Belmont Public Library

LBC Meeting #8 April 9, 2019

Oudens Ello Architecture

NZE Study Update

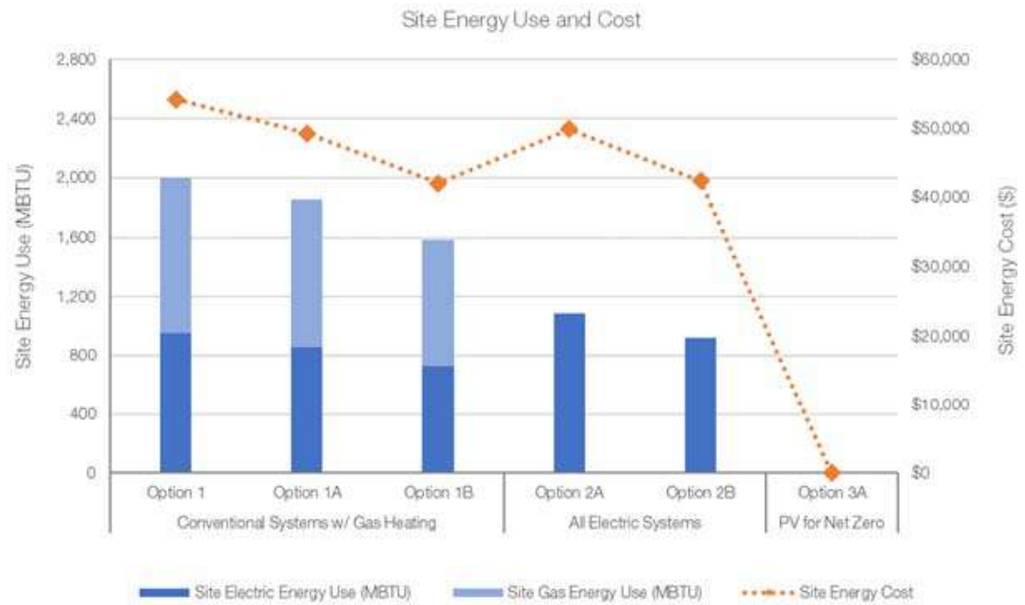
Memo

Project: Belmont Public Library
Re: Early Energy Analysis
Date Issued: April 8, 2019

Executive Summary

The purpose of this study is to outline a set of performance goals for the Belmont Public Library project, both to identify potential options for optimizing energy performance and to identify a pathway to being a net-zero emissions ready building. "Net Zero emissions ready" is understood to be a building that has a low site energy consumption and uses no fossil fuels. A Net Zero building is often also referred to as a building that produces as much energy as it uses. This preliminary analysis indicates that the project can achieve an Energy Use Intensity of EUI of 23 kBTU/SF. Additionally, with installed PV on-site can further reduce the EUI to 13 kTBU/SF.

Based on the analysis and looking at program options we propose that the target performance goal for the project w/o on-site solar be set to **22 kBTU/SF**.



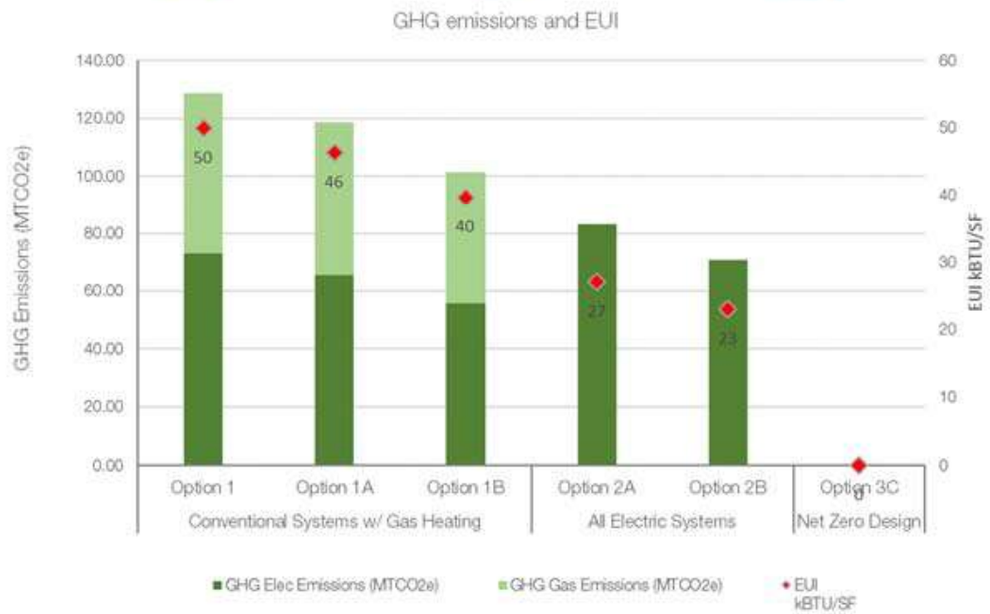


Table 1 below summarizes Energy Use, Energy Cost and EUI reductions

Option		Site Energy Use		Site Energy Use Intensity		Site Energy Cost	
		Total Energy Use (kBtu)	% Reduction	EUI (kBTU/SF)	% reduction	Annual Cost ($)	% Reductionn
Conventional Systems	Option 1	2,000,000		50		$54,242	
	Option 1A	1,855,056	7.2%	46	7.2%	$49,273	9.2%
	Option 1B	1,586,645	20.7%	40	20.7%	$42,024	22.5%
All Electric Systems	Option 2A	1,084,418	45.8%	27	45.8%	$49,898	8.0%
	Option 2B	921,594	53.9%	23	53.9%	$42,406	21.8%

Preliminary Energy Use Analysis

EUI (energy use intensity) is a measure of how much energy a building uses. EUI is expressed as energy per square foot per year. It is calculated by dividing the total energy consumed by the building in one year (often measured in kBtu) by the total gross floor area of the building. A lower EUI signifies better energy performance. EUI 0 signifies a Net Zero building, often achieved through a combination of energy efficient systems and renewable energy systems.

Based on analysis of the code complaint building (EUI of 50 kBTU/SF) and potential for improvement beyond the code compliant building, several Energy Conservation Measures (ECMs) above the code compliant envelope and systems were considered to perform preliminary analysis to lower the EUI targets.

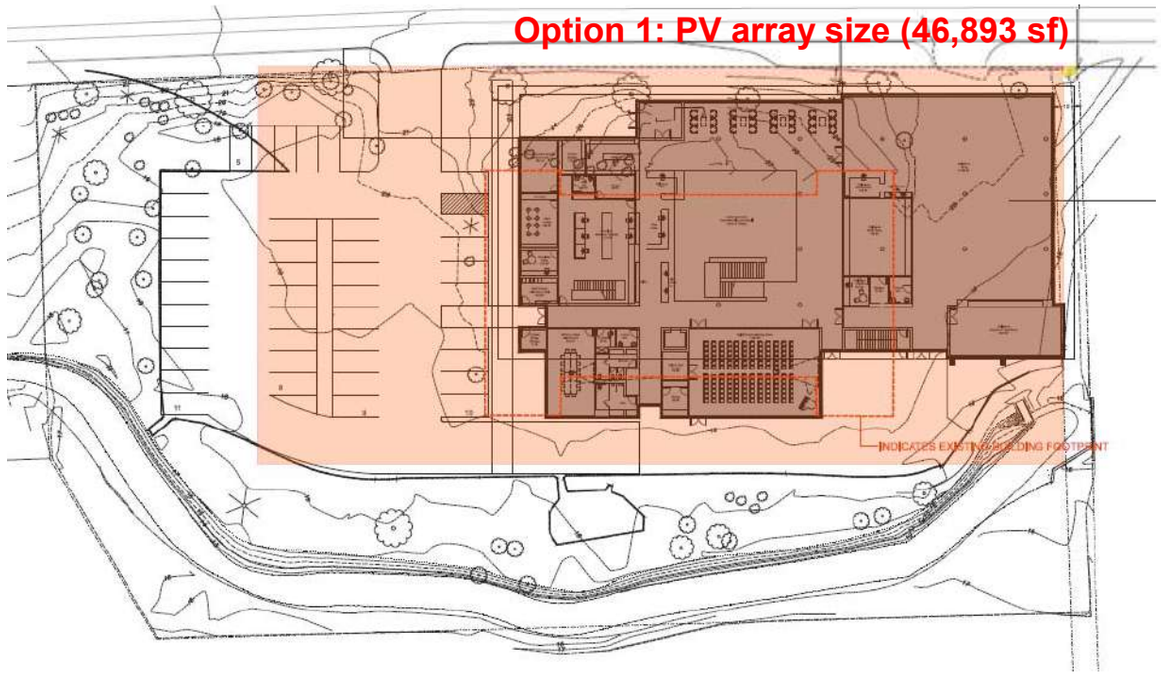
The options are divided in two categories of HVAC systems: Conventional fossil fuel system vs. all electric VRF system. Other ECM considerations are around envelope and lighting improvements beyond the new MA energy code.

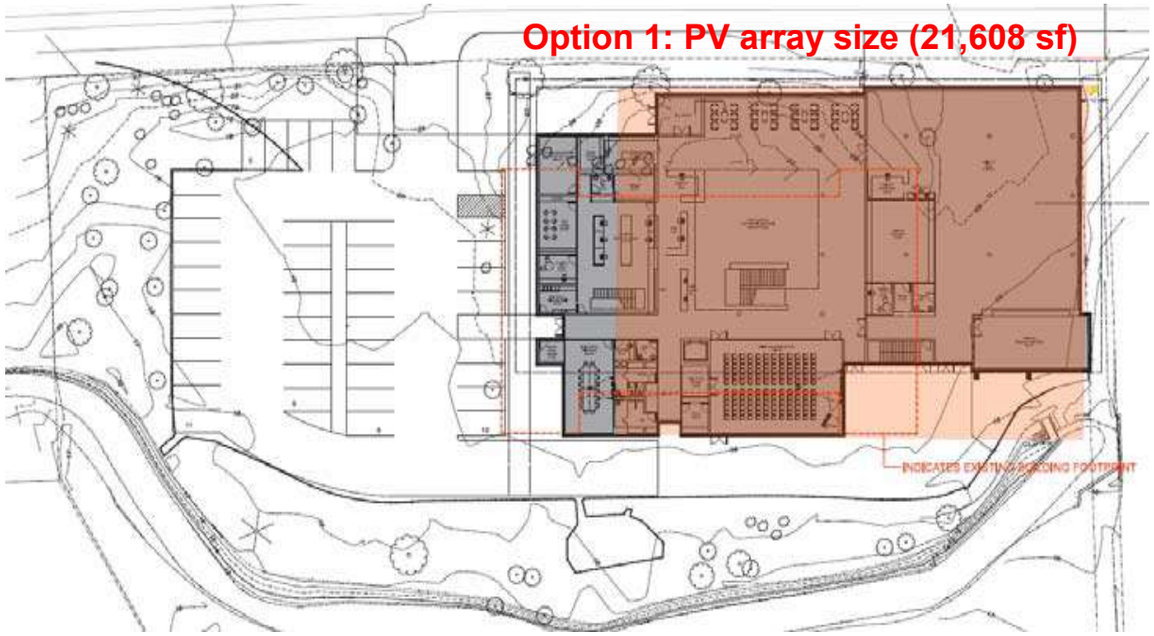
Table 2 below summarizes ECMs

		Envelope Options			LPD Options			HVAC Systems		Renewable Energy	
		ASHRAE 90.1-2016 Code Compliant Envelope	~ 20% Better Than Code Envelope	Passive House Envelope	Code Compliant Lighting	20% Better Than Code Lighting	40% Better Than Code Lighting	Conventional System DX VAV Condensing Boilers	All Electric ASHP Sytems	On-site PV on roof	Off site PV
Convention System DX VAV unit w/ Condensing Boilers	Option 1	X			X			X		X	
	Option 1A		X			X		X		X	
	Option 1B			X			X	X		X	X
All Electric VRF Systems	Option 2A		X			X			X	X	X
	Option 2B			X			X		X	X	X

Findings summarized in Table 1 above indicate that Option 2B - all electric VRF system will be the most energy efficient HVAC option, and Option 1 - conventional fossil fuel system with code required envelope and lighting design will be the least efficient. Both the systems will require a significant amount of PV's (some on site and some off site) to achieve net zero. See table 2 for details.

Table 2: PV Array Size for Net Zero Energy Building						
Scenario	Required Output (kWh)	Required Capacity (kWp)	Approx SF	Cost per Watt	Approximate Cost Solar Cost ($)	Total Cost to get to NZE ($)
Option 1	586,166	469	46893	$3.00	$1,406,800	
Option 1A	543,686	435	43495	$3.00	$1,304,846	
Option 1B	465,019	372	37202	$3.00	$1,116,045	
Option 2A	317,825	254	25426	$3.00	$762,779	
Option 2B	270,104	216	21608	$3.00	$648,249	





On Site Solar PV

Based on a potential building footprint for the new design, the available area for a PV installation is approximately 10,000 SF. This would accommodate a 100 kWp PV system on-site (Figure 3). This is equivalent to off-setting about 46% of the project's energy use by on-site PV for the most efficient design option 2B. The remainder of the renewable energy required to achieve net zero would need to be provided for off-site through off-site PV's or community solar, renewable energy credits (REC's) or carbon offsets.

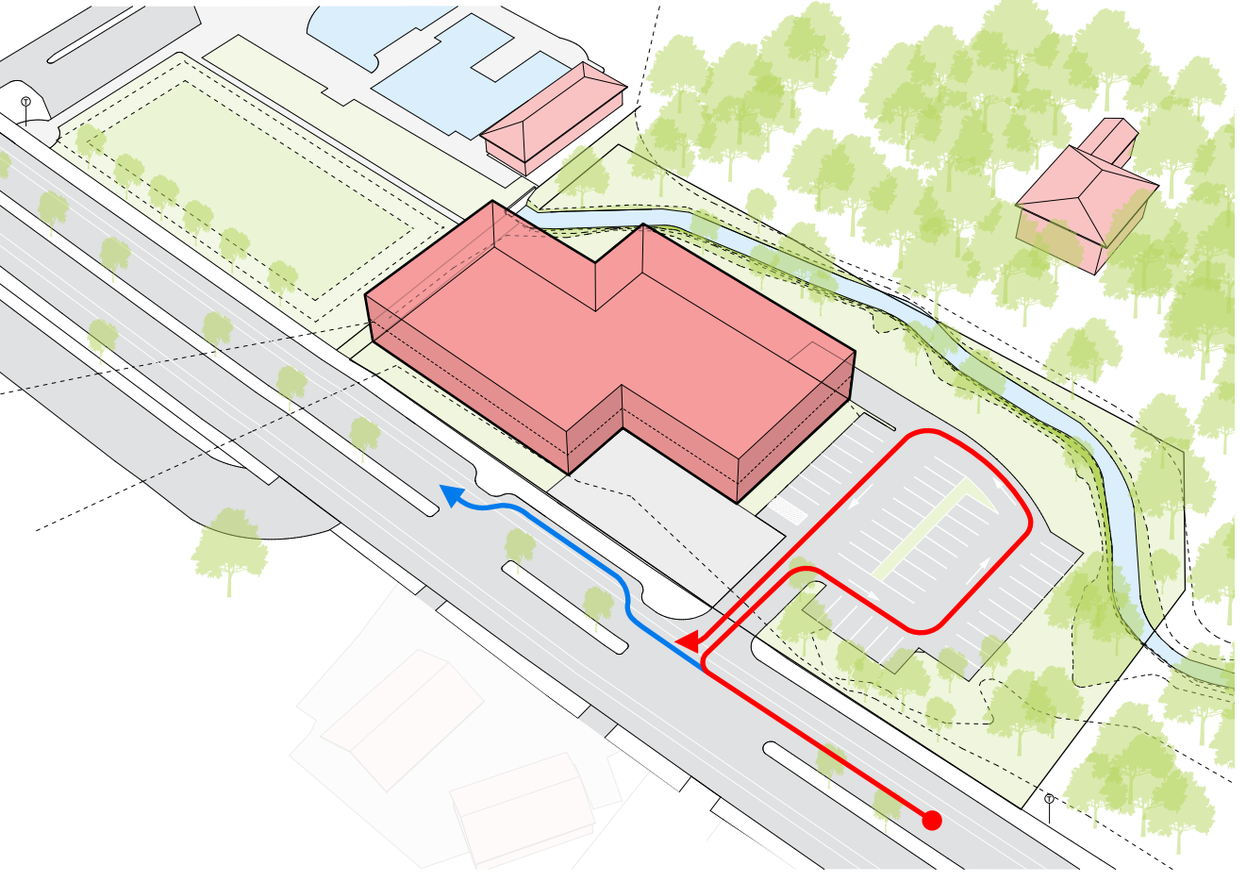
Table 3: % On site PV generation

Scenario	Total Energy (kWh)	Required Capacity (kWp)	Approx SF	Cost per Watt	Annual Generation (kWH)	% On site PV	Approximate Cost Solar Cost ($)
Option 1 + PV Roof	586,166	100	10000	$3.00	125,000	21.3%	$300,000
Option 1A + PV Roof	543,686	100	10000	$3.00	125,000	23.0%	$300,000
Option 1B + PV Roof	465,019	100	10000	$3.00	125,000	26.9%	$300,000
Option 2A + PV Roof	317,825	100	10000	$3.00	125,000	39.3%	$300,000
Option 2B + PV Roof	270,104	100	10000	$3.00	125,000	46.3%	$300,000

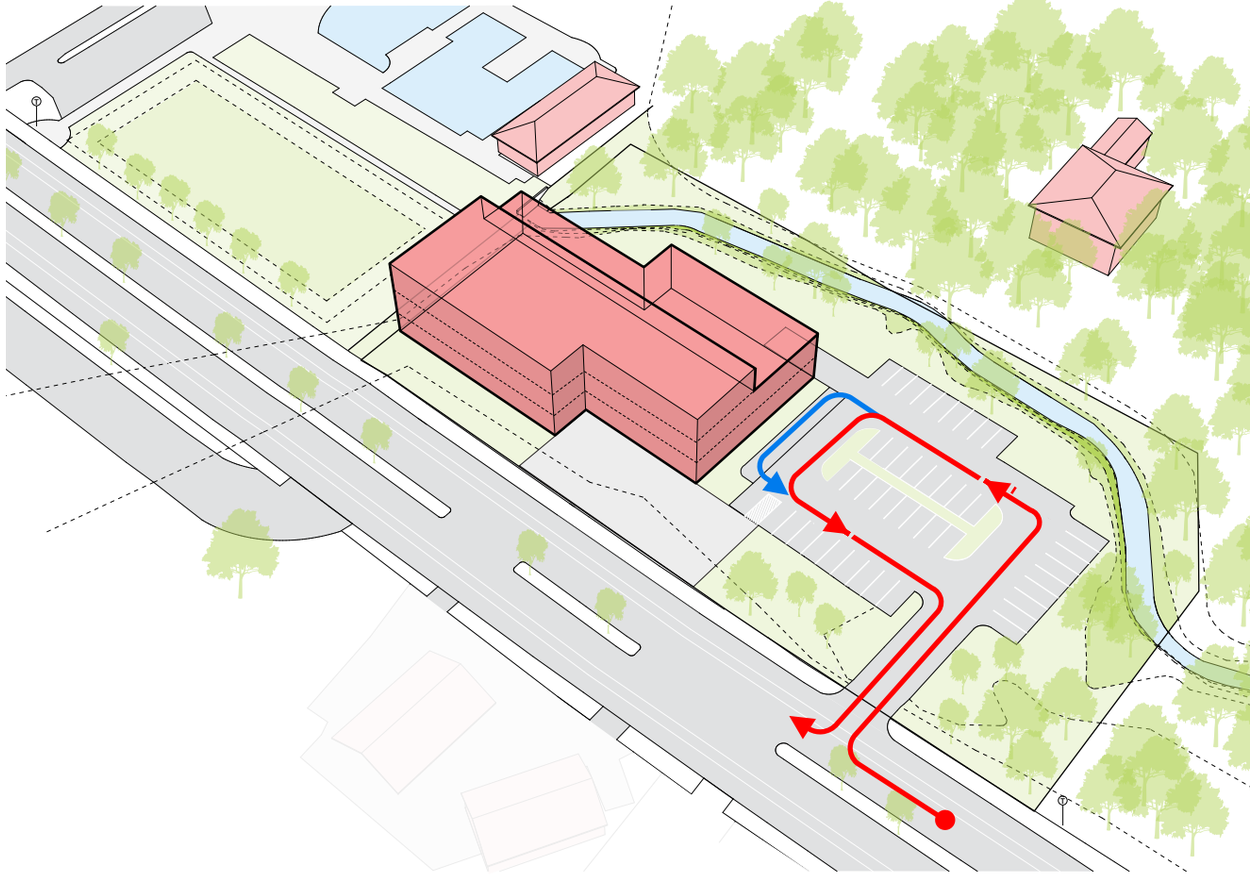
Figure 3: Potential available roof area

END OF MEMO

Design Update



Option 2.0 - 2-stories, 21,000 SF Footprint



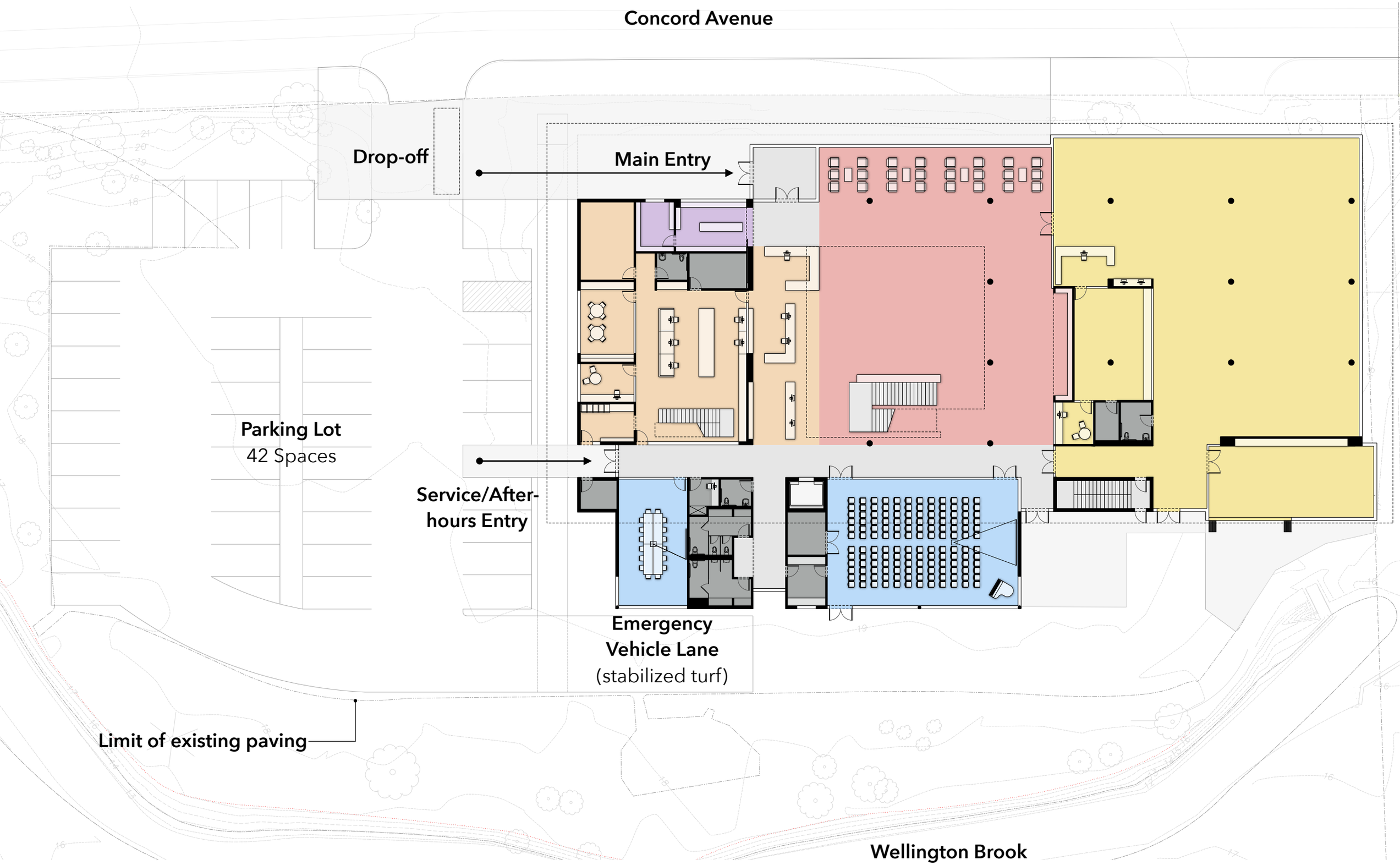
Option 2.5 - 2.5 stories, 17,500 SF Footprint

Conditions:

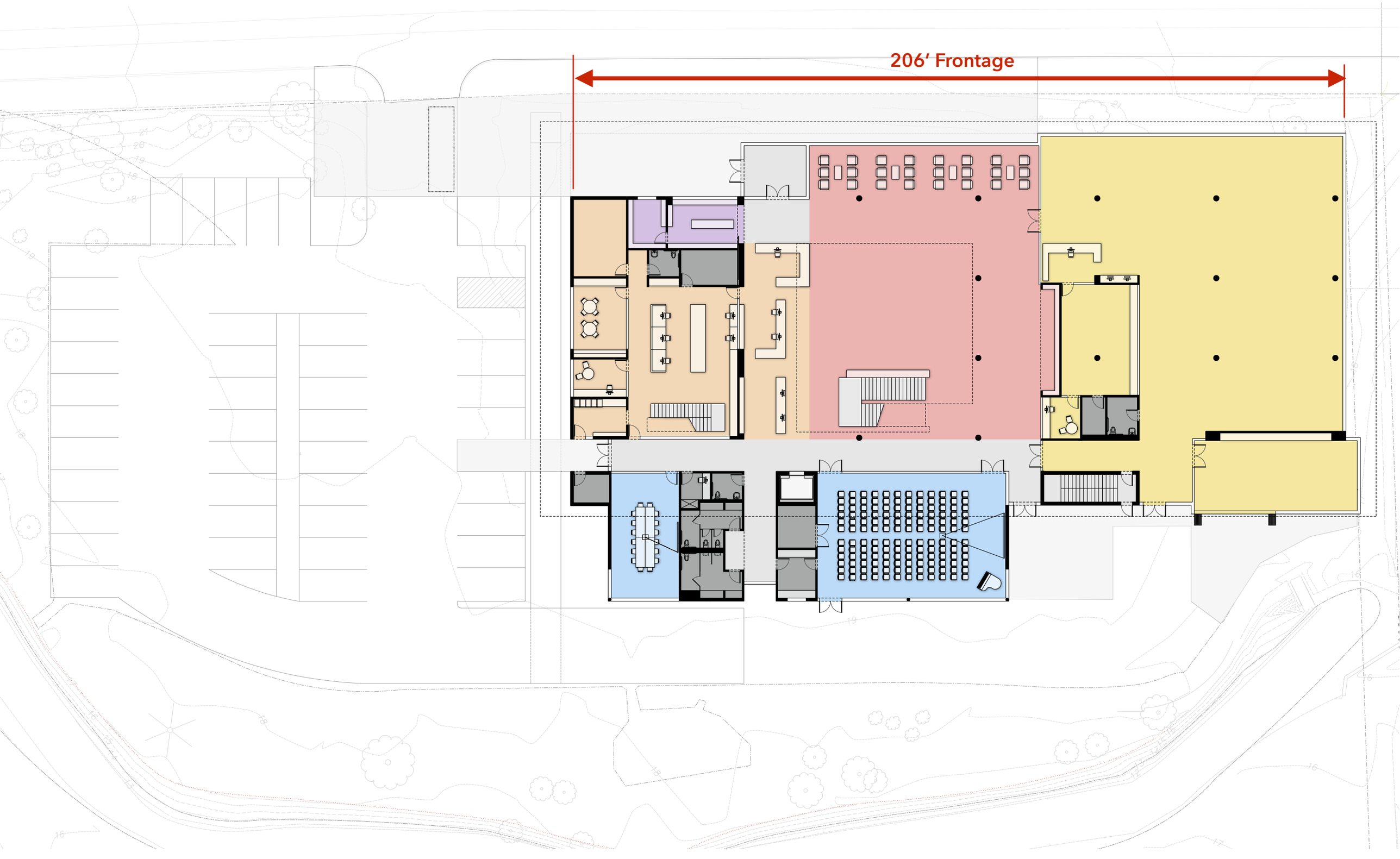
- Maintain existing vehicular ingress-egress lane
- Children's wing on ground floor level

03.05.19 LBC Meeting

Option 2.0

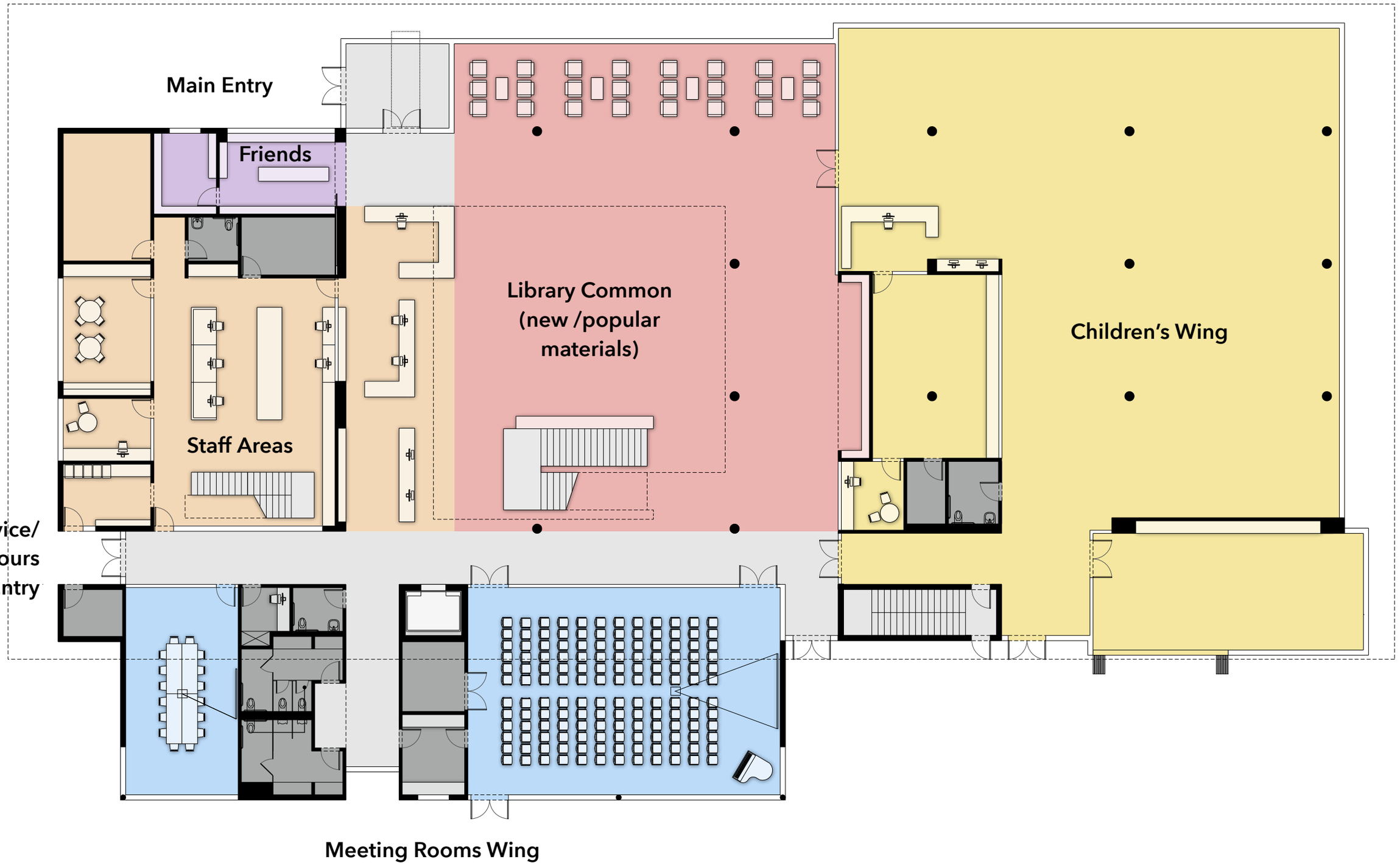


Option 2.0 - Site Plan



Option 2.0 - Site Plan

Concord Avenue



Option 2.0 - First Floor Plan

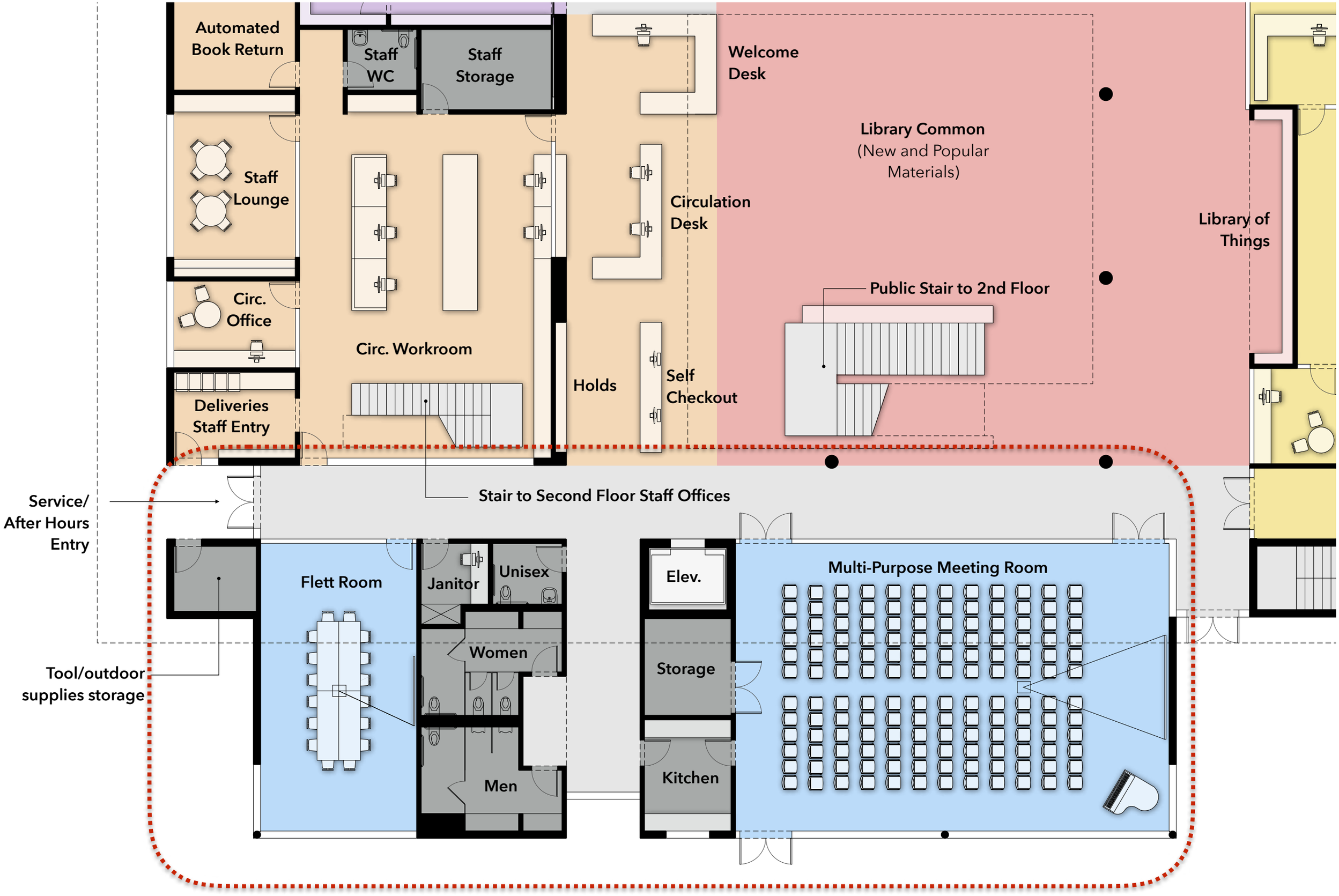
Concord Avenue

Option 2.0 - Second Floor Plan

Option 2.0 - First Floor Plan

Option 2.0 - Library Common View

Option 2.0 - First Floor Plan



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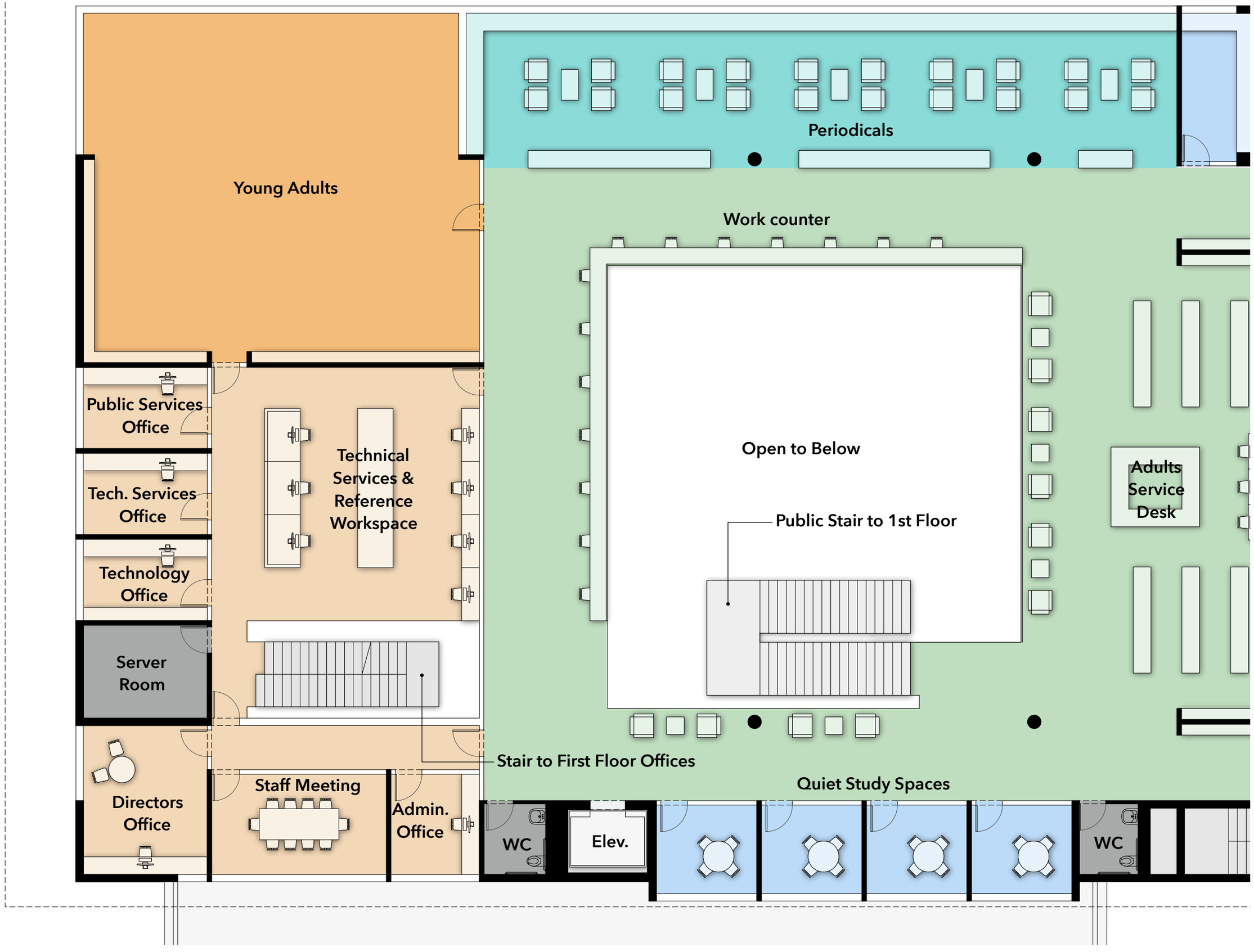
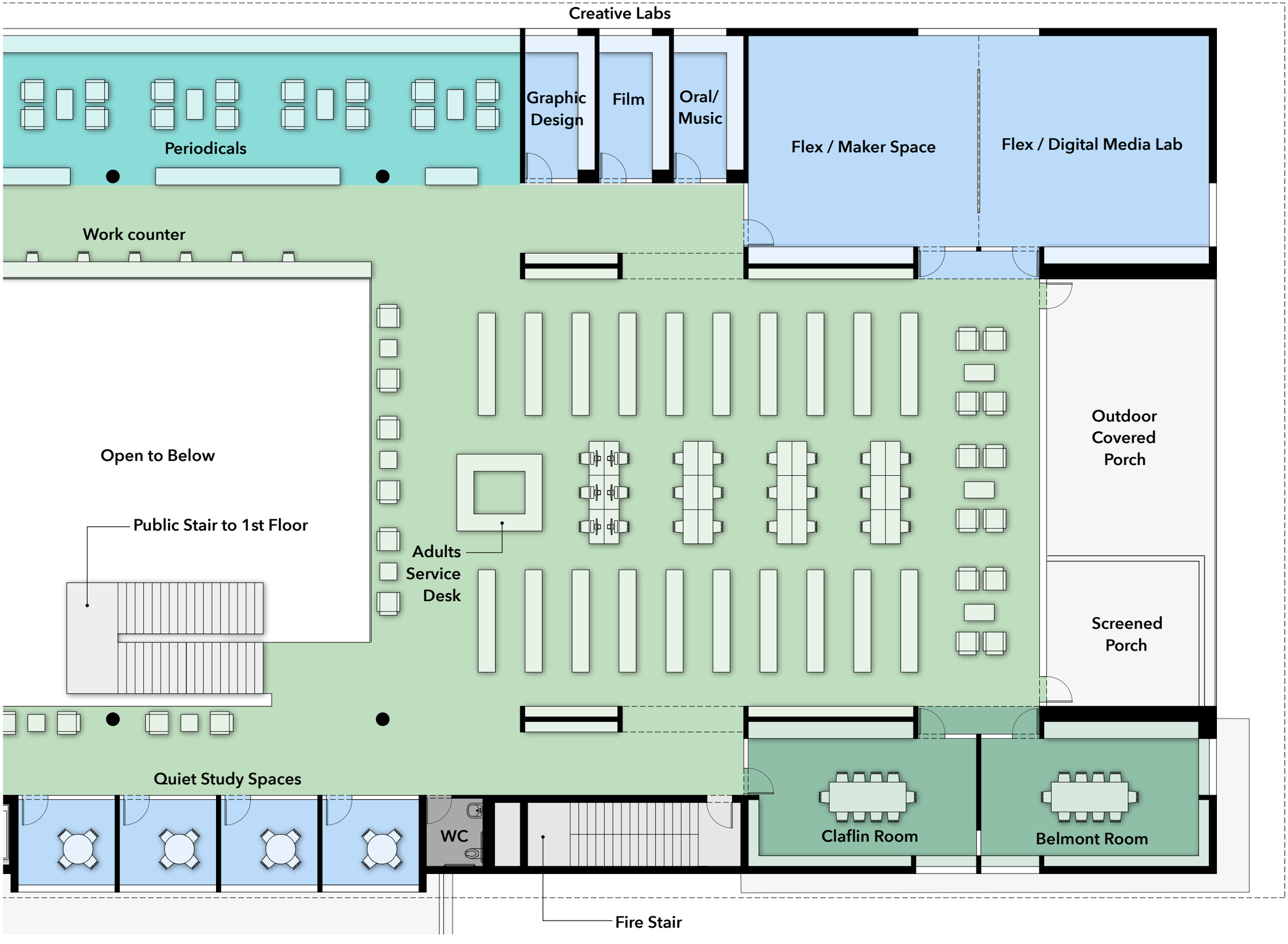


Option 2.0 - Second Floor Plan

Option 2.0 - Balcony View



Option 2.0 - Second Floor Plan

Option 2.0 - Balcony View

Belmont Public Library

Building Program Summary

AREA COMPARISON	Existing Area	Program 2018	Option 2.0
CIRCULATION & STAFF AREAS	3,324 SF	3,725 SF	5,148 SF
POPULAR MATERIALS	500 SF	2,100 SF	4,732 SF
MEETING ROOMS	1,637 SF	1,175 SF	2,716 SF
MAKER SPACE		975 SF	1,821 SF
ADULT COLLECTIONS & INFO SERVICES	9,200 SF	11,730 SF	6,987 SF
LOCAL HISTORY	740 SF	1,155 SF	880 SF
PERIODICALS		825 SF	1,400 SF
FRIENDS		600 SF	385 SF
YOUNG ADULT / TEEN	700 SF	1,400 SF	1,743 SF
CHILDREN'S DEPARTMENT	2,870 SF	6,650 SF	6,828 SF
CUSTODIAL & STORAGE	1,760 SF	725 SF	577 SF
Total Program Area	20,731 SF	31,060 SF	33,217 SF
Non Assigned	8,919 SF	13,311 *SF	6,198 SF
Gross Building Area	**29,650 SF**	**44,371 SF**	**39,415 SF**

* (42% - Assumes 70% Net to Gross Efficiency)

Option 2.0 - Square Footage Summary

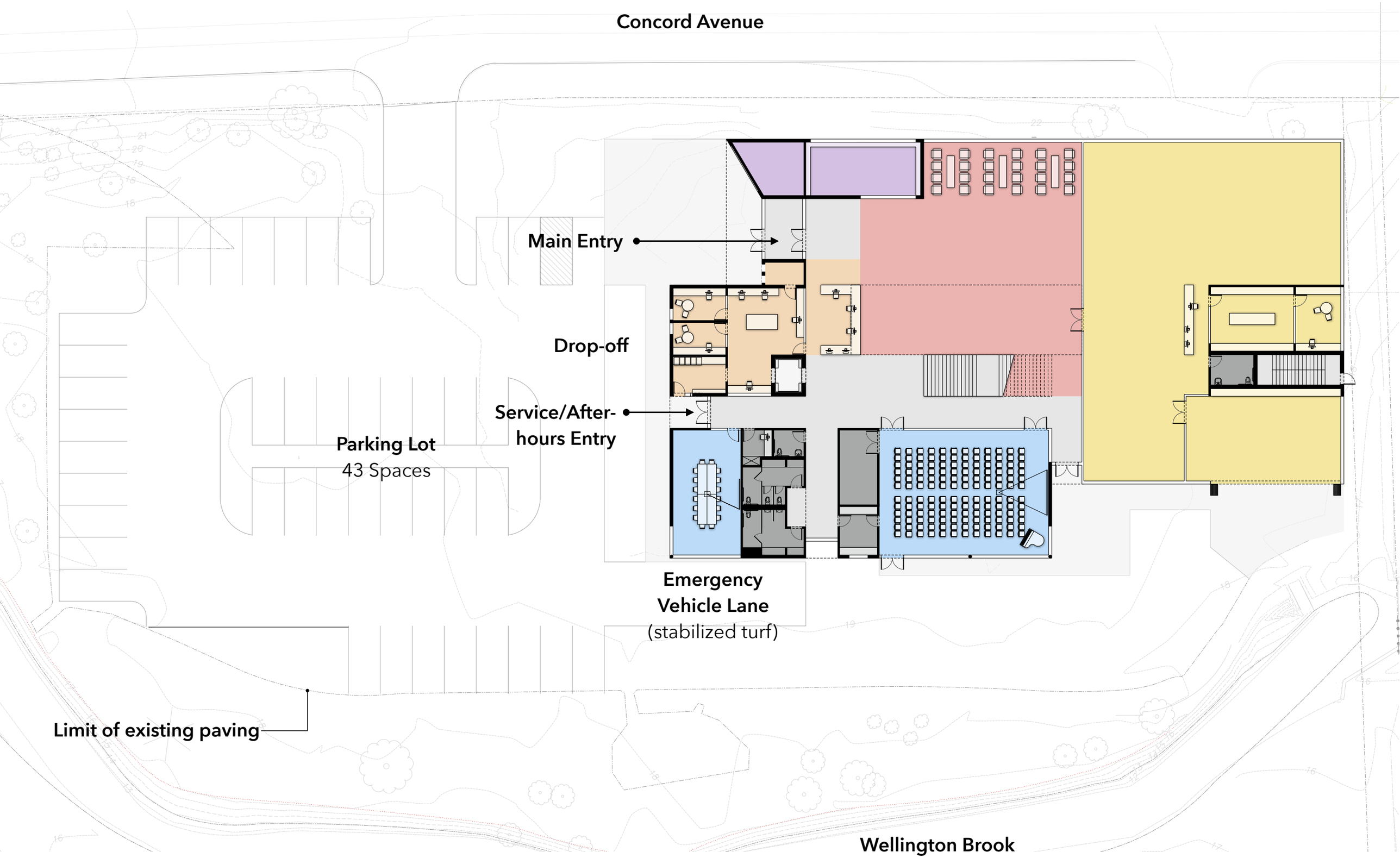
Option 2.0 - Aerial View Along Concord Avenue

Option 2.0 - Concord Avenue Facade

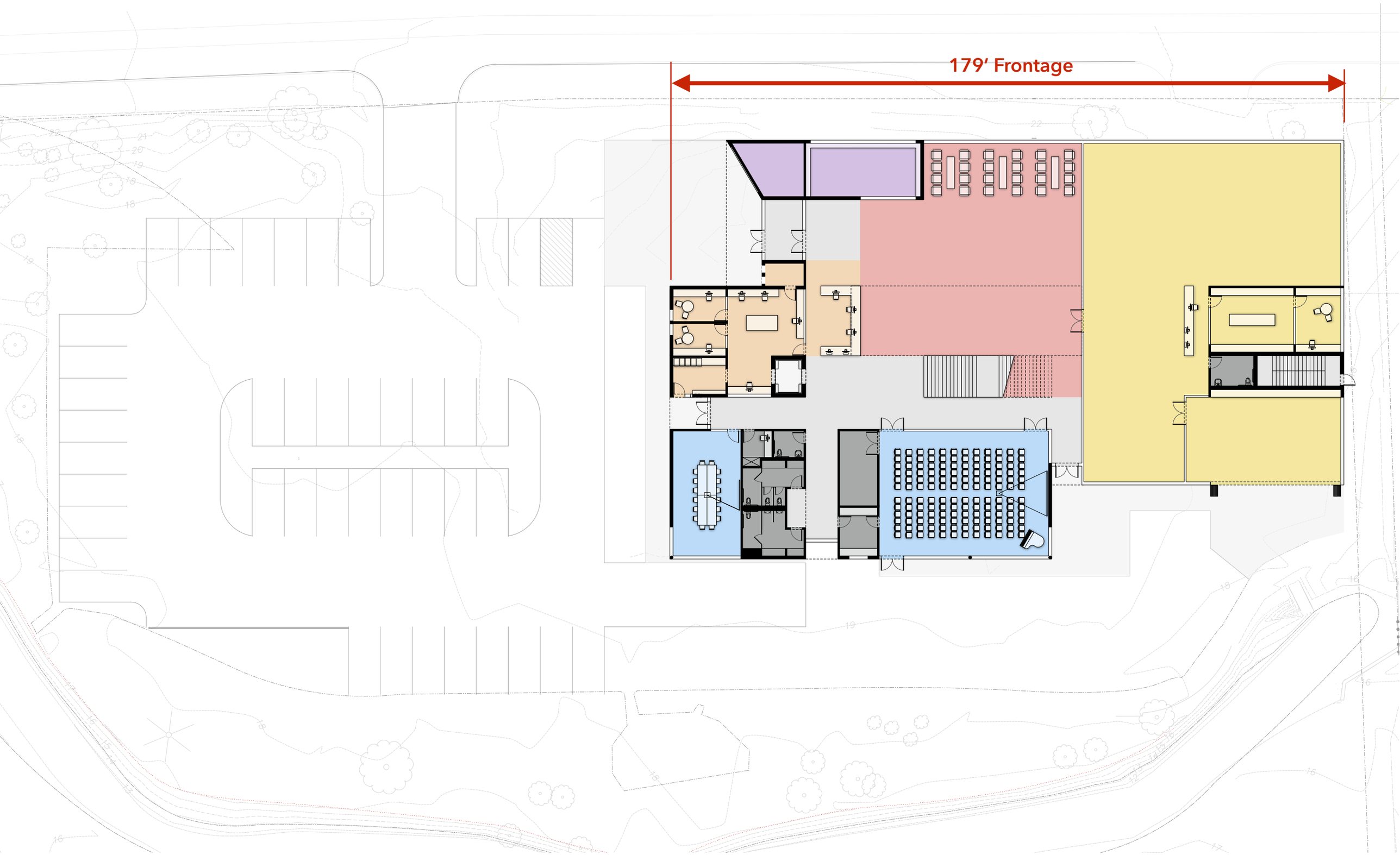
Option 2.0 - View from Underwood Lawn

Option 2.0 - View from Underwood Park

Option 2.5

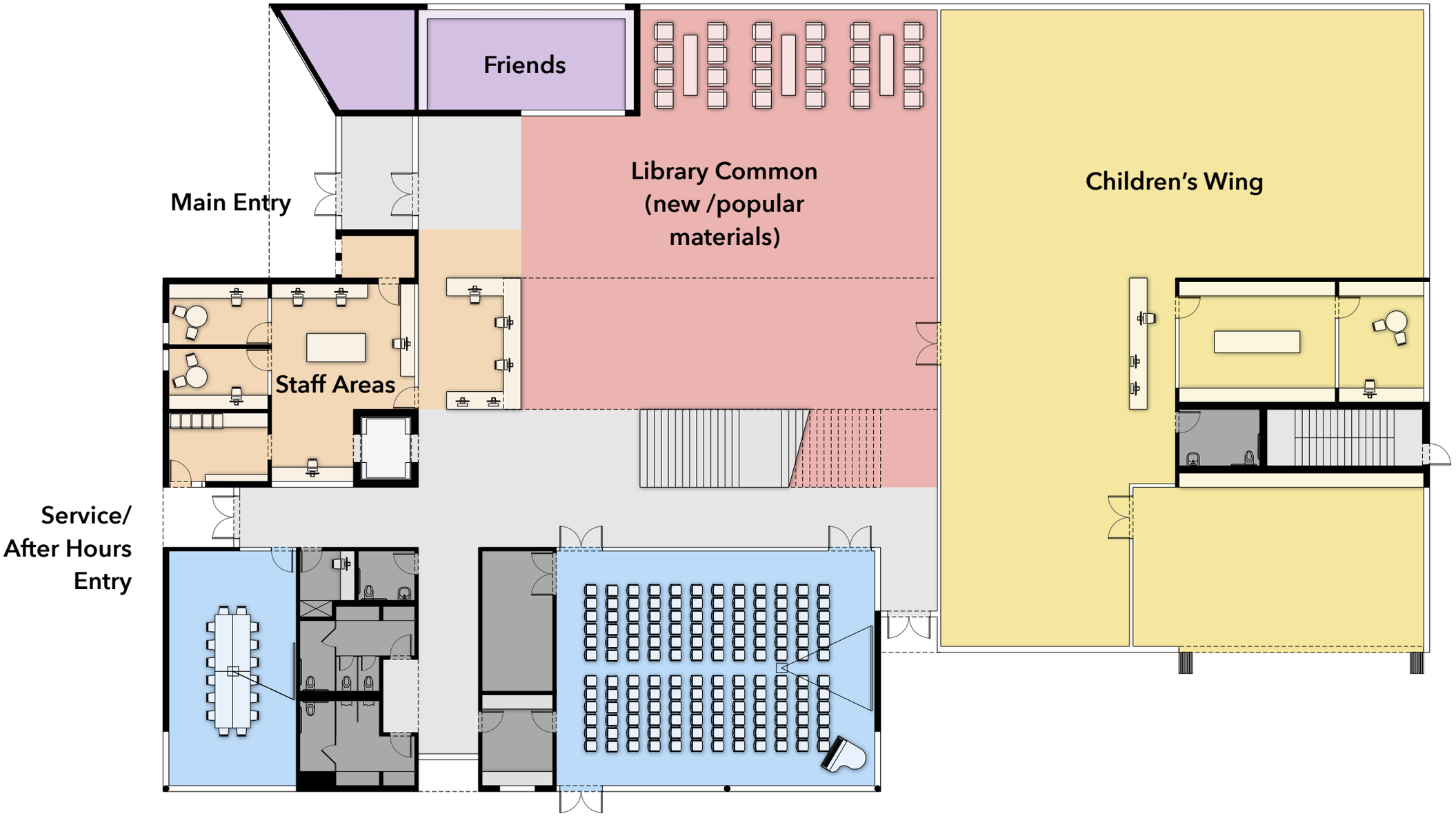


Option 2.5 - Site Plan

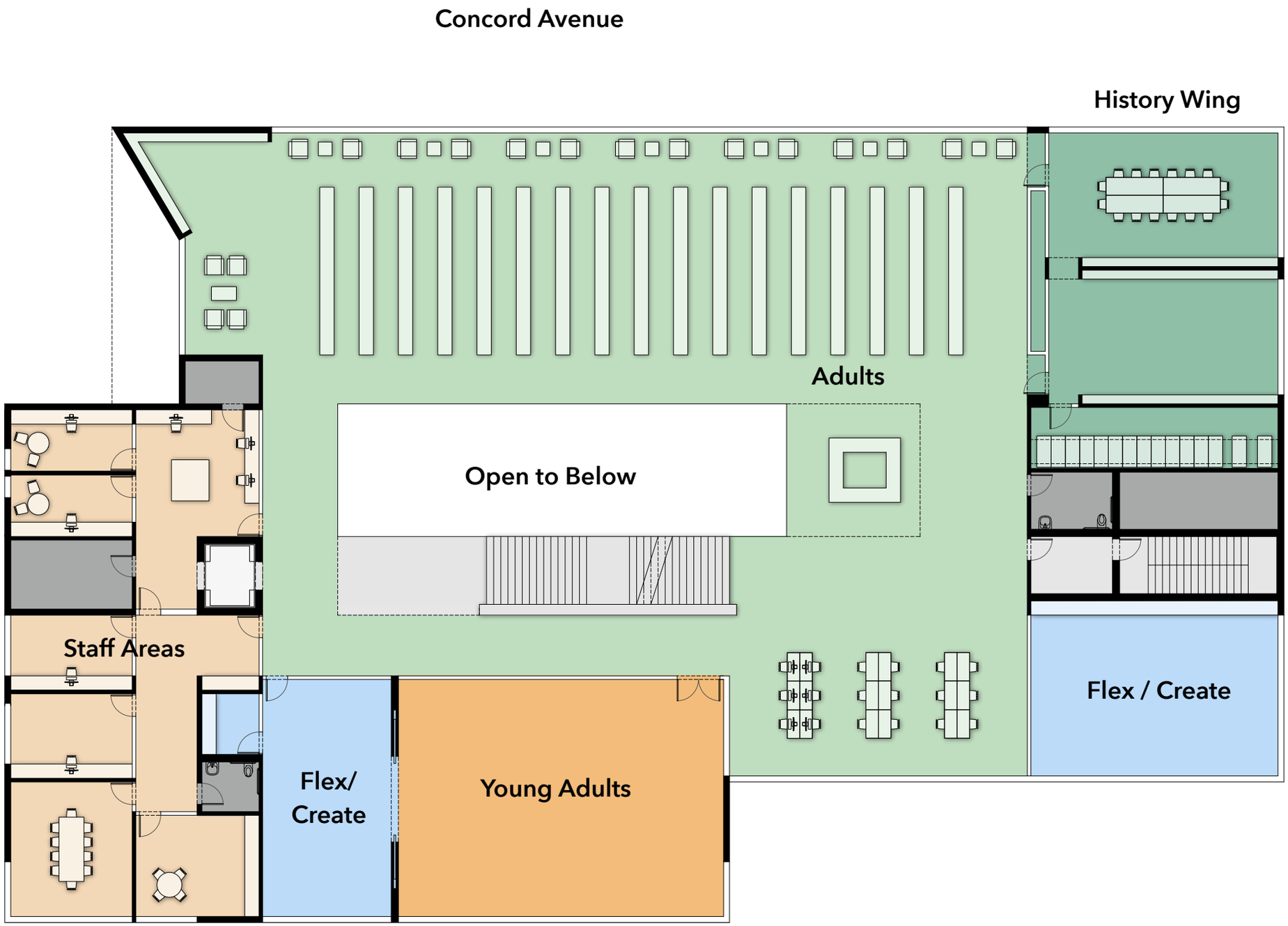


Option 2.5 - Site Plan

Concord Avenue

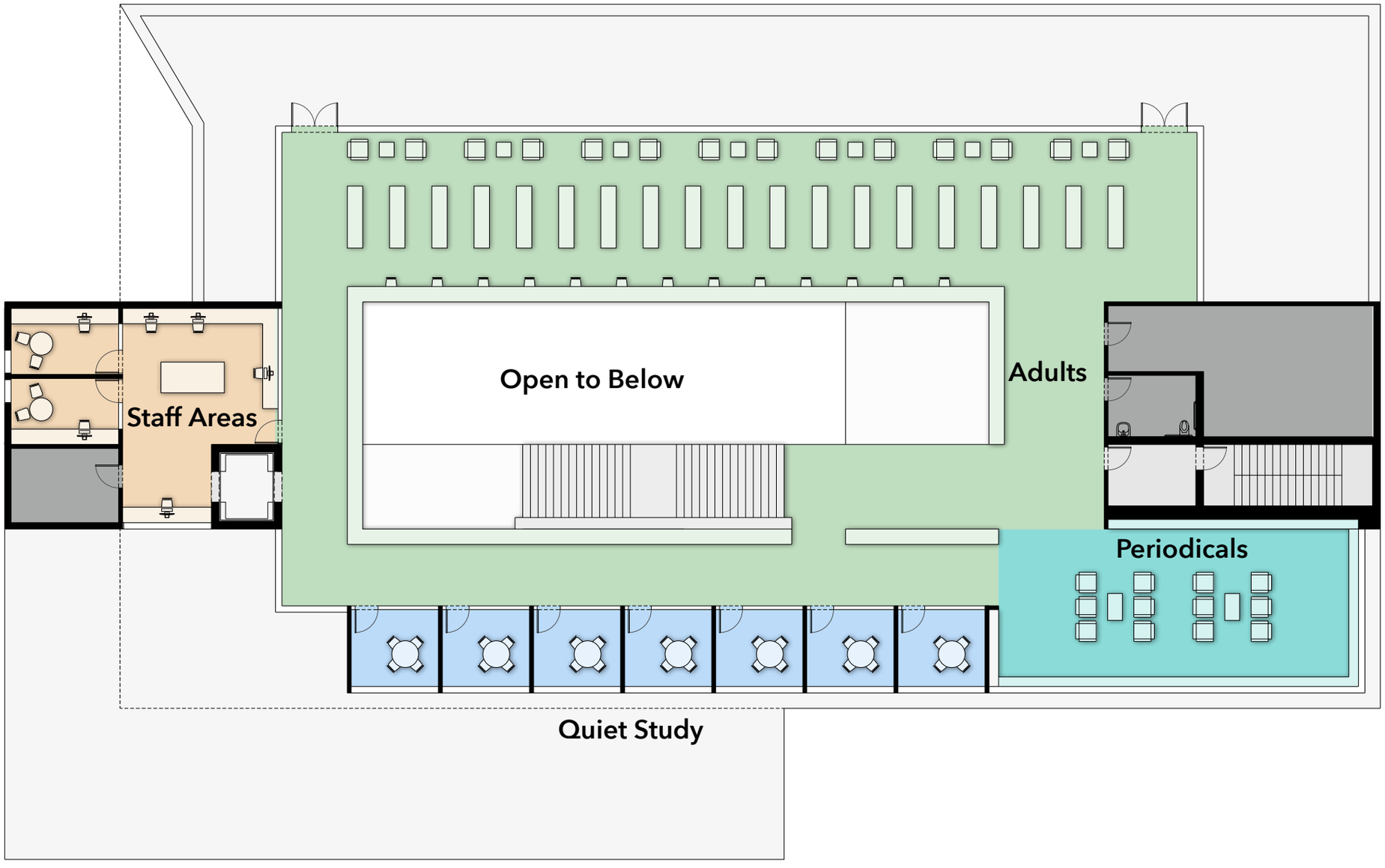


Option 2.5 - First Floor Plan



Option 2.5 - Second Floor Plan

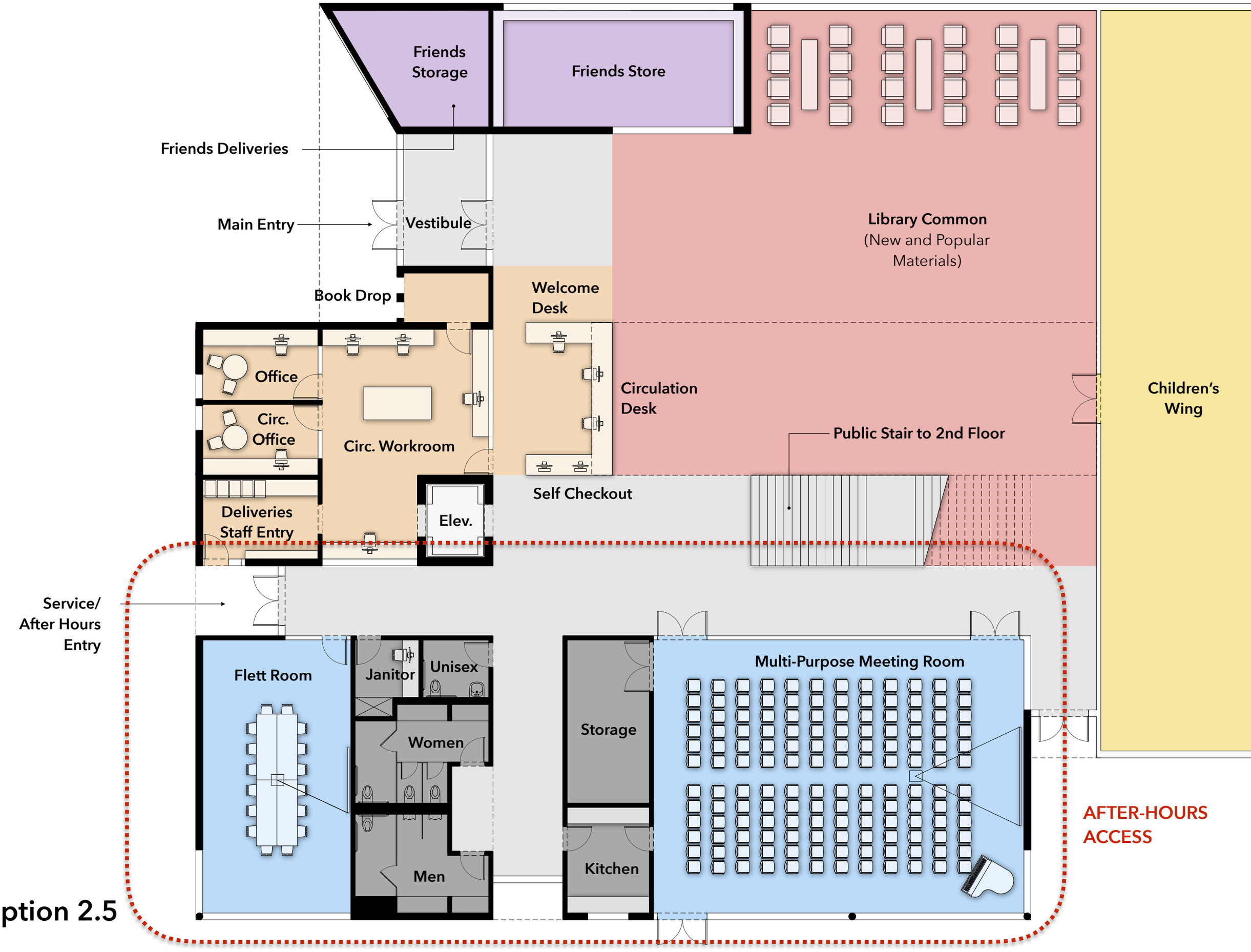
Concord Avenue



Option 2.5 - Third Floor Plan

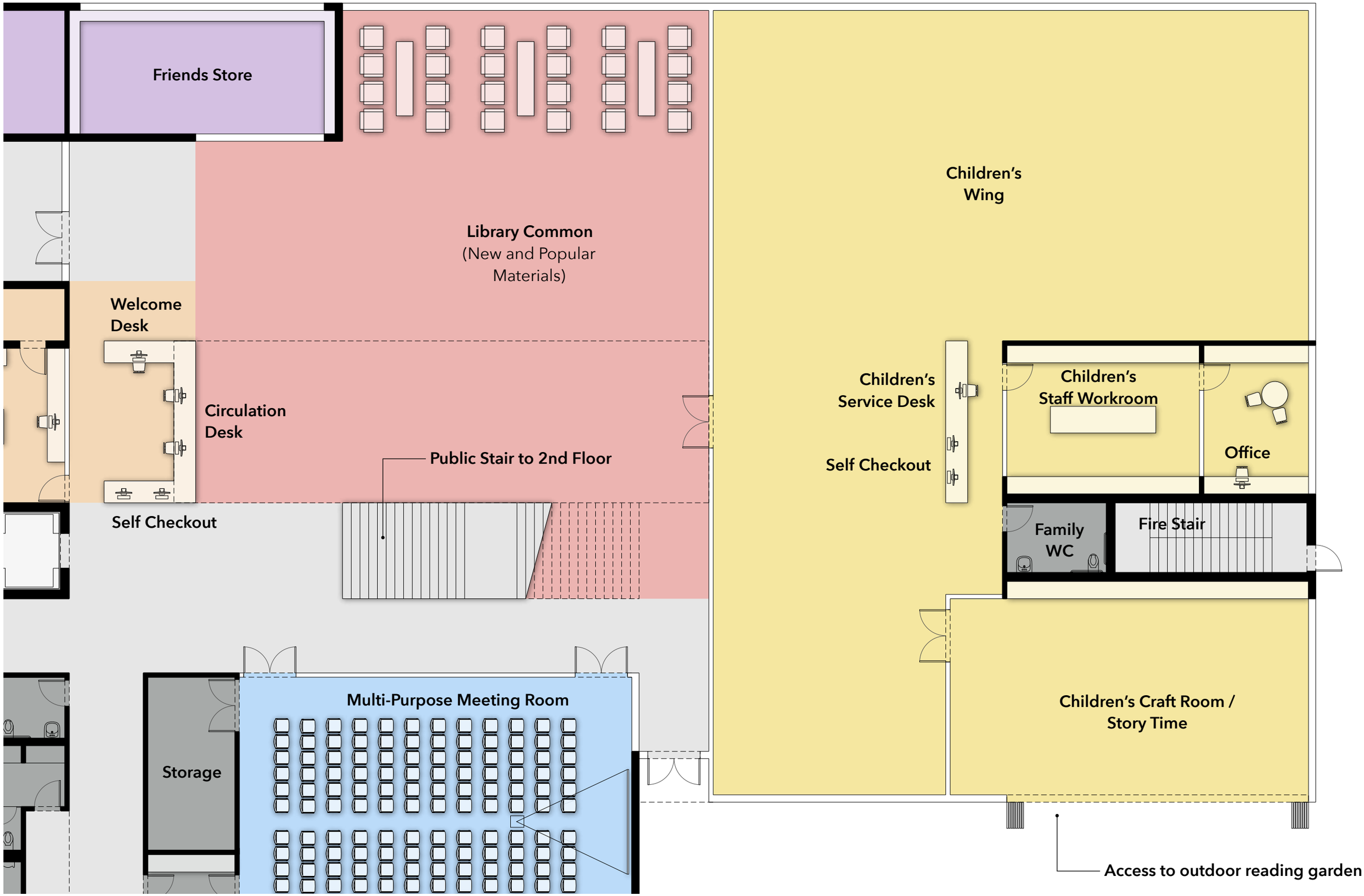

Friends Storage
Friends Store
Friends Deliveries
Main Entry
Vestibule
Library Common
(New and Popular Materials)
Book Drop
Welcome Desk
Office
Circulation Desk
Circ. Office
Circ. Workroom
Public Stair to 2nd Floor
Children's Wing
Deliveries Staff Entry
Elev.
Self Checkout
Service/ After Hours Entry
Flett Room
Janitor
Unisex
Women
Men
Storage
Kitchen
Multi-Purpose Meeting Room

Option 2.5


Friends Storage
Friends Store
Friends Deliveries
Main Entry
Vestibule
Library Common
(New and Popular Materials)
Book Drop
Welcome Desk
Office
Circ. Office
Circ. Workroom
Circulation Desk
Public Stair to 2nd Floor
Children's Wing
Deliveries Staff Entry
Elev.
Self Checkout
Service/ After Hours Entry
Flett Room
Janitor
Unisex
Women
Men
Storage
Kitchen
Multi-Purpose Meeting Room
AFTER-HOURS ACCESS

Option 2.5

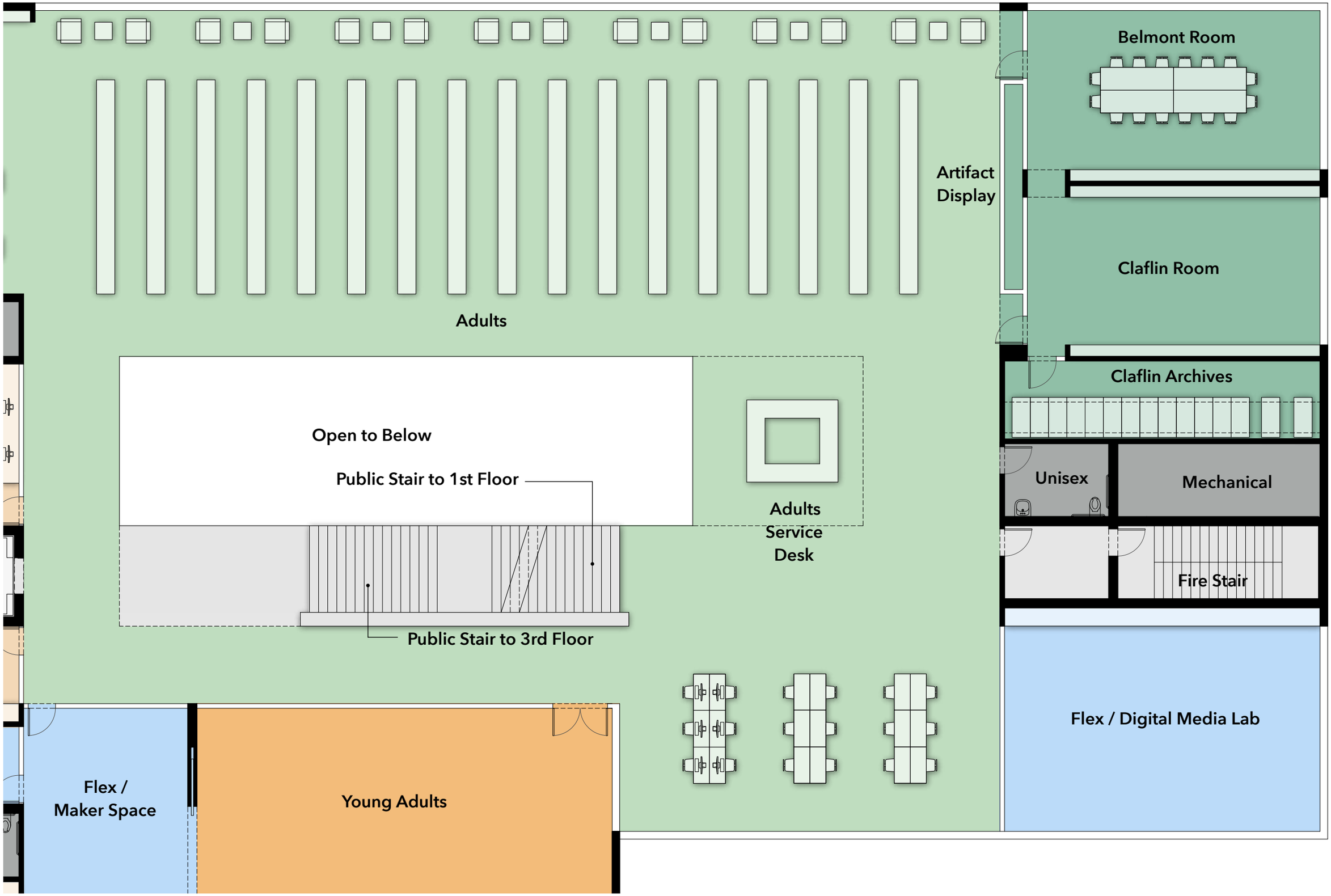
Option 2.5 - Library Common View



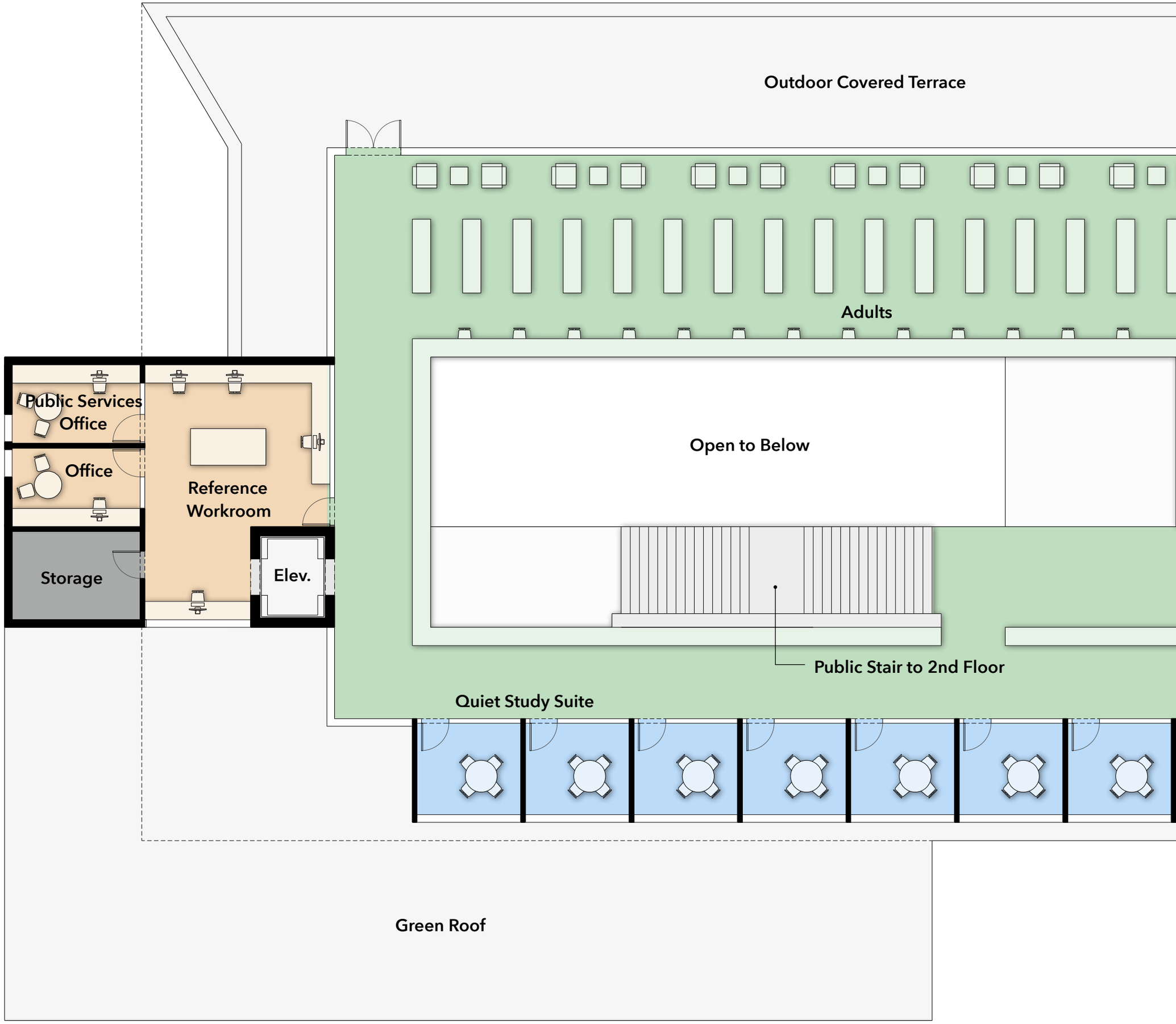
Option 2.5 - First Floor Plan


Adults
Storage
Tech. Services Office
Technology Office
Tech. Services Workroom
Server Room
Elev.
Admin. Office
Director's Office
Lab
Staff Wc
Staff Meeting
Staff Lounge
Flex / Maker Space
Young Adults
Open to Below
Public Stair to 1st Floor
Adults Service Desk

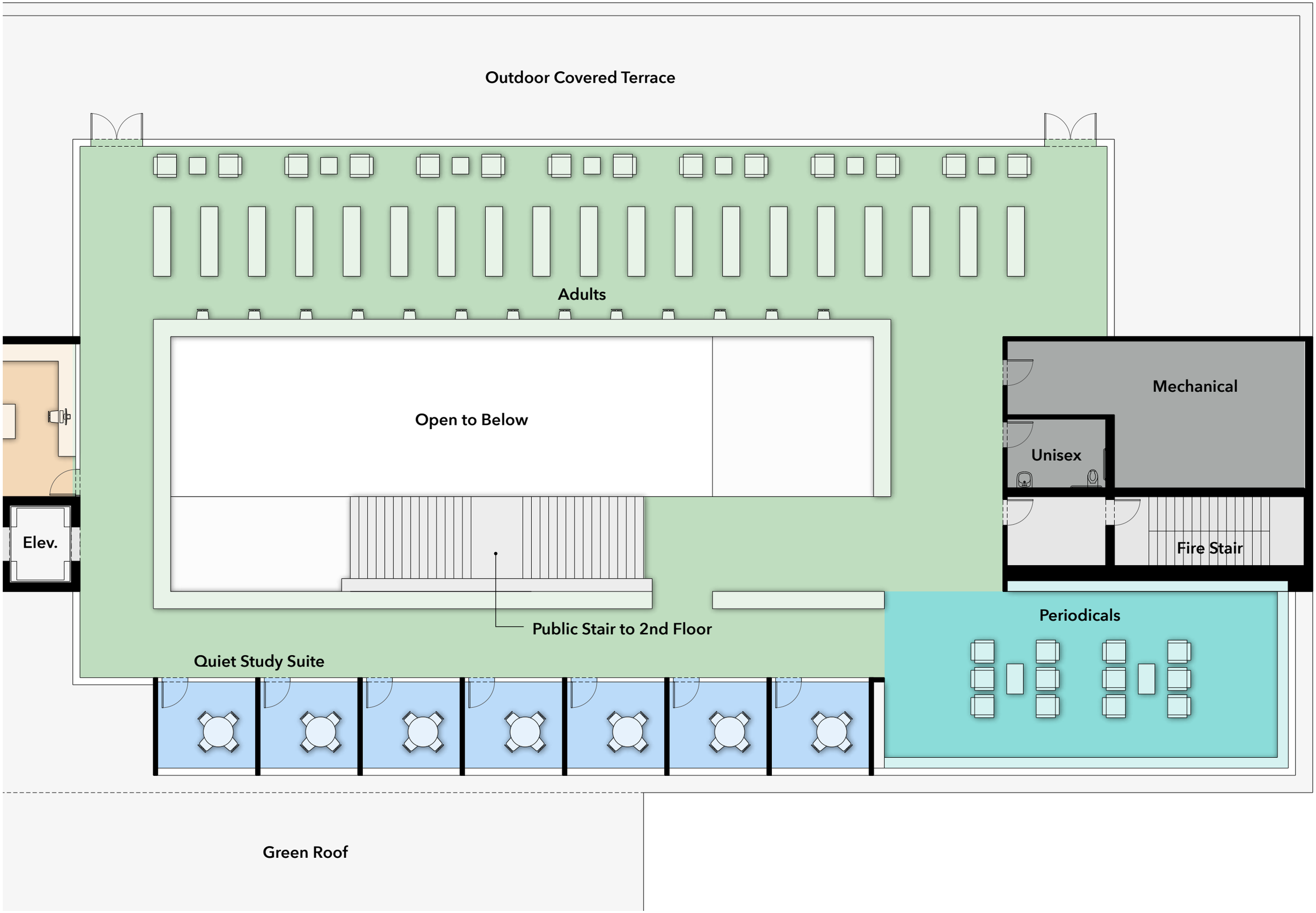
Option 2.5



Option 2.5 - Second Floor Plan


Outdoor Covered Terrace
Adults
Public Services Office
Office
Reference Workroom
Storage
Elev.
Open to Below
Public Stair to 2nd Floor
Quiet Study Suite
Green Roof

Option 2.5



Option 2.5 - Third Floor Plan

Option 2.5 - Third Floor Balcony View

Option 2.5 - Third Floor Roof Terrace View

Belmont Public Library

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Gross Building Area	**29,650 SF**	**44,371 SF**	**39,415 SF**	**41,941 SF**

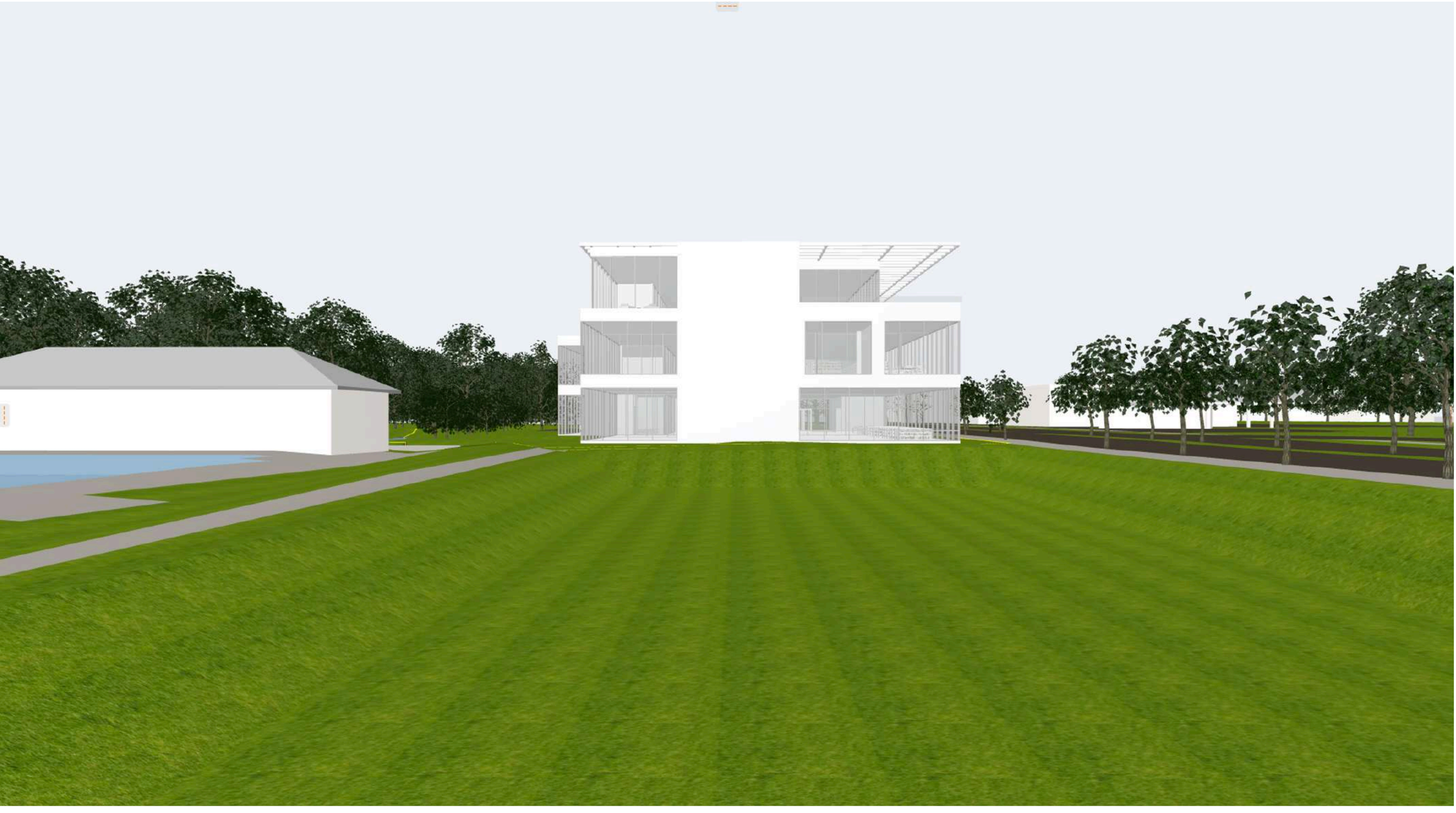
* (42% - Assumes 70% Net to Gross Efficiency)

Option 2.5 - Square Footage Summary

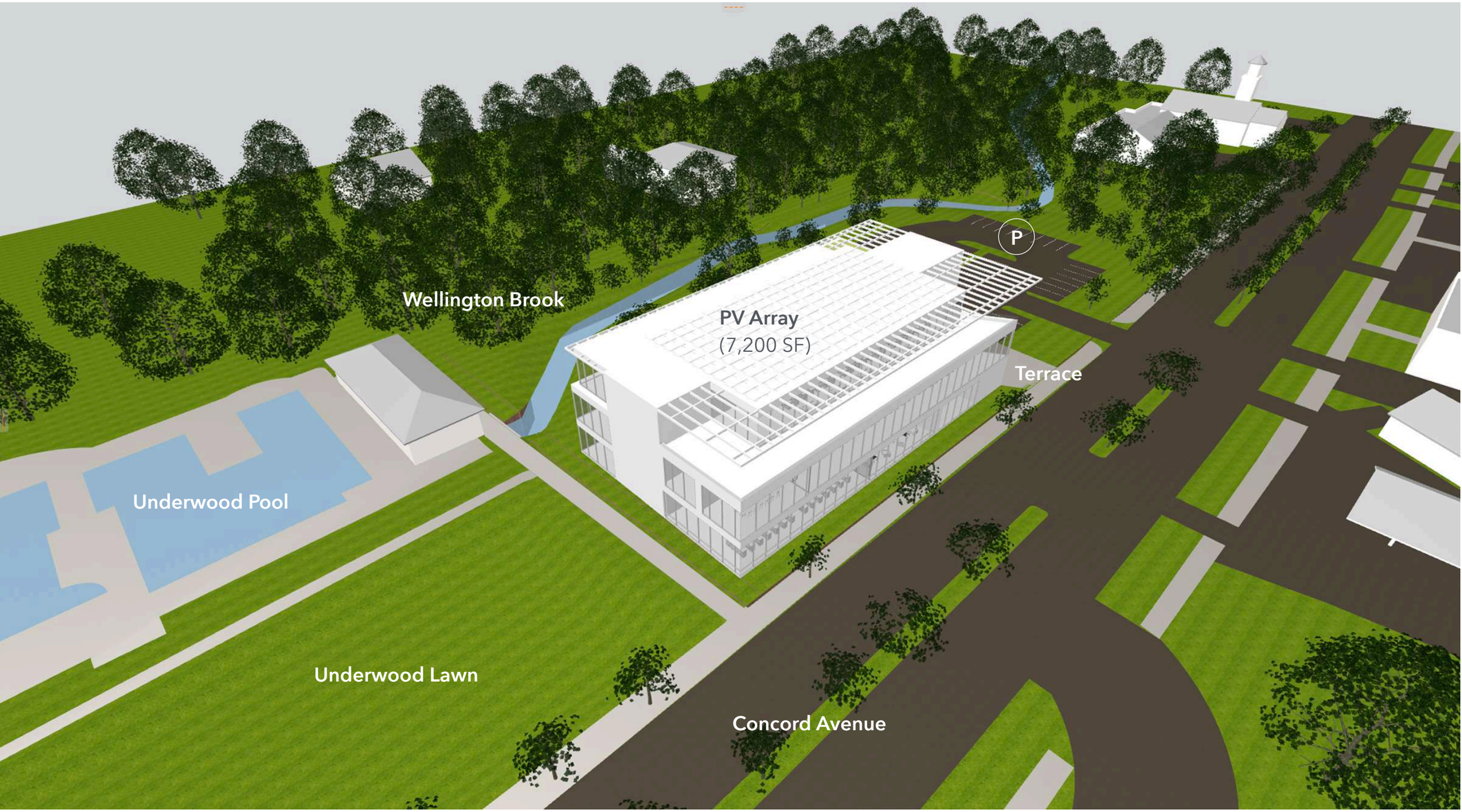
Option 2.5 - Cross Section

Option 2.5 - Cross Section

Option 2.5 - Concord Avenue Facade



Option 2.5 - View from Underwood Lawn


Wellington Brook
PV Array
(7,200 SF)
P
Terrace
Underwood Pool
Underwood Lawn
Concord Avenue

Option 2.0

- 2 Stories
- 39,415 GSF
- 43-feet High
- 42 Parking Stalls
- 10,000 SF PV Array

Option 2.5

- 3 Stories
- 41,941 GSF
- 48-feet High
- 43 Parking Stalls
- 7,200 SF PV Array

Oudens Ello Architecture