outside via in-line return fan.
The remaining portion of air not returned to the air handling unit will be utilized as make-up air for the exhaust systems and building pressurization.

Ducted return air system will be used instead of return air ceiling plenum to return air from the spaces back to the AHU.

Air handling system will operate 10 hours per day, 5 days per week. Air handling system will operate with occupied, unoccupied and morning warm-up control cycles.

Laboratory Air Handling Systems

Factory fabricated custom air handling units will be manifolded to serve the laboratory and laboratory support spaces.

System will be single duct, variable air volume, reheat system, providing heating, cooling and humidification control to the spaces.

Heat recovery coils will be provided to recover heat from combined fume exhaust system

Air supplied to all spaces will be exhausted to outdoors. No air from the laboratory or support spaces will be returned to the air handling unit.

Air handling unit will operate 24 hours per day, 365 days per year.

Mechanical Room Air Handling Systems

Individual air handling units will provide ventilation for the penthouse mechanical room, electrical room and emergency generator room. Systems will be single duct, variable air volume with return air.

System will consist of one packaged air handling unit.

Air handling unit will operate as required.

Equipment and Components

Chilled water secondary pumps will be double suction horizontal split case centrifugal type with a variable frequency drive.

The chilled water system will also include the following components:

- Chemical pot feeder
- Air separator
- Bladder type expansion tank
- Make-up water assembly
- Cooling coils
- Appropriate valving and piping specialties

Subcircuits will be selected for linear control characteristics of the terminal device and control valve combination.

Equipment and Components

Components	AHU Systems		
	General / Lecture	Laboratory	Mechanical
Supply Air Module			
Outside Air Intake Damper	X	X	X
Air Mixing Device	X		
Run-around heat recovery coils		X	
Total Energy Recovery Wheel	X		
Return Air Mixing Chamber	X		X
Glycol Run-Around Coil		X	
Hot Water Preheating Coil	X	X	
Steam Humidifier	X	X	
Chilled Water Cooling Coils	X	X	
Supply Fan Arrangement	Multi-fan array(2)	Multi-fan array(2)	DWDI
Supply Fan to VFD ratio	2:1	2:1	1:1
Sound Attenuator	Duct mounted supply air	Duct mounted supply air	
MERV 8 2" Prefilters	X	X	X
MERV 14 Bag Final Filters	X	X	
Isolation/Smoke Dampers	X	X	

Components	AHU Systems		
	General / Lecture	Laboratory	Mechanical
Electronic Airflow Measuring Stations	X	X	
Return Air Module			
Return Fan Arrangement	Mixed Flow		
Isolation/Smoke Dampers	X		
Return Air Damper	X		X
Relief Air Damper	X		
Fan Inlet Side Sound Attenuator	X		
Electronic Airflow Measuring Stations	X		

(1) Components are not listed in airflow tunnel order.

(2) Quantity of fans dependent on size of unit. Utilize economies of scale to select the appropriate number of fans for each individual unit.

Supply fans will be plenum or double width double inlet centrifugal type with airfoil blades. Fan speed and air volume will be modulated through variable frequency drives (VFDs) controlled by supply duct static pressure controller.

Return fans will be mixed flow type with air foil blades. Fan speed and air volume will be modulated through VFDs controlled by return fan discharge static pressure controller.

Design Criteria

Air Handling Unit Maximum allowable nominal face velocities at Maximum airflow	
Air Intake Louvers	400 fpm through free area of louver
Hot Water Heating Coils	500 fpm
Energy Recovery Coil	500 fpm
Chilled Water Cooling Coils	350 fpm
Pre-filters	350 fpm
Final-filters	350 fpm
Sound Attenuating Devices	Located in ductwork: Maximum 1,200 fpm or maximum 0.25" w.g.

Laboratory Exhaust Systems

System Description

Combined Laboratory Exhaust System

Building will be served by a central exhaust air system. The system will combine laboratory fume hood, snorkel, and canopy hoods with general exhaust.

System will consist of exhaust fans connected to a common exhaust fan inlet plenum and will be located on the roof. The fans are intended to operate in parallel and will each be sized for a fraction of the design load.

Cold rooms that are work-in will be exhausted via a small constant volume exhaust terminal unit. Make up air is from the adjacent laboratory spaces.

Combined laboratory exhaust system will be variable air volume. The speed of the exhaust fans will modulate to provide the required system exhaust rate while also maintaining the minimum exhaust stack discharge velocity. The exhaust fans will operate in parallel, with the outside air bypass damper closed, to maintain the static pressure set point, as measured by static pressure sensors located within the ductwork. When the exhaust airflow requirement for the system drops, the exhaust fan speed would be reduced accordingly, until the fan speed reaches the minimum set point, as defined in the control system to maintain the minimum required exhaust discharge stack velocity (as defined by wind tunnel consultant). The exhaust fans will continue to operate at this minimum speed and the outside air bypass damper at the heat recovery plenum will be modulated to maintain the minimum static pressure set point as measured by the static pressure sensor in the exhaust fan inlet plenum. If the exhaust requirements for the system become greater, the opposite sequence will occur.

System will operate 24 hours per day, 365 days per year.

Exhaust fans will be of AMCA Class "C" spark-proof construction with bearings and motors out of the air stream. Motors will have electric brakes to prevent counter rotation during start up.

Fans and heat recovery coils will have baked heresite chemical resistant coating on surfaces in contact with air stream.

Fans will have packless type sound attenuating devices on the exhaust main, and the outside air by-pass duct.

Heat recovery coil will be provided at the inlet of the fan. 30% pleated filters will be provided at the inlet of coil with face damper and by-pass damper/duct around filter and coil to allow serving of filter and coils while the exhaust fans are operating. Heat recovery coils and filters will be located in penthouse. The heat recovery pumps will be variable volume and will be stopped when heat recovery is not effective to reduce system energy consumption.

Equipment and Components

Components	Combined Laboratory Exhaust
Common exhaust fan intake plenum	X
Sound attenuating device.	X
Isolation damper at each fan inlet.	X
Exhaust fans	SWDI Centrifugal fan
Exhaust stack for each fan discharge.	X
Outside air bypass ductwork with sound attenuating device, control damper, and appropriate balancing devices.	X
MERV 8 Filters	X
Heat recovery coils with coil with by-pass duct and dampers	X

Design Criteria

Exhaust System Unit Maximum allowable nominal face velocities or pressure drop	
Heat Recovery Coils	500 fpm
MERV 8 Filters	500 fpm

Air Terminal Devices

Individual spaces up to three spaces having a common exterior exposure or a common interior space, and common occupancy, will be served by one supply air terminal (AT) device.

One air terminal device will be provided where individual space temperature control is required.

Return air terminal devices will be provided for rooms requiring pressure control.

Air terminal devices will be utilized for fume hoods, biosafety cabinets, snorkel exhausts, and general exhaust.

Air Terminal Devices			
Spaces and System	Service	Type	Sound Attenuation
General / Lecture	Supply	Galvanized steel single blade damper ATs will have internal liner with airflow measuring ring. [1]	(2)
	Return/Exhaust	Galvanized Steel single blade damper ATs will have internal liner with airflow measuring ring. [1]	(2)
Laboratory	Supply	Supply Galvanized steel single blade damper ATs will have internal liner with airflow measuring ring. (1)	(2)
Combined Laboratory	General Room Exhaust	Galvanized steel single blade damper ATs will have internal liner with airflow measuring ring. (1)	(3)
	Fume Hood, Snorkel and Canopy Hood	Heresite coated aluminum, two position, pressure independent Venturi type ATs will have characterized plunger and fast acting 24V actuator.	

(1) ATs will be provided with system pressure independent DDC controllers with 24 V electric actuators.

(2) Ductwork will be lined for 5 ft downstream of air terminal devices. Sound attenuating flexible duct up to 6 ft in total length, will be provided at the diffusers and grilles to control noise. Sound attenuators at the discharge of supply and inlet of exhaust/return air terminal devices will not be provided unless required to meet noise criteria.

Generator Exhaust System

System Description

System will consist of generator exhaust piping from the outlet of the generator engine exhaust muffler and extend above the roof.

Design Criteria

Exhaust system will be designed per manufacturer's recommendations or within maximum backpressure of 27" WG.

Generator Ventilation System

System Description

Emergency Generator ventilation system will provide air for engine makeup combustion and radiator cooling.

Equipment and Components

The ventilation system will consist of the following components:

- Outside air intake
- Outside air intake dampers
- Outside air sound attenuators
- Exhaust air acoustic louvers
- Return air damper
- Exhaust air dampers
- Discharge air sound attenuators
- Supply Fan

Ductwork Systems

Ductwork will be constructed in accordance with SMACNA Standards for appropriate pressure class. Ductwork will be sealed to meet SMACNA Seal Class A as a minimum and to limit ductwork leakage not exceeding 1% of the design flow rate for high pressure ductwork and 2% for low pressure ductwork. Duct System Distribution Criteria based on diversified CFM where applicable.

Generator Exhaust

Piping system will utilize welded carbon steel piping with stainless steel bellows type expansion joints.

Piping and muffler will be insulated with 4" hydrous calcium silicate and aluminum jacket.

Generator exhaust system will extend from the outlet of the generator engine exhaust muffler to a minimum of 8 feet above the roof .

Generator Ventilation

Duct sizing criteria of outside air ductwork, radiator exhaust air ductwork, outside air dampers, radiator exhaust air dampers, outside air SAD and radiator exhaust air SAD will be sized not to exceed 0.5" WG static pressure.

Miscellaneous Systems

Elevator Machine Rooms

Elevator machine rooms will be provided with single fan coil unit, return/relief fans for economization as required, associated control dampers and ductwork to maintain required space temperatures depending on the room size and HVAC load.

Fan coil unit to include supply fan driven by electronically commutated motor, filters, and chilled water cooling coil.

Technology Space Cooling

Intermediate Distribution Framework (IDF) Rooms that require cooling will be provided with self-contained fan-coil units to maintain required space temperature and humidity

Fan coil unit to include supply fan driven by electronically commutated motor, filters, and chilled water cooling coil.

Design Criteria

Air Handling Unit Maximum allowable nominal face velocities or pressure drop	
Air Intake Louvers	350 fpm through free area of louver
Exhaust Louvers	400 fpm through free area of louver
Outside air sound attenuating device (SAD)	400 fpm
Exhaust air sound attenuating device (SAD)	400 fpm

Supply and Return/Exhaust System with Air Terminals

Description	Construction	Design Criteria	Insulation
Shaft	Galvanized Steel	(1)	Fiberglass insulation
Air Handling Unit to Air terminal (AT) Device	Galvanized Steel	(1)	Fiberglass insulation
Air Terminal Device to Supply Diffuser	Galvanized Steel Ductwork will be lined for 5 ft downstream of air terminal devices	(2)	Fiberglass insulation
Return/Exhaust Ductwork Sizing	Galvanized Steel	(2)	None
Return/Exhaust Grille to AT	Galvanized Steel	(2)	None
Return/Exhaust Air Terminal (AT) Device to fan	Galvanized Steel	(1)	None

(1) Maximum pressure drop of 0.15"/100 ft when ≤ 10,000 cfm

Maximum velocity of 2,000 fpm when > 10,000 cfm

Maximum velocity of 2,500 fpm when > 10,000 cfm in mechanical room, risers in shafts, and where space constraints dictate quantity of fans dependent on size of unit. Utilize economies of scale to select the appropriate number of fans for each individual unit.

(2) Maximum pressure drop of 0.1"/100 ft when ≤ 8,000 cfm

Maximum velocity of 1,600 fpm when > 8,000 cfm

Combined Laboratory Exhaust

System	Construction	Design Criteria	Insulation
Exhaust Grille to Air Terminal Device	galvanized steel	(1)	None
Fume Hood, Snorkel, Canopy Hood, etc. to Air Terminal Device	PVC coated steel	(1)	None
Exhaust Grille Run-Outs - Air Terminal Device to Main	Galvanized steel	(2)	None
Fume Hood, Snorkel, Canopy Hood Run-Outs - Air Terminal Device to Main	PVC coated steel	(2)	None
Main to Heat Recovery Device	PVC coated steel	(2)	None
Heat Recovery Device to Fan Inlet	PVC coated steel	(2)	None
Exhaust Fan Stack Discharge Velocity	+10" Pressure class 316 stainless steel, all welded construction	(3)	None

(1) Maximum pressure drop of 0.1"/100 ft when ≤ 8,000 cfm

(2) Maximum pressure drop of 0.15"/100 ft when ≤ 10,000 cfm
Maximum velocity of 2,000 fpm when > 10,000 cfm

(3) Nozzle velocity 3000 – 3500 fpm

TECHNICAL NARRATIVE: CONTROLS

Table M29 – BAS Systems	
System	Description
Computer Room Air Conditioning Units (CRAC)	BAS will provide graphical interface including equipment flow diagram showing all sensing and control devices associated with the system and provide ability to monitor, schedule and override applicable controls.
Variable Frequency Drives	BAS will provide additional monitoring and remote notification for alarming.
Packaged HVAC equipment	Packaged equipment will include but not be limited to air handling units, fan coil units, cabinet unit heaters, fume hoods, and numerous other pieces of equipment.
Fume Hood and Laboratory Air Flow Control System	BAS will provide additional monitoring and remote notification for alarming.

Executive Summary

A complete, direct-digital control (DDC) based Building Automation System (BAS) will be installed to control all new mechanical systems throughout the facility. The control system will have the ability to integrate with the numerous systems for monitoring, data collection, and alarming purposes. The new DDC devices shall be viewable through the existing Webserver and Operator Workstations.

System Description

Primary mechanical systems will be controlled and monitored through a DDC based Building Automation System (BAS) with distributed processing at the local level. These DDC devices will be provided by Johnson Controls, Inc.

Individual laboratory spaces, with three or more fume hoods, shall have zone DDC provided by Phoenix Controls, Siemens – Landis Division, or TSI. These zone controls will provide full VAV control of fume hood face velocity and maintain laboratory pressurization control. These 'Fume Hood and Laboratory Airflow Control' devices shall be integrated into the existing Johnson Controls Webserver.

Low Voltage Electric actuation (24VAC) will be utilized for most control valves and dampers, as well as for terminal unit control. High Voltage Electric actuation (120VAC) will be utilized for all larger control valves and dampers when necessary, but will most likely not be needed.

The BAS will reside on the campus Enterprise network.

BAS will integrate with the following control systems/ equipment via communication based interface or dedicated contacts and will provide graphical user interfaces via BAS Web server as necessary.

Design Criteria

DDC controllers will utilize distributed architecture and will not rely on "front-end" or higher level controller to perform required control sequence.

Systems with redundant mechanical equipment will have redundant controls installed to prevent a single controller failure from causing a total system failure.

DDC controllers serving major equipment will have a minimum of 2 spare points of each type (DI, DO, AI and AO) at each panel. For universal points, the spares will be divided evenly between the analog and digital types of points.

Control panels and DDC controllers serving equipment fed by emergency/stand-by power shall also be served by emergency/standby power. All BAS and DDC system primary controllers, PC's and communications equipment that monitors life safety and critical points (fire alarm, elevator emergency, etc.) will be supported by emergency generators.

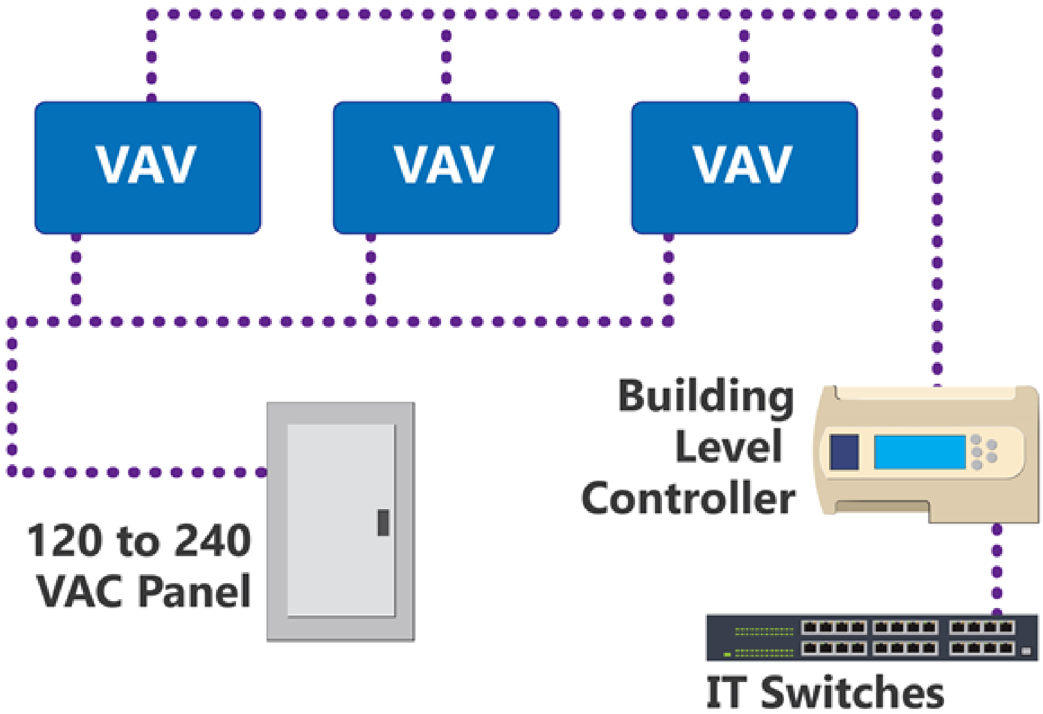
Airflow tracking control using DDC will be utilized instead of space pressure control, to maintain the space pressure (positive, neutral or negative) as required by the programming.

Equipment and Material

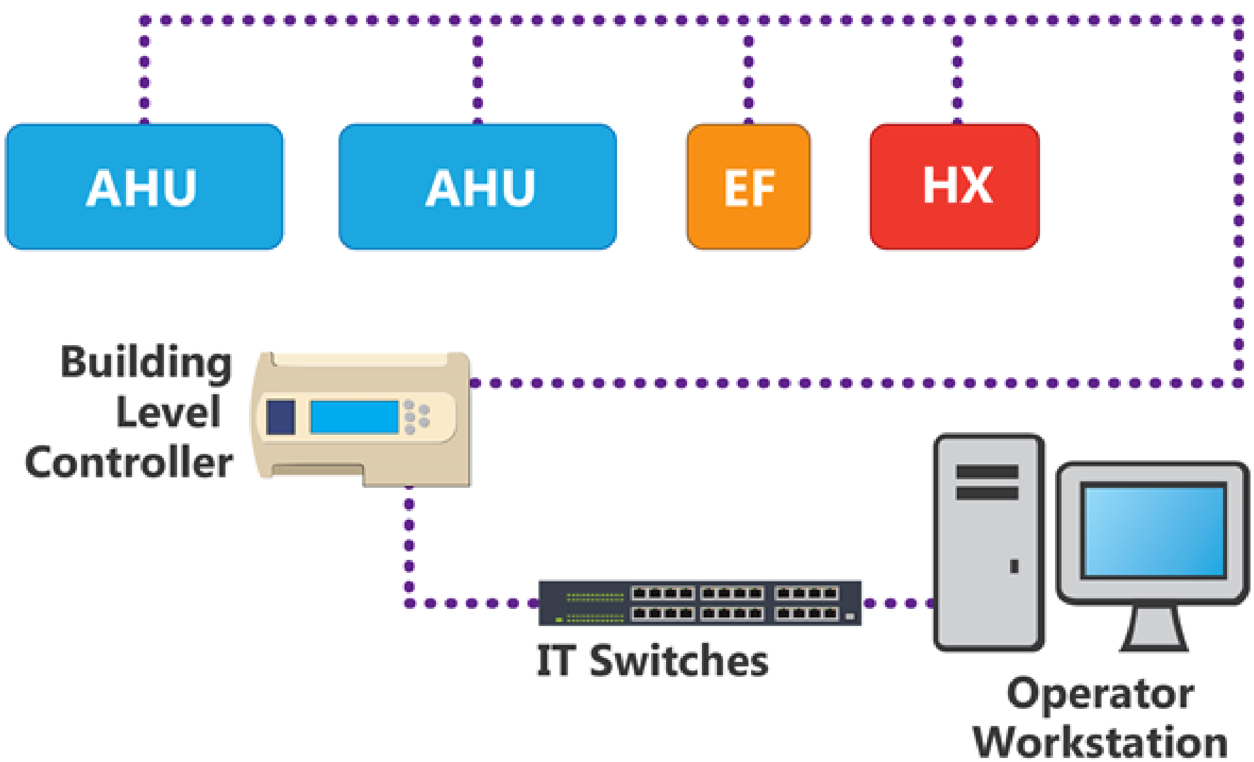
Concealed control wiring, installed above lay-in ceilings, may be installed on J-hooks. All other control wiring will be installed in dedicated metal conduit.

Existing graphic workstations will be updated with new systems. Graphics will be designed to match any existing graphic displays on the existing system when integrate with existing systems. Transition from existing graphics to new graphics shall be seamless transition for operator in look, functionality, and operation.

ROOM CONTROLS



SYSTEM CONTROLS



SITE AND BUILDING SYSTEMS DESCRIPTIONS: PLUMBING

Storm and Clearwater Waste Systems Materials		
System	**Below Ground**	**Above Ground**
Storm and Clearwater Waste and Vent	• Schedule 40 PVC with DWV pattern solvent cement socket fitting joints • Schedule 40 chlorinated polyvinyl chloride pipe (CPVC), ASTM D1784, with solvent cement joints	• Schedule 40 PVC with DWV pattern solvent cement socket fitting joints • Schedule 40 chlorinated polyvinyl chloride pipe (CPVC), ASTM D1784, with solvent cement joints
Pressurized Storm and Clearwater Waste and Vent	• Schedule 40 PVC with solvent cement socket fitting joints • Copper water tube, Type K, soldered joints and fittings	• Schedule 40 galvanized steel with threaded joints and fittings

Plumbing/piping systems for University of Wisconsin Milwaukee Chemistry Building will consist of storm and overflow drainage, subsoil drainage, laboratory (corrosion resistant) waste and vent, sanitary waste and vent, domestic cold water, domestic hot water, domestic hot water return, non-potable water, high purity water, specialty gas (type(s) to be determined) laboratory compressed air, laboratory vacuum and natural gas systems.

Base Design Criteria

Applicable Codes and Standards

Wisconsin Administrative Code including the following:

- SPS 382 – Design, Construction, Installation, Supervision, Maintenance and Inspection of Plumbing

Division of Facilities Development & Management Plumbing Guidelines and Peer Review

NFPA 54 - National Fuel Gas Code

ANSI Z358.1 Emergency Eyewash and Shower Equipment, 2009

American Society of Plumbing Engineers (ASPE) Engineering Design Handbooks

Storm and Clearwater Drainage

A storm drainage system will be provided to convey rainwater from flat roofs to site storm sewers.

Secondary roof drainage will be reviewed for incorporation into the project using parapet roof scuppers. Where scuppers are not feasible, secondary roof drainage will be accomplished by using a dedicated piped overflow drainage system separate from the primary storm drainage system which will discharge through the building wall onto grade.

Clearwater waste from air handling units, coolers, and other devices and equipment that discharge clearwater will be conveyed by gravity flow through a separate piping system and will connect to the building storm drain.

Design Criteria

The primary storm drainage system will be sized based on a maximum rainfall rate of 26 gpm per square foot of roof area. The secondary storm drainage system will be sized based on the same design criteria as the primary system.

The sizing for all clearwater discharge from equipment system will be based on the maximum flow rate of the equipment.

Equipment and Material

Storm and clearwater drainage systems which cannot discharge to the storm sewer by gravity flow will be drained by gravity to a sump with pump(s) and will be pumped into the building storm drainage system.

Sump pumps will be connected to the emergency (standby) power system to permit operation during a loss of normal power.

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for pump redundancy.

Distribution

Roof and overflow drain bodies and above ground storm, secondary roof drainage and clearwater waste piping will be insulated.

Sub-soil Drainage

System Description

If a sub-soil drainage system is required by the Geotechnical Report, it will convey groundwater from exterior footing, interior footing or underslab to a sump. The effluent will be pumped into the building storm drainage system.

Design Criteria

Design criteria for the subsoil drainage system will be defined by the Geotechnical Report.

Equipment and Material

Subsoil drainage systems which cannot discharge to the storm sewer by gravity flow will be drained by gravity to sump pump(s) and will be pumped into the building storm drainage system. Each sump pump will be sized for 100% of the estimated design flow.

Sump pumps will be connected to the emergency (standby) power system to permit operation during a loss of normal power.

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for pump redundancy.

Distribution

Subsoil drainage piping will be corrugated polyethylene perforated piping with mechanical couplings.

Piping will be sized in accordance with the Geotechnical Report recommendations and code requirements.

Waste and Vent Systems

System Description

A sanitary waste and vent system will be provided for all plumbing fixtures and other devices that produce sanitary waste. Plumbing fixtures will be drained by gravity through conventional soil, waste and vent stacks and building drains to the site sewer.

Plumbing fixtures in laboratories and laboratory support spaces will be provided with a drainage system separate from the sanitary drainage system. The laboratory waste system will drain by gravity flow to an exterior sampling manhole. The effluent from the sampling manhole will discharge into the site sanitary sewer.

All fixtures will have traps and will be vented through the roof. Vent terminals will be located away from air intakes, exhausts, doors, openable windows and parapet walls at distances required by the plumbing code.

Sanitary waste drainage systems which cannot discharge to the sanitary sewer by gravity flow will be drained by gravity to a sump with pump(s) and will be pumped into the building sanitary drainage system. Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for pump redundancy.

Design Criteria

The waste and vent piping will be sized in accordance with code requirements.

Equipment and Material

The laboratory waste discharge will have a pH monitor with alarm that will report locally and to building automation system prior to exiting building.

Floor drains, floor sinks and indirect waste receptors will be provided with trap seal inserts when subject to loss of their trap seals due to evaporation caused by infrequent use.

Sewage ejectors will be connected to the emergency (standby) power system to permit operation during a loss of normal power.

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for pump redundancy.

Distribution

Waste piping will be pitched according to code to maintain a minimum velocity of 2 fps when flowing half full.

Vents and the venting systems will be designed and installed so that the water seal of a trap will be subject to a maximum pneumatic pressure differential equal to 1" water column. This will be accomplished by sizing and locating the vents in accordance with the venting tables contained in the plumbing code.

Waste System Materials		
System	**Below Ground**	**Above Ground**
Gravity Sanitary Waste and Vent	• Schedule 40 PVC with DWV pattern solvent cement socket fitting joints • Schedule 40 chlorinated polyvinyl chloride pipe (CPVC), ASTM D1784, with solvent cement joints	• Schedule 40 PVC with DWV pattern solvent cement socket fitting joints • Schedule 40 chlorinated polyvinyl chloride pipe (CPVC), ASTM D1784, with solvent cement joints
Pressurized Sanitary Waste	• Schedule 40 PVC with solvent cement socket fitting joints • Copper water tube, Type K, soldered joints and fittings	• Schedule 40 galvanized steel with threaded joints and fittings
Laboratory Waste and Vent	• Schedule 40 chlorinated polyvinyl chloride pipe (CPVC), ASTM D1784, with solvent cement joints	• Schedule 40 chlorinated polyvinyl chloride pipe (CPVC), ASTM D1784, with solvent cement joints
Laboratory Waste – High Temperature	• 316L stainless steel pipe, ASTM A112.3.1, with hub and spigot joints	• 316L stainless steel pipe, ASTM A112.3.1, with hub and spigot joints

Elevator Sump Pumps

System Description

An elevator sump shall be required in the base of each elevator pit. Unless noted otherwise sump pit shall be formed into the elevator hoist-way base. Sump pump discharge will be with an air gap to a receptor and into the building sanitary drainage system. Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for pump redundancy.

Design Criteria

Sump pump will be sized in accordance with code requirements. Provide a pump sufficient to discharge 30 gpm per elevator hoist-way.

Equipment and Material

Sump pump shall be submersible type. Sump pumps will be connected to the emergency (standby) power system to permit operation during a loss of normal power.

Distribution

Piping shall be the same material and joint type as sanitary drainage system(s).

Domestic and Non-potable Water

System Description

Domestic water will be provided to all toilet room fixtures, electric water coolers/drinking fountains, sinks, emergency shower/eyewash units, and any other devices that require a domestic water supply. Laboratory fixtures will be provided with domestic water and will be provided with point-of-use backflow prevention.

Hot water at 120°F will be provided to all fixtures and devices that require hot water.

Emergency showers and eyewashes will be supplied with tepid water per the ANSI Z358.1 definition of tepid water.

Non-potable water system will provide make-up water to irrigation, mechanical (HVAC) systems such as heating hot water, chilled water, and cooling towers. A reduced pressure backflow preventer will protect the domestic water supply.

Design Criteria

Each water heater will be sized for 66% of the design hot water load at an outlet temperature of 120°F.

Backflow preventers will be sized for 100% of the design flow.

Equipment and Material

A water meter will be provided on the building service entrance. The water meter will be sized for the building's maximum design flow rate.

A water pressure booster pump system will be provided. The booster pump system will be configured such the system is capable of 100% of the total design flow with the loss of the largest pump.

Domestic hot water will be produced by duplex steam-fired, semi-instantaneous water heaters. Tube bundles in water heaters will be double walled.

Remote fixtures will be provided with hot water by electric instantaneous water heaters.

Booster water heaters will be provided as part of equipment, dishwashers, laundries, etc., which have water temperature requirements above the normal distribution temperature stated above.

The hot water system temperature will be maintained by recirculating the hot water through a continuous loop with an in-line circulating pump.

Water hammer arrestors will be provided at all quick closing solenoid valves and at other potential water hammer sources.

Tepid water to emergency fixtures will be provided by a point of use thermostatic mixing valve with cold water bypass device at each fixture.

Refer to Section 11.3 -System Equipment Reliability, Generator Power, and Capacity Matrix for water heater and pump redundancy.

Distribution

The hot water system will be insulated in accordance with Code. The cold water system will be insulated to prevent condensation from forming. Isolation valves will be provided at all riser connections, branch piping run-outs to fixture groups, and at devices requiring maintenance.

The piping will be sized to limit the velocity in any section of the system to a maximum of 8 fps for cold water system and 4 fps for hot water and hot water circulating systems.

The hot water system will be insulated in accordance with Code. The cold water system will be insulated to prevent condensation from forming. Isolation valves will be provided at all riser connections, branch piping run-outs to fixture groups, and at devices requiring maintenance.

The piping will be sized to limit the velocity in any section of the system to a maximum of 8 fps for cold water system and 4 fps for hot water and hot water circulating systems.

Water System Materials		
Size	**Below Ground**	**Above Ground**
2-1/2" and Smaller	Copper water tube, Type K, soldered joints and wrought copper fittings	• Type L copper tube with soldered joints and wrought copper fittings • Cross-linked polyethylene (PEX-a) pipe and fittings
Underground (3" and larger): Ductile Iron	• Ductile iron, Class 52, AWWA C151, cement mortar lined with restrained mechanical joints and ductile iron fittings	• Not applicable
Copper (3" and larger)	• Not applicable	• Type L copper tube with brazed joints and wrought copper fittings with rolled groove couplings
Stainless Steel (3" and larger)	• Not applicable	• 304L, schedule 10, stainless steel with welded or roll grooved joints and welded or grooved fittings with grooved couplings

Plumbing Fixtures			
Fixture	**Type**	**Operation**	**Flow Rate**
Water Closets	Wall hung, vitreous china, with elongated bowls, high efficiency.	Flush valves will be diaphragm type, manual	1.28 gallon flush
Urinals	Wall hung, vitreous china, high efficiency	Flush valves will be diaphragm type, sensor operated, hard wired or battery operated	0.125 gallon flush
Lavatories	Wall hung or self-rimming, vitreous china. Refer to architectural floor plans for areas with wall hung units and counter mounted units.	Faucets will be hot and cold mixing type, wrist blades handles, and ceramic disc cartridges	0.5 gpm flow control
Sinks	Countertop mounted stainless steel	Faucets will be hot and cold mixing type. Sinks in break rooms will be fitted with garbage disposals.	1.5 gpm flow control

Plumbing Fixtures			
Fixture	**Type**	**Operation**	**Flow Rate**
Laboratory Sinks, Cup Sinks	Integral with casework. Faucets will be furnished with the casework and installed by the Division 22 contractor		
Showers	Built-up ceramic tile walls and floors with floors drains	Pressure balanced shower valves. Barrier-free showers will also have with hand spray with hose and adjustable wall bar	1.5 gpm flow control
Electric Water Coolers	Wall mounted, recessed self-contained, dual level with bottle filler	Manual push button operated, with stainless steel cabinets and disposable activated carbon water filters	
Janitor Sinks	Floor mounted, precast terrazzo, with stainless steel splash wall panels	Faucets will be hot and cold mixing type with hose connections and [elevated][integral spout]vacuum breaker	
Exterior Hose Bibbs	Recessed mounted freeze resistant with vacuum breaker and loose key operator	Manual	-
Mechanical Room Hose Bibbs	Surface mounted with in-line vacuum breakers	Manual	-
Emergency Eyewashes	Counter mounted, fixtures will comply with ANSI Z358.1.	Manual, Stay open valve.	
Emergency Showers and eyewashes	Fixtures in laboratory areas will be furnished by the casework contractor and installed by the Division 22 contractor.	Manual, Stay open valve.	-

Design Standard	Resistivity	Silica	Sodium	pH	Chlorides	TOC
ASTM Type III	≥4 MΩ-cm @25°C	≤500µg/L	≤10µg/L	No Limit	≤10µg/L	≤200µg/L

High Purity Water

System Description

A system will be provided to produce and distribute water meeting the quality requirements of ASTM Type III from the facilities potable water system.

This system will not be validated.

Pure water will be continuously circulated in closed loops to users throughout the building.

Point of use polishing units will be provided for use points that require a higher level of quality water.

The system will be automatically monitored and controlled by a dedicated PLC based control system that will send a discrete alarm signal to the Building Automation System in the event of deviations.

Design Criteria

The system design will be based on performing sanitation using peracetic acid solution.

The capacity of the production equipment and the storage tank will be based on the programmed use points.

The production equipment shall be sized to produce the total estimated consumption in 16 hours of operation.

The storage tank will be sized to provide storage for 24 hours of estimated usage.

The distribution system will be designed to maintain the temperature of the water under 80°F.

The distribution system will be designed to continuously circulate water at a minimum velocity corresponding to a Reynolds number of 20,000.

Equipment and Material

The production equipment is anticipated to consist of a prefilter, multimedia filter, carbon filter, water softener, RO unit, two-bed deionization exchange cylinders, mixed bed deionization exchange cylinders, a one micron post filter, a 185 nm ultraviolet light, and a 0.2 micron final filter.

The distribution system equipment will include centrifugal pump(s) to provide circulation and 254 nm UV lights followed by 0.2 micron filters to control bacterial growth.

Materials in contact with pure water will be:

- Equipment: 316L stainless steel polished to 25 Ra
- Storage tank: vinyl ester, steam-cured fiberglass
- Piping: high purity Polypropylene
- Elastomers: EPDM

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for production and distribution equipment redundancies

Distribution

The distribution system will be comprised of loops through which water will be continuously circulated. Each distribution loop will employ a series loop layout. Branch take-offs from main to use point will be dead leg.

High purity water system distribution system shall be:

- LXT PVC piping will be used for the distribution system. Joints will be made by solvent cement. Piping will be continuously supported.

All tee connections shall be installed to minimize the dead leg.

Piping will be installed so that it is completely free draining.

Sink use points shall be a non-recirculating faucet.

The quality of the water in the distribution system will be monitored by the PLC that will send a discrete alarm signal to the Building Management System in the event of deviations.

Table 2 Special Gases System Diversity Factors			
Number of Outlets	Diversity Factor	Minimum Flow (scfm)	Empirical Formula for Flowrate (scfm)
1-5	1.00	0	No. of Outlets*1
6-12	0.80	5	5+(No. of Outlets-5)*5/7
13-33	0.60	10	10+(No. of Outlets-12)*10/21
34-80	0.50	20	20+(No. of Outlets-33)*20/47
81-150	0.40	40	40+(No. of Outlets-80)*20/70
151-315	0.35	60	60+(No. of Outlets-150)*50/165
566 and up	0.25	170	170+(No. of Outlets-565)*80/435

Special Gases-Laboratory System

System Description

Special gases will be provided to all points of use as required by the Owner. Specialty gas types to be determined. Cylinders may be user provided and placed adjacent to equipment or points of uses.

Design Criteria

The special gas system will be designed to provide 50 psig gas at the most remote lab outlet. The system will be sized based upon a load of 1 scfm per outlet and the total number of connected outlets connected to the system. Any point loads for specific equipment will be added to the outlet load after any diversity factors are applied. The diversity factors indicated below will be used for determining the load for outlets:

The special gases piping will be sized to limit the pressure drop across the system to 5 psi.

Equipment and Material

Special gases service will be supplied by manifold systems consisting of primary and reserve cylinders. The number of cylinders on each system will be based upon building use criteria, but will not be less than two cylinders per bank. The manifold system will be an automatic switchover type set to distribute special gases at 55 psig.

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for special gas equipment redundancy.

Distribution

Special gases piping will be:

- ASTM B-280 Type L, oxygen cleaned, tube with brazed joints. Laboratory outlets will be quarter-turn type outlets as provided by lab programming.

Table 2			
Compressed Air System Diversity Factors			
Number of Outlets	Diversity Factor	Minimum Flow (scfm)	Empirical Formula for Flowrate (scfm)
1-5	1.00	0	No. of Outlets*1
6-12	0.80	5	5+(No. of Outlets-5)*5/7
13-33	0.60	10	10+(No. of Outlets-12)*10/21
34-80	0.50	20	20+(No. of Outlets-33)*20/47
81-150	0.40	40	40+(No. of Outlets-80)*20/70
151-315	0.35	60	60+(No. of Outlets-150)*50/165
316-565	0.30	110	110+(No. of Outlets-315)*60/250
566 and up	0.25	170	170+(No. of Outlets-565)*80/435

Laboratory Compressed Air

System Description

Laboratory grade compressed air will be provided to all laboratory areas at a pressure of 100 psig and a dewpoint of -40°F. Compressed air will be provided as required by the Owner.

Design Criteria

Compressed air piping system will be sized based on 1 scfm per outlet plus any flow required for individual pieces of equipment. Diversity factors will be applied to laboratory outlets as indicated in the chart.

The compressors will be controlled by pressure switches in receiver set to operate between 100 and 115 psig. Each compressor will be sized for 66% of the maximum total demand. The compressors will be controlled on lead/lag/alternate basis.

Equipment and Material

Laboratory grade compressed air will be produced by duplex oil-free rotary screw air compressors. Compressors will be base mounted. Air will be treated with coalescing filters and particulate filters and dried with duplex heatless desiccant air dryers. Compressed air will be stored in an ASME rated vertical receiver with outlet pressure regulator.

Pressure regulating valves will be provided at laboratory supply pipes to allow pressure reduction down to 55 psi.

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for equipment redundancy.

Distribution

Compressed air piping system will be ASTM B-280 Type L, oxygen cleaned copper piping with brazed joints.

Table 2 Laboratory Vacuum System Diversity Factors			
Number of Inlets	Diversity Factor	Minimum Flow (scfm)	Empirical Formula for Flowrate (scfm)
1-5	1.00	0	No. of Inlets*0.5
6-12	0.80	2.5	(5+(No. of Inlets-5)*5/7)*0.5
13-33	0.60	5	(10+(No. of Inlets-12)*10/21)*0.5
34-80	0.50	10	(20+(No. of Inlets-33)*20/47)*0.5
81-150	0.40	20	(40+(No. of Inlets-80)*20/70)*0.5
151-315	0.35	30	(60+(No. of Inlets-150)*50/165)*0.5
316-565	0.30	55	(110+(No. of Inlets-315)*60/250)*0.5
566 and up	0.25	85	(170+(No. of Inlets-565)*80/435)*0.5

Laboratory Vacuum

System Description

Laboratory vacuum air will be provided to all laboratory areas as programmed. Vacuum will terminate at laboratory outlets or equipment connections as required. Basis of design is for a centralized system with an option to provide regional vacuum systems in lieu of a centralized system.

Design Criteria

Laboratory vacuum piping system will be sized based on 0.5 scfm per outlet plus any flow required for individual pieces of equipment. Diversity factors will be applied to laboratory outlets as indicated in the chart.

The piping system will be sized to limit pressure drop across the system to maximum of 3" of mercury vacuum.

The pumps will be controlled by pressure switched in receiver set to operate between 23" and 27" of mercury vacuum. Each pump will be sized for 66% of the maximum total demand. The pumps will be controlled on lead/lag/alternate basis.

Equipment and Material

Laboratory vacuum will be produced by rotary vane vacuum pumps. Pumps will be base mounted. Vacuum will pass through a liquid separator and an ASME rated vertical receiver prior to passing through the pumps.

Regional system option: Laboratory vacuum will be produced by regional oil-free diaphragm vacuum pumps and a modular vacuum network. Pumps will be base mounted. Vacuum will pass through a liquid separator prior to passing through the pumps.

Refer to Section 11.3-System Equipment Reliability, Generator Power, and Capacity Matrix for laboratory vacuum equipment redundancy.

Distribution

Laboratory vacuum piping will be:

- Type L copper, ASTM B88 with soldered joints
- Regional system option: VacuuBrand VacuuLAN PTFE tubing with PVDF compression fittings and joints. Vacuum turrets will be VacuuBrand fixtures.

Table 2 Natural Gas System Diversity Factors			
Number of Inlets	Diversity Factor	Minimum Flow (cfh)	Empirical Formula for Flowrate (cfh)
1-5	1.00	0	No. of Inlets*5
6-12	0.80	5	(5+(No. of Inlets-5)*5/7)*5
13-33	0.60	50	(10+(No. of Inlets-12)*10/21)*5
34-80	0.50	100	(20+(No. of Inlets-33)*20/47)*5
81-150	0.40	200	(40+(No. of Inlets-80)*20/70)*5
151-315	0.35	300	(60+(No. of Inlets-150)*50/165)*5

Natural Gas

System Description

Natural gas is anticipated to be a centrally piped and distributed system to serve lab outlets. Natural gas will be extended to the building from the gas company's natural gas main in the street. It is anticipated that the gas meter(s) will be located at grade at the service entrance to the building.

Design Criteria

All design and installation will be in accordance with the applicable codes.

Natural gas will be supplied at a pressure of 7" water column. The piping will be sized to limit the pressure drop across the system to 0.5" water column.

Natural gas shutoff valves within the laboratory areas, where required, will be located in a recessed wall valve box at 4'-6" above finished floor or by solenoid valve with emergency shut-off control panel.

Natural gas piping system will be sized based on 5 cfh per outlet plus any flow required for individual pieces of equipment. Diversity factors will be applied to laboratory outlets as indicated in the chart.

Equipment and Material

Natural gas meter and building pressure regulating valves will be provided by and in accordance with gas utility company requirements.

Where shutoff valves are installed in valve boxes, the valve boxes will be steel frames with steel doors, piano hinges and level latches. All pipe penetrations through the box walls will be sealed.

Point of use pressure regulators will be self-operated spring-loaded constant pressure valves with internal relief capability.

Distribution

Natural gas piping 2-1/2" and smaller will be Schedule 40 black steel pipe with malleable iron threaded fittings. Natural gas piping 3" and larger will be Schedule 40 black steel pipe with welded fittings.

Natural gas valves 2-1/2" and smaller will be two-piece ball valves with bronze bodies and stainless steel balls. Valves 3" and larger will be plug valves with cast iron bodies.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: FIRE PROTECTION

Executive Summary

The fire protection systems for the University of Wisconsin Milwaukee Chemistry Building will consist of a new fire pump supplying a standpipe system in each stairwell and sprinkler systems at every floor level.

Fire Service

System Description

An underground fire line will supply the sprinkler systems in the new Chemistry Building.

Design Criteria

The design of the underground fire lines shall comply with NFPA 24.

Current water supply flow test data will be obtained from the City Water Department in order to determine the capacity of the water mains.

Equipment and Material

Piping for all underground lines will be cement lined ductile iron or, where approved by the Owner and local Authority Having Jurisdiction, Polyvinyl Chloride (PVC).

Fire Pump

System Description

The building standpipe and sprinkler system will be served by a UL Listed centrifugal fire pump when water supply pressures are not adequate to meet minimum fire protection demands. When required by the local Authority Having Jurisdiction (AHJ), or recommended by the Owner or Owner's insurance carrier, the fire pump will be installed in a dedicated fire pump room with direct exterior access.

Design Criteria

The fire pump will be sized in accordance with NFPA 13, NFPA 14, and NFPA 20. Current water supply flow test data will be obtained from the City Water Department in order to determine the required pressure rating of the fire pump.

Equipment and Material

The fire pump will be a horizontal split case centrifugal fire pump. The jockey pump will be a centrifugal type pump and is intended to be utilized for pressure maintenance in the fire protection piping system.

The fire pump controller will include all features required in NFPA 20 with a soft type starter.

Distribution

The fire pump installation will include a fire pump test header, fire department connection, and fire pump bypass line. Piping and valves will be configured in accordance with NFPA 20.

Fire Pump Test Header (FPTH) – A fire pump test header will be provided for the fire pump. The test header will consist of 2-1/2" outlets with caps and chains.

- An automatic ball drip valve will be installed between the control valve for the test header and the header itself to allow any water to drain out of the piping.
- The FPTH location will be coordinated with the local Fire Department, Project Architect, and Civil Engineer to ensure that adequate drainage is provided in the area to prevent any water damage from occurring.
- The test header will be installed on the exterior wall of the building.

- Fire Department Connection (FDC) - The fire department connection will consist of 2-1/2" inlets with drop clappers, snoots, caps and chains.

- A check valve will prevent flow from the fire protection system to the FDC.

- An automatic ball drip valve will be installed between the check valve and the FDC to allow any minor leakage past the check valve to drain out of the system.

- The FDC location will be coordinated with the local Fire Department and Project Architect.

- Typically, the design will require a fire hydrant within 100 feet of the FDC.

- The FDC will be installed on the exterior wall of the building.

Standpipe System

System Description

When required, the building will be protected by a hydraulically designed, Class I Standpipe System without hoses or hose cabinets.

Design Criteria

The design of the standpipe system will comply with NFPA 14.

For automatic standpipe systems in a fully sprinklered building, the standpipe system will be designed and hydraulically calculated to provide a flow of 250 gpm at 100 psig residual pressure at the highest fire department valve located on the most remote standpipe. An additional flow of 250 gpm will be added at the next highest valve on that standpipe. Finally, 250 gpm flows will be added at the two next remote standpipes, bringing the total to 1,000 gpm.

Equipment and Material

The standpipe system piping will be black steel. Piping will either be Schedule 10 with welded fittings or roll groove couplings or Schedule 40 with welded fittings or roll groove couplings.

Distribution

Standpipe risers within a standpipe system shall be interconnected.

A 2-1/2" fire department valve will be provided on the stair's intermediate landing between each floor level.

Additional fire department valves will be provided on the roof and at other locations as required by Code or the local authority.

All roof exterior fire department valves will be protected from freezing with shutoff valves located inside the thermal envelope of the building.

Wet Pipe Sprinkler System

System Description

The building will be protected throughout with hydraulically calculated sprinkler systems, which except for special protection needs, will be wet pipe systems. All areas of the building will be protected per NFPA 13, including electrical rooms (i.e. switchgear rooms, transformer rooms, generator rooms, electrical closets, and similar rooms), loading docks, stair towers, exterior canopies, and mechanical rooms.

Design Criteria

The sprinkler system for the building will be designed and installed in accordance with NFPA 13.

All systems will be hydraulically calculated with a computer calculation program using the Hazen-Williams method.

Sprinkler Design Densities			
Hazard-Areas Designated as	Density-Minimum Sprinkler Flow	Remote Area	Hose Stream Allowance
Light Hazard	0.10 gpm per sq ft	1500 sq ft	100 gpm
Ordinary Hazard Group 1	0.15 gpm per sq ft	1500 sq ft	250 gpm
Ordinary Hazard Group 2, where stockpiles of combustibles do not exceed 12 ft.	0.20 gpm per sq ft	1500 sq ft	250 gpm
Extra Hazard Group 1, where the quantity and combustibility of contents is very high and the probability of rapidly developing fires with high rates of heat release are expected	0.30 gpm per sq ft	2500 sq ft	500 gpm
Extra Hazard Group 2, with moderate to substantial amounts of flammable or combustible liquids or where shielding of combustibles is extensive	0.40 gpm per sq ft	2500 sq ft	500 gpm

If there are no special Client standards or Client insurance carrier recommendations, the sprinkler design densities noted in the chart shall apply.

The pipe sizing for the systems will be as required to satisfy the hydraulic demand.

Equipment and Material

Piping 2" and smaller in size will be Schedule 40 black steel with threaded joints.

Piping larger than 2" will be Schedule 10 black steel with welded fittings or roll groove couplings or Schedule 40 black steel with welded fittings, threaded joints, or roll groove couplings.

All sprinklers in Light Hazard areas will be quick-response type.

The type of sprinkler installed in a particular area will be selected by the Engineer and the Project Architect. Generally, concealed sprinklers will be installed in areas of high visibility and quality of finishes. Recessed sprinklers will be installed in other areas having suspended ceilings. Pendent or upright sprinklers will be installed in areas without ceilings. Sidewall sprinklers will be provided only when other types cannot be utilized.

Areas subject to temperatures below 40°F will be protected by dry sprinklers when possible. If dry sprinklers cannot be provided, then a dry pipe sprinkler system will be installed. Glycol antifreeze system will not be an option to dry sprinklers or dry pipe system.

Distribution

The sprinkler system will be provided throughout the building in accordance with NFPA 13 and, when required by the Owner, with insurance carrier recommendations.

Sprinkler Design Densities			
Hazard-Areas Designated as	Density-Minimum Sprinkler Flow	Remote Area	Hose Stream Allowance
Light Hazard	0.10 gpm per sq ft	1950 sq ft	100 gpm
Ordinary Hazard Group 1	0.15 gpm per sq ft	1950 sq ft	250 gpm
Ordinary Hazard Group 2, where stockpiles of combustibles do not exceed 12 ft.	0.20 gpm per sq ft	1950 sq ft	250 gpm

Dry Pipe Sprinkler System

System Description

Areas of the building subject to temperatures below 40°F will be protected by a dry pipe sprinkler system.

Design Criteria

The dry pipe sprinkler system will be designed and installed in accordance with NFPA 13.

All systems will be hydraulically calculated with a computer calculation program using the Hazen-Williams method.

If there are no special client standards or client insurance carrier recommendations, the sprinkler design densities noted in the chart shall apply.

- The system demand will be based upon the most remote 1950 sq ft for ceilings that are pitched less than or equal to a 2 in 12 slope. Ceilings exceeding this pitch will require that the 1950 sq ft remote area size is increased by 30%.

The pipe sizing for the systems will be as required to satisfy the hydraulic demand.

Equipment and Material

Piping 2" and smaller will be Schedule 40 black steel with threaded joints.

Piping larger than 2" will be Schedule 10 black steel with welded fittings or roll groove couplings or Schedule 40 black steel with welded fittings, threaded joints, or roll groove couplings.

All sprinklers in Light Hazard areas will be quick-response type.

Depending upon the actual installation method, sprinklers on dry pipe systems will be either: upright type; dry pendent type; or pendent and sidewall type sprinklers installed on return bends, where the sprinklers, return bend, and branch line piping are in an area maintained at or above 40°F.

A UL Listed dry pipe valve with trim will be provided.

Distribution

The sprinkler system will be provided throughout the building in accordance with NFPA 13 and, when required by the Owner, with insurance carrier recommendations.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: ELECTRICAL

Executive Summary

Electrical systems for the new University of Wisconsin Milwaukee Chemistry Building will include normal, emergency and standby power, building lighting, lightning protection and fire alarm. A centralized UPS system is not currently planned for this facility. Telecommunication, building automation, security, fire alarm and detection systems and selected laboratory equipment will be provided with their own dedicated UPS system if required.

System descriptions below will describe in greater detail the specifics of each system.

Base Design Criteria

Applicable Codes and Standards

Wisconsin Administrative Code, including SPS 316

Division of Facilities Design (DFD) Electrical Systems Standards and Design Guidelines

Division of Facilities Development and Management Policy and Procedure Manual for Architects/Engineers and Consultants

Division of Facilities Development Daylighting Standards for State Facilities

IEEE – Institute of Electrical and Electronics Engineers

IESNA – Illuminating Engineering Society of North America

NEC – (2017) National Electrical Code

NECA – National Electrical Contractors Association

NEMA – National Electrical Manufacturers Association

UL – Underwriters Laboratories

NFPA 72 – (2016) National Fire Alarm and Signaling Code

NFPA 101 – (2015) Life Safety Code

NFPA 110 – (2016) Standard for Emergency and Standby Power Systems

Design Voltages

Type	Voltage
Building Service	4160V, 3 phase, 3 wire + ground
Motors; 1/2 HP and larger	480V, 3 phase, 3 wire
Motors; less than 1/2 HP	120 or 208 Volts, 1 phase, 2 wire + ground
Lighting	277 Volts, 1 phase, 2 wire + ground
Specific Equipment	480 Volts, 3 phase, 3 wire + ground
Lab Support and Specialty Equipment	208Y/120V, 3 phase, 4 wire
Receptacles	120V, 1 phase, 2 wire + ground

Equipment Sizing Criteria

Branch Circuit Sizing Criteria

Type	Load
Lighting	Actual Installed VA
Receptacles	180 VA per outlet (duplex or single)
Multiple Outlet Assemblies	180 VA per 2'-0"
Special Outlets	Actual Installed VA of Equipment Served
Motors	125% of Motor VA
Special Equipment	Actual Installed VA

Diversity Factor

Diversity factors will be used, per the Wisconsin Administrative Code, in establishing power service, feeder and equipment capacities. The diversity factor represents the ratio of the sum of the individual non-coincident maximum demands of various subdivisions of the system to the maximum demand of the complete system and will be established using historical data from similar buildings in conjunction with industry standards.

Long Continuous Load/Demand Factors Criteria

Type	LCL Factor
Lighting (Continuous Loads)	125% of installed VA
General Receptacles	100% of first 10 kVA installed plus 50% of remainder
Motors	125% of VA of largest motor plus 100% of VA of all other motors
Fixed Equipment	100% of total installed VA

Load Calculation Criteria

Functional Area Load Density Criteria – Peak Connected

Functional Area	Service Load Density (VA/sq ft)	EM-SB Load Density (VA/sq ft)
Office Receptacle	4.0	0.0
Lighting	1.5	0.2
Teaching Lab	8.0	0.0
Teaching Lab Support	12.0	0.0
Lab	12.0	2.0
Lab Support	30.0	2.0
General Receptacle/Building Support	2.0	0.0
Classroom	4.0	0.0

Notes:
1. VA/sf values is based on historical data from projects with similar program elements.
2. EM-SB = Emergency -Standby

Mechanical Equipment Load Density Criteria - Peak Connected

Mechanical System	Service Load Density (VA/sq ft)	EM-SB Load Density (VA/sq ft)
Ventilation (V)	11.0	1.0
Refrigeration Systems (Process and Comfort) (R)	1.75	0.0
Heating Systems (H)	0.75	0.5
Piping Systems (P)	0.5	0.0
Miscellaneous Equipment (M)	1.0	0.0
Fire Protection Systems (FP)	0.75	0.75
Elevators (EL)	0.75	0.75

Notes:
1. VA/sf are values that will be calculated using the equipment data list established for use on this project. Until this data is available, the above values are assumptions developed using historical data from similar building types.
2. EM-SB = Emergency - Standby

Load Tables

System Capacity and Calculated Demand Load

Building Load Summary		
	Normal Power	Standby [Essential] Power
kVA	1,836	688
VA/SF	12.0	4.5

Building Load Summary		
	Normal Power	Standby [Essential] Power
W/SF	10.8	4.05

Notes:

1. Calculation assumes supporting approximately 153,000 GSF.
2. Includes 20% spare capacity.
3. Power factor is anticipated to be 90% and is derived from historical data on recent projects with similar program elements.

Systems Descriptions

Electrical Service

System Description

Primary electric service at 4.16kV voltage will be derived from the UW campus utility grid. Two new dedicated feeders will be extended to the facility, one from the campus West Substation and the other from the campus East Substation (refer to the Site Electrical Distribution Concept Diagram for anticipated routing). The feeders will be extended to the new facility via existing pathways and new ductbanks, one from manhole P-15 and the other from manhole P-42.

The West Substation has utility transformer capacity available, but does not currently have any spare breakers available for a new feeder to serve the new Chemistry Building (along with other future SW Quad loads). The substation room does have physical space for an additional lineup of medium voltage breakers for these future loads, and is therefore recommended to provide at least two additional breakers of this new lineup for this project. A load study should be performed to determine if enough capacity exists on existing feeders to tap those feeders for the new Chemistry Building instead of installing/utilizing new breakers and feeders.

Medium voltage pad mounted switchgear (S&C deadfront manually operated or equal) shall be provided at grade level on the exterior of the facility. The primary feeders from the campus utility grid shall be extended to the switchgear to provide redundant primary power to the facility similar to that used throughout the campus. The switchgear shall contain two main air interrupter switches. Feeder switches shall also be provided within the switchgear to power the facility electrical loads. Switching between main sources shall be performed manually (automatic operation shall not be provided).

A radial distribution system (without redundancy) shall be provided from the medium voltage switchgear to the low voltage power distribution system via two transformers. Two liquid-filled, pad mounted transformers shall be provided adjacent to the medium voltage switchgear. Each transformer shall serve a switchboard distribution section located in the main electrical room of the facility.

Design Criteria

The primary system capacity will be designed to serve the calculated connected load of the facility plus an additional 20% for anticipated future loads.

The design shall meet the requirements of the International Building Code, the Wisconsin Administrative Code (Comm. 16) and the National Electrical Code.

The primary feeders shall be sized to each support the full load of the facility so that the building can remain in operation should one source be taken out of service.

Should one of the primary feeders lose power as a result of an outage, the main shall be manually opened and the alternate main closed. Should routine maintenance require the shutdown of one of the feeders, the alternate main switch shall be closed prior to opening the main with no power interruption to the building.

New ductbank sections shall contain spare conduits.

Surge arrestors shall be provided on the primary side of each medium voltage switch.

Emergency/Standby Power System

System Description

Emergency power source for the facility will consist of an Emergency Power Supply (EPS) coupled to an emergency Power supply System (EPSS). The EPS will include a single diesel operated engine generator set. The emergency power system will be a Level 1 system per NFPA 110.

The emergency/standby power source will be derived from a single 800 KW/1000 KVA, 480Y/277V diesel-powered engine generator set located inside the facility in a dedicated EPS room. A sub-base fuel tank will have adequate capacity to operate the generator at full load for at least 8 hours, if fuel storage limitations allow it. The sub-base fuel tank installed in the generator room will not exceed 660 gallons (the maximum allowable per NFPA). The diesel engine exhaust will be piped to the roof or other appropriate area.

The emergency/standby power will be distributed to multiple automatic transfer switches segregated by system. Segregated systems are as described in the chart.

An emergency electrical room will contain emergency/standby switchboards and distribution panels that will be used to distribute emergency/standby power to the loads.

Metering will be provided to indicate various parameters including voltage, amperage, power factor, demand, and energy.

Emergency system power distribution transformers will be provided to transform voltage from 480V to 208Y/120V between the emergency system lighting panels and the emergency system branch circuit panelboards.

Standby power distribution transformers will be provided to transform voltage from 480V to 208Y/120V between the standby equipment panelboards and the standby branch circuit panelboards.

Standby MCCs will be provided as load dictates. Standby MCC's (if required) will be located near the loads they serve.

Standby branch circuit panelboards, emergency egress lighting panels, and emergency branch circuit panelboards will be located on each level as required.

As required by NEC, the feeders and branch circuit wiring to Emergency System loads will be in dedicated raceways.

Design Criteria

The capacity of the generator will be sufficient to serve the facility, with approximately 20% future capacity. The diesel engine cooling system will include a local radiator. Generator room will be 3-hour fire rated construction. The emergency/standby switchboard and automatic transfer switches will be in a dedicated emergency electrical room.

Electrical Distribution

System Description

Normal Power Distribution

The normal distribution system shall include all electrical distribution equipment from the serving utility service point to the branch distribution outlet device, not including those systems and devices as described in the following subsections.

Secondary electric service at 480Y/277 volts will be provided from a switchboard to distribution panelboards and mechanical equipment via motor control centers. 208Y/120 volts will be provided from a switchboard to distribution panelboards for building user loads. Conduit and wire shall be routed vertically through the building to distribute power to lighting and branch circuit loads at each floor. The use of busway for vertical distribution will also be explored to help provide flexibility for future user needs at the lab floors.

System	Associated Loads
Emergency Systems NEC Article 700	Egress Lighting
	Exit Signs
	Fire Alarm Detection and Annunciation Systems
	Elevator Cab Lighting
	Fire Pump / Jockey Pump
	Elevators for accessible means of egress (if required)
	Generator Set Accessories
Legally Required Standby Systems NEC Article 701	One Elevator per Elevator Bank (if required by code)
	Public Safety Communication System
	Ventilation systems where essential to maintain life, fire detection and alarm systems
	Mechanical smoke control equipment associated with the atrium exhaust and stair pressurization
	Building automation systems associated with control of required ventilation systems
	Sewage ejectors
	Sump pumps
Optional Standby Systems NEC Article 702	Access Control System
	Telecommunication System
	Building Automation System (BAS) and Accessories
	Select Mechanical Equipment
	Compressed air systems
	Select Chillers and Chilled Water Pumps
	Uninterruptable Power Systems
	Water Booster Pumps
	Fire Smoke Dampers
	Select research laboratory receptacles/equipment

Laboratories shall have an individual wall mounted circuit breaker panel located within or near the laboratory module. Panels shall be 100 amp minimum with three phases, four wire plus ground construction. It is anticipated that laboratory panels will typically be 225 amp rated with 150 amp main breakers unless the load dictates another size be utilized.

Normal power Motor Control Centers (MCC's) or distribution panels for VFD motors will be located in proximity to the equipment they serve.

A central, uninterruptible power supply (UPS) system to serve user loads will not be designed for installation under this project. The user of equipment that requires UPS power shall provide local UPS including imaging equipment. The installation of a UPS to serve the server room will be explored as the design progresses.

A central power conditioning system will not be designed for installation under this project.

Electrical metering shall be provided on all major loads in the building including substations, substation feeder breakers, switchboards, automatic transfer switches and the generator. Metering shall include voltage, amperage, power factor and demand values at a minimum.

The use of an electrical riser shaft will be explored for vertical distribution to the lab floors and penthouse though it is anticipated that stacked electrical rooms will be used to accommodate electrical distribution vertically up the building.

Emergency/Standby Power Distribution

As required by Code, the feeders and branch circuit wiring to emergency loads (lighting, fire alarm, telecommunications, etc.) will be in dedicated raceway. Individual feeders will originate at the emergency distribution panel and will rise through the building to serve the emergency lighting panels. The emergency branch circuit panelboards will be served from the emergency lighting panels via the distribution transformer.

Individual standby equipment feeders will originate at the standby equipment switchboard and will rise through the building to serve the standby equipment distribution transformers. The transformers will serve 208Y/120V distribution panels which will in turn serve the individual standby equipment branch circuit panelboards.

Individual standby motor feeders will originate at the standby motor switchboard and will rise through the building to serve standby MCC's located in the exhaust fan rooms. Feeders to standby MCC's in basement areas will be routed through the ceiling spaces of the respective levels.

Design Criteria

Building service and distribution equipment sizes will be based on estimated demand plus known or anticipated future loads.

Power distribution equipment will be sized to support spare capacity (amperes) in amounts to be determined during design phase to accommodate functional changes over the life of the building.

Power distribution equipment will be sized to include spare circuit breakers in amounts to be determined during design phase.

Power factor correction will be considered in the design of the power distribution system to bring the calculated power factor to 90% or better.

Equipment and Components

Equipment	Description of Components
Medium Voltage Fusible Interrupter Switchgear	Metal Enclosed Interrupter Switchgear – ANSI C37.20.3 Copper Bus NEMA 3R Enclosure Expulsion Type Fuses Fully shielded, dead front, metal-oxide, elbow type surge arrester
Switchboards	UL 891 construction Front access NEMA 1 enclosure Copper Bus Main Circuit Breaker Group mounted bolt-on feeder circuit breakers Electronic trip circuit breakers with field-adjustable and field-changeable trip units will be used for all circuit breakers 150 amps and greater and for smaller sizes if special circumstances exist. Circuit breakers 800 amps and greater will be UL listed for applications at 100% of their continuous ampere rating in their intended enclosure
Distribution Panelboards	UL 891 listed, front access NEMA 1 enclosure switchboards Copper Bus Main Circuit Breaker Electronic trip circuit breakers with field-adjustable and field-changeable trip units will be investigated for use as design progresses.
Branch Panelboards	UL 67 listed 42 Pole, NEMA 1 enclosure, recessed and/or surface mounted Copper Bus Main Circuit Breaker All circuit breakers will be bolt-on style Panelboard covers will be hinged trim
Pad Mounted Transformers	Liquid Filled, Less Flammable Insulation Copper Winding Medium voltage primary, 480/277V secondary, 55°C/65°C rise Dead front incoming medium voltage feeder connections Load break, gang operated, oil immersed switch with eye for hot stick operation.
Substation Transformers	Liquid Filled, Less Flammable Insulation Copper Winding Medium voltage primary, 480/277V secondary, 55°C/65°C rise

Equipment	Description of Components
Distribution Transformers	480 Delta to 208Y/120 VAC, Wye, three-phase, four-wire; 3-coil, 2-winding type; 150°C rise above 40°C ambient Copper or Aluminum Winding K rated as required Neutral conductors for K-4 and higher units to be increased in size from the transformer to the first distribution panel and will be able to support 200% of the normal phase current. Transformers will incorporate vibration isolation pads in their construction located between the core/coil assembly and the transformer case
Automatic Transfer Switches	Four-pole Copper Bus Open Transition Transfer Controls: Solid State microprocessor Isolation Bypass: Yes

Grounding System

System Description

A complete low-impedance grounding electrode system will be provided for this facility. The grounding electrode system will include the main water service line, structural steel, Ufer ground, and ground ring around the perimeter of the building. The equipment grounding system will extend from the building service entrance equipment to the branch circuit. All grounding system connections will be made using exothermic welds or irreversible compression connections.

Bonding jumpers will be provided as required across pipe connections to water meters, dielectric couplings in a metallic cold water system, and across expansion/deflection couplings in conduit and piping systems.

All feeders and branch circuits will be provided with an equipment ground conductor. Under no circumstances will the raceway system be used as an equipment grounding conductor.

Design Criteria

The grounding electrode system will be designed in accordance with NEC article 250.

System resistance to ground will be 5.0 ohms or less.

Equipment and Components

The reference ground for the equipment grounding system will be established from a structural ground grid as follows:

- A No. 4/0 AWG bare copper ground wire will be installed at 30" below grade around the entire perimeter of the building. 3/4” x 10 ft driven copper ground rods (test wells) will be installed and connected to this ground loop at not-greater-than 200’ intervals with a No. 4/0 AWG bare copper conductor. Steel columns in exterior walls will also be connected to this ground loop with 4/0 AWG bare copper at intervals not to exceed 60’. Interior steel columns will be connected to the exterior ground loop on each side of the building at intervals not to exceed 200’ with a No. 4/0 AWG bare copper conductor.

- A “Ufer” ground will be provided in the footing of the building consisting of 20’ of No. 4/0 AWG wire located 3” from the bottom of the footing.

Wall-mounted copper ground bus will be located in the main electrical room, floor electrical rooms, and voice/data rooms. The main electrical room ground bus will be connected to exterior ground loop and “Ufer” ground.

Distribution

A separate, insulated 4/0 AWG ground wire will be provided from the main electrical room ground bus to each floor's electrical room ground buses, underground incoming water service line ahead of meter, and underground gas line at the building entrance.

The main service entrance neutral will be bonded to the system ground bar within the switchboard by a removable bus bar link.

A code-sized, unbroken bond leader will be connecting the electrical room ground bar to the XO terminal of the local transformers.

A No. 4/0 AWG, bare copper, grounding electrode conductor will be extended to all voice/data rooms, so that those systems can be properly bonded.

A separate ground wire will be provided for all circuits.

Lightning Protection System

System Description

A lightning protection system will be provided to protect structure and associated appurtenances as recommended in the Lightning Risk Assessment which will consist of a system of conductance designed to safely divert the energy of a lightning strike to the earth while minimizing damage to the facility.

Design Criteria

System will comply with NFPA 780 - Standard for the Installation of Lightning Protection Systems. The installer will be certified with the Lightning Protection Institute and the installing Contractor will provide a UL Master Label for the completed system.

Equipment and Components

Materials will be rated Class I for structure heights of 75′ or less. Class II for structure heights above 75′.

Air terminals will be solid copper with a tapered point, 10″ minimum height, and have a mounting base suitable for the location.

Conductors will be bare-stranded copper, except aluminum will be used where installation is in contact with aluminum surfaces.

Ground rods will be copper-clad steel, 3/4″ diameter by 10′ long, with a bronze mechanical-type conductor clamp.

Distribution

The system layout and design will encompass all exterior surfaces of the facilities under a complete zone of protection as defined by NFPA 780. Air terminal spacing will not exceed 20 ft, except spacing up to 50′ is allowed for non-perimeter areas of flat roofs. Locations will comply with NFPA 780 and will generally follow the building roof ridges and/or perimeters.

One (1) down conductor will be provided for every 250 ft of building perimeter, with a minimum of two (2) conductors. Conductors will be configured to provide a two-way path to earth. Metal bodies will be bonded to the conductor system in accordance with NFPA 780.

A ground rod will be connected to each down conductor. The electric power service grounding system will be bonded to the Lightning Protection System.

Lighting Systems

System Description

A complete lighting system for all indoor and outdoor illumination will be provided. The lighting systems will consist primarily of energy-efficient LED lighting fixtures. Incandescent and fluorescent lighting will not be used.

In general, indoor lighting controls will consist of low-voltage switches controlled by low-voltage lighting control system for lecture halls, classrooms and public spaces, and room occupancy sensors for nearly all other spaces. Timer switches will be used in janitor’s closets and similar storage spaces. Mechanical and electrical rooms will include some lighting that is not automatically controlled for safety purposes. Outdoor lighting controls will utilize photocells and time switches with line voltage manual override switches.

Emergency/night lighting will be provided by a combination of unswitched and controlled branch circuits. These unswitched branch circuits will be fed from an emergency lighting panel. UL listed transfer devices to allow switching of emergency fixtures will be provided to save energy.

Exit signs and emergency egress lighting will be provided throughout the facility to illuminate egress corridors, stairwells, lobbies, etc. Exit and egress lighting circuits will originate from emergency system branch panels.

Illuminance Levels Design Criteria

Space	Average Maintained Footcandles
Office	30-50
Classroom	30-50
Lecture Hall	30-50
Laboratory, Support, Technical Area	50-60
Laboratory Bench and Table Top	50-60 (plus task lighting)
Conference	50-60
Corridor	15-20
Lobby	10-25
Toilets	5-20
Storage	10-30
Mechanical/Electrical	40
Open Parking	0.5
Covered Parking	1-2
Exterior Lighting	1-2

Equipment and Components

Space	Fixture Type
Laboratory and Laboratory Support	Direct/indirect LED fixtures.
Office	Recessed LED troffer or suspended indirect LED fixtures.
Common Area	Premium quality architectural fluorescent, LED or HID lighting
Circulation	1' x 4' LED troffer or wall-mounted LED sconces
Building Support	4' surface- or pendant-mounted industrial LED fixture
Open Parking	LED parking lot pole mounted fixture
Closed Parking	LED surface mounted fixture
Washrooms and Wet Areas	UL Listed for a wet location

EXIT signs will be State Fire Marshal approved LED type, located in all paths of egress.

Lamps and Ballasts

LED lamps to be LM-79 and LM-80 tested, have two step MacAdam ellipse tolerance, and have a minimum CRI of 80 to be supplied with applicable drivers or power supplies.

Lighting Control

Photocells and occupancy sensors will be utilized in select spaces to minimize energy consumption. Occupancy sensors will be passive infrared or a combination infrared/ultrasonic type.

Dimmers will be provided in conference rooms and lecture halls as required. All corridor lighting, except life-safety branch lighting, will be controlled by a time clock.

A programmable, low-voltage control system will be provided for lecture halls and lobby space. It will consist of low-voltage switching and relays and will control all lighting within these spaces. The system will be software based and will provide flexible control of automatic and manual on/off, recording, and reporting functions.

Lighting within 15'-0" of natural sight sources will be automatically controlled to reduce light fixture output to 50%.

Distribution

In general, lighting will be 277V.

All lighting circuit wiring will be in conduit and routed concealed within walls, partitions, or ceiling spaces. Surface-mounted conduit will be minimized and used only in non-finished spaces.

The ampacity of lighting circuits will be sized for 25% future growth plus 125% continuous loading factor per the National Electric Code.

Fire Alarm System

System Description

The fire alarm system will be a stand-alone, fully addressable system as manufactured by Notifier, Simplex, Pirotronics or approved substitution. The fire alarm system will be comprised of smoke detectors, heat detectors, duct detectors, manual pull stations, and audio/visual signaling devices.

Design Criteria

The fire alarm system will comply with requirements of NFPA 72 for a protected premises signaling system except as modified and supplemented by this document.

A main fire alarm control panel will be located in the fire command center near the main building entrance.

A fire alarm annunciator panel will be provided at the main building entrance if the fire command center is not directly adjacent to the main entrance.

Audio/visual devices will be installed in all areas of the building in accordance with the NFPA and the ADA Guidelines.

Smoke detectors shall be installed as required by the National Fire Protection Association, the International Building Code and the International Fire Code. Smoke detectors will be installed in, but not limited to, the following locations: air handling units, elevator lobbies, elevator control/machine rooms, and electrical equipment rooms. Smoke detectors will be located within 15' of all fire alarm control equipment panels.

Heat detectors will be installed in areas that are not feasible for smoke detectors, such as laboratories.

Manual Pull Stations will be installed adjacent to all exit doors and in each elevator lobby.

The fire alarm system will be linked with the campus central system via the Building Automation System to allow monitoring by the UW Milwaukee Police.

Visual and audible signals shall be on separate circuits.

Equipment and Material

The fire alarm system will be an electronically multiplexed voice communication system.

Remote transponder panels will be used to provide supervised amplifiers and signal circuits for audio/visual devices and magnetic door holders.

The system will utilize individual, addressable photoelectric smoke detectors; heat detectors; addressable manual pull stations; and addressable monitor and control modules. The system will monitor all sprinkler supervisory and water flow switches and will interface with elevators, HVAC smoke control, and smoke fire dampers.

Distribution

All initiating and signaling devices will operate at 24VDC and will be installed in accordance with manufacturer's specifications.

All wiring will be installed in conduit. Minimum conduit size will be 3/4”.

Area of Rescue Assistance System

System Description

The area of rescue assistance system shall be a stand-alone two-way communication system between individual call-in stations and the master control station.

Design Criteria

The master station shall be located adjacent to the fire alarm control panel in the Fire Command Center.

All call-in stations shall be located at each designated area of refuge as required by ADA and the International Building Code.

Equipment and Materials

The system shall be UL listed.

The system shall be capable of two-way communication with the UW Milwaukee Police to allow for 24-hour monitoring.

All wiring shall be supervised.

Once activated, the system shall allow hands free two-way communication.

Distribution

All wiring shall be installed in conduit. Minimum conduit size shall be 3/4".

All areas of refuge shall be designated by illuminated signage.

Clock System

System Description

A complete second impulse type digital clock system synchronized and traceable to NIST atomic clock in Fort Collins, Colorado. The system shall provide time correction signaling to all remote clocks via wireless communication.

Design Criteria

The clock system shall receive radio frequency or GPS impulses via a roof-mounted antenna for time corrections.

Master control clock shall store one to four independent program schedules.

Equipment and Materials

The manufacturer to be provided will be Simplex, Edwards or Franklin Time Systems.

All clocks shall be microprocessor based with high output, wide angle, 4-digit red LED display.

A master control panel shall be located at the main telecommunications equipment room or the building engineer’s office.

Clocks will be semi flush or surface, digital type.

Distribution

Clocks shall be located in corridors, lecture/auditorium/discussion/seminar spaces, teaching prep room, laboratories and all general public areas.

All clocks shall be supplied from 120V power supplies.

Clocks will receive wireless correction signals from master system.

Circuit Voltage Length	Wire Size
480Y/277 volt circuits over 150’ in length	Increase wire size one size for each 150’ of length
208Y/120 volt circuits over 60’ in length	Increase wire size one size for each 60’ of length

Electrical System Standards

Feeder and Branch Circuits

Secondary distribution and branch circuit system design will be based on a maximum of 5% voltage drop from the transformer to the utilization equipment

Neutral conductors derived from harmonic mitigating transformers will be capable of carrying 200% of normal phase current from transformer to first distribution panelboard. Neutral conductors from distribution panelboard to downstream panelboard or device will not be increased in size.

Feeder and branch circuit sizes will be based on the load supplied and adjusted for voltage drop.

Feeder and branch circuit ampacity will not be smaller than the upstream overcurrent device or downstream equipment bus.

Overcurrent Protective Device Coordination

Overcurrent protective devices supporting Emergency NEC Article 700 (typically exit and egress lighting), Legally Required NEC Article 701) and NEC Article 695 (fire pump) systems will be selectively coordinated from source of supply (normal and emergency) through final device. Selectivity will be through the entire instantaneous region including ground fault.

Overcurrent protective devices supporting normal power systems and NEC 702 systems will be selectively coordinated with supply side overcurrent protection to the greatest extent possible given the material capabilities of breaker types selected with the exception of the instantaneous region devices in keeping with industry practice.

Overcurrent protective device will be selectively coordinated with supply side overcurrent protective devices as shown in the chart.

Arc Flash

The electrical distribution system will be configured to allow equipment to be worked on energized using reasonable PPE (category 3 or less). Arc flash calculations for Arc Flash Incident Energy (AFIE) levels and flash protection boundary distances will be by the contractor based on the actual equipment supplied using an independent Registered Profession Engineer in the State of Wisconsin using SKM System Analysis tools.

Fault Current Ratings

Short circuit withstand and interrupting ratings will be provided for electrical distribution equipment, feeder conductors, etc. based upon the actual available fault current and system motor contribution.

The preliminary available fault current will be determined design of the project and will be verified by 3rd party calculations provided in contractor submittals.

Equipment will have ratings not less than the calculated symmetrical short circuit value at each point in the distribution system.

Equipment will be fully rated for the calculated available short circuit. Series ratings will not be allowed.

System	Seconds
Emergency System (NEC 700)	0.01
Legally Required System (NEC 701)	0.01
Optional Standby System (NEC 702)	0.10
Fire Pump	0.01
Elevators	0.01
Normal Power System	0.10

Conduit will be run concealed, unless installed in mechanical, electrical, telecom, interstitial areas and other similar unfinished spaces.

Minimum conduit size for power circuits will be 3/4".

Conduits will be independently supported.

All conduit stub-ups from below floor or in floor (where specifically allowed) will be galvanized rigid steel.

Surface mounted conduits below 6'-6" will be rigid galvanized steel with threaded fittings and boxes will be cast steel.

EMT fittings will be all steel set screw type.

Conduits may be installed below floor slabs on grade.

Conduits and boxes will be installed a minimum of 1' and a maximum of 3' above ceilings. Installation outside of this zone will not be allowed. Special permission may be obtained to run ceiling conduits outside of this zone providing that pull and junction boxes are unobstructed and accessible from floor using a standard 8 foot ladder. Also, light fixtures, smoke detectors, junction and pull boxes and other equipment that is installed on or directly above the ceiling will be serviced and maintained without damage to ceiling tiles and other building elements.

Raceways for 2-hour rated systems shall be installed in either: UL listed assemblies for 2 hour fire rated applications or in 2-hour rated enclosures.

For lighting conduit homeruns, a j-box will be located above light fixture in an accessible location to allow for future expansion.

No home run will terminate in a wall mounted device box. A separate J-box will be provided above device box above ceiling in an accessible location.

Short Circuit Ratings	
208Y/120V	**480Y/277V**
10 kAIC where fed via 75kVA and smaller transformers	14 kAIC where fed via 300 kVA and smaller transformers
22 KAIC where fed via 112.5 kVA transformer	30 kAIC where fed via 500 kVA transformer
22 KAIC where fed via 150 kVA transformer	35 kAIC where fed via 750 kVA transformer
42 KAIC where fed via 225 kVA transformer	42 kAIC where fed via 1000 kVA transformer
42 KAIC where fed via 300 kVA transformer	65 kAIC where fed via 1500 kVA transformer
65 KAIC where fed via 500 kVA transformer	100 kAIC where fed via 2000 kVA transformer
-	100 kAIC where fed via 2500 kVA transformer

Conduit and Raceway

Conduit Types and Application	
Conduit Type	**Application**
Electrical Metallic Tubing (EMT)	Low voltage feeders and branch circuit wiring where installed above 6’-6” AFF, when exposed in unfinished spaces.
Galvanized Rigid Steel (GRS)	Low voltage feeders and branch circuit wiring where exposed below 6’-6” AFF. Exterior locations, Under slab, Areas subject to physical abuse
Intermediate Metal Conduit (IMC)	Low voltage feeders and branch circuit wiring where exposed below 6’-6” AFF.
Schedule 40 PVC	Concrete encased ductbanks and direct buried under slab

Wire and Cable

Cable Types		
Voltage Class	**Insulation**	**Notes**
15 kV	EPR, 105 C	133% rated, extruded semiconductor layer with copper tape shield
600 V	THHN/THWN-2 or XHHW-2	All conductors will be stranded copper

Minimum wire size #12 AWG, for all areas.

Multi-wire branch circuits will be provided with dedicated neutral conductors for each phase, common neutral circuits will not be permitted.

Feeder conductors will be terminated using compression lugs. Mechanical lugs will not be used for feeders. Branch circuit conductors will typically be terminated using mechanical lugs.

Conductor insulation color code will be as follows:

Conductor Color Code	
208Y/120V	**480Y/277V**
Phase A – Black	Phase A – Brown
Phase B – Red	Phase B – Orange
Phase C – Blue	Phase C – Yellow
Neutral – White	Neutral – Gray
Ground – Green	Ground – Green

Wiring Devices

Wiring devices will be specification grade, complete with all accessories.

Isolated ground receptacles will be used only when necessary. If used, isolated grounds will be in addition to equipment ground. Panelboard will have an isolated ground bus that will be connected back to applicable derived system or service.

Motors and Motor Control

Stand-alone motor disconnects (separate from starter) shall be fused and shall be installed at each motor that is not in sight of its source.

Motors smaller than 50 HP that are not provided with a variable frequency drive (VFD) will be provided with an across the line combination magnetic motor starter. Motors 50 HP and larger that are not provided with a variable frequency drive (VFD) will be provided with reduced voltage motor starter. Refer to other sections of the narrative for VFD requirements.

Combination motor starters will use circuit breakers or motor circuit protectors in lieu of fuses to reduce the possibility of single phasing. For mechanical and HVAC equipment that are not provided with a VFD, individual combination motor starters will be located within sight of the motor.

VFD drive specifications will require that the VFDs for the project be provided such that the Special Category harmonic limits recommended in IEEE 519-2014 be maintained. The supplier of the drive will be required to perform harmonic analysis as defined in IEEE 519-2014 to confirm VFD package complies with the limits set forward for the facility.

Equipment that is provided with more than one motor such as duplex or triplex sump pumps, air compressors, vacuum pumps, etc. will be connected to redundant power supplies and controls such that one motor and associated power source can be taken out of service for maintenance without disabling the complete system.

Grounding and Bonding

A separate, insulated equipment grounding conductor, sized per the National Electrical Code, will be provided within each raceway and cable tray, with each end terminated on a suitable lug, bus, enclosure, or bushing.

A grounding riser with ground bar will be located in each electrical closet.

Surge Protection

Surge Protective Devices (SPD) will be used as design dictates. A single SPD device will be installed on the load side of each main service disconnects, the generator switchboard, all Article 700 panelboards and at the first distribution panel on the load side to each automatic transfer switch. Second-tier SPD devices at branch panelboards and other locations will be incorporated as required but is not anticipated at this time.

EMF and Harmonics

Electrical vaults and major electrical equipment rooms containing transformers larger than 300 kVA to not be located adjacent to occupied workstations or lab/lab support spaces with sensitive equipment, unless EMF shielding or metal conduit is provided.

The power service will be required to meet the requirements IEEE Standard 519 to insure proper service. Harmonic distortion will be limited to 5% maximum at the point of common coupling. The point of common coupling is being defined as the primary side of upstream utility transformer.

Electrical Rooms

Electrical equipment rooms will be positioned to facilitate unobstructed initial installation of large equipment, and unobstructed removal and replacement of defective equipment.

Adequate space will be provided for maintenance of electrical equipment and equipment removal.

Power Distribution Acceptance Testing

Items to be tested and inspected are as follows:

Acceptance Tests	
600V Conductors and Cables	Medium Voltage Surge Arresters
Medium Voltage Conductors and Cables	Automatic Transfer Switches
Electrical Metering	Motor Control and Motor Control Centers
Engine Generators	Metal Enclosed Busway
Dry Type Transformers (Small)	Ground Fault Protection Systems
Dry Type Transformers (Large)	Grounding Systems
Low-Voltage Switchgear	Protective Relays
Switchboards	Instrument Transformers
Medium Voltage Metal Enclosed Air Switches	Thermographic Survey
Medium-Voltage Vacuum Circuit Breakers	Power Distribution Units
Low-Voltage Power Circuit Breakers	Lighting and Appliance Panelboards
Low-Voltage Insulated-Case/Molded-Case Circuit Breakers	Static and Flywheel Uninterruptable Power Supply Systems
Low-Voltage Disconnect Switches	Distribution Panelboards
Enclosed Circuit Breakers	Surge Protective Devices
Lightning Protection System	

Pipes and other equipment foreign to the electrical equipment will not be located in, enter, or pass through such spaces or rooms.

Panelboards will be grouped, surface-mounted, in dedicated ventilated rooms. Electrical rooms will be stacked vertical whenever practicable.

Penthouses and mechanical rooms will be utilized for electrical equipment and panelboard placement where applicable for optimization of space.

Panelboards serving lighting and appliance circuits will be located on the same level as the circuits they serve and will be served from source of supply with a dedicated feeder.

Feed through, subfed and double section panelboards will not be used unless required to comply with selective coordination requirements.

Prohibited Materials and Construction Practices

The entire Emergency/Standby power distribution system will consist of conduit and wire. Busway will not be used in any portion of this system.

Use of wood strips and wood screws to support lighting fixtures.

Extra-flexible non-labeled conduit.

Conduit installation in concrete slabs.

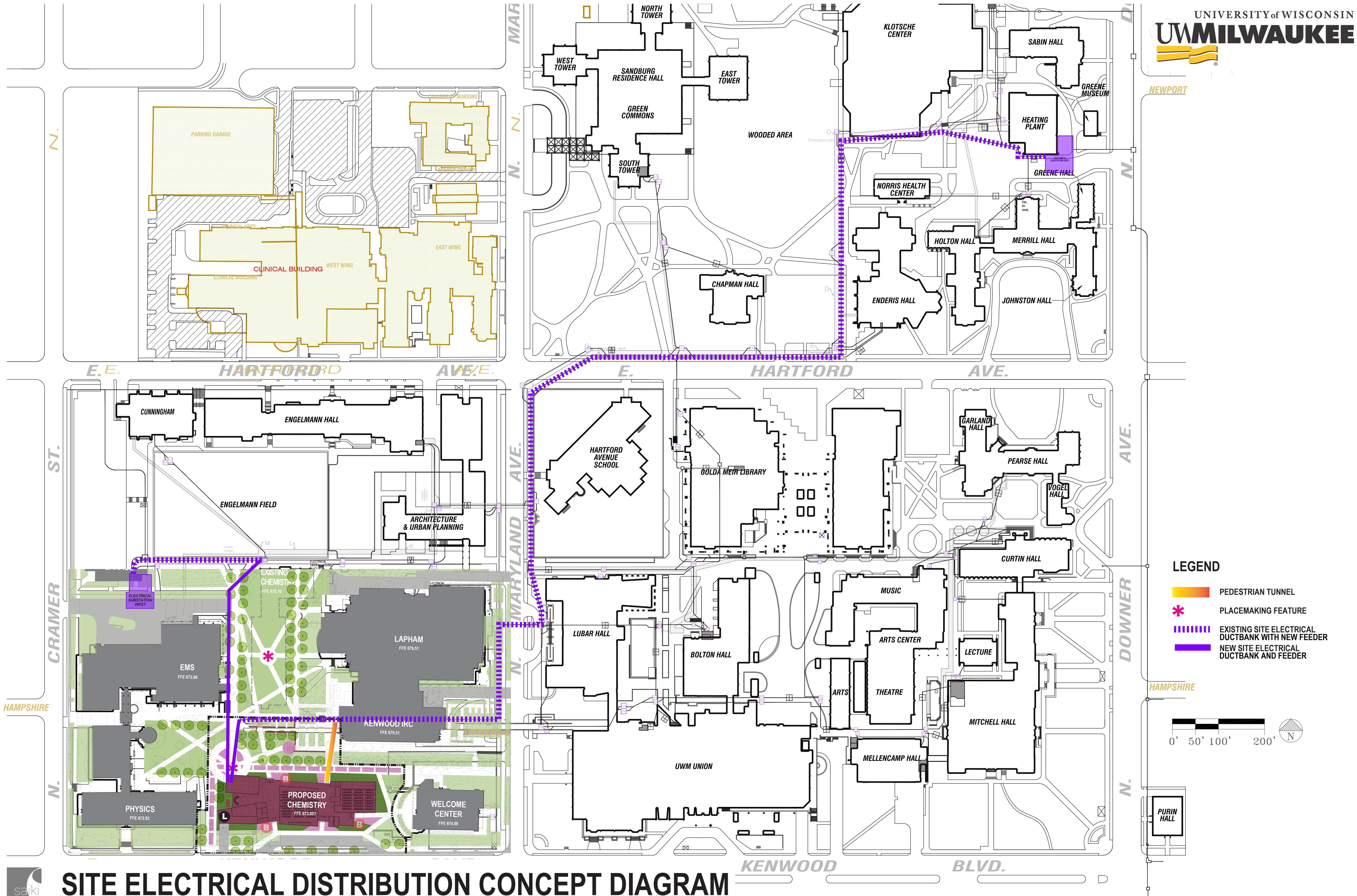
Conduit less than 3/4" diameter will not be used except for switch legs, fixture whips and door controls.

Use of wire ties to support conduit.

Suspension systems for conduits, fixtures, etc. connected to other utility equipment is prohibited. Any suspension system with multiple levels must be hung from trapeze suspension systems.

Use of Incompatible Materials: Aluminum fittings and boxes will not be used with steel conduit. All materials in a raceway system will be compatible.

Direct burial electrical cable.



SITE ELECTRICAL DISTRIBUTION CONCEPT DIAGRAM

SITE ELECTRICAL DISTRIBUTION CONCEPT DIAGRAM

SITE AND BUILDING SYSTEMS DESCRIPTIONS: COMMUNICATIONS

Purpose

This Basis of Design (BOD) describes the magnitude, functions and requirements of the low voltage Communications systems in the new Chemistry Building on the UW Milwaukee campus. It presents a description of the individual systems' proposed design and function and represents decisions and information available to the design team through the date this document was delivered.

Approach

Identify the Communications systems included in the project.

Coordinate the intrabuilding cabling plan and Communications support spaces with UW Milwaukee, DFDM and the Architectural team.

Coordinate the interbuilding cabling plan with UW Milwaukee and DFDM.

Coordinate Communications systems' Mechanical, Electrical, Structural and Architectural needs.

Coordinate development of Communications Design Documents with entire Project team.

Scope of Work

The Communications systems in this Project will include design and implementation information for the building structured cabling system. This system will support voice and data applications using equipment supplied by the Owner.

Definitions	
ABF	Air Blown Fiber – Microfiber cable propelled through microduct pathways using compressed air to reduce installation friction
Backbone Cabling	Cables connecting EF to MER and MER to TRs
Cable	Assembly of one or more conductors or optical fibers within enveloping sheath, constructed to permit the use of conductors singly or in groups.
Cable Link	Includes EO, horizontal cable and termination hardware in consolidation points and MER or TR.
Cable Channel	Same as Cable Link, plus patch cords at EO and in MER or TR.
Consolidation Point	Interconnection point within the horizontal cabling using TIA-568-C compliant connecting hardware rated for at least 200 cycles of reconnection.
Cross-Connect	Group of connection points, wall or rack mounted, used to mechanically terminate and administer building wiring.
EF	Entrance Facility - Located in **XXX**. Voice, data and video services are brought into the building in this room.
EO	Equipment Outlet
Faceplate	Component at EO that holds the jacks.
Horizontal Cabling	Cables connecting EOs to MER, TRs and consolidation points.
Intrabuilding	Within a single building.
Interbuilding	Between two or more buildings.
IT	Information Technology
Jack	Modular connector located in EO.
LAN	Local Area Network - Network or networks typically covering a small geographic area. Typically includes only Client-owned cabling and equipment.
MER	Main Equipment Room - Located in **XXX**. Building voice, data and video services are distributed to TRs on all levels from this room.
Outlet	See EO
Station Cabling	See Horizontal Cabling.
Telecommunications	Any transmission, emission, or reception of signs, signals, writings, images, sounds, or information of any nature by wire, radio, visual, optical, or other electromagnetic systems.
TR	Telecom Room - Used to distribute horizontal cabling to workstation outlets and to house communications equipment.
UTP	Unshielded Twisted Pair - Balanced, 4-pair cable used for copper horizontal cabling and multi-pair copper backbone cables.
WAP	Wireless Access Point - Device that allows wireless devices to connect to a wire network.

Structured Cabling

Equipment Outlet Quantities

The following outlet quantities indicate the general outlet densities expected for the project. Specific requirements to satisfy user needs will be implemented as space programming is completed.

The values in this table show the number of faceplates in each room and the number of jacks at each faceplate. For example, an office would have a total of 2 faceplates containing a total of 2 voice and 4 data jacks:

Room or Space Function	No. of Faceplates	Voice Jacks per Faceplate	Data Jacks per Faceplate
Typical Office	2	1	2
Conference Room	1 (in floor box)	1	2
	2	0	2
Modular Furniture	1	1	2
Lab Support Rooms	As programmed	0	2
Research Labs – Bench top (per 8 lf of bench)	As programmed	0	2
Teaching Labs – Bench top (per bench)	As programmed	0	2
Wireless access points	N/A	0	2
Security surveillance cameras	N/A	0	1

Table 2 - Outlet Quantities

Equipment Sizing Criteria

Pathways

Cable pathways will be sized with typical pathway sizing as follows:

- Outdoor Interbuilding - 100% spare capacity over initially installed cabling.
- Indoor Intrabuilding - Fill to 50% of maximum allowed by Code.
- Station - 1" minimum conduit size.

Pathways will be installed to connect EF, MER and TRs in an efficient manner.

Termination and Mounting Space

Equipment racks and wall fields will be sized with a minimum of 30% spare capacity.

Copper Voice Backbones

Intrabuilding copper voice backbones will be sized at 4 pairs per installed voice horizontal cable.

Network Electronics

Network electronics will be sized, furnished and installed by the Owner.

System Description

The structured cabling system will be provided as a certified cabling system. The manufacturer or manufacturers of the cable and termination components will qualify and warranty the performance of the entire system.

Support Rooms

All Communications support rooms have several common requirements. Each room will be provided with card access security control, emergency and/or UPS power and continuous HVAC cooling.

The support rooms should be located central to the areas that they serve and have clear access to cable pathways coming in and out of the rooms. Pedestrian and equipment access should be through a door located off a building corridor and should not require access through any other locked room. Door width will be at least three feet.

Suspended ceilings should not typically be provided, however some means of maintaining the environmental parameters of the rooms must be implemented. If a suspended ceiling is required to maintain environmental integrity, the ceiling should be installed high enough to allow all pathways and room services to come into the rooms below the ceiling.

Floors, walls and ceilings in the support rooms will be treated to minimize dust and the potential for static electricity. At least two walls will be covered with fire treated plywood (3/4 inch thick, 8 feet high, A-C grade).

Entrance Facility (EF)

Interbuilding services will be brought into the facility at the EF and the building demarcation will be located in this room.

The EF requires a minimum of 80 square feet of space (10 feet by 8 feet).

Main Equipment Room (MER)

The building MER provides a protected environment for terminating all backbone cables and is located [insert location in building here]. This room is where the building Communications systems connect to the campus Communications systems and distribute to the rest of the new Chemistry Building.

The MER requires a minimum of 120 total square feet (10 feet by 12 feet). The room will house intra-building voice cable terminations, data network equipment and fiber optic cable terminations. This room may also server the TR function for areas surrounding the MER.

Telecom Room (TR)

Each floor will have one TR, and each TR will connect to the building MER with intrabuilding backbone cabling. The TRs provide a protected environment for terminating backbone cabling and horizontal cabling on each floor and Communications services to the floor will be provided from the TRs. Network electronics will also be housed in the TRs.

Each TR requires a minimum of 120 square feet (10 feet by 12 feet) of space.

Server Rooms

No dedicated server rooms are anticipated in the new Chemistry Building.

Backbone Cabling

Backbone cable summary table

Backbone Cable Application	Cable Type	Cable Quantity
Interbuilding Data	SM Fiber Optic	72 strands
Interbuilding Voice	Copper UTP	400 pairs
Intrabuilding Data	SM Fiber Optic	24 strands
Intrabuilding Voice	Copper UTP	4-pair per horizontal cable

Table 3 - Backbone Cabling

The existing campus duct bank and manhole system will extend to the new Chemistry Building to provide connection to the Campus Communications infrastructure. All Communications services will enter through the duct bank and manhole system.

Interbuilding Data Backbone Cabling and Connection Hardware

The data system will use air blown fiber optic cabling to bring data service into the building at the EF from the EMS core room. The ABF will be installed through existing ABF microducts in existing campus duct banks. New microducts will be installed in the new duct bank extension from the nearest manhole into the new building. The data backbone will be sized at 72 single mode strands.

A future secondary fiber connection is planned from the Northwest-Quad core room, but this connection will not be included with the initial building construction.

All fiber strands will terminate on duplex-LC connectors in rack mounted patch panels in the EF

Intrabuilding Data Backbone Cabling and Connection Hardware

The data system will use air-blown fiber optic cabling to distribute data service from the MER to the TRs. The data backbone from the MER to each TR will be sized at 48 single mode strands.

All fiber strands will terminate on duplex-LC connectors in rack mounted patch panels in the MER and TRs.

Interbuilding Voice Backbone Cabling and Connection Hardware

- The voice system will use high pair-count copper cabling to bring voice service into the building at the EF. The voice backbone will be sized at 400 pairs.
- All cable pairs will terminate on wall-mounted protector panels and be cross-connected to rack-mounted system terminal blocks.

Intrabuilding Voice Backbone Cabling and Connection Hardware

- The voice system will use high pair-count copper cabling to distribute voice service from the MER to the TRs. The voice backbone will typically be sized at 4 pairs per voice horizontal cable served by each TR.
- All cable pairs will terminate on rack-mounted 110-blocks.

Data Horizontal Cabling and Connecting Hardware

Each data jack will connect to the nearest TR with a 4-pair UTP, Category 6A cable. All four pairs will terminate at the outlet and in the TR.

Category 6A rated 8P8C type jacks will be used at the outlet locations and rack mounted patch panels will be used in the TRs.

Cables from EOs will run in conduit, J-hooks and cable trays to the TRs.

Horizontal Cabling

Horizontal Cable Application	Cable Type	Cable Quality
Data (i.e. computer networking)	Copper UTP	6A
Wireless Data (i.e. WAP connections)	Copper UTP	6A
Voice	Copper UTP	6
Security (i.e. CCTV) Cameras	Copper UTP	6A

Table 4 - Horizontal Cabling Summary

Voice Horizontal Cabling and Connecting Hardware

Each voice jack will connect to the nearest TR with a 4-pair UTP, Category 6 cable. All four pairs will terminate at the outlet and in the TR.

Category 6 rated 8P8C type jacks will be used at the outlet locations and wall mounted 110-blocks will be used in the TRs.

Cables from EOs will run in conduit, J-hooks and cable trays to the TRs.

Fiber Optic Horizontal Cabling and Connecting Hardware

Horizontal fiber optic cabling is not planned for this project.

Patch Cables

Patch cables will be provided by the Owner

Support Equipment

Innerduct

Backbone fiber optic cabling will not be installed in flexible, nonmetallic innerduct. Air-blown fiber will be installed in nonmetallic microducts designed to work with the ABF.

Equipment Racks

All copper and fiber optic patch panels will be installed in 7 foot high, standard TIA 19" equipment racks. Patch panels will be angled-type to facilitate improved patch cord routing.

High-density horizontal and vertical cable management will be provided in all equipment racks.

Cable Raceways

The cable raceway system will consist of a combination of cable tray, J-hooks, conduit, surface raceway, cable runway and D-rings. The cable runway and D-rings will only be used in the support rooms.

Cable pathways from the EOs to the TRs will use conduit above inaccessible ceilings, cable tray above accessible ceilings and major cable runs and J-hooks for aggregating small quantities of cables in common areas.

Grounding System

The Communications grounding system will provide equipment protection in all support rooms, and will be designed based on DFDM guidelines and the TIA-607 standard. Ground bars and conductors will be provided to minimize the potential difference between the grounding system and the electrical sources powering the Communications equipment. Refer to Electrical narrative section for additional information.

MEP Requirements

No piping or ductwork will pass over or through any Communications support room, unless they are used to provide services to the support rooms. Piping and ductwork used to provide services to these rooms will be coordinated with the anticipated Communications equipment layout within the rooms.

Electrical Requirements

Communications support rooms will be connected to the building standby power source. Rack-mounted UPS equipment will be used to maintain system operation while the standby power source comes on-line.

The intent of the electrical service described above is to accommodate rack-mounted UPS equipment connected to the standby power source. Dual-corded network equipment will then typically plug one cord into a normal power circuit and the other cord into the rack-mounted UPS.

Communications support rooms will be lit to a minimum of 50 foot candles horizontal illumination and 20 foot candles vertical illumination between the equipment rack rows (measured at three feet above the floor).

Access to Communications support rooms will be controlled by the building access control system to allow the Owner to track access to the rooms.

Mechanical Requirements

Communications support rooms will be maintained at between 68 and 72 degrees Fahrenheit with 30% to 50% relative humidity at all times. If the building HVAC system cannot provide continuous operation or adequate capacity to meet these criteria, supplemental cooling units will be installed.

Cooling requirements for the MER and TRs will be sized at 2 tons per room.

Piping Requirements

The EF, MER and TRs will be sprinkled and include protective cages around the sprinkler heads.

Electrical Circuit Type	Source	Circuit Quantity	Device Type
120V, 20A	Normal	(2) per equipment rack	L5-20R
208V, 20A, single-phase	Standby	(1) per equipment rack	L6-20R

Table 5 – MER and TR Electrical Service

Two-Way Communication System

System Description

As described in section 1009.8 of the International Building Code, a two-way communication system shall be provided [in each area of refuge identified on the life safety plans][at the landing serving each elevator or bank of elevators] on each accessible floor that is one or more stories above or below the level of exit discharge.

Landings serving only service elevators that are not designated as part of the accessible means of egress or do not serve as part of the required accessible route into a facility do not require installation of a two-way communication system. A two-way communication system is also not required at landings serving only freight elevators.

System Requirements

The two-way communication system shall provide communication between each required location and the fire command center or a central control location approved by the fire department. If the central control location is not a constantly attended location, the two-way communication system shall automatically dial-out to a monitoring location or 9-1-1.

All devices shall provide real-time, two-way communication between the calling remote station and the central control location, including if the central control location is offsite or via 9-1-1.

The two-way communication system devices shall include both audible and visible signals.

Cabling between devices shall have a survivability level of 3 as defined in NFPA 72. This survivability level will be achieved by using CI or CIC rated cable in either open air or conduit pathways.

System operation instructions and signage indicating special accessibility provisions shall be provided as required by the IBC.

Emergency Responder Radio Reinforcement System

System Description

As described in section [510 of the International Fire Code][9.6 of NFPA 1221], all new buildings shall have approved radio coverage for emergency responders within the building based on the existing coverage levels of the public safety communication systems of the jurisdiction at the exterior of the building.

Licensing and approval for this system shall be accomplished through the entity holding the FCC license for the existing public safety communication systems.

System Requirements

Minimum required system coverage and signal strength shall be as defined in [section 510.4.1 of the International Fire Code][sections 9.6.7 and 9.6.8 of NFPA 1221]. System shall be capable of receiving final approval from the local fire code official.

The system shall be powered from at least two independent power sources. The primary source shall be a dedicated branch circuit from the building's normal power distribution system. The secondary source shall be a [dedicated battery system][dedicated branch circuit from the building's life safety emergency power distribution system (and enough UPS runtime to provide power during generator startup)] with a minimum of 12 hours runtime at 100 percent system load.

The system shall include automatic supervisory signals to communicate system malfunctions to the building's fire alarm system, in addition to annunciating system faults at a dedicated system panel.

The system shall be capable of adapting to frequency changes in the public safety communication system without having to replace the entire system head-end.

The system will use a roof-mounted donor antenna to connect to the public safety communication system.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: AUDIOVISUAL

Purpose

This Basis of Design (BOD) describes the magnitude, functions and requirements of the low voltage Technology systems in the new Chemistry Building on the UW Milwaukee campus. It presents a description of the individual systems' proposed design and function and represents decisions and information available to the design team through the date this document was delivered.

General

Audiovisual technology planning will adhere to Wisconsin DFDM guidelines for AV and IT, as well University of Wisconsin – Madison campus standards and AVIXA's AV industry accepted design standards. In some applications, other standards apply including ISO, NFPA, NEC and other building codes.

In recent years, AV has migrated to an IT solution for video, audio, control, paging and conferencing. The development of any AV application must be coordinated in concert with the development of the IT solution.

Classrooms and Instructional Labs

General Assignment classrooms and Instructional Labs will feature similar technology for instructors and students. Primary display methods will be through front projection with motorized screen. HDMI inputs for personal devices at the teacher's station, as well as an instructor PC. Display resolutions will be 1080p HD minimum, with 4k on the higher end. Some medium classrooms will feature two projection screens, with one being on each end of the room. Functionality will be the same across all classroom sizes. Small and medium classrooms do not anticipate microphone voice reinforcement and will only have front speakers for program audio. The AV systems will be controlled via a touch panel at the instructor station. AV equipment is anticipated to be located inside the instructor station, or in an equipment in the adjacent prep rooms.

Labs

Currently no fixed AV equipment is planned for these rooms. There will be several portable AV carts that can connect to power around the room. The cart will consist of a large display with HDMI and wireless presentation capabilities. This will keep the teaching flexible and allow for the cart to be in a number of locations depending on the need. These portable carts can be stored in an alternate location, and deployed to a room as needed.

Large Lecture

Large Lecture Halls will maintain the same core functionality of the other classrooms, while adding to accommodate the larger capacity. Dual projection screens and projectors will be used to allow mirroring or content, or showing two different pieces of content simultaneously. Ceiling speakers will be used to enhance program audio, and for voice reinforcement through wireless microphones. Lecture capture or conferencing is not anticipated. All video switching and device control will be through a touch control panel at the instructor's station. The system will support sources such as, HDMI devices, Fixed instructor PC, and wireless presentation sources.

Collaboration Spaces

Formal Collaboration Rooms are located integral to the staff office and lab spaces. There are two sizes for these rooms, a small 4-to-6 person room and also a larger 10-person room. Collaboration rooms will include a single wall-mounted flat screen display supporting connectivity of portable user devices (computers, laptop, tablet, mobile phone) for presenting content using HDMI and wireless video sharing (Apple Play, etc.).

The smaller 4-6 person rooms will be supplemented with a wall mounted unified communications (Skype, WebEx, Zoom, etc.) AV sound bar with integral stereo loudspeakers, microphones and video camera. Sound bar will include USB cable for connection to user mobile device for integration with mobile unified communications software.

The larger rooms will include similar capabilities are smaller 4-6 person rooms, however will be supported with larger flat screen video display and potentially with higher level audio capture solution using ceiling array microphone and AV Bridging product with integral audio DSP.

Digital Signage

Digital Signage refers to electronic video displays which display marketing, scheduling, wayfinding and other information. These video displays can be enhanced to include interactive touch-sensitive applications. These displays typically include an IT-networked media player/computer. At present, it is assumed one Digital Signage display will be located at each Circulation areas and public areas e.g. Waiting Rooms. Content and interactive content is provided by the Owner.

SITE AND BUILDING SYSTEMS DESCRIPTIONS: ACOUSTICS

General Vibration Criteria for Sensitive Equipment		
Vibration Classification	Description of Use	Maximum Vibration Velocity, rms
Residential (ISO)	*Threshold of human perception* Microscopes up to 20x magnification	8000 µinches/sec (200 µmeters/sec)
Operating Theater (ISO)	*Vibration not perceptible* CT Scanners Microscopes up to 100x magnification	4000 µinches/sec (100 µmeters/sec)
VC-A	Microscopes up to 400x magnification Optical and micro balances Proximity and Projection aligners, etc.; Clinical Laboratories	2000 µinches/sec (50 µmeters/sec)
VC-B	Micro surgery, eye surgery, neuro surgery Microscopes up to 400x magnification Inspection and lithography equipment to 3µm line-width	1000 µinches/sec (25 µmeters/sec)
VC-C	Magnetic resonance imagers Microtomes Inspection and lithography equipment to 1µm line-width	500 µinches/sec (12.5 µmeters/sec)
VC-D	Mass Spectrometers Cell implant equipment	250 µinches/sec (6.25 µmeters/sec)

Introduction

The following narrative includes initially proposed acoustical criteria, comments, and recommendations for acoustically sensitive areas on the above-noted project. Information provided is primarily based on a review of in-progress space layouts received on October 24, 2019. The following areas of acoustical design are discussed within:

1. Floor Vibration Control
2. Acoustical Separation
3. Interior Room Acoustics
4. HVAC Noise and Vibration Control

This narrative is intended to provide design direction to the team for coordination of acoustic requirements into drawings and specifications for the project. Any feedback on the assumptions and preliminary recommendations in this document are requested to ensure that appropriate design input is provided during subsequent coordination efforts.

Floor Vibration Control

Controlling floor vibration levels will be an important design consideration in any lab spaces that may contain vibration sensitive equipment. The table above includes more conservative design criteria that has been compiled from a wide range of manufacturer specifications for vibration sensitive equipment and test data that has been linked to successful operation of such equipment in various facilities. Criteria are expressed in terms of maximum RMS (root mean square) micro-inches/second within 1/3 octave bands between 8-80 Hz (with slightly higher levels at frequencies less than 8 Hz). These goals can be considered for initial planning efforts.

Per a review of the structural design narrative, it is noted that the floor structure for lab areas that may contain vibration sensitive equipment is initially planned to be designed for a 2000 micro-inches/sec criteria. SM&W expects this approach can provide a high degree of stiffness and control floor vibrations to levels that will permit acceptable function of the types of equipment typically used in these types of environments. Any manufacturer specific criteria or requirements for vibration sensitive lab equipment should be sent to SM&W for further review and comment as applicable.

Walking Speed Guidelines		
Walking Speed	**Paces per Minute**	**Location**
Fast	125	Bays with main corridors and/or corridors with major rolling material handling loads
Moderate	110	Side corridors; In-room "ghost" corridors; Large rooms
Slow	95	Small rooms with limiting walking pathways containing several people
Very Slow	75	Small rooms with limiting walking pathways containing one or 2 people

The obvious sources of structural vibration are MEP and conveying equipment (elevators), but the worst-case source that must be considered in the analysis is typically walking and material handling within the area of the occupancy. The speed of walking determines the amount of impact or vibrational energy imparted into the structure.

Compliance with floor vibration design goals can be determined per the methods described in the American Institute of Steel Construction (AISC), Steel Design Guide Series 11, "Floor Vibrations Due to Human Activity", Chapter 6 "Design for Sensitive Equipment and Sensitive Occupancies" with a 185 pound person walking in the center of bay; though the walking position is dependent on project conditions (mostly corridor positions relative to the primary occupancy or area of concern). Alternate design guides and methodologies may be available in other recognized publications; SM&W recommends that the structural engineer evaluate the base-building structure with respect to footfall activity using the appropriate resource for the project.

The appropriate design walking speed is generally based on space and corridor layouts. A typical application of walking speeds is summarized in the table above. The specific walking speed for individual areas should be established based on corridor and space orientations with respect to the referenced AISC Guidelines (or other applicable design standards). In some areas, walking may be off-center from the occupancy, such as floors were the corridor is towards the interior; off-center within the room's structural bays. Fast walking speed typically imposes significant cost, and thus may not be practical or possible within project constraints.

Structural Design Considerations

The following are a few structural design considerations that may be needed or beneficial to achieving previously noted floor vibration criteria:

- Limit structural bay dimensions. A typical 30ft x 30ft bay can be impractical to design to certain vibration limits. Maintaining at least one dimension in the 20-23 ft range is typically desirable.
- Locate circulation corridors within separate structural bays from sensitive spaces.
- Girders and/or beams along column lines deeper than mid-span beams. This helps interrupt transverse waves within an otherwise common-member floor plate.
- Concrete structures tend to be more rigid than steel. Steel can be designed to match the rigidity of concrete structures, though has practical limits and depths.
- Mechanical and electrical room floor and ceiling slabs designed with extra mass to provide a stable base for vibration isolation devices and a barrier for air-borne sound.
- Strategic locations for building expansion joints can also be helpful in mitigating vibration translation through a building.

STC Rating	Speech Privacy Expectations
STC 40	**'Fair' Privacy** Normal voices in adjacent space audible and intelligible part of the time. Raised voices and amplified audio mostly intelligible.
STC 45	**'Good' Privacy** Normal voices in adjacent office space audible but unintelligible most of the time. Raised voices and amplified audio partially intelligible.
STC 50	**'Excellent' Privacy** Normal voices in adjacent space is barely audible. Raised voices and amplified audio are audible but mostly unintelligible.
STC 55	**'Confidential' Privacy** Normal voices in adjacent space are not audible. Raised voices and amplified audio are barely audible but not intelligible.
STC 60+	**'Isolated' Acoustical Separation** Renders most typical interior sounds to inaudible or just barely audible levels. Amplified low frequency sounds may still be partially audible.

- Equipment that is particularly sensitive to vibration should be located slab-on-grade with full resilient isolation joint to the surrounding structure if applicable.

Acoustical Separation

Acoustical separation primarily addresses the control and mitigation of airborne noise transmission between spaces. The standard metric for acoustical separation performance is in terms of Sound Transmission Class (STC) which is a rating on the ability of a construction element, such as a partition or window, to reduce sound transmission. Published acoustical performance ratings and reference tables from manufacturers are typically provided in terms of STC. Higher STC ratings correspond to lower degrees of sound transmission through the construction.

STC ratings focus on sound reduction for frequencies in the human speech range, so there is a correlation between the STC rating of the partition and the speech privacy provided. The table above provides a subjective description for general speech privacy expectations in spaces separated by various STC rated construction when combined with a moderate background noise level.

It should be noted that the above speech privacy descriptions generally assume that spaces are normally furnished and separated by 'solid' demising partitioning without doors or openings. Doors can severely limit acoustic separation and significantly degrade the privacy condition (unless high-performance acoustic door seals or full sound rated door packages are specified). Ambient background noise levels can also strongly influence perceived degrees of speech privacy.

Adjacency		Min. Recommended STC
Standard Office	Corridor/Open Office	STC 40
	Occupied Space/Stairs	STC 45
Classroom Lab Research	Corridor/Open Office/Stairs	STC 45
	Occupied Space	STC 50
Lecture Room	Lobby	STC 55
Student Outreach	Lobby	STC 50
Mechanical /Electrical Room	Occupied Space	STC 55 to 60

Design Criteria

Initially recommended STC design criteria for enclosed, acoustically sensitive space types are tabulated above based on space layouts and industry standard best practices. This criterion can be used as a starting point to define acoustical separation requirements on the project.

Vertical Sound Transmission Control

Maintaining appropriate degrees of sound control and floor impact isolation between vertically adjacent spaces will be an important design consideration. Airborne acoustical separation between vertically adjacent spaces is primarily determined by the mass of the overall floor slab, and to some extent the construction and detailing of any finished ceilings. Impact isolation performance is typically defined in terms of single number IIC ratings which are a similar laboratory measured STC ratings except that it measures the amount of structure-borne noise transmission as opposed to airborne noise transmission. Higher IIC ratings correspond to lower degrees of impact noise transmission through a floor-ceiling assembly. Meeting sufficient IIC performance will primarily be a concern where hard surface flooring finishes (e.g. concrete, tile, etc.) are planned and typically requires the use of an appropriately selected resilient underlayment material to properly control impact noise. Areas with carpet as floor finish should inherently have the potential to provide very high impact isolation performance. Additionally, controlling impact sound transmission between non-acoustically sensitive adjacencies such as stacked bathrooms, corridors, etc. is typically not a needed consideration.

Adjacency	Minimum Floor Slab Mass / Approx. STC Rating	Impact Isolation Class (IIC)
Typical Floor Slab	60 PSF (~STC 50) e.g. minimum 5" thick NWC	IIC 45
Floor Slab Above Lecture Spaces	75 PSF (~STC 55) e.g. minimum 6" thick NWC	IIC 60
Floor Slab Between Basement Mechanical and 1st Floor Lecture Spaces	100 PSF (~STC 58) e.g. minimum 8" thick NWC	N/A
Penthouse Floor Slab **(1)**	100 PSF (~STC 58) e.g. minimum 8" thick NWC	N/A

Notes

1. Initial recommendation based on the assumption that main MEP equipment will be located in the Penthouse spaces, to control noise from mechanical equipment to spaces below and provide stiff platform for proper vibration isolation. Refer to the MEP noise control section of this document for additional information.

The table above includes initially recommended criteria and guidelines for controlling airborne sound transmission and structure-borne impact noise transmission between vertically adjacent spaces in terms of overall STC and IIC ratings.

In situations where project constraints may prohibit the use of floor-ceiling constructions as recommended in the previous table, incorporating appropriately detailed sound barrier ceiling construction can offer an alternate option for controlling airborne and structure-borne sound transmission between spaces. However, sound barrier ceiling approaches typically require more specialized means and methods and more careful installation which can impose additional costs or other challenges. Specific approaches will require further review and coordination as space layouts, functions, and initial equipment selections are developed in more detail.

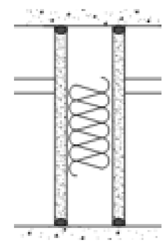
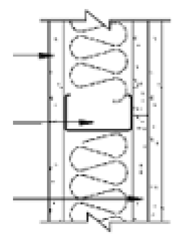
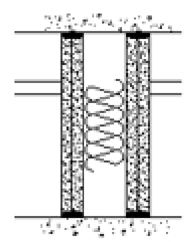
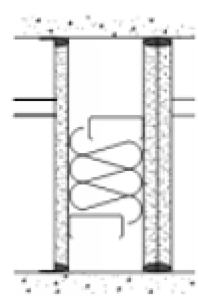
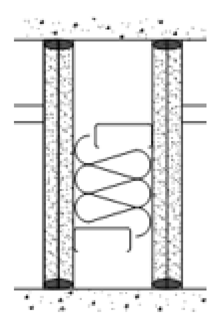
Partition Construction

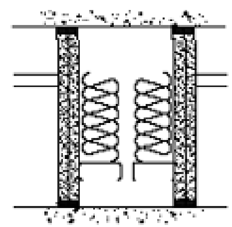
Some example drywall and metal stud partition constructions that can be utilized to achieve STC design goals for horizontal separation between spaces noted in the previous section are provided on the next two pages. It should be noted most published literature regarding drywall partition acoustical performance is based on lab tests performed using light 25-gauge metal studs spaced at 24" on center. Modern partition construction approaches are typically based on 20-gauge or heavier metal studs, spaced at 16" on center, which do not perform as well for reducing sound transmission.

Nominal STC performance values tabulated on the following pages are provided for different metal stud configurations which SM&W has compiled from various sources.

Glass Partitioning

It is assumed that interior glass partitioning will be desired in certain areas. While there are many benefits to using glass partitioning between spaces (i.e. aesthetics, natural daylight, etc.), it is important to note that sound isolation performance of glass is much lower in comparison to solid gypsum board partitioning. Published STC ratings for typical 1/4" and ½" thick glass are approximately STC 31 and STC 36 respectively. Field performance tends to be even lower due to mullions or joints between glazings which can serve as additional weak points. Thicker lites of laminated glass and/or insulated glazing units (IGUs) can increase the STC rating,

Partition Description	Drywall Partition Cross Section
2 Layer Full Height Drywall w/ Insulation Single row of metal studs with one layer of GWB on each side, full-depth batt insulation in the stud cavity, extending from structure-to-structure: 20ga or heavier studs; 16" o.c. ...... STC 40+/- 25ga studs; 24" o.c. .... STC 45+/-	
3 Layer Full Height Drywall w/ Insulation Single row of metal studs with one layer of GWB on one side and two layers on the other, full-depth batt insulation in the stud cavity, extending from structure-to-structure. 20ga or heavier studs; 16" o.c. ...... STC 43+/- 25ga studs; 24" o.c. .... STC 50+/-	
4 Layer Full Height Drywall w/ Insulation Single row of metal studs with two layers of GWB on each side and full-depth batt insulation in the stud cavity, extending full-height from structure-to-structure. 20ga or heavier studs; 16" o.c. ...... STC 48+/- 25ga studs; 24" o.c. .... STC 55+/-	
Staggered Studs w/ 3 Layer Full Height Drywall and Insulation Staggered metal studs in common tracks. One layer of GWB on one side and two layers of GWB on the other side with full-depth batt insulation in the stud cavity, extending full-height from structure-to-structure. Any stud gauge or spacing .... STC 52+/-	
Staggered Studs w/ 4 Layer Full Height Drywall and Insulation Staggered metal studs in common tracks. Two layers of GWB on each side with full-depth batt insulation in the stud cavity, extending full-height from structure-to-structure. Any stud gauge or spacing .... STC 57+/-	

Partition Description	Drywall Partition Cross Section
Double Studs w/ 4 Layer Full Height Drywall and Insulation Two rows of independent metal studs with two layers of GWB on each side and full-depth batt insulation in each stud cavity, extending full-height to structure. Any stud gauge or spacing.............. STC 60+	

<u>Notes</u>

1. Nominal STC ratings for single stud partitions noted above are based on the use of 5/8" thick layers of gypsum board, minimum 3-5/8" wide studs, and 1.5 to 3.0 lb density batt insulation unless otherwise noted.
2. Design goal acoustical separation is for "solid" demising partitions without doors. Doors can severely limit the acoustic separation and significantly degrade the privacy condition (unless high-performance acoustic-rated door, frame, seal assemblies are utilized). Project requirements or desires for function and circulation may take precedence over design goal acoustical separation.
3. Partitions that utilize heavy-gauge closely-spaced support and/or structural members, as required for security and/or load bearing purposes, will perform similar to 20ga/16"o.c. partitions.
4. Resilient channels and clips can increase the acoustic separation of a partition construction, but the construction means and methods dramatically change, and thus providing these specialized materials and details is discouraged. Field installed performance is typically far less than published data; due mostly to incorrect installation.
5. Acoustically-enhanced drywall is a possible option, such as QuietRock "EZ-SNAP/ES". However, the material cost tends to be significantly higher than standard drywall and is typically prohibitive for medium to large scale projects; though layers of drywall can potentially be reduced when using these specialized products. Budget pricing, mock-up construction of means and methods, and testing of sound transmission are highly recommended before seriously considering these products.

It should be noted that Sound Transmission Class (STC) ratings of partitions are the ideal laboratory rated values which are measured in highly controlled environments where careful attention to detail is ensured. In actual field construction, the comparable rating methodology is in terms of Noise Isolation Class (NIC) which inherently takes into account all acoustical imperfections and weak points in the construction (e.g. ceiling conditions, wall receptacles, perimeter/exterior/mullion conditions, etc.). Field measured acoustical separation will almost always be lower as a result of these acoustical weak points and are highly dependent on the quality of materials and craftsmanship. STC ratings cannot be determined empirically for field-built partitions and should only be used as a basis for design and construction intent.

To achieve the best installed acoustic performance possible, partition construction details must be consistent with good acoustical design practice. It is recommended that all acoustical partition types conform to the instructions stated in Section III of the Gypsum Association 2006 Fire Resistance Design Manual. The practices outlined below should be incorporated into the project design where a specific acoustic requirement is to be met:

- Provide continuous beads of non-hardening caulk on both sides of the top and bottom stud runner, along each intersection of the runner, floor, and drywall. (see Figure 1)
- Electrical and service outlets in a common wall serving adjacent rooms are to be positioned minimum 16-inches apart and in separate stud spaces. (see Figure 2)
- Utilize acoustical caulking to close gaps between drywall and outlet boxes.
- No drywall layers are to be continuous between two adjacent rooms. (see Figure 3)
- Demising partitions should seal directly to the base building construction, such as at column enclosures, etc. (see Figure 4, Figure 5, Figure 6)
- Multiple layers of drywall should be applied with staggered joints. Joints should be positioned a minimum of 16-inches apart.
- Return air transfer and pathways are to be coordinated with mechanical engineers.
- Penetrations that interrupt studs should be framed out; the framing should maintain less than a 2-inch gap around the penetrating element. There should be no direct contact between the penetrating element and the partition. (See Figure 7, Figure 8, Figure 9)
- Penetrations (ducts, pipes, conduit, etc.) through acoustical partitions are to be handled as follows:
    - Gap up to ½-inch: Acoustical sealant or similar non-hardening, ever-resilient caulking compound.
    - Gap from ½-inch up to 1-inch: Compressed foam backer rod with acoustical sealant or similar non-hardening, ever-resilient caulking compound.
    - Gaps between 1-inch and 2-inches: Filled tightly with batt insulation, then sealed with heavy-density putty such as STI Firestop or Smoke 'N' Sound spray, Nelson FSP or CLK Sealant; J.M. Clipper 'Duxseal'; 3M 'Moldable Putty.' Fire ratings of materials to be verified by others.
- Where penetrations through the floor structure are required, the penetrating element should be centered within the opening and sealed airtight as shown schematically in Figure 10 and Figure 11.
- Cable trays should not be located within acoustical partitions. If cable trays are required within acoustical partitions, all space to be packed tightly with firestop pillows and sealed heavy density putty, as above, once cables are pulled.

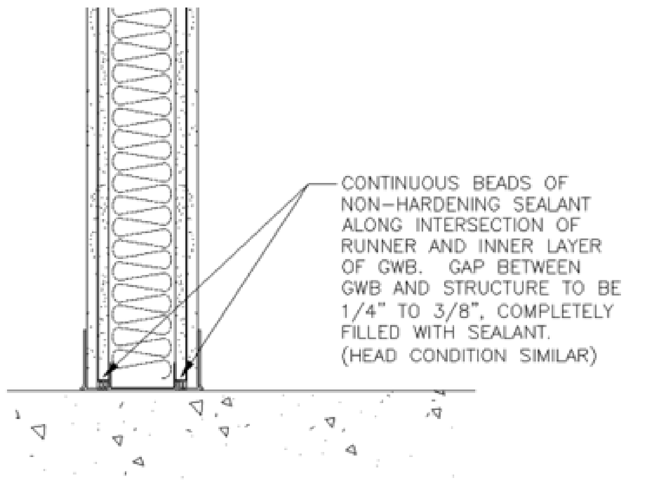


Figure 1: Typical Demising Partition and Caulk Details

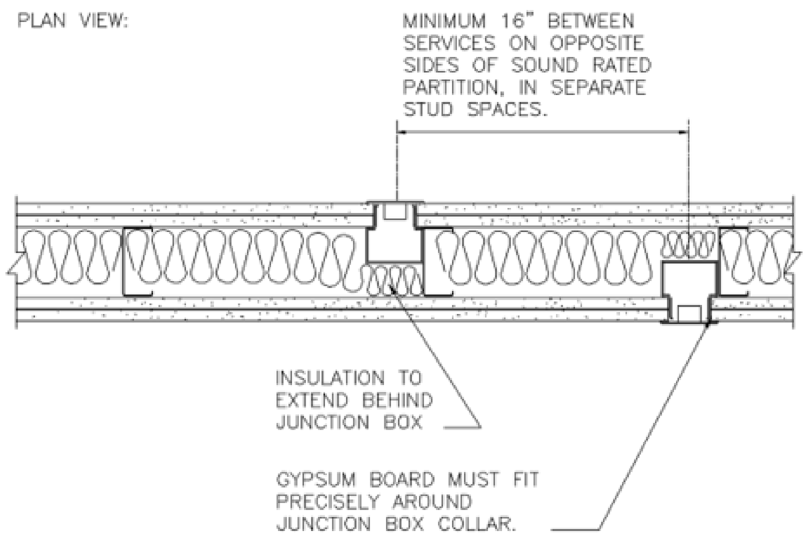


Figure 2: Offset of Junction Boxes Necessary for Sound Critical Partitions

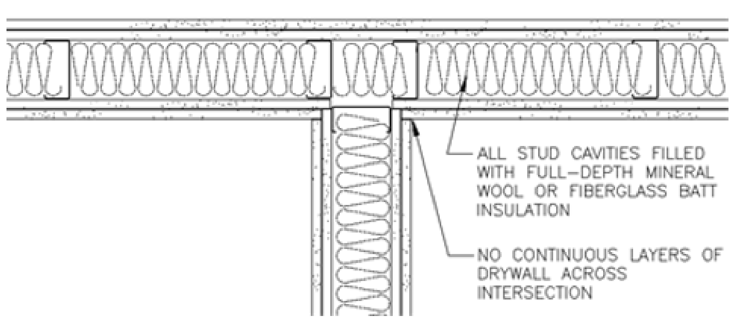


Figure 3: Typical Intersection Detail for Sound Critical Partition, with No Continuous Drywall Across the Intersection

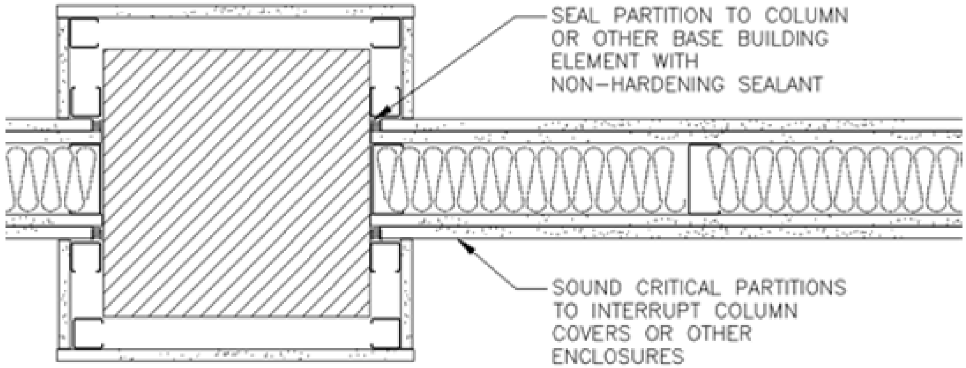


Figure 4: Partition Intersection with Column or Other Base-Building Element

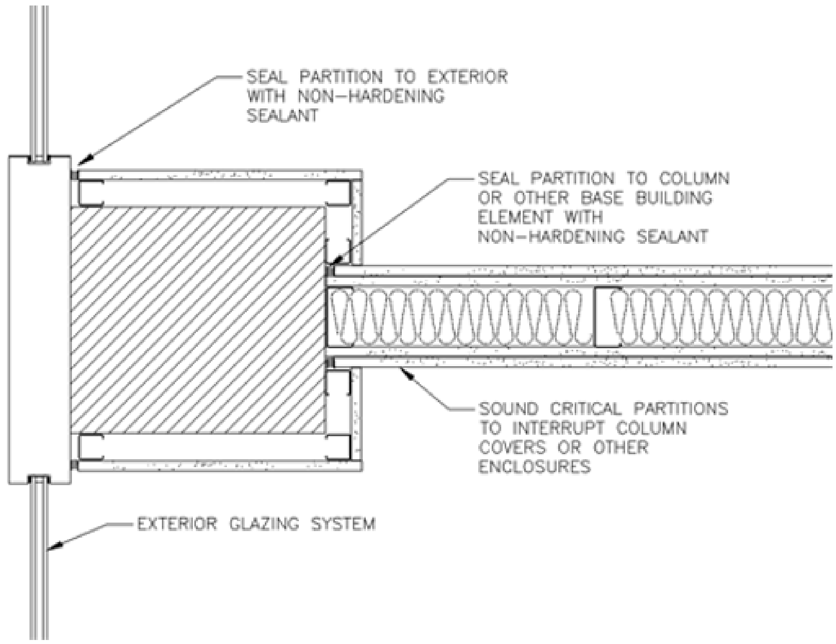


Figure 5: Partition Terminating at Solid Wall or Column at Perimeter

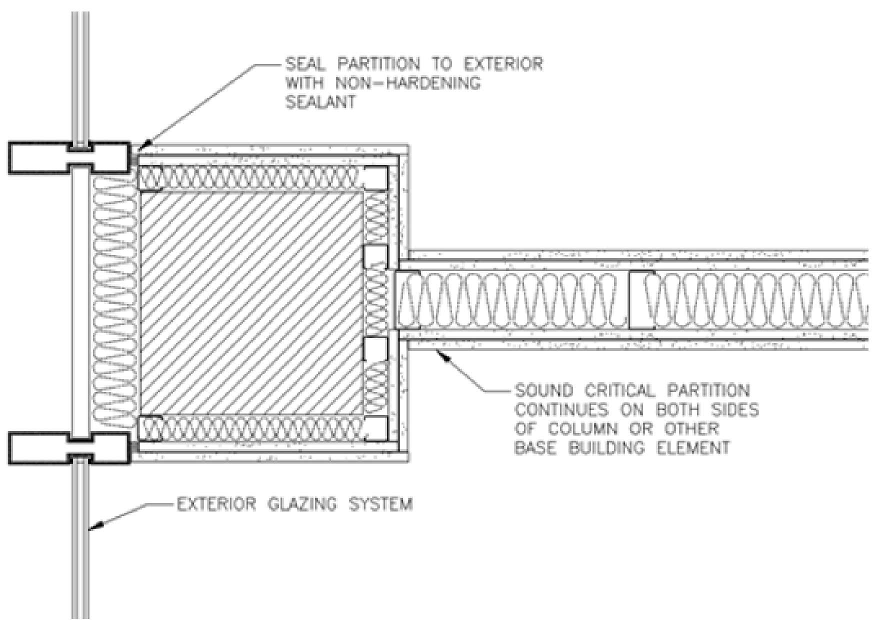


Figure 6: Alternate Partition Configuration Enclosing Elements at Perimeter

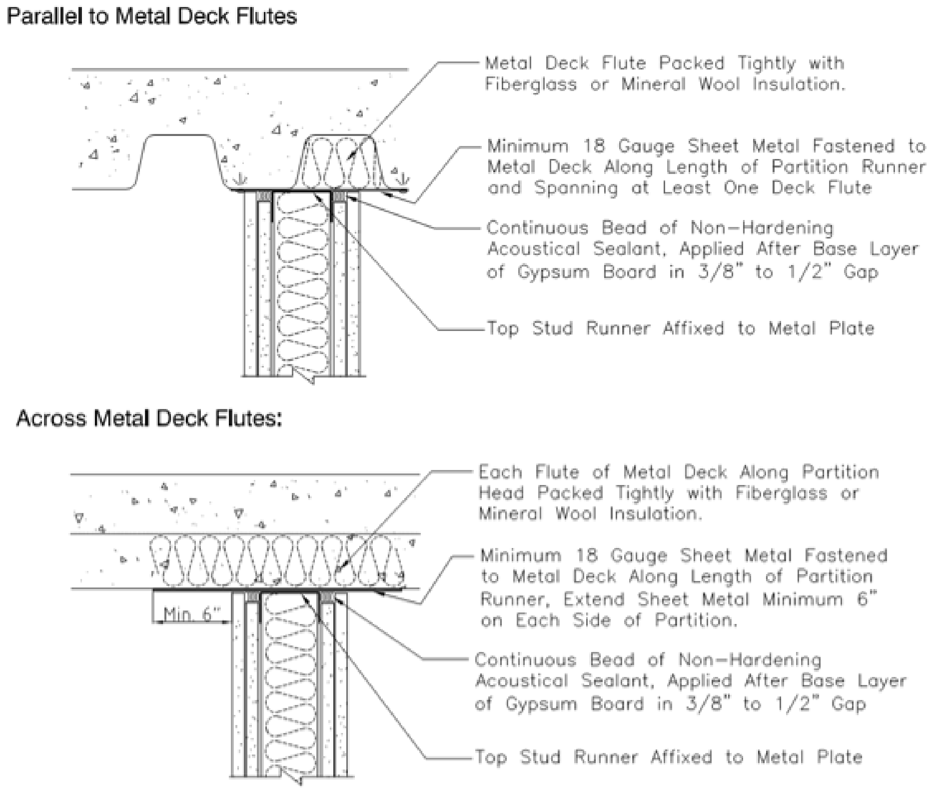


Figure 6: Partition and Metal Deck Acoustical Closure

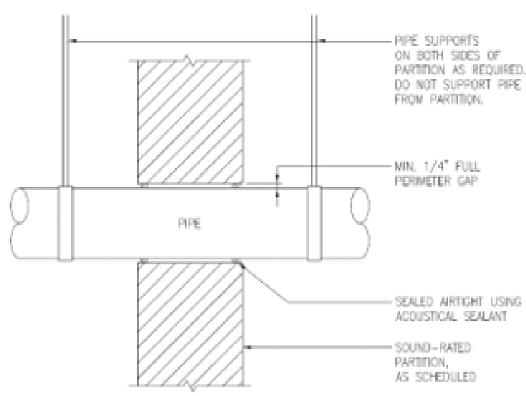


Figure 7: Pipe (Less than 2" Diameter) Penetration at Full Height Partitions

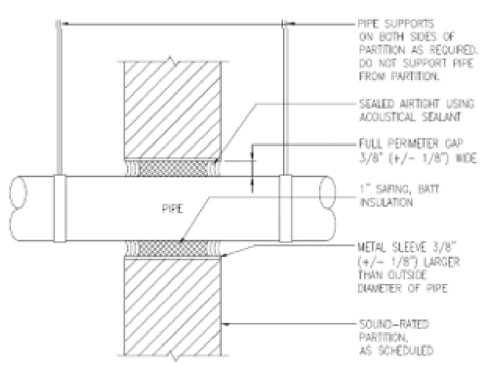


Figure 8: Large Pipe (Equal or Greater than 2" Diameter) Penetration at Full Height Partitions

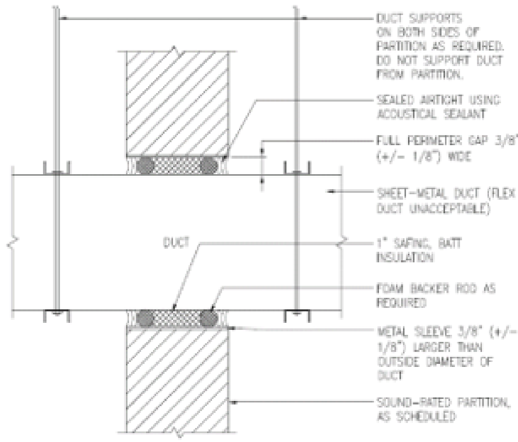


Figure 9: Non-Fire-Rated Duct Penetration at Full Height Partitions

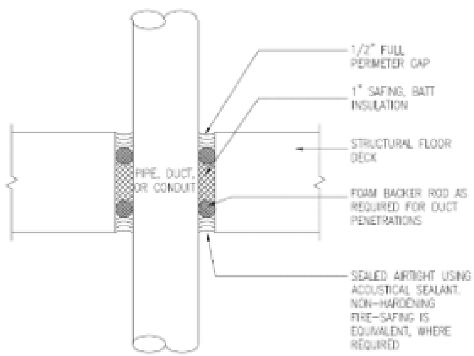


Figure 10: Small Pipe (Less than 2" Diameter), Non-Fire-Rated Duct, or Conduit Penetration at Floor Structure

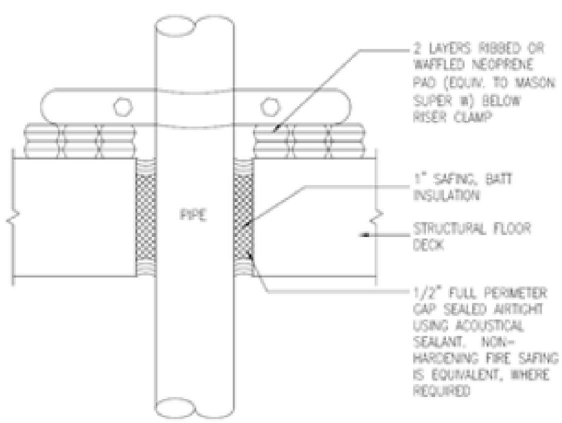


Figure 11: Large Pipe (Equal or Greater than 2" Diameter) Penetration at Floor Structure

but the upper STC limit of most practical systems will still not achieve the same level of acoustic separation as full-height drywall partition types can provide. Thus, lower degrees of acoustical separation should be expected at such locations or alternately providing upgraded glazing assemblies or other design approaches may need to be considered.

The acoustic performance of any smaller side-light glazing assemblies adjacent to entrance doors should not be important since sound leakage through the entrance door will typically be the limiting factor to achievable sound separation regardless of the side-light glazing type.

Doors

Doors are often the main limiting acoustical weak-point that reduces acoustical separation at the entrance condition between spaces; a standard door without acoustical gasketing can reduce the overall rating of the partition construction by 10 or more STC points. This is primarily due to door undercuts and air gaps between the frame and door which permit sound to “leak” through with minimal resistance. Such gaps must be acoustically sealed to reduce sound leakage. Sliding doors and frameless pivot doors typically permit even higher degrees of sound leakage and should be avoided for sound sensitive adjacencies as they generally do not accept seals other than the brush-type seals which are ineffective for sound reduction purposes.

As a result, lower degrees of acoustical separation should be expected at typical door locations. For spaces or areas where controlling sound transmission at the door condition will be important, placement and detailing of door constructions will require more careful consideration. The use of acoustically gasketed doors and/or full sound rated door packages may need to be considered at such locations. Double door ‘sound lock’ vestibule configurations can also offer a highly effective method for reducing sound transmission at door conditions.

Room Acoustics

Room acoustics refers to the shaping and finishes of a room as they affect sound. The standard metric for determining how “live” or “dead” a room behaves is called the Reverberation Time (RT). RT measures the time in seconds that it takes sound energy to decay by 60dB. It is officially measured as the decay time within the 500 Hz frequency band; however, it is important to consider reverberation times in other frequencies as well.

A room’s volume and interior finishes primarily control the degree of reverberation. Hard materials, such as gypsum board, glass, or concrete reflect sound, which increases reverberation time. The longer the reverberation time, the longer sound persists before dying out, and the more difficult speech intelligibility becomes. Adding sound absorptive materials can help to reduce reverberation times, mitigate the build-up of sound energy, control unwanted sound reflections, and/or permit good speech intelligibility to maintain environments that are comfortable and conducive to intended programmatic functions.

Noise Reduction Coefficient (NRC) is the standard metric used to rate the overall ability of finish materials to absorb sound reflections within the typical speech frequency range and is based on a scale of 0 to 1.00. A material with a 0 NRC reflects all sound energy which isn’t transmitted through it, while a material with 1.00 NRC rating absorbs 100% of the sound energy that isn’t transmitted through it.

Design Criteria

The table on the next page includes initially recommended Reverberation Time (RT) criteria and guidelines for acoustically sensitive spaces currently noted on the plans. Specific acoustical finish approaches to meet noted RT criteria and control sound reflections will require further review and coordination as the spaces are developed in more detail.

Lecture Space

Initial design considerations and guidelines regarding interior acoustical treatment approaches for the 1st floor lecture spaces are provided below. More specific comments and recommendations regarding acoustical finish approaches will be developed and coordinated as space designs and aesthetic intent is further refined.

- Incorporate angled ceiling surface or angled ceiling clouds above the lectern position composed of an acoustically reflective material such as gypsum board, wood, etc. Lower ceiling heights above the presenter position are acoustically preferable to increase the amount of early sound reflections at listener positions.

- Remaining ceiling areas above seating positions will likely need to be composed primarily of sound absorptive finish treatments.

Space	Reverberation Time (RT) Criteria	Comments
Large Lecture Space	≤ 0.7 seconds	See Section 4.2
Classroom Teaching	≤ 0.5 seconds	Acoustical ceiling finish with NRC ≥ 0.70
Private Office	≤ 0.6 seconds	Acoustical ceiling finish with NRC ≥ 0.70
Conference Room	≤ 0.7 seconds	Acoustical ceiling finish with NRC ≥ 0.80 Rooms supporting audio/video conferencing should ideally incorporate sound absorptive treatment on at least 2 non-parallel walls to improve speech intelligibility and audio quality for far-end participants
Research	≤ 1.0 seconds	Acoustical ceiling finish with NRC ≥ 0.70

- Sidewalls adjacent to the lectern position should also be composed of an acoustically reflective material and ideally splayed outward towards seating positions by least a few degrees to aid in natural sound projection and to prevent unwanted sound reflection patterns (e.g. flutter echo).

- Side-walls adjacent to seating areas may need to consider some degree of sound absorptive treatment to control Reverberation Time and sound reflections appropriately. Treatment is typically best located on the upper portions of wall, starting from approximate seated head height. Parallel wall surfaces with smooth, acoustically reflective finishes should be avoided throughout the seating areas.

- A majority of the rear wall should plan to receive a sound absorptive finish to minimize the potential for unwanted sound reflection patterns.

- Floor treatment typically has minimal impact in terms of controlling sound reflections within a space, however, carpeting can help be beneficial to reduce footfall circulation noise.

HVAC Noise Control

Noise and vibration produced by mechanical systems will need to be controlled to appropriate levels in terms of overall Noise Criteria (NC) ratings and devoid of any undesirable tonal sound qualities (e.g. whine, hum, or rumble) so that it does not interfere with speech intelligibility or acoustical comfort. NC is a standard, single number rating system developed by ASHRAE that is used to define maximum limits on background noise levels in occupied spaces due to the operation of building MEP systems. It is calculated by combining the weighted octave band noise levels based on the ear's sensitivity to the perceived loudness of sound energy across the audible spectrum.

The sections following include preliminary noise and vibration control criteria and design guidelines for HVAC systems serving acoustically sensitive spaces. Specific noise and vibration control approaches will be further reviewed and coordinated with the project team as the design is developed in more detail.

Design Criteria

Background Noise Criteria (NC) design goals, as produced by the normal operation of mechanical, electrical, and plumbing equipment, are initially recommended for spaces in the following table:

Space	Maximum Noise Criteria (NC)
Lecture Space	NC 30
Classroom Teaching Research Private Office	NC 35
Lobby Corridor Typical Lab	NC 40
Lab with Fume Hood Restroom	NC 45 to 50

General Noise Control Approach

The general noise control approach for HVAC equipment serving acoustically sensitive space types should be established early in the design process. SM&W has traditionally preferred the use of internal fibrous duct liner in supply and return ductwork for noise control of air handling equipment as it has proven effective in most applications, both in terms of cost and acoustical performance. However, per a review of the mechanical design narrative, it is noted that internal lining will only be provided 5 feet downstream of terminal devices serving non-laboratory spaces and similar areas where IAQ requirements are less stringent.

The primarily alternate means of mechanical noise control is using sound attenuators. Sound attenuators will impart more static pressure than duct lining, thereby reducing system efficiency and consuming more energy. Sound attenuators also require greater lengths of straight duct runs and larger ductwork sizes to avoid generating excessive turbulence induced noise. Leaving space for sound attenuators is advisable early in the HVAC design effort. Typical attenuators would be 3 to 5 feet in length and should be planned for the intake and discharge side of each air handling system. Ductwork prior to and following each attenuator should be straight and equal to a minimum of two duct diameters in length.

The chart on the next page is a generalized extent of sound attenuators for the project to be considered for layout and budget purposes. The type and performance will be verified during further design phases of the project.

Main Air Handling Equipment Noise Control

- There are several approaches for reducing noise produced by main air handling equipment that can be considered during the equipment selection process, which may reduce requirements for supplemental noise control provisions such as the following:
- Select the largest, lowest speed, "quietest" fans possible within mechanical and physical constraints.
- Select units with plenum or fan-wall type supply fans which tend to exhibit quieter noise output as compared to other fan types of similar capacity and speed.
- Provide variable speed fan controllers to ensure the lowest sound output at any given time.
- Casing panels of the air-handling unit should consider double wall perforated construction. The insulation may be encapsulated in a protective plastic liner if needed or desired for other non-acoustic reasons.
- Incorporate placeholders for 3 to 5 foot long sound attenuators within the AHU or in ductwork within the MER for the supply and return. Maintain at least 2 duct diameters of straight duct at the inlet and discharge side of each attenuator.
- Provide long runs of duct in mechanical or support spaces before entering occupied areas (dependent on fan operating conditions and type of occupied space,

System/Location	Attenuator Type	Length	Comment
AHU Intake	Film Lined	5 Foot	Positioned upstream of initial filters
AHU Discharge	Film Lined	5 Foot	Within AHU is preferred, but may be within main ductwork before leaving mechanical room
General Supply/ Exhaust Boxes	Film Lined	3 to 5 Foot	Sized for 800-1000 fpm
Hood and/or Special Exhaust Valves	No Media	3 to 5 Foot	Typically round no media; Sized for 1000+/- fpm

but 15 to 20 feet is typically a good base approach for noise control.

- Supply and return ductwork should be routed over the corridor when leaving the mechanical room, and not directly over acoustically sensitive spaces.

- Fresh air intake openings/louvers should be sized for a maximum of 500 fpm (net) air velocity.

- Air Intake/ exhaust / return air fans are recommended to be mixed flow type sized and selected for typical operation near 1000 rpm.

Laboratory Exhaust Fans

The primary acoustical issue associated with the laboratory exhaust fans is campus noise emissions. Typical exhaust fan systems used for laboratory facilities can generate a significant amount of exterior noise that could impact nearby outdoor areas or adjacent buildings on the campus without appropriate noise control provisions. Noise propagation back into the building can often be dissipated by heat recovery elements and the medium & low-pressure distribution ductwork. Initial noise and vibration control guidelines for planning purposes are as follows:

- Select oversized, lower speed fans to the degree possible (nominal 800 rpm).

- If possible, provide centrifugal type fans in lieu of axial fans to avoid the tonal 'whine' associated with axial flow fans that is often harder to control

- Provide manufacturer's discharge and radiated noise control packages. A third party discharge attenuator and/or sound barrier wall may be required depending on fan sizing

- Provide attenuation on the inlet plenum induced air opening(s), in the form of an attenuator and/or offset ductwork.

- Mount the fans on minimum 2 inch deflection vibration isolation springs.

- Locate fume-hood control valves over less sensitive lab areas such as storage spaces, lab prep rooms, etc. wherever possible.

Main Duct Velocities

When designing duct sizes, it is recommended to use the lowest possible air velocities consistent with air change requirements. The ASHRAE HVAC Applications Handbook lists maximum recommended air velocities in main ductwork based on duct construction and location as shown above.

All branch ducts off the main duct should have velocities that are a maximum of 80% of the velocities listed above. The velocities in the final runout ducts to outlet devices should be a maximum of 50% of the velocities in the table. Any diffusers/grilles should be selected to have an NC rating at least 5 points lower than target NC rating, per manufacturer performance tables.

Mechanical Noise Control Best Practices

- Do not locate any fans above spaces with a Noise Criteria of NC 35 or less. Instead, locate the units in corridors. If this is not possible, an acoustical enclosure or wrap may be required.

- If terminal units are used, it is recommended to use 'valve-only' VAV terminals as a basis of design as opposed to fan-powered boxes. If fan-powered

Main Duct Location	NC Design Criterion	Maximum Airflow Velocity (FPM)	
		Rectangular Duct	*Circular Duct*
In shaft, above drywall ceiling, below raised floor	45	3500	5000
	35	2500	3500
Above acoustic ceiling tile	45	2500	2800
	35	1700	3000
Exposed Duct in Occupied Space	45	2000	3900
	35	1450	2600

terminal units must be used, it is recommended to select series-flow boxes over parallel boxes. The intermittent operation of parallel box units is more perceptible from an acoustic standpoint. Individuals tend to be less sensitive to noise if it is at a constant level.

- Select air diffusers at least five points below the NC rating of the room they serve.
- Do not exceed 1" static pressure at VAV box inlets, if possible.
- Do not use rooftop "down discharge" air-handling units, if possible. Instead, use side discharge units. Noise mitigation of down discharge may be prohibitively complicated and expensive.
- Do not use face dampers. Locate volume dampers as far upstream from diffusers as possible, and at least 10 feet in room with NC criteria of NC 35 or less.
- Allow for at least 3' of insulated-type flexible ductwork, such as the Thermaflex M-KE, prior to each supply diffuser and return grille, where possible. The flexible ductwork should be free from duct configurations that constrict the airflow in any way.
- Ducts penetrating sound-rated wall, floor and ceiling assemblies should be insulated in a sleeve between independent construction elements. Ducts penetrating the building structure should have a clear distance of ½" around the perimeter. The perimeter void should be packed with glass fiber batts at both ends, and caulked airtight with a non-shrinking, non-hardening flexible acoustical sealant and a backer rod, if required.

Vibration Isolation

All rotating mechanical equipment and electrical equipment (transformers) are to be resiliently mounted to the building structure on appropriate vibration isolation devices and should generally comply with ASHRAE guidelines. Once the equipment selection and specification has been further developed, SM&W will provide a recommended vibration isolation schedule. Initial guidelines for vibration isolation are as follows:

- Locate major equipment on grade or near structural columns and above main girders. Support suspended equipment from major structural members. Avoid mid-span locations whenever possible.
- All rotating mechanical equipment and large piping to have some form of vibration isolation mounting. Exact requirements to be coordinated as equipment selections are developed.
- All piping connected to vibration-isolated equipment must be vibration-isolated from the building structure within mechanical rooms or for a distance of 50 feet from the equipment, whichever is greater.
- All ductwork is to be connected to units with flexible connections.

- All transformers are to be resiliently mounted or suspended from the building structure.

- Conduit connections to vibration-isolated equipment should include a 360-degree turn of flexible conduit.

- Allow 6-inch minimum clearance between any vibrating equipment and building structure.

- Provide adequate clearance under mechanical equipment for vibration isolators.

- Seismic restraints, if required on the project, are to be separate from vibration isolation devices and shall not degrade vibration isolation efficiency. Determining the requirements, detailing, and specification for seismic restraint is the responsibility of others.

Emergency Generator

Diesel engine generators, for use during emergency power outages only, normally do not require full acoustical isolation if they can be tested 'off-hours' or less during less sensitive times of the day when the building is not normally occupied. However, incorporating sound attenuators for the air intake/exhaust as well as a muffler for the hot-exhaust gas is often still a needed or beneficial consideration to limit the amount of exterior noise emissions.

More specific comments and recommendations will be developed as the mechanical design is further developed and sound data for the basis of design generator selection can be provided to SM&W for review.

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8 REGULATORY REQUIREMENTS

CODE ANALYSIS

Summary

The team analyzed the major code considerations for a new academic building with a large quantity of research and teaching laboratory space and determined that adopting 2018 International Codes would be most appropriate and allows the most flexibility in current and future modifications. The 5-story building, with a basement and mechanical penthouse, will be constructed with noncombustible materials to pursue Type IA construction.

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
JURISDICTION	State of Wisconsin	Milwaukee County	City of Milwaukee
APPLICABLE CODES	International Building Code (IBC) 2018, Wisconsin Department of Safety & Professional Services (SPS) Chapter 362		National Fire Protection Association (NFPA-1) 2018, International Code Council / American National Standards Institute ICC/ANSI A117.1 (2017), International Fire Code (IFC), ASTM International (ASTM) UL Underwriters Laboratory, International Mechanical Code (IMC)
CHAPTER 3: USE AND OCCUPANCY CLASSIFICATION			
PRIMARY USE	IBC (304.1)	Business Group B: (Educational occupancies above the 12th Grade)	Quantity of hazardous materials and flammable liquids to be limited to avoid H occupancies.
ACCESSORY USE	IBC (303.4) IBC (311.3)	Assembly Group A: A-3 Assembly (Lecture Halls)	Quantity of hazardous materials and flammable liquids to be limited to avoid H occupancies. Verify lecture halls don't exceed 10% of the bldg area per floor
HAZARDOUS MATERIALS	IBC (307.1.1)	Hazardous materials in any quantity shall conform with IBC 307, Section 414, and IFC.	Quantity of hazardous materials and flammable liquids to be limited to avoid H occupancies.
CHAPTER 4: SPECIAL DETAILED REQUIREMENTS BASED ON USE AND OCCUPANCY			
ATRIUMS	IBC (404)	Atrium spaces shall be separated by a 1 hr rated fire barrier Travel distance at the main floor of the atrium shall not exceed 200 ft	
CHAPTER 5: BUILDING HEIGHTS AND AREA LIMITATIONS			
GENERAL	IBC (503.1)	The building heights and areas shall not exceed the limits specified in Table 503 based on Type of Construction determined by Section 602 and the occupancies determined by Section 302.	
ALLOWABLE BUILDING HEIGHTS AND AREAS CONSTRUCTION TYPE & ALLOWABLE AREA	IBC (Table 503) IBC (504)	Construction Type IA with a group B allows unlimited height and unlimited area.	Program area = 159,220 gsf (5) stories with mechanical penthouse
INCIDENTAL ACCESSORY OCCUPANCIES	IBC (Table 508.4)	Incidental accessory occupancies shall be separated from the remainder of the building, or be equipped with automatic fire-extinguishing system, or both per table 508.4. Where sprinkler and no fire partition are allowed walls must be smoke barriers	Verify separation required for furnace room, boilers, laboratories, battery systems, or fire pump rooms, etc. (Storage rooms over 100 sq ft, Refuse rooms over 100 sq ft, Mechanical room w/ +400,000 BTU/Hr input require 1 hour rated separation)
CHAPTER 6: TYPES OF CONSTRUCTIOIN			
CONSTRUCTION CLASSIFICATION	IBC (602.2)	Type IA (rated) - Noncombustible (Highest class)	This will allow the greatest flexability with any future additions to this building.
FIRE-RESISTANCE RATING FOR BUILDING ELEMENTS	IBC (Table 601)	Structural Frame = 3a hours Bearing Walls - Exterior = 3 hours Bearing Walls - Interior = 3a hours Nonbearing Walls - Exterior = (See Table 602) Nonbearing Walls - Interior = 0 hours Floor Construction = 2 hours Roof Construction & Secondary Members = 1 1/2b	a. If only supporting a roof, permitted to be reduced by 1 hour b. Except in Group H, M, S-1 & F-1 occupancies
FIRE-RESISTANCE RATING REQUIREMENTS FOR EXTERIOR WALLLS BASED ON FIRE SEPARATION DISTANCE	IBC (Table 602)	Less than 5' = 1 hour Greater than or equal to 5' but less then 10' = 1 hour Greater than or equal to 10' but less then 30' = 1 hour Greater than or equal to 30' = 0 hours	(See section 706.1.1 for party walls)

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
COMBUSTIBLE MATERIAL IN TYPE I AND TYPE II CONSTRUCTION	IBC (603.1) Allowable materials	Combustible materials shall be permitted in building Type I and II construction in accordance with Sections 603.1.1 - 603.1.3.	Verify no fire-retardant-treated wood or thermal or acoustical insulation, other than foam plastics, having a flame spread index of not more than 25 exist. Exception: insulation placed between two layers of noncombustible materials without intervening airspace is allowed to have a flame spread index of not more than 100
CHAPTER 7: FIRE AND SMOKE PROTECTION FEATURES			
MAXIMUM AREA OR EXTERIOR WALL OPENINGS BASED ON FIRE SEPARATION DISTANCE AND DEGREE OF OPENING PROTECTION	IBC (Table 705.8)	Fire Separation - Opening & Protection = Allowable area 0 < 3' b,c - unprotected, sprinklered = Not permitted 3' to < 5' d,e - (UP, S) = 15% 5' to < 10' e,f - unprotected, sprinklered = 25% 10' to < 15'e,f,g - unprotected, sprinklered = 45% 15' to < 20' f,g - unprotected, sprinklered = 75% 20' to < 25 'f,g - unprotected, sprinklered = No Limit 25' to < 30'f,g - unprotected, sprinklered = No Limit 30' or > - unprotected, sprinklered = No Limit	b. Section 706.6.1 for different height fire walls c. Section 706.8 for openings in fire wall for buildings on the same lot. e. Unprotected openings not permitted for fire separation distances less then 15' in Group H-2 or H-3 f. Area of unprotected and protected not limited in Group R-3 with fire separation 5' or greater g. Area of openings in an open parking structure with a fire separation distance of 10' or greater shall not be limited. (705.8.1) In other than H occupancy unlimited unprotected openings on first floor allowed where wall faces a street and fire separation is greater than 15 ft or next to a 30 ft wide unoccupied space with access from a street to a posted fire lane
VERTICLE SEPARATION OF OPENINGS	IBC (705.8.5)	Openings in exterior walls in adjacent stories shall be separated vertically to protect against fire spread on exterior of buildings where the openings are within 5' of each other horizontally and the opening in the lower story is not a protected opening with a fire protection rating of not less than 3/4 hour. Such openings must be separated vertically by at least 3' by assemblies with a fire resistance rating of at least 1 hour or by 1 hour rated flame barriers that extend horizontally at least 30" beyond the exterior wall.	Exception 2: This section shall not apply to buildings equipped throughout with automatic sprinkler system in accordance with Sections 903.3.1.1 or 903.3.1.2.
FIRE WALLS - GENERAL	IBC (706.1)	Each portion of a building separated by one or more fire walls that comply with the provisions of Section 706 shall be considered separate buildings.	Unlimited area buildings will not require fire walls
FIRE BARRIERS	IBC (707), IBC (Table 707.3.10)	Fire barriers or horizontal assemblies separating a single occupancy into different fire areas shall comply with Table 707.3.10.	Fire-resistance rating requirements for fire barrier assemblies or horizontal assemblies between fire areas for Group B = 2 hours.
CONTINUITY	IBC (707.5)	Fire barriers shall extend from the top of the foundation or floor/ceiling assembly below to the underside of floor or roof sheathing, slab, or deck above and shall be securely attached thereto. Continuous through concealed spaces, such as above suspended ceilings.	
SHAFT ENCLOSURES - GENERAL	IBC (713.1)	Shafts required to protect openings and penetrations through floor/ceiling and roof/ceiling assemblies shall be constructed as fire barriers per Section 707 or horizontal assemblies per Section 711, or both.	
FIRE RESISTANCE RATING	IBC (713.4)	Shaft enclosures shall have a fire- resistance rating of not less than 2 hours where connecting four or more stories and not less than 1 hour where connecting less than four stories (including basements). The rating shall not be less than the floor assembly penetrated, but need not exceed 2 hours and shall meet Section 703.2.1 requirements.	Floor assembly is required to be 2 hour, therefore shaft enclosures must be 2 hour.

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
FIRE PARTITIONS - FIRE RESISTANCE RATING	IBC (708.3)	Fire partitions shall have a fire-resistance rating of not less than 1 hour.	Exception 1: Corridor walls permitted to have a 1/2 hour fire-resistance rating per Table 1020.1.
SMOKE BARRIERS	IBC (709)	Continuity = wall to wall/ floor to ceiling 1 hr fire resistance rating is required for smoke barriers	Openings shall be protected in accordance with section 716. Penetrations shall comply with section 714.
SMOKE PARTITIONS	IBC (710)	Not required to have a fire-resistance rating unless specified elsewhere in the code	
FLOOR AND ROOF ASSEMBLIES	IBC (711)	Rating of floor and roof assemblies shall not be less than that required by the building type and type of construction	(711.2.2) Continuity - Shall be continuous without openings except where permitted in section 711 and 712.
PENETRATIONS - SCOPE	IBC (714.1)	This section governs the materials and methods of construction used to protect through penetrations and membrane penetrations of horizontal assemblies and fire-resistance-rated wall assemblies.	
THROUGH-PENETRATION FIRESTOP SYSTEM	IBC (714.5.1.2)	Through penetrations shall be protected by an approved through-penetration firestop system.	System shall be installed and tested per ASTM E 814 or UL 1479 with a min. positive pressure differential of .01” of water and a F rating of not less than than required of the floor penetrated.
MEMBRANE PENETRATIONS	IBC (714.5.2)	Penetrations of membranes that are part of a horizontal assembly shall comply with Section 714.5.1.1 or 714.5.1.2. Where floor/ceiling assemblies are required to have a fire-resistance rating, recessed fixtures shall be installed such that the required fire resistance will not be reduced.	
DISSIMILAR MATERIALS	IBC (714.5.3)	Noncombustible penetrating items shall not connect to combustible materials beyond the point of firestopping, unless fire-resistance of assembly can be maintained.	
PENETRATIONS IN SMOKE BARRIERS	IBC (714.5.4)	Penetrations in smoke barriers shall be tested per the requirements of UL 1479 for air leakage.	
FIRE-RESISTANT JOINT SYSTEMS	IBC (715)	Joints installed in fire resistance rated walls or floors/ceilings and roofs shall be designed to resist the passage of fire for a time period not less than the rating of the wall, floor or roof it is installed in	
OPENING PROTECTIVES FIRE DOOR AND SHUTTER ASSEMBLIES	IBC (716) (Table 716.1)	Approved fire door and fire shutter assemblies shall be constructed of materials that conform to the test requirements of sections 715.4.1 - 715.4.3, Table 715.4, and NFPA 80.	Doors in 4-hour walls: 3-hour rated Doors in 3-hour walls: 3-hour rated Doors in 2-hour walls: 1 1/2-hour rated Doors in 1-hour shaft and exit enclosure walls: 1-hour rated Other 1-hour fire barriers: 3/4-hour rated Doors in fire partition: .5 to 1-hour corridors walls: 1/3- hour rated Doors in 2 to 3-hour exterior walls: 1 1/2-hour rated Doors in 1-hour exterior walls: 3/4-hour rated Doors in 1-hour smoke barriers: 1/3-hour rated
GLAZING IN DOOR ASSEMBLIES	IBC (716.2.5.2)	In 20 minute fire door assembly, the glazing in door shall have a min. 20 minute fire rating. (exempt from hose stream test) Other glazing areas shall be tested per NFPA 257 or UL 9 and hose stream test.	
GLAZING IN DOORS	IBC (716.2.2.3.1), (716.2.2.3)	Fire-protection-rated glazing in excess of 100 square inches is permitted when tested as a door component and not a glass light. Maximum transmitted temp rise of 450 degrees F.	Exception: Max transmitted temp rise not required with automatic sprinkler system.

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
FIRE DOOR FRAMES WITH TRANSOM LIGHTS AND SIDELIGHTS	IBC (716.2.5.4)	Door frames with transom lights, sidelights, or both shall be permitted where a 3/4 hour fire protection rating or less is required and in 2-hour fire-resistance-rated exterior walls in accordance with Table 716.1. Fire door frames with transom lights, sidelights, or both, installed with fire-resistance-rated glazing tested as an assembly in accordance with ASTM E119 or UL 263 shall be permitted where a fire protection rating exceeding 3/4 hour is required in accordance with Table 716.1.	
FIRE DOOR LABELING REQUIREMENTS	IBC (716.2.9.4)	Fire doors shall be labeled showing name of manufacturer, third party inpection agency, and protection rating	
FIRE WINDOW ASSEMBLIES PERFORMANCE REQUIREMENTS	IBC (716.3.2)	Fire window assemblies shall be installed in the assemblies and comply with the fire proteciton rating specified in Table 716.1.	716.3.4.1 Glass and Glazing - glazing in fire doors shall comply with size limitations of NFPA 80 Exceptions: 1. Fire protection rated glazing in fire doors in a horizontal exit are permitted to have a vision panel of not more than 100 square inches with no dimension exceeding 10 inches. 2. Fire protection rated glazing shall not be installed in doors having 1 1/2 hour rating in a fire barrier
DOOR CLOSING	IBC (716.2.6)	Fire doors shall be latching and self- or autmotaic-closing in accordance with this section.	Exception 2: Elevator car doos and the associated hoistway enclosure doors at the floor level designated for recall in accordance with Seciton 3003.2 shall be permitted to remain open during Phase I emergency recall operation
SMOKE-ACTIVATED DOORS	IBC (716.2.6.6)	Automatic-closing doors by actuation of smoke detectors per Section 907.3 or by loss of power shall not have more than a 10 second delay.	Requirements for door installed: 1) In walls that separate incidental uses in accordance with Section 509.4, 2) In fire walls in accordance with Section 706.8, 3) in fire barriers per Section 707.6, 4) In fire partitions per 708.6, 5) In smoke barriers in accordance with Section 709.5, 6) In smoke partitions per 710.5.2.3, 7) In Shafts enclosures per 713.7
FIRE-PROTECTION-RATED GLAZING	IBC (715.5)	Glazing in fire window assemblies shall be rated in accordance with section and table 716.1. Opening in nonfire-resistance-rated exterior walls that require protection by section 705.3, 705.8, 705.8.5 or 705.8.6 shall have a fire-protection rating of not less than 3/4 hour Fire-protection-rated glazing in 1/2 hour rated partitions are permitted to have .33 hour (20 minute) protection rating	Interior walls: Fire Walls - All ratings - Not Permitted (except as specified in Section 715.2) Fire Barriers - > 1 hr = Not Permitted; 1 hr = 3/4 hour window assembly Smoke Barriers - 1 hour = 3/4 hour window assembly Fire Partitions - 1 hour = 3/4 hour window assembly; 1/2 hour = 1/3 hour window assembly Exterior Walls: > 1 hour = 1 1/2 hour window assembly; 1 hour = 3/4 hour window assembly
DUCTS AND AIR TRANSFER OPENINGS	IBC (717.1.1)	Penetrations of fire-resistance-rated walls by ducts that are not protected with dampers shall comply with Sections 714.3 - 714.4.3.	Duct and air transfer openings that are protected with dampers shall comply with Section 717.
FIRE DAMPERS - WHERE REQUIRED	IBC (716.5) (716.5.1) (716.5.2) (716.5.3)	Required for duct penetrations of fire walls (horizontal exits) fire barriers, and shaft enclosures,.	(716.5.2) Exception 3: Not required in 1-hour fire rated barriers (716.5.3) Exception 1: Not required at shaft penetrations where steel exhaust subducts extend at least 22"" vertically in exhaust shafts provided there is a continuous airflow upward to outside.
SMOKE DAMPERS - HORIZONTAL EXITS	IBC (716.5.1.1) (716.5.2.1)	A listed smoke damper designed to resist the passage of smoke shall be provided at each point a duct or air transfer opening penetrates a fire wall or fire barrier that serves a horizontal exit.	Not required at duct penetrations of shaft enclosures.

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
CONCEALED SPACES & COMBUSTIBLE MATERIALS IN CONCEALED SPACES IN TYPE I & TYPE II CONSTRUCTION	IBC (718.2 & 718.3) (718.5) (805)	Refer to Section 717.2 for Fireblocking requirements and Section 717.3 for Draftstopping requirements. The permitted use of combustible materials in concealed spaces of buildings of Type I or II construction shall be limited to the applications indicated in Section 718.5.	Exceptions; 1) Per Section 603, 2) In plenums per Section 602, 3)Class A interior finishes per Section 803, 4) Combustible piping in partitions or shafts enclosures, 5) Combustible piping in concealed ceiling spaces, 6) Combustible insulation & pipe covering in concealed spaces other than plenums per 720.7.
THERMAL AND SOUND INSULATION MATERIALS	IBC (720.3 & 720.7)	Exposed insulating material and coverings on pipe and tubing shall have a flame spread index of not more than 25 and a smoke index of not more than 450 and shall comply with all IMC requirements.	
PRESCRIPTIVE FIRE RESISTANCE	IBC (721) (Table 721.1(1)	In accordance with Table 721.1(1) Structural parts to be protected: All steel framing minimum thickness should be that which provides a 4 hour fire-resistance.	
CHAPTER 8: INTERIOR FINISHES			
INTERIOR WALL AND CEILING FINISHES	IBC (803.1.1) (Table 803.13)	ASTM E 84 or UL 723 material classifications: Class A: Flame spread index 0-25; Smoke index 0-450 Class B: Flame spread 26-75; Smoke 0-450 Class C: Flame spread 76-200; Smoke 0-450	Group A-3: Sprinklered - Exit enclosure and exit passageway = B, Corridors = B, Rooms and Enclosed spaces = C Group B: Sprinklered - Exit enclosure and exit passageway = B, Corridors = C, Rooms and Enclosed spaces = C
CHAPTER 9: FIRE PROTECTIVE SYSTEMS			
AUTOMATIC SPRINKLER SYSTEM	IBC (903) (903.2.1.3) (903.2.10) (903.2.11.4)	Group A-3: An automatic sprinkler system shall be installed where: 1) Fire area exceeds 12,000 sf 2) Fire area has an occupant load of 300+ 3) Fire area not on the level of discharge serving occupants Ducts conveying hazardous exhausts - Where required by IMC automatic sprinklers shall be provided in ducts larger than 10 inches in diameter conveying hazardous, flammable or combusitble materials	
ADDITIONAL REQUIRED SUPPRESSION SYSTEM	IBC (Table 903.2.11.6)	For Additional Required Suppression Systems refer to Sections: (507) for Unlimited area buildings, (509.4) for Incidental accessory occupancies)	No additional requirements for unlimited area building
STANDPIPE SYSTEMS - GENERAL	IBC (905.3.1)	Standpipe systems shall be installed where required per Sections 905.3.1 - 905.3.7 and in locations per Sections 905.4 -905.6. They can be combined with automatic sprinkler systems.	(905.4) Class I standpipe required in every required stairway with hose connections at every level and intermediate landing unless otherwise approved by fire code official Locate on each side of the wall adjacent to the exit opening of a horizontal exit; and in every exit passage. Exception: not required within 30 ft of 100 ft hose attached to the hose connection of an exit
HEIGHT	IBC (905.3.1)	Class III standpipe systems shall be installed where the floor level of the highest story is located more than 30 feet above the lowest level of fire department vehicle access.	Refer to Exceptions: 1) Class I standpipes are allowed in buildings with automatic sprinkler systems. Installation shall comply with NFPA 14 and locations per Section 905.4. 2) Class I standpipes are allowed in Group B and E occupancies. 3) Class I standpipes are allowed in basements equipped throughout with
PORTABLE FIRE EXTINGUISHERS	IBC (906)	Portable fire extinguishers shall be installed and maintained per this section and NFPA 10.	Install per Table (906.3(1)); max floor area per extinguisher 11,250 sf; max travel distance = 75ft
FIRE ALARM AND DETECTION SYSTEMS	IBC (907.2)	An approved fire alarm system installed per this code and per NFPA 72 shall be provided.	

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
GROUP A	IBC (907.2.1)	A manual fire alarm system that activates the occupant notification system in accordance with Section 907.5 shall be installed in Group A occupancies having an occupant load of 300 or more, or where the Group A occupant load is more than 100 persons above or below the lowest level of exit discharge.	Exception: Not required where the buildings equipped throughout with automatic sprinkler system in accordance with Sections 903.3.1.1 and the occupant notification appliance will activate in the zone upon waterflow.
GROUP B	IBC (907.2.2)	A manual fire alarm system shall be installed in Group B where one of the follow exists: 1) The combined Group B occupant load of all floors is 500 or more, 2) The Group B occupant load is more than 100 persons above or below the lowest level of exit discharge., 3) area contains ambulatory health care.	Exception: Not required where the buildings equipped throughout with automatic sprinkler system in accordance with Sections 903.3.1.1 and the occupant notification appliance will activate in the zone upon waterflow.
VISIBLE ALARMS	IBC (907.5.2.3)	Visible alarm notification appliances shall be provided in all public and common areas and in employee work areas that have audible alarm coverage	
FIRE DEPARTMENT CONNECTIONS	IBC (912.1)	Fire department connections shall be installed per NFPA standards applicable to the system design and per Sections 912.2 - 912.6 in a location on the street side of the building and approved by the fire code official.	
FIRE PUMPS	IBC (913.1)	Where provided fire pumps shall be installed per NFPA 20 and this section.	Fire-resistance rating of fire pump room is 1 hour for floors and ceiling where building is sprinkled
EMERGENCY RESPONDER SAFETY FEATURES -	IBC (914.1)	Vertical shafts shall be identified per Sections 914.1.1 - 914.1.2.	Verify all shaftways exterior or interior are labeled "SHAFTWAY" per requirements of this section.
MASS NOTIFICATION SYSTEMS	IBC (917.1)	Prior to construction of a new building requiring a fire alarm system on a multiple-building college or university campus having a cumulative building occupant load of 1,000 or more, a mass notification risk analysis shall be conducted in accordance with NFPA 72. Where the risk analysis determines a need for mass notification, an approved mass notification system shall be provided in accordance	
EMERGENCY RESPONDER RADIO COVERAGE	IBC (918.1)	Emergency responder radio coverage shall be provided in all new buildings per Section 510 and the IFC.	Provide radio coverage as required.
CHAPTER 10: MEANS OF EGRESS			
DESIGN OCCUPANT LOAD	IBC (1004.1)	In determining means of egress requirements, the number of occupants for whom means of egress facilities shall be provided shall be determined in accordance with this section. Where occupants from accessory areas egress through a primary space, the calculated occupant load for the primary space shall include the total occupant load of the primary space plus the number of occupants egressing through it from the accessory area.	

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
EGRESS WIDTH MINIMUM REQUIRED EGRESS WIDTH	IBC (1005.1)	The means of egress width shall not be less than required by this section. The total width of means of egress in inches shall not be less than the total occupant load served by the means of egress multiplied by 0.3 inch per occupant for stairways and by 0.2 inch per occupant for other egress components. The width shall not be less than specified elsewhere in this code. Multiple means of egress shall be sized such that the loss of any one means of egress shall not reduce the available capacity to less than 50 percent of the required capacity. The maximum capacity required from any story of a building shall be maintained to the termination of the means of egress. Exit capacity shall not decrease in the direction of egress travel.	
DOOR (WIDTHS) AND DOOR HARDWARE ENCROACHMENT	IBC (1005.2 - 1005.3)	Doors, when fully opened, and handrails shall not reduce the required means of egress width by more than 7 inches. Doors in any position shall not reduce the required width by more than one-half. Surface-mounted latch release hardware shall be exempt from inclusion in the 7-inch max. rule when: 1. The hardware is mounted to the side of the door facing the corridor width when the door is in the open position; and 2. The hardware is mounted not less than 34 inches or more than 48 inches above the finished floor.	
MEANS OF EGRESS ILLUMINATION	IBC (1008.1) (1008.4)	The means of egress, including the exit discharge, shall be illuminated at all times the building space served by the means of egress is occupied. Provide 1 foot candle at walking surface and a maximum-to-minimum illumination uniformity ratio of 40 to 1 shall not be exceeded.	Emergency power system to provide power for not less than 90 minutes
ACCESSIBLE MEANS OF EGRESS	IBC (1009.1)	Accessible spaces shall be provided with not less than one accessible means of egress. Where more than one means of egress are required by Section 1006.1 or 1006.2 from any accessible space, each accessible portion of the space shall be served by not less than two accessible means of egress.	Exceptions: 1. In assembly areas with sloped or stepped aisles, one accessible means of egress is permitted where the common path of travel is accessible and meets the requirements of section 1029.8
ELEVATORS REQUIRED	IBC (1009.2.1)	In buildings where a required accessible floor is four or more stories above or below a level of exit discharge, at least one required accessible means of egress shall be an elevator	Exceptions: 1. In buildings with an auotmatic sprinkler system an elevator is not required on floors provided with a horizontal exit and located at or above the levels of exit discharge. 2.In buildings with an auotmatic sprinkler system an elevator is not required on floors provided with a ramp conforming to section 1012.
CONTINUITY AND COMPONENTS	IBC (1009.2)	Each required accessible means of egress shall be continuous to a public way.	
STAIRWAYS	IBC (1011.1)	In order to be considered part of an accessible means of egress, an exit access stairway shall have a clear width of 48 inches minimum between handrails and shall either incorporate an area of refuge within an enlarged floor-level landing or shall be accessed from either an area of refuge or a horizontal exit.	Required stair width of 48 inches and area of refuge is exempt with an automatic sprinkler system, but may want to considered for design of the facility.
DOORS, GATES, AND TURNSTILES SIZE OF DOOR	IBC (1010.1.1)	32" minimum clear width & 48" maximum single door leaf	36" recommended for wheelchair use
DOOR SWING	IBC (1010.1.2) (1010.1.2.1)	Doors shall swing in the direction of egress travel where serving an occupant load of 50 or more persons or a Group H occupancy.	

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
LOCKING ARRANGEMENTS IN EDUCATIONAL OCCUPANCIES	IBC (1010.1.4.4)	In Group E and Group B educational occupancies, egress doors from classrooms, offices, and other occupied rooms shall be permitted to be provided with locking arrangements designed to keep intruders from entering the room where all of the following conditions are met: 1) The door shall be capable of being unlockced from outside the room with a key or other approved means, 2) The door shall be openable from within the room in accordance with Section 1010.1.9., 3) Modifications shall not be made to listed panic hardware, fire door hardware or closers.	Remote operation of locks complying with 1010.4.4 shall be permitted.
LANDINGS AT DOORS	IBC (1010.1.6)	Landings shall have a width of not less than the width of the stairway or the door. Doors in the fully open position shall not reduce the required dimension by more than 7". When a landing serves an occupant load of 50 or more a door in any position shall not reduce the width by more than half. Landings shall be a minimum of 44"	Stairs and landings a minimum of 44"
HARDWARE	IBC (1010.1.9.1)	Door handles, pulls, latches, locks and other operating devices on doors shall not require tight grasp, pinching, or twisting of the wrist to operate.	
HARDWARE HEIGHT	IBC (1010.1.9.2)	Door handles, pulls, latches, locks and other operating devices shall be installed 34 inches minimum and 48 inches maximum above the finished floor.	
STAIRWAY DOORS	IBC (1010.1.9.12)	Interior stairway means of egress doors shall be operable from both sides without the use of a key or special knowledge or effort.	
PANIC & FIRE EXIT HARDWARE	IBC (1010.1.10)	Doors serving a Group H occupancy and doors serving rooms or spaces with an occupant load of 50 or more in a Group A or E occupancy shall not be provided with a latch or lock unless it is panic hardware or fire exit hardware.	
STAIRWAY WIDTH	IBC (1011.1)	Stairways serving 50 or more occupants are required to be a minimum of 44"" wide, an occupant load of less than 50 shall have a width of not less than 36 inches. Also see Sections 1005.1 and 1007.3	
HEADROOM	IBC (1011.2)	Stairways shall have a minimum headroom clearance of 80 inches measured vertically from a line connecting the edge of the nosings.	
RISER HEIGHT AND TREAD DEPTH	IBC (1011.5.2)	Stair riser heights shall be 7 inches maximum and 4 inches minimum. Tread depth shall be a minimum of 11"	Exceptions: Ships ladders, alternating tread devices, spiral stairs, and aisle stairs

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
STAIRWAY LANDINGS	IBC (1011.6)	There shall be a floor or landing at the top and bottom of each stair. Landings shall have a width of not less than the width of the stairway they serve. Every landing shall have a minimum dimension measured in the direction of travel equal to the width of the stair or 48", whichever is less. Doors opening onto a landing shall not reduce the landing to less than one-half the required width. Doors in the fully open position shall not reduce the required dimension by more than 7".	
STAIRWAY CONSTRUCTION	IBC (1011.7)	Stairways shall be built of materials consistent with the types permitted for the type of construction of the building, except that wood handrails shall be permitted for all types of construction.	
ENCLOSURE UNDER STAIR	IBC (1011.7.3)	The walls and soffits within enclosed usable spaces under enclosed and unenclosed stairways shall be protected by 1-hour fire-resistance-rated construction or the fire-resistance rating of the stairway enclosure, whichever is greater. Access to the enclosed space shall not be directly from within the stair enclosure.	2 hour rated enclosure required
VERTICAL RISE	IBC (1011.8)	A flight of stairs shall not have a vertical rise greater than 12 ft between floor levels or landings	Exceptions: Aisle Stairs or alternating tread devices
HANDRAILS	IBC (1011.11) (1014.6) (1014.3) (1024.7) (1014.3) (1014.7)	Stairways shall have handrails on each side. Where handrails are not continuous between flights, the handrails shall extend horizontally at least 12 inches beyond the top riser and continue to slope for the depth of one tread beyond the bottom riser. A stairway in an exit enclosure shall not continue below its level of exit discharge unless an approved barrier is provided at the level of exit discharge to prevent persons from unintentionally continuing into levels below. Directional exit signs shall be provided.	Height (1014.2) measured above stair tread nosing shall be not less than 34" and not more than 38"
ROOF ACCESS	IBC (1011.12.2) (1011.13)	In buildings without an occupied roof, access to the roof shall be permitted to be a roof hatch or trap door not less than 16 square feet in area and having a minimum dimension of 2 feet. Buildings four or more stories require a stair to the roof. Provide protection if within 10 feet of roof edge.	
STAIRWAY TO ROOF	IBC (1011.12)	In buildings four or more stories above grade plane, one stairway shall extend to the roof surface. Where a stairway is provided to the roof, access to the roof shall be through a penthouse complying with 1510.2	

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
RAMPS	IBC 1012	Ramps used as a means of egress shall have a running slope not steeper than 1:12, other pedestrian ramps can be 1:8 Vertical Rise: Maximum rise = 30" Width: Min width = 36" or that required for corridors Landings shall be provided at the top and bottom min width shall be as wide as the widest ramp run, length to be 60"" except as not part of an accessible means of egress length can be 48" Where ramp changes direction, landing shall be 60"x60"	
EXIT SIGNS	IBC (1013.1) (1013.3)	Required indicating the direction of egress travel for rooms and areas that require more than one exit access. No point in exit access corridor shall be more than 100' from visible exit sign. Signs shall be provided adjacent to each door to an egress stairway.	
GUARDS	IBC (1015.2) (1015.3)	Guards shall be located along open-sided walking surfaces, mezzanines, platforms, stairs, ramps and landings that are located more than 30 inches measured vertically to the floor or grade below at any point within 36 inches horizontally to the edge of the open side. Guards shall also be located where mechanical equipment or roof hatches are within 10ft of the roof edge	Guards shall be not less than 42 inches in height.
EXIT ACCESS - EGRESS THROUGH INTERVENING SPACES	IBC (1016.2)	Egress from a room or space shall not pass through adjoining or intervening rooms or areas, except where such adjoining rooms or areas and the area served are accessory to one or the other, are not a Group H occupancy and provide a discernible path of egress travel to an exit.	Exception: Means of egress are not prohibited through adjoining or intervening rooms or spaces in a Group H, S or F occupancy when the adjoining or intervening rooms or spaces are the same or a lesser hazard occupancy group.
TWO EXIT AND EXIT ACCESS DOORWAYS	IBC (1007.1.1) (1006.2.2.1)	Where two exits or exit access doorways are required from any portion of the exit access, the exit doors or exit access doorways shall be placed a distance apart equal to not less than one-half of the length of the maximum overall diagonal dimension of the building or area to be served measured in a straight line between exit doors or exit access doorways. Two exits are required in boiler and furnace rooms where the area exceeds 500sf and any fiel fired equipment exceeds 400,000 BTU's	Where a building is equipped throughout with an automatic sprinkler system the separation distance of the exit doors or exit access doorways shall not be less than one-third of the length of the maximum overall diagonal dimension of the area served.
EXIT TRAVEL DISTANCE	IBC (Table 1017.2)	The maximum travel distance to an exit (exterior exit, enclosed stairway, or horizontal exit) is 250 feet (A-3 Occupancy), with 300 feet permitted (B Occupancy) with a sprinkler system.	
CONSTRUCTION	IBC (1020.1) (708.1)	The corridor walls required to be fire- resistance rated unless an automatic sprinkler system is installed.	Greater than 30 than no rating required with an automatic sprinkler system installed.
CORRIDOR WIDTH OR EXIT PASSAGEWAYS	IBC (1020.2)	The minimum corridor width shall be as determined in Section 1005.1 , but not less than 44 inches.	Exception: May be reduced to 36 if serving 50 or fewer occupants.

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
DEAD ENDS	IBC (1020.4)	The dead end in a corridor shall not exceed 50 feet with automatic sprinkler system. A dead-end corridor shall not be limited in length where the length of the dead-end corridor is less than 2.5 times the least width of the dead-end corridor.	
NUMBER OF EXITS AND CONTINUITY	IBC (Table 1006.3.3)	Stories with one exit allowed for B occupancies not exceeding 49 occupants and 75' travel distance for the first story and basement and 29 occupants and 75' travel distance for the second story.	
EXIT ENCLOSURES	IBC (1023.2)	Exit enclosures shall have a fire- resistance rating of not less than 2 hours where connecting four stories or more and not less than 1 hour where connecting less than four stories, but shall not have a rating of less than the floor it is penetrating.	A shaft enclosure is not required with sprinkler system for a stairway that is not a means of egress. Exception 2: The section shall not apply to buildings equipped throughout with automatic sprinkler system in accordance with Sections 903.3.1.1 for stairway that is not a portion for the means of egress and where the floor area does not exceed twice the horizontal projected area of stair and is protected by draft curtain and NFPA 13 approved sprinklers.
EXIT ENCLOSURE EXTERIOR WALLS	IBC (1023.7)	Exterior walls of an exit enclosure shall comply with the requirements of section 705. Where nonrated walls or unprotected openings enclose the exterior of the stiarway and the walls or openings are exposed by other parts of the building at an angle less than 180 degrees the the building exterior walls within 10 ft horizontally shall have a fire resistance rating of not less than 1 hour, and any openings in that wall shall be 3/4 hour	
REDUCED VERTICAL CLEARANCE AND PROTRUSION LIMITS.	ICC/ANSI A117.1 (307.2) (307.4)	Guardrails or other barriers shall be provided where object protrusion is beyond 4" max. and greater than 27" and not more than 80 inches above floor.	Provide guardrails or barriers at 27" max. above floor where required.
DISCHARGE IDENTIFICATION	IBC (1023.8) (1023.8.1)	A stairway in an exit enclosure shall not continue below its level of exit discharge unless an approved barrier is provided at the level of exit discharge to prevent persons from unintentionally continuing into levels below. Signage shall be provided per Section 1023.8.1.	Provide barriers and signage at the level of discharge as required.
HORIZONTAL EXITS	IBC (1026)	Horizontal exits serving as an exit in a means of egress system shall comply with the requirements of this section. A horizontal exit shall not serve as the only exit from a portion of a building, and where two or more exits are required, not more than one-half of the total number of exits or total exit width shall be	
EXIT DISCHARGE	IBC (1028)	Exits shall discharge directly to the exterior of the building. The exit discharge shall be at grade or shall provide direct access to grade. The exit discharge shall not reenter a building. The combined use of Exceptions 1 and 2 below shall not exceed 50 percent of the number and capacity of the required exits.	A maximum of 50 percent of the number and capacity of the exit enclosures is permitted to egress through a vestibule or areas on the level of discharge provided all of the Section 1028.1 sub-requirements are met.
ASSEMBLY	IBC (1029)	Width of means of egress = .3"" for each occupant Travel Distance = 250 ft in sprinkled building Common Path of Egress = 30 ft from any seat Minimum Aisle Width = 48"" for aisles with seats on both sides	

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
CHAPTER 16: STRUCTURAL DESIGN			
LIVE LOAD CAPACITY	IBC 1607.3	Structure to be designed to meet the live loads noted below: Current IBC Load Requirements are: Classroom = 40 psf Office = 50 psf Corridors, Lobbies = 80 psf upper floors, 100 psf first floor Stairs = 100 psf Partitions = 15 psf Promenade = 60 psf Library Stack Rooms = 150 psf Laboratory = 100psf or greater Roof = 20 psf	
SNOW LOAD CAPACITY	ASCE 7-05 Section 7.7 & 7.8 IBC (1608)	Structural elements shall comply with the current IBC	
WIND LOAD CAPACITY	ASCE 7-05 Chapter 6 IBC (1609)	Structural elements shall comply with the current IBC	
SEISMIC LOAD CAPACITY	ASCE 7-05 Chapters 11 & 12 IBC 1613	Structural elements shall comply with the current IBC	
CHAPTER 29: PLUMBING SYSTEMS			
FIXTURE CALCULATIONS		Fixture calculations for Business Occupancy:	
		Male & Female:	
		Water closets - Provide 1 per 25 for the first 50 and 1 per 50 after.	
		Urinals - Not more than 50%.	
	IBC (2902.1.1) (Table 2902.1)	Lavatories - 1 per 40 for the first 80 and 1 per 80 after. Fixture calculations for Assembly Occupancy: Male & Female:	
		Water closets - Provide 1 per 125 Male, 1 per	
		Lavatories - 1 per 200	
		Drinking Fountains: 1 per 500	
		Service sink: 1 per building	
CHAPTER 30: ELEVATOR & CONVEYING SYSTEMS			
HOISTWAY ENCLOSURE	IBC (3002.4) (3003 - 3004)	An elevator car to accommodate ambulance stretcher in buildings 4 stories in height or more.	Must be enclosed in a 2 hr shaft enclosure Standby power is required, however hoistway venting is not required where an automatic sprinkler
NFPA 45 (IN LIEU OF IBC): LABORATORY REQUIREMENTS			
CHAPTER 4			
LABORATORY UNIT FIRE HAZARD CLASSIFICATION	NFPA 45 (4.2.1.1) (4.2.2.1)	Class A Unit = High Fire Hazard Class B Unit = Moderate Fire Hazard Instructional - Class C Unit = Low Fire Hazard Class D Unit = Minimal Fire Hazard	Educational laboratory units should be classified as Class D or shall be limited to 50% of flammable & combustible liquids of Class C units from Table 10.1.1. Classification is based on the quantity of: Flammable liquids, combustible liquids, and flammable gases.
CHAPTER 5: LABORATORY UNIT DESIGN AND CONSTRUCTION			

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
LABORATORY UNIT CLASSIFICATION	NFPA 45 (5.1.1) (9.1.1a)	LAB UNIT CLASS MAX QUANITTY CLASS I LIQUIDS CLASS A 20gal/100sf - 480gal max per lab CLASS B 10gal/100sf - 480gal max per lab CLASS C 4gal/100sf - 300gal max per lab CLASS D 2gal/100sf - 150gal max per lab	Max Area Fire Separation Stories above grade 10,000 sf 2-Hour 1-3 10,000 sf 1-Hour 1-3 10,000 sf 2-Hour 4-6 Unlimited Nonrated 1-3 Unlimited 1- hour 4-6 Unlimited Nonrated No Limit
		** Class C unit max. permitted Class I, II & IIIA liquids is 8gal/100sf - 400gal total per lab unit No limit on number of labs per floor. Reduction by in quantity of 25% for labs on the 4-6 floor. Supporting construction shall have corresponding fire rating.	** Class D unit max. permitted Class I, II & IIIA liquids is 2gal/100sf - 150gal total per lab unit No limit on number of labs per floor. Reduction in quantity by 25% for labs on the 4-6 floor. Supporting construction shall have corresponding fire rating. **Quantities and Class of liquids to be stored is unknown at this point
MEANS OF EGRESS TO AN EXIT	NFPA 45 (5.4.1)	A second means of egress is required from lab work area if: (1) a explosion hazards threatens the exit access (2) Class A lab unit is > 500sf (3) Class B, C, or D lab unit is > 1,000sf (4) a hood is adjacent to primary exit access (5) a flammable gas or health hazard 3 or 4 is > lecture bottle size (6) a Cryogenic gas container exists near exit	
EXIT DOOR SWING	NFPA 45 (5.4.2-5.4.3)	For Class A & B lab work areas the door swing must be in direction of egress for any occupant load.. For Class C & D lab work areas the door may swing against the direction of egress if the occupant load is < 50. Horizontal sliding doors may be used per	
CHAPTER 6 FIRE PROTECTION			
AUTOMATIC SPRINKLER SYSTEM	NFPA 45 (6.1.1)	Automatic sprinkler system required in all new labs and shall be the quick response type	Sprinkler density: Ordinary hazard Group 2 - A/B lab units Ordinary hazard Group 1 - C/D lab units
STANDPIPES	NFPA 45 (6.2.1)	Standpipes shall be installed in lab buildings 2 or more stories above or below grade.	
PORTABLE FIRE EXTINGUISHERS	NFPA 45 (6.4 - 6.4.2) NFPA 10 (Table 6.2.1.1) Class A (See NFPA 10 (Table 6.3.1.1) Class B)	Portable fire extinguishers to be placed, sized, and maintained per lab unit type. Fire extinguishers ratings are: (1) Light, (2) Ordinary, and (3) Extra for each Class Unit: Class A units = High fire hazard Class B units = Moderate fire hazard Class C units = Low fire hazard Class D units = Minimal fire hazard	Class A Hazards Light Hazard - Minimum rated 2-A extinguisher with a maximum floor area of 3,5000 sf (per unit of A) and Maximum travel distance of 75 feet to an extinguisher. Ordinary Hazard - Minimum rated 2-A extinguisher with a maximum floor area of 1,500 sf (per unit of A) and Maximum travel distance of 75 feet to an extinguisher. Extra Hazard - Minimum rated 4-A extinguisher with a maximum floor area of 1,000 sf (per unit of A) and
FIRE ALARM SYSTEMS	NFPA 45 (6.4 - 6. 4.4)	Class A and B units require a manual system fire alarm system.	Manual system fire alarm system must alert all required personnel as well as emergency local responders or public fire department.
FIRE PREVENTION PROCEDURE	NFPA 45 (6.5)	Provide lab procedure for these critical areas: (1) Chemical handling and storage (2) Open flame, spark, or hot work permits (3) Portable electrical cords (4) Smoking area controls	

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
EMERGENCY PLANS	NFPA 45 (6.5.3.1)	Provide laboratory emergency plan for: (1) Alarm activation, (2) Building evacuation and re-entry, (3) Equipment shut down, (4) Fire fighting operations, (5) Non-fire hazards that threaten emergency operations.	
CHAPTER 7: LABORATORY VENTILATION & HOOD REQUIREMENTS			
BASIC REQUIREMENTS	NFPA 45 (7.5.10)	A dedicated exhaust or fume hood is required for each lab unit to exterior, rated shaft, or to mechanical penthouse.	
SUPPLY SYSTEMS	NFPA 45 (7.3.3)	Air pressure in lab work areas shall be negative with respect to corridors and non-lab areas.	Except for: (1)Clean rooms, (2) Short term operations, (3) Electrically classified hazard areas per NFPA 496.
EXHAUST AIR DISCHARGE	NFPA 45 (7.4.1)	Air exhaust from a chemical fume hood shall be positioned so that exhaust can not be recirculated.	
DUCT CONSTRUCTION	NFPA 45 (7.5.2 - 7.5.3)	Ducts should be of non-combustible materials or have a flame spread of < 25.	No fiberglass, mineral wool, or foam insulation linings or coatings allowed within exhaust system.
EXHAUST (FANS)	NFPA 45 (7.7 - 7.7.4)	Exhaust fans conveying corrosive, flammable or combustible vapors shall have a flame spread of < 25 and rotating elements shall be non-ferrous of spark- resistant.	
CHEMICAL FUME HOOD INTERIORS	NFPA 45 (7.8.1 - 7.8.7)	Chemical fume hood interiors to have a flame spread of < 25 per NFPA 255	Provided fixed baffles which will not reduce the volume of exhaust flow and a means to prevent overflow spills of 2L of liquid and a device to measure air flow.
CHEMICAL FUME HOOD FIRE PROTECTION	NFPA 45 (7.10 - 7.10.1) IBC (414.5.2) & CH. 27	Automatic sprinkler system shall not be required in chemical fume hoods.	Exceptions: (1) Flame spread is > 25, (2) If hazard assessment recommends one. Emergency power is required for fume hood exhaust systems.
	NFPA 45 (7.10.3.1)	Fire damper not permitted in lab exhaust duct systems.	Alternatives: (1) enclose exhaust for 10 feet on either side of rated penetration, (2) Use sub-ducts per NFPA 45 - Dedicated exhaust duct risers and/or 22"" sub-ducts with continuous upward air movement.
CHAPTER 8 : CHEMICAL STORAGE, HANDLING, AND WASTE DISPOSAL			
STORAGE	NFPA 45 (8.2.4.1.1 - 8.2.4.1.3)	Maximum allowable quantities shall be reduced by 50% for Class B lab units located above 3RD Floor. Maximum allowable quantities shall be reduced by 25% for Class D & D lab units located on floors 4TH - 6TH.	
	NFPA 45 (8.2.4.3)	Class I flammable liquids & Class II combustible liquids shall be stored in safety can or approved NFPA30 constructed cabinet.	No storage in fume hoods.
WASTE HANDLING AND DISPOSAL	NFPA 45 (8.3.4)	Class I liquid waste containers in laboratory work areas shall not exceed 20L (5gal)	All waste containers to be labeled.
CHAPTER 9: FLAMMABLE AND COMBUSTIBLE LIQUIDS			
QUANTITY LIMITATIONS	NFPA 45 (9.1.2)	Container types and maximum sizes shall comply with Table 9.1.2	Exceptions: (1) Glass containers up to 1 Gal are permitted if liquid is corrosive, for purity, or container size in table 10.1.2 is not available (2) Containers not greater than 60 Gal permitted if area meets NFPA30 requirements, (3) In Educational and Instructional labs containers shall not exceed a max. 2.1 Gal for safety cans or a max. 1 Gal for other containers.
LIQUID DISPENSING	NFPA 45 (9.3.1 - 9.3.2)	Dispensing of Class I liquids from < 5 Gal container shall be done in: (1) chemical fume hood, (2) in a vented area with (LEL) lower explosive limit < 25%, (3) in a NFPA 30 compliant room.	"Dispensing of Class I liquids from > 5 Gal container shall be done in: (1) in a separate area outside of building, (2) in a NFPA 30 compliant room."
CHAPTER 10: COMPRESSED AND LIQUID GASES			

CATEGORY	APPLICABLE CODE REFERENCE	DESCRIPTION	REMARKS
VENTILATION REQUIREMENTS	NFPA 45 (10.1.4.2)	In lab units a continuously mechanically vented hood or enclosure is required for lecture bottles-size cylinders containing the following gases: (1) Health hazard 3 and 4, (2) Health hazard 2 with no physiological warning properties, (3) pyrophoric gases.	
	NFPA 45 (11.1.4.3)	Cylinders of all gases greater than lecture size and are rated as health hazard 3 or 4, and hazard 2 with no warning properties, shall be placed in a continually mechanically vented gas cabinet and meet NFPA 55.	
	NFPA 45 (11.1.4.4)	Cylinders of pyrophoric gas greater than lecture size shall be placed in a continually mechanically vented, sprinklered gas cabinet.	
CYLINDARS ""IN USE""	NFPA 45 (11.1.6.4)	Cylinders ""in use"" shall not be stored in laboratory unit	
	NFPA 45 (11.1.6.5) - The amount of compressed and liquid gas for Class A, B, & C laboratory shall be as listed per Table 6.3.1 in NFPA 55	Gas quantity limits for areas < 500 sf : Flammable & Oxidizing - 6 cu ft Liquefied flammable - 1.2 cu ft Health hazard 3 or 4 - .3 cu ft	Gas quantity limits for areas > 500 sf : Flammable & Oxidizing - .012 cu ft / sf Liquefied flammable - .0018 cu ft / sf Health hazard 3 or 4 - .0006 cu ft/ sf
	NFPA 45 (11.1.6.6)	Number of lecture bottles in Class A, B, & C laboratory = 25 max.	
	NFPA 45 (11.1.6.7)	The amount of compressed and liquid gas in Class D Lab to be 50% of that listed per Table 6.3.1 in NFPA 55	
	NFPA 45 (11.1.6.9)	The amount of compressed and liquid gas for Educational Lab areas shall be: (1 & 2) Max. quantity limits for Flammable & Oxidizing gas = 100cf, (3) A max. of (2)-1 LB Liquefied flammable gas cylinders are permitted, (4) health hazard 3 and 4 gas not permitted.	
OUTDOOR STORAGE	NFPA 45 (11.3)	Per NFPA 55. No flammable gas cylinders: Within 6 feet of windows, door, or other openings and Within 30 feet of ventilation intakes	
CHAPTER 11: LABORATORY OPERATIONS			
REFRIGERATION AND COOLING EQUIPMENT	NFPA 45 (11.3.2.1)	All cooling equipment shall be prominantly marked per safety and use requirements.	
HEATING EQUIPMENT	NFPA 45 (11.3.3.1)	All unattended electrical heating equipment shall be equipped with manual reset over-temperature shutoff switch in addition to normal controls.	
HEATED CONSTANT TEMPERTURE BATHS	NFPA 45 (11.3.4.1)	All electrically heated constant temperature baths shall be equipped over-temperature shutoff switch in addition to normal controls.	Electrical equipment classified for flammable or combustible liquids shall be installed per NFPA 70. Ovens and furnaces shall be installed per NFPA 86.
	NFPA 45 (11.3.5.1 -11.3.5.2)	Equipment used at pressure above 15 psi should be design and constructed by qualified individuals for use at the expected temperature, pressure, and operation in regards to safety.	All equipment shall be fitted with a pressure release device.
CHAPTER 12: INSTRUCTIONAL LABORATORY OPERATIONS			
CHEMICAL STORAGE AND HANDLING	NFPA 45 (12.3.1)	Bulk quantities of chemicals shall be stored in a locked room outside of the classroom.	
CHAPTER 13: HAZARD IDENTIFICATION			
IDENTIFICATION & LABELING	NFPA 45 (13.1 - 13.3)	Aid for Emergency Operations should include: (1,) Identification of entrances, (2) Hazards in fire fighting plans, (3) Marking of hazardous exhaust systems, (4) Container labeling	

CHEMICAL STORAGE

Chemical Storage

Building code restricts the maximum allowable quantities of hazardous materials (laboratory consumables) within a building based on reference to ground plane. Some increases are allowable based on criteria, i.e.. storage of 120 gallons of IB and IC flammable liquids becomes 240 gallons per d., and 480 gallons per e.

Quantities may be allocated within each control area, with number of controls areas based on reference to ground plane. The following graphics illustrate the maximum allowable control areas and associated maximum allowable quantity percentages for materials .

Hazardous material management systems, strategically located supply rooms and just-in-time deliveries enable research teams to function within code requirements without loss of functionality.

Two strategies are shown on the following pages. The first is based on larger control areas and the second defining laboratory suites. The final recommendation for the new Chemistry Building is the second, where each floor considered one laboratory suite. This strategy will ensure maximum flexibility for laboratory areas throughout the building and accommodate more chemicals than the control areas strategy. Each floor will therefore need to be constructed per IBC 2018 Section 3804.

SECTION 3804
LABORATORY SUITE CONSTRUCTION

3804.1 General. Where laboratory suites are provided, they shall be constructed in accordance with this chapter and Section 428 of the *International Building Code*.

3804.1.1.6 Standby or emergency power. Higher education laboratory suites shall be provided with emergency or standby power in accordance with Section 1203.2.13.

3804.1.1.7 Ventilation. Ventilation shall be in accordance with Chapter 7 of NFPA 45, and the *International Mechanical Code*.

3804.1.1.8 Liquid-tight floor. Portions of laboratory suites where hazardous materials are present shall be provided with a liquid-tight floor.

3804.1.1.9 Automatic fire-extinguishing systems. Buildings containing laboratory suites shall be equipped throughout with an *approved automatic sprinkler system* in accordance with Section 903.3.1.1.

Laboratory Suite Construction Requirements
SOURCE: 2018 International Building Code

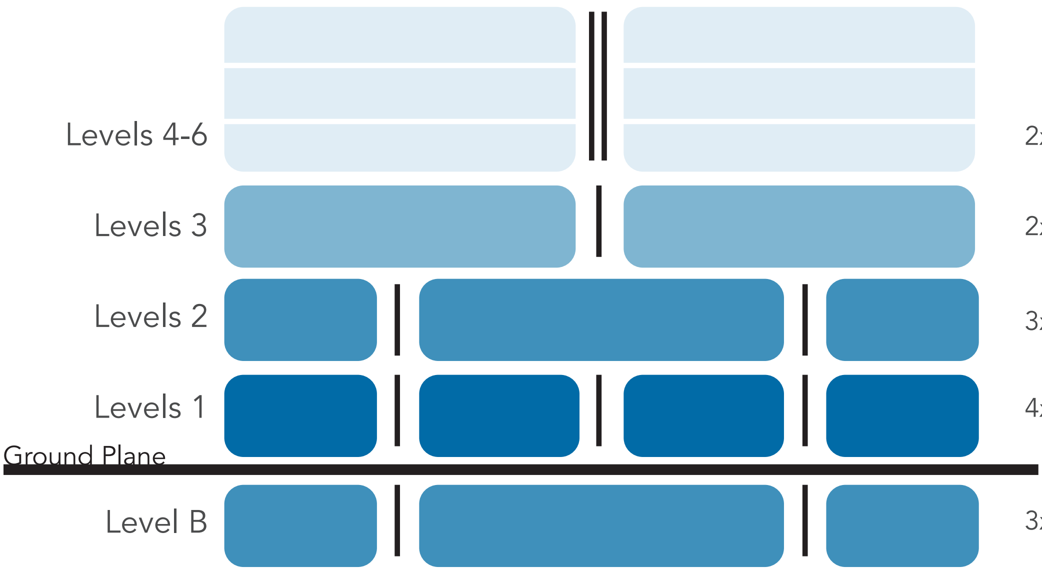
TABLE 307.1(1)
MAXIMUM ALLOWABLE QUANTITY PER CONTROL AREA OF HAZARDOUS MATERIALS POSING A PHYSICAL HAZARD[a, j, m, n, p]

MATERIAL	CLASS	GROUP WHEN THE MAXIMUM ALLOWABLE QUANTITY IS EXCEEDED	STORAGE[b]			USE-CLOSED SYSTEMS[b]			USE-OPEN SYSTEMS[b]	
			Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)	Gas cubic feet at NTP	Solid pounds (cubic feet)	Liquid gallons (pounds)
Combustible dust	NA	H-2	See Note q	NA	NA	See Note q	NA	NA	See Note q	NA
Combustible fiber[q]	Loose Baled[o]	H-3	(100) (1,000)	NA	NA	(100) (1,000)	NA	NA	(20) (200)	NA
Combustible liquid[c, i]	II IIIA IIIB	H-2 or H-3 H-2 or H-3 NA	NA	120[d, e] 330[d, e] 13,200[e, f]	NA	NA	120[d] 330[d] 13,200[f]	NA	NA	30[d] 80[d] 3,300[f]
Cryogenic flammable	NA	H-2	NA	45[d]	NA	NA	45d	NA	NA	10[d]
Cryogenic inert	NA	NA	NA	NA	NL	NA	NA	NL	NA	NA
Cryogenic oxidizing	NA	H-3	NA	45[d]	NA	NA	45[d]	NA	NA	10[d]
Explosives	Division 1.1 Division 1.2 Division 1.3 Division 1.4 Division 1.4G Division 1.5 Division 1.6	H-1 H-1 H-1 or H-2 H-3 H-3 H-1 H-1	1[e, g] 1[e, g] 5[e, g] 50[e, g] 125[e, l] 1[e, g] 1[e, g]	(1)[e, g] (1)[e, g] (5)[e, g] (50)[e, g] NA (1)[e, g] NA	NA	0.25[g] 0.25[g] 1[g] 50[g] NA 0.25[g] NA	(0.25)[g] (0.25)[g] (1)[g] (50)[g] NA (0.25)[g] NA	NA	0.25[g] 0.25[g] 1[g] NA NA 0.25[g] NA	(0.25)[g] (0.25)[g] (1)[g] NA NA (0.25)[g] NA
Flammable gas	Gaseous Liquefied	H-2	NA	NA (150)[d, e]	1,000[d, e] NA	NA	NA (150)[d, e]	1,000[d, e] NA	NA	NA
Flammable liquid[c]	IA IB and IC	H-2 or H-3	NA	30[d, e] 120[d, e]	NA	NA	30[d] 120[d]	NA	NA	10[d] 30[d]
Flammable liquid, combination (IA, IB, IC)	NA	H-2 or H-3	NA	120[d, e, h]	NA	NA	120[d, h]	NA	NA	30[d, h]
Flammable solid	NA	H-3	125[d, e]	NA	NA	125[d]	NA	NA	25[d]	NA
Inert gas	Gaseous Liquefied	NA NA	NA NA	NA NA	NL NL	NA NA	NA NA	NL NL	NA NA	NA NA
Organic peroxide	UD I II III IV V	H-1 H-2 H-3 H-3 NA NA	1[e, g] 5[d, e] 50[d, e] 125[d, e] NL NL	(1)[e, g] (5)[d, e] (50)[d, e] (125)[d, e] NL NL	NA	0.25[g] 1[d] 50[d] 125[d] NL NL	(0.25)[g] (1)[d] (50)[d] (125)[d] NL NL	NA	0.25[g] 1[d] 10[d] 25[d] NL NL	(0.25)[g] (1)[d] (10)[d] (25)[d] NL NL
Oxidizer	4 3[k] 2 1	H-1 H-2 or H-3 H-3 NA	1[g] 10[d, e] 250[d, e] 4,000[e, f]	(1)[e, g] (10)[d, e] (250)[d, e] (4,000)[e, f]	NA	0.25[g] 2[d] 250[d] 4,000[f]	(0.25)[g] (2)[d] (250)[d] (4,000)[f]	NA	0.25[g] 2[d] 50[d] 1,000[f]	(0.25)[g] (2)[d] (50)[d] (1,000)[f]
Oxidizing gas	Gaseous Liquefied	H-3	NA	NA (150)[d, e]	1,500[d, e] NA	NA	NA (150)[d, e]	1,500[d, e] NA	NA	NA
Pyrophoric	NA	H-2	4[e, g]	(4)[e, g]	50[e, g]	1[g]	(1)[g]	10[e, g]	0	0
Unstable (reactive)	4 3 2 1	H-1 H-1 or H-2 H-3 NA	1[e, g] 5[d, e] 50[d, e] NL	(1)[e, g] (5)[d, e] (50)[d, e] NL	10[e, g] 50[d, e] 750[d, e] NL	0.25[g] 1[d] 50[d] NL	(0.25)[g] (1)[d] (50)[d] NL	2[e, g] 10[d, e] 750[d, e] NL	0.25[g] 1[d] 10[d] NL	(0.25)[g] (1)[d] (10)[d] NL
Water reactive	3 2 1	H-2 H-3 NA	5[d, e] 50[d, e] NL	(5)[d, e] (50)[d, e] NL	NA	5[d] 50[d] NL	(5)[d] (50)[d] NL	NA	1[d] 10[d] NL	(1)[d] (10)[d] NL

d. Maximum allowable quantities shall be increased 100 percent in buildings equipped throughout with an automatic sprinkler system in accordance with Section 903.3.1.1. Where Note e also applies, the increase for both notes shall be applied accumulatively.

e. Maximum allowable quantities shall be increased 100 percent when stored in approved storage cabinets, day boxes, gas cabinets, gas rooms or exhausted enclosures or in listed safety cans in accordance with Section 5003.9.10 of the *International Fire Code*. Where Note d also applies, the increase for both notes shall be applied accumulatively.

Control Areas Per IBC 2018 414.2.2



	# of Control Areas	MAQ per Control Area	Gallons per Control Area
Levels 4-6	2x	12.5%	60
Levels 3	2x	50.0%	240
Levels 2	3x	75.0%	360
Levels 1	4x	100.0%	480
Level B	3x	75.0%	360

Class 1A, 1B and 1C Flammable Liquid Quantity calculations

Levels 4-6:
15 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **60 gallons per Control Area**

Level 3:
60 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **240 gallons per Control Area**

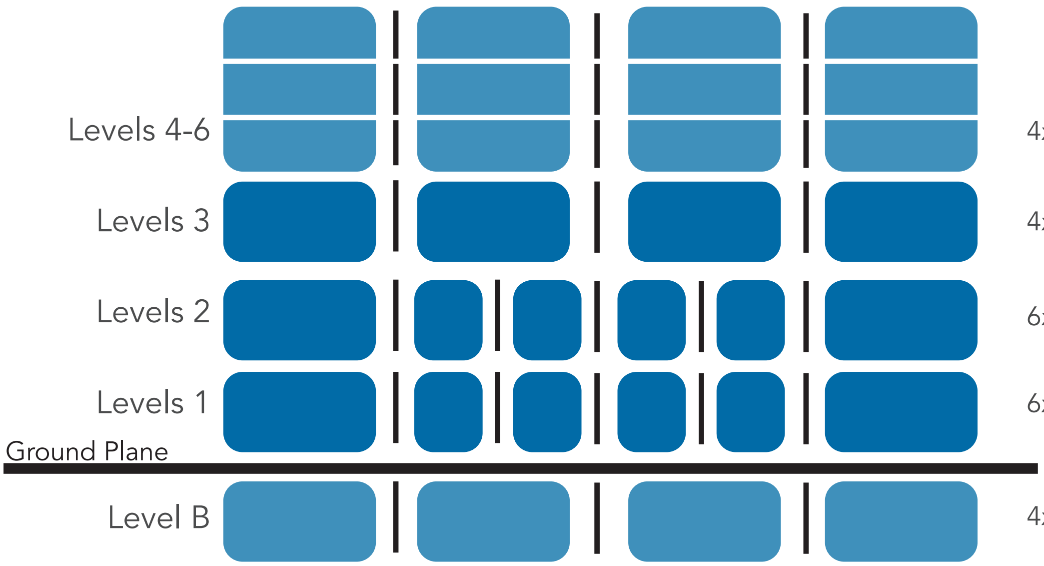
Level 2:
90 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **360 gallons per Control Area**

Level 1:
120 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **480 gallons per Control Area**

Level B:
90 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **360 gallons per Control Area**

Maximum Allowable Quantities (MAQ), Strategy 1: Large Control Areas

Control Areas Per IBC 2018 428.3



	# of Control Areas	MAQ per Control Area	Gallons per Control Area
Levels 4-6	4x	75.0%	360
Levels 3	4x	100.0%	480
Levels 2	6x	100.0%	480
Levels 1	6x	100.0%	480
Level B	4x	75.0%	360

Class 1A, 1B and 1C Flammable Liquid Quantity calculations

Levels 4-6:
15 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **60 gallons per Control Area**

Level 3:
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120 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **480 gallons per Control Area**

Level B:
90 gallons x 2 (sprinkler) x 2 (stored in approved safety cabinets) = **360 gallons per Control Area**

Class 1A, 1B and 1C Flammable Liquid Density Limitation

6 gallons per 100 square feet (levels 4-6) [20,000 SF / 100 SF x 6 gallons = **1,200 gallons]**

8 gallons per 100 square feet (levels 1-3) [20,000 SF / 100 SF x 8 gallons = **1,600 gallons]**

Maximum Allowable Quantities, (MAQ)
Strategy 2: Laboratory Suites

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BUDGET

BUDGET SUMMARY

Budget Process

The Chemistry Building conceptual level construction cost estimate was generated in an iterative fashion during the Pre-Design process in an effort to ensure the most reasonably accurate estimate possible. When the building program and overall layout became generally final, a preliminary cost estimate was generated to give stakeholders a sense of how the project was tracking in relation to the project budget. The cost estimate was then revised and finalized based upon the final project scope outlined in this report. Each major draft estimate was reviewed by design team staff as well as staff with experience in estimating the costs of similar facilities around the region. Refer to Section 11.4 for additional detailed cost breakdown.

	CURRENT ESTIMATE		COMMENTS
	$/SF	TOTAL	
BUILDING CONSTRUCTION COST			Budget Square Footage 130,100 GSF, Estimated Square Footage 159,220 GSF
General Construction		$41,048,379	
Conveying		$591,075	
HVAC		$11,495,980	
Plumbing		$3,662,016	
Fire Suppression		$504,411	
Electrical		$7,318,614	
AV		$1,166,000	AV equipment. Rough-in is part of electrical estimate.
Earthwork/Exterior Improvements/Utilities		$688,687	
CENTRAL UTILITIES		$4,325,468	
ESCALATION (4.5%)		$3,133,559	Start of construction Spring 2021 with a 24 month construction duration.
GENERAL CONDITIONS (7.0%)		$5,093,773	
CONTRACTOR'S FEES (4.0%)		$3,114,478	
DESIGN CONTINGENCY (10.7%)		$8,200,000	
CONSTRUCTION COST TOTAL	**$582**	**$90,342,440**	
PROJECT CONTINGENCY (10%)		$9,035,000	
EQUIPMENT			
FF & E		$6,430,000	Cost carried forward from budget to estimate.
DESIGN FEES			
A/E Fee Pre-Design and Basic Services		$7,200,000	Fee includes Pre-Design and Basic Service fee for the building, utilities extension and site development.
Reimbursables		$244,500	
Commissioning		$862,200	
DESIGN FEES TOTAL		**$8,306,700**	
DFDM FEE		$3,975,100	
PROJECT TOTAL	**$760**	**$118,089,240**	

*NOTE: Numbers shown in this table represent costs for the 159,220 GSF building detailed in this report, based on the budget in Section 11.4. The cost estimate detailed in Section 11.4 is based on a 155,340 GSF building and will be updated in subsequent design phases.

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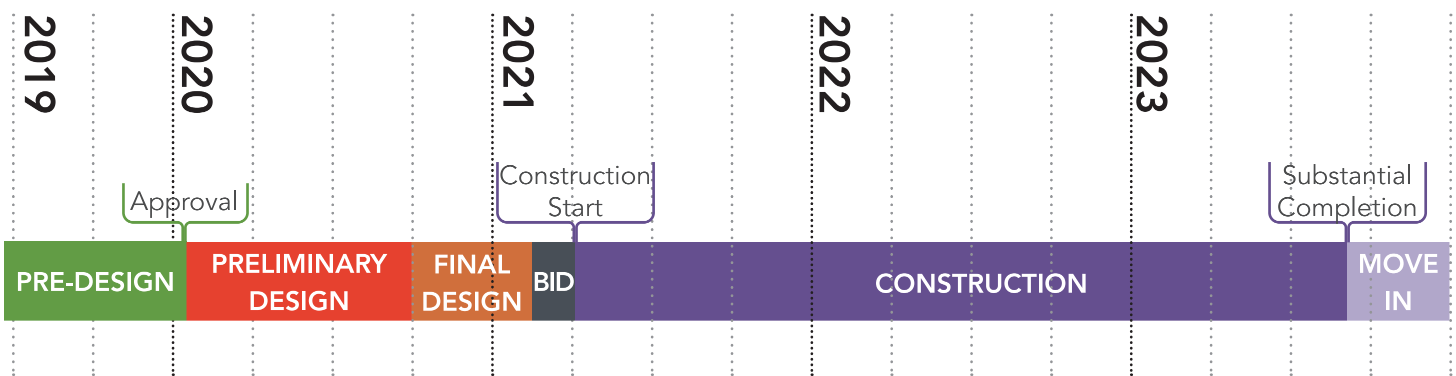
SCHEDULE PHASING

PROJECT SCHEDULE



Schedule Summary

The new Chemistry Building is the first project to be implemented from the SWQ Redevelopment Plan, and the process will move forward as shown above. Upon completion of the Pre-Design report the project team will immediately proceed into Preliminary Design with a target construction start date of Spring 2021. The project is anticipated to reach substantial completion two years later in Spring 2023. The budget shown in Section 07 of this document is based upon the schedule shown here.

ACTIVITY	Begins	Ends	Duration
Basic Servcies Pre-Work			
Finalize Basic Services Proposal	2-Dec-19	20-Dec-19	15 day
Execute Prime Contract	22-Jan-20	22-Jan-20	1 day
Execute Contracts for Team Members	6-Jan-20	31-Jan-20	20 days
Develop Schedule	2-Dec-19	13-Dec-19	10 days
Review Schedule with Core Committee	13-Jan-20	17-Jan-20	5 days
Place Holds on Calendars	13-Jan-20	17-Jan-20	5 days
A/E Team Organization Meeting	27-Jan-20	31-Jan-20	5 days
Pre-Design			
Pre-Design Report			
Prepare Written Report	4-Oct-19	6-Dec-19	15 days
DFDM, Campus, UW System Review of Draft Report	6-Dec-19	20-Jan-20	25 days
Receive Comments from DFDM, Campus, UW System	10-Jan-20	10-Jan-20	1 day
Incorporate Comments into Final Draft Pre-Design Report	10-Jan-20	22-Jan-20	9 days
Issue Final Draft Pre-Design Report for Approval by DFDM, Campus and UW System	22-Jan-20	22-Jan-20	1 day
Preliminary Design			
Begin Preliminary Design	27-Jan-20	27-Jan-20	1 day
Schematic Design	27-Jan-20	1-May-20	70 days
Design Development	20-Apr-20	31-Jul-20	75 days
Peer Review	29-Apr-20	29-Feb-20	1 day
Issue documents for Preliminary Design Estimate	10-Jul-20	10-Jul-20	1 day
Preliminary Design Estimate	13-Jul-20	31-Jul-20	15 days
Present Preliminary Design Construction and Project Estimates	12-Aug-20	12-Aug-20	1 day
Preliminary Review			
Prepare Preliminary Review Documents	6-Jul-20	31-Jul-20	20 days
Issue Preliminary Review Documents for Review	31-Jul-20	31-Jul-20	1 day
DFDM, Campus, System Preliminary Review	3-Aug-20	4-Sep-20	25 days
Receive Preliminary Review Comments	4-Sep-20	4-Sep-20	1 day
Incorporate Preliminary Review Comments into Documents	7-Sep-20	25-Sep-20	15 days
Final Design			
Begin Final Design	7-Sep-20	7-Sep-20	1 day
Final Design	7-Sep-20	30-Dec-20	83 days
Issue documents for Final Design Estimate	18-Nov-20	18-Nov-20	1 day
Final Design Estimate	18-Nov-20	18-Dec-20	23 days
Present Final Design Construction and Project Estimates	7-Jan-21	7-Jan-21	1 day
Final Review			
Prepare Final Review Documents	14-Dec-20	15-Jan-21	25 days
Issue Final Review Documents for Review	18-Jan-21	18-Jan-21	1 day
DFDM, Campus, System Final Review	18-Jan-21	12-Feb-21	20 days
Receive Final Review Comments	15-Feb-21	15-Feb-21	1 day
Incorporate Final Review Comments into Documents	15-Feb-21	26-Feb-21	10 days
Issue Documents for Bidding	1-Mar-21	1-Mar-21	1 day
Preliminary Design Meetings			
Schematic Design Workshop - 2 day workshop to include			
Steering Committee Meeting			
Chemistry/BioChemistry User Group Meeting			
Building Safety and Security Group			
Site Design User Group Meeting			
Building Systems User Group Meeting			
Utility / Infrastructure User Group Meeting			
Design Development Workshop - 2 day workshop to include			
Steering Committee Meeting			
Chemistry/BioChemistry User Group Meeting			
Building Safety and Security Group			
Site Design User Group Meeting			
Building Systems User Group Meeting			
Utility / Infrastructure User Group Meeting			
Meeting with Other Interested Parties			
A/E Design Team Meetings			

UW-Milwaukee Project No 18H3D **Chemistry Building Pre-Design** | **245**

DETAILED SCHEDULE

UNIVERSITY of WISCONSIN
UW MILWAUKEE

Kahler Slater | CANNONDESIGN