CIRCULUS AQUATILIS

DESIGNING AIR CIRCULATION FOR A BETTER SWIMMING EXPERIENCE

THESIS STATEMENT

How to design a natatorium that efficiently circulates the air to keep the air quality at a comfortable level for those using the facility at all times.

BACKGROUND

PROBLEM

- Water damage in the walls
- Improper maintenance
- Old age

IMPORTANCE

- Importance of swim lessons
- High school and club teams
- Leisure swimming
- Bring in new sports (water polo, or diving)

GOALS

- Design an HVAC system to properly cool and keep chlorine/chlorimine levels low
- Provide a natatorium that will be designed for the high school/club teams to practice in and host large meets
- Be able to provide multiple opportunities for water based classes

CENTRAL HIGH SCHOOL

UND HYSLOP

RESEARCH

CHLORINE LEVELS

- Meet warm ups
- Not showering before entering the water
- Unbalanced chemicals
- Not enough air changes per hour

HVAC LAYOUT

- Format in a "U" shape
- High, medium, and low returns
- Exhaust to push along the water surface

PARAMETERS

Temperature:
- Water: 80-84
- Air: 84

Humidity:
- Relative: 55%
- Summer: 60%
- Winter: 50%

Air Change Rate:
- Minimum of 6-8 per hour
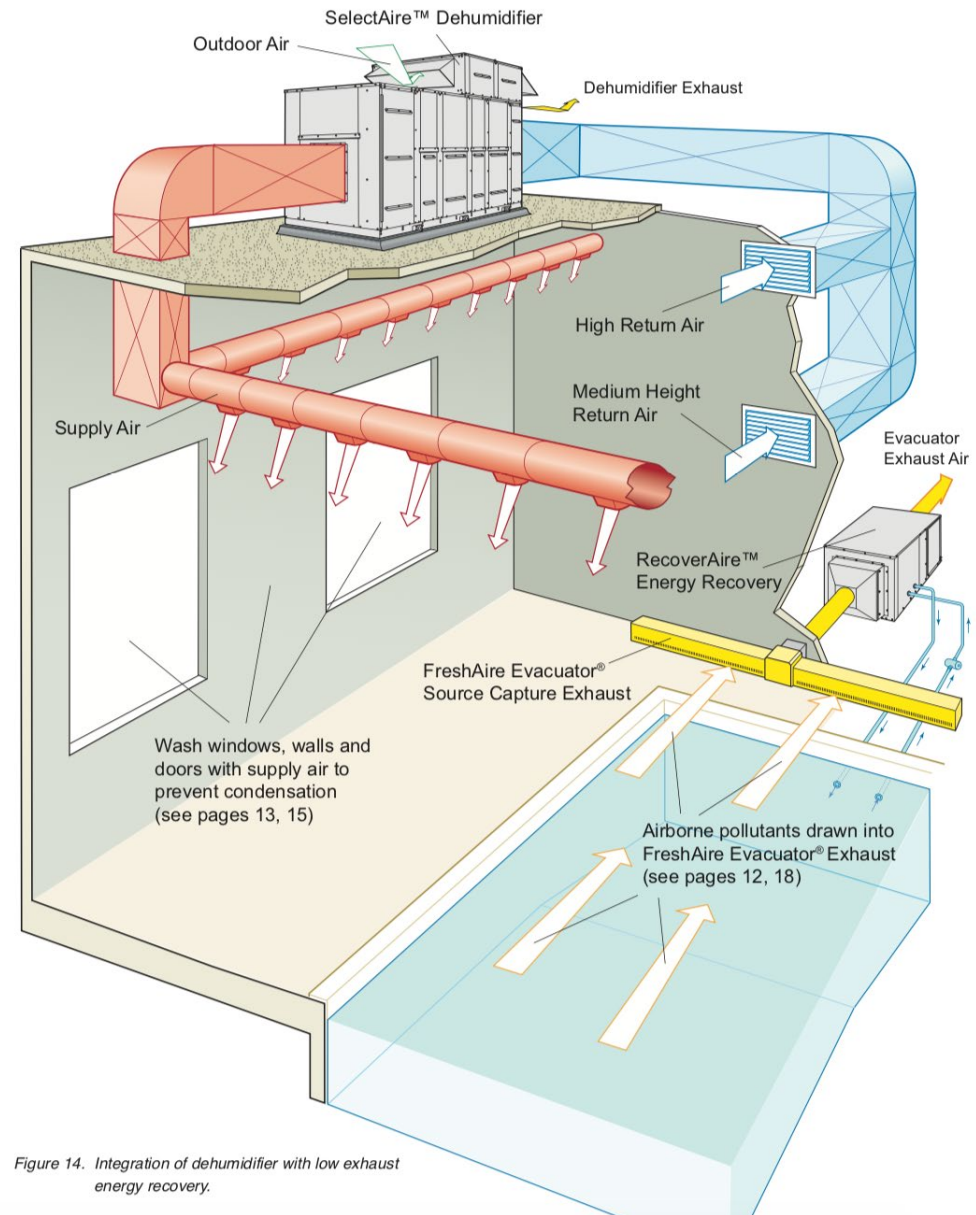
Air Flow Rate:
- Regular Air Flow: 50-100 ft/s
- Air Flow Across the Water: 10-30 ft/s

Figure 14. Integration of dehumidifier with low exhaust energy recovery.

https://www.desert-aire.com/sites/default/files/Brochure-21st-Century-Pool-Design-Guide-DA030.pdf

METHODOLOGY

APPROACH

- Use Revit/SketchUp to model systems
- Use Autodesk CFD (Computation Fluid Dynamics)
- Change elements to see what works or hinders

INITIAL ISSUES

- Model was too detailed
- Model was too big
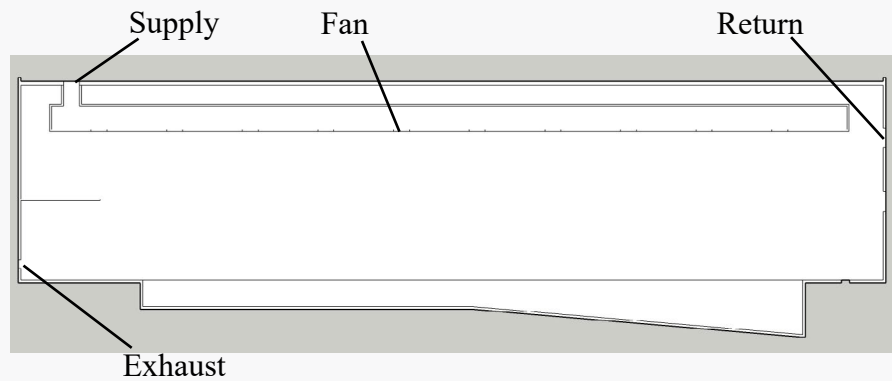- No openings for HVAC ducts
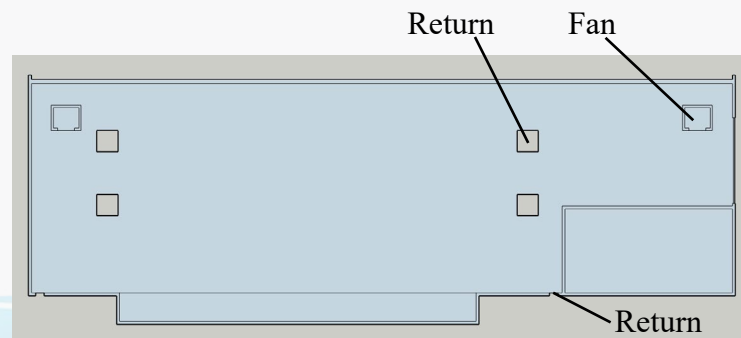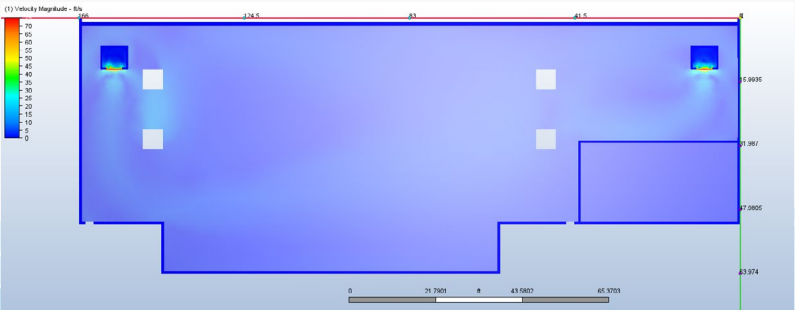- Shell not fully sealed errors
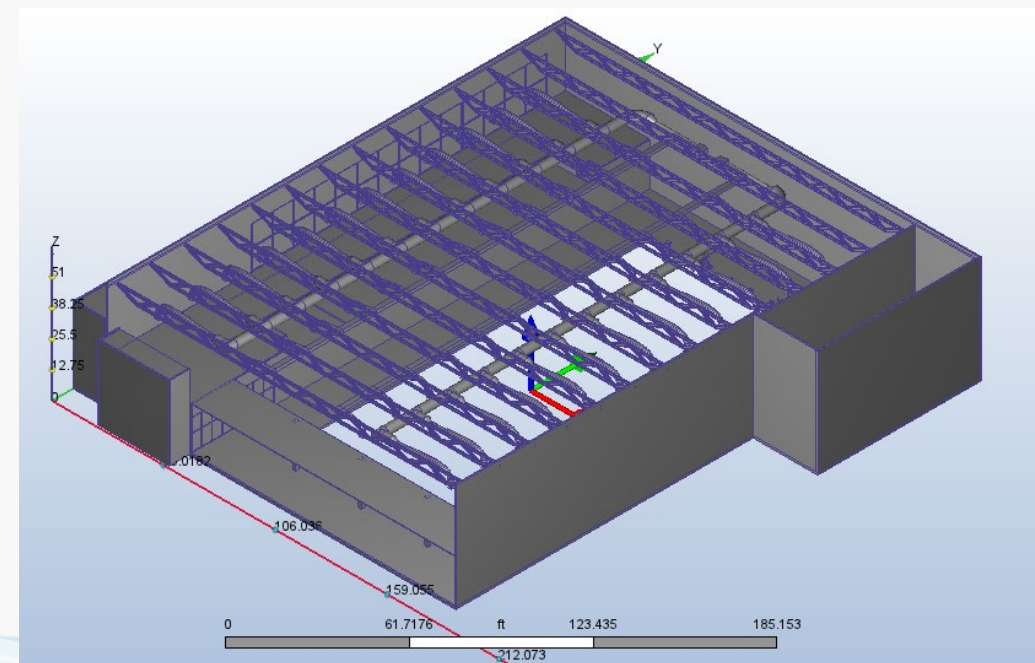
Original Draft Model

METHODOLOGY

NEW APPROACH

- Use 2D section cuts instead of a 3D model
- Change HVAC system only for each interation
- Have FormIt Pro format it into a .sat file
- Continue to use Autodesk CFD for simulations

Length of Pool

Width of Pool
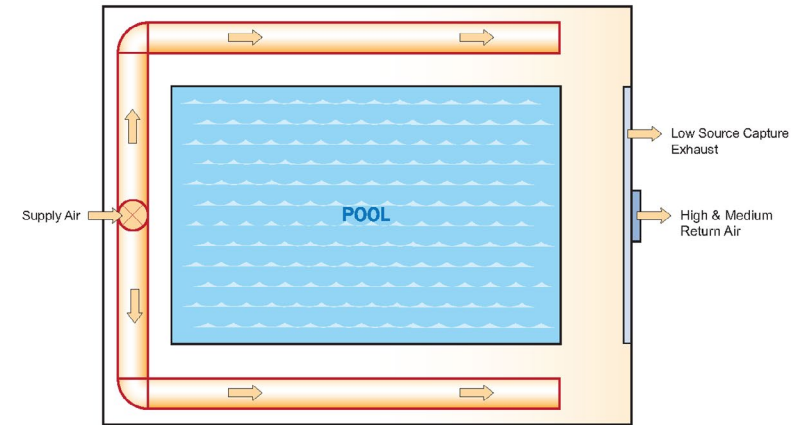
Figure 8. Top view of duct design
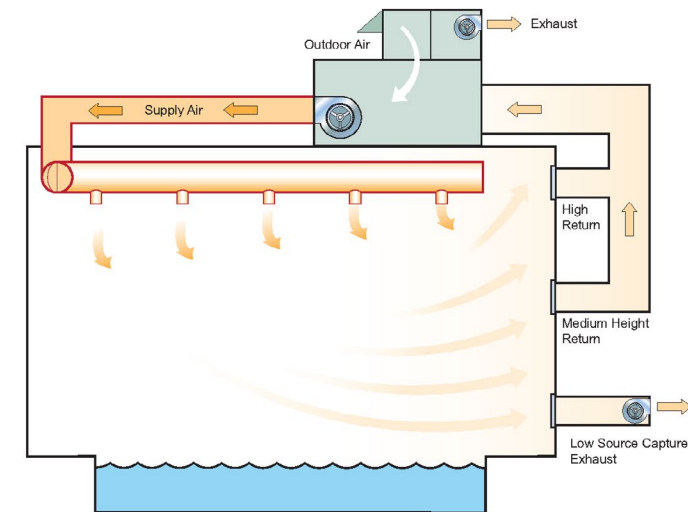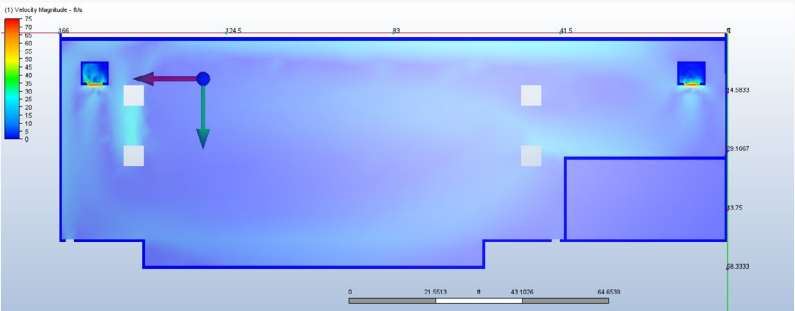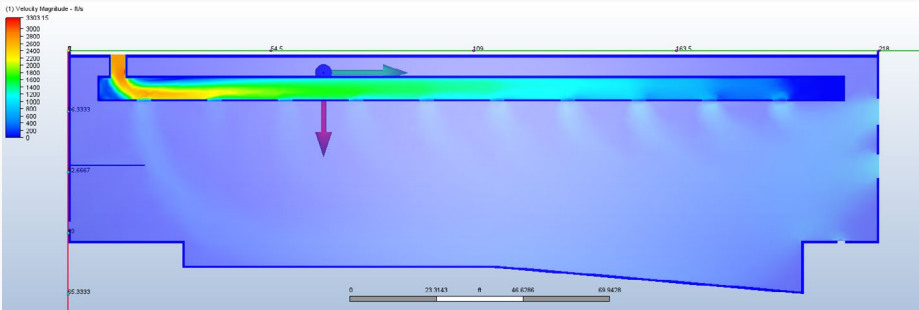
Figure 9. Plan view of duct design

https://www.desert-aire.com/sites/default/files/Brochure-21st-Century-Pool-Design-Guide-DA030.pdf
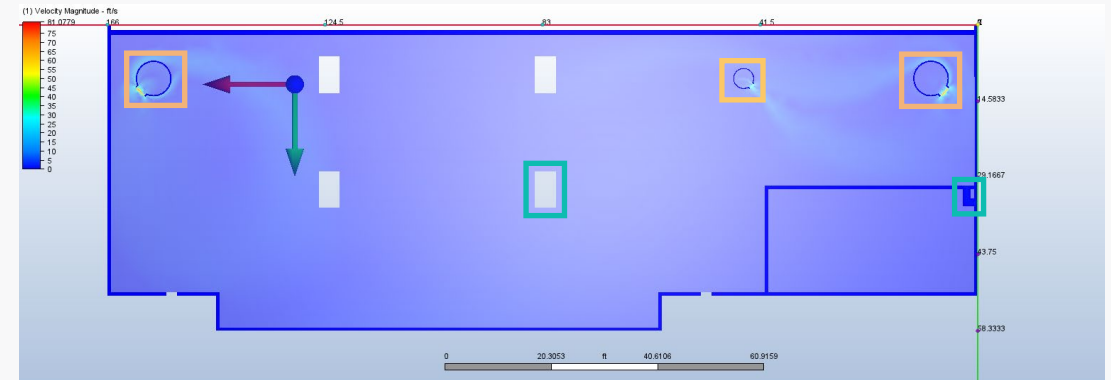
TESTING
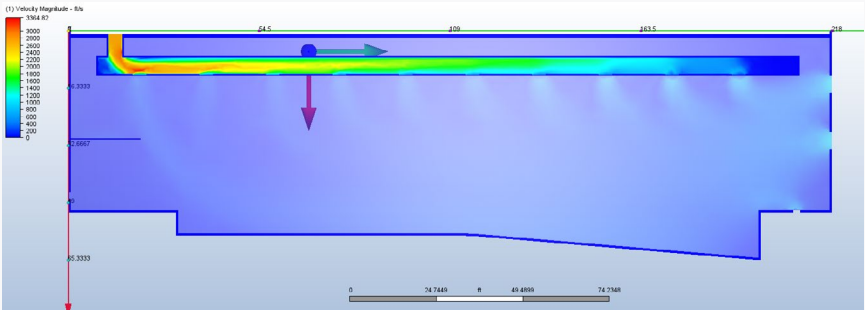
Variant 1

Variant 2
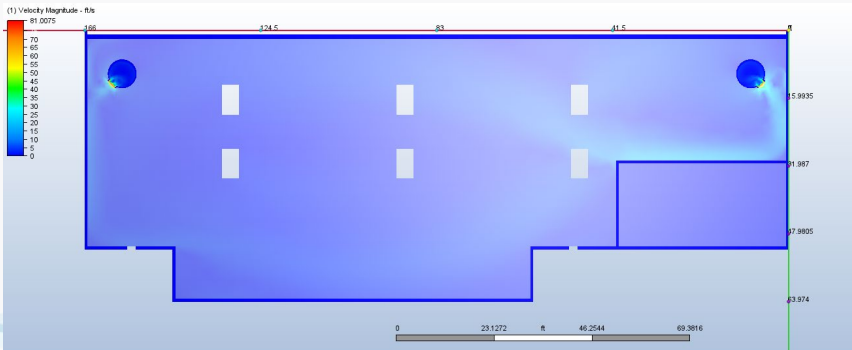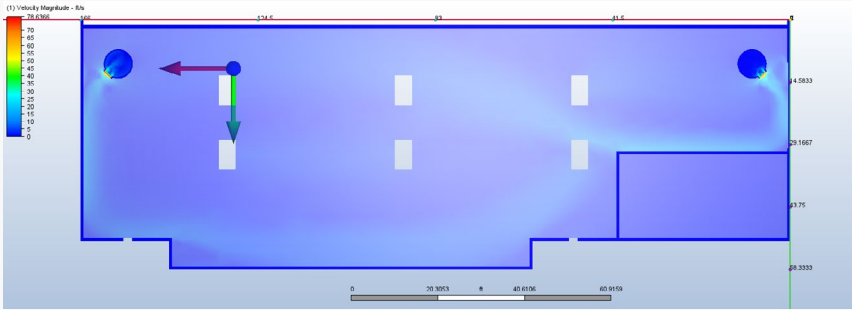
FINAL RESULTS

POSITIVES

- Easy to understand how the air circulates
- Can adjust air flow quickly to see how elements change
- Able to adjust SketchUp model and upload quickly for adjustments
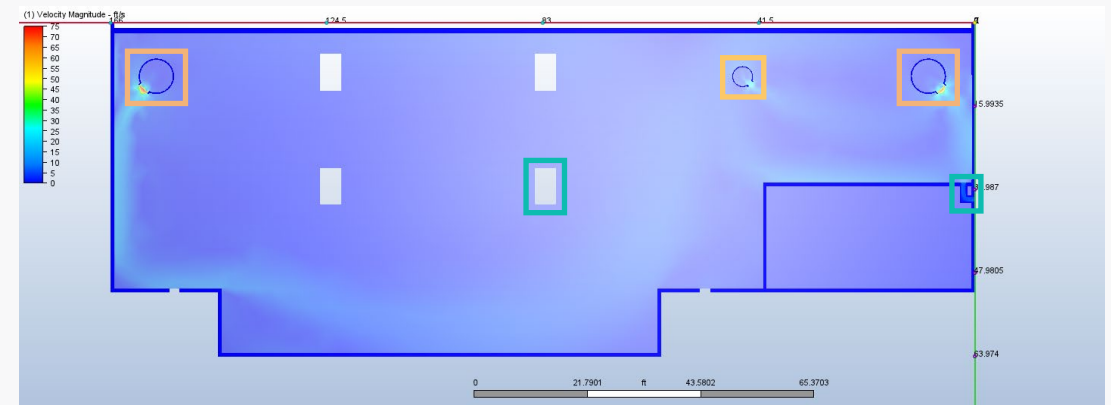
NEGATIVES

- 2D drawing can't too be detailed
- Cannot see how air circulates in a 3D space
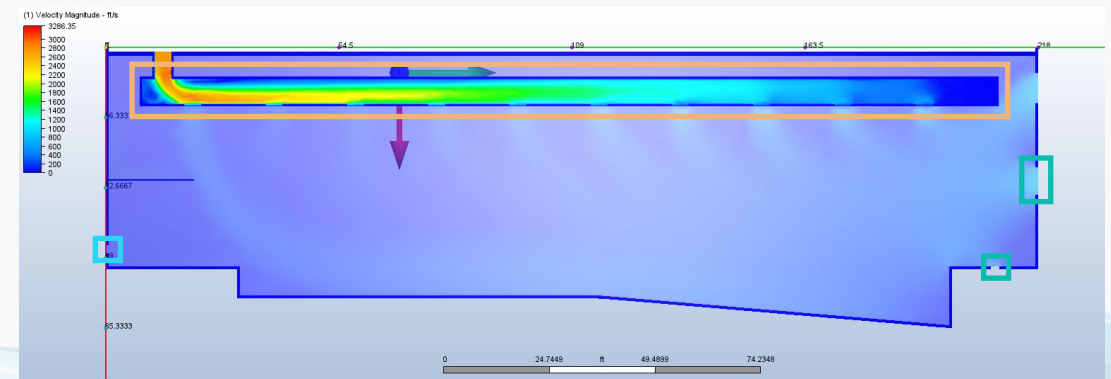- Cannot have water and air toucing in the same model

SHALLOW END

DEEP END

LENGTH OF POOL

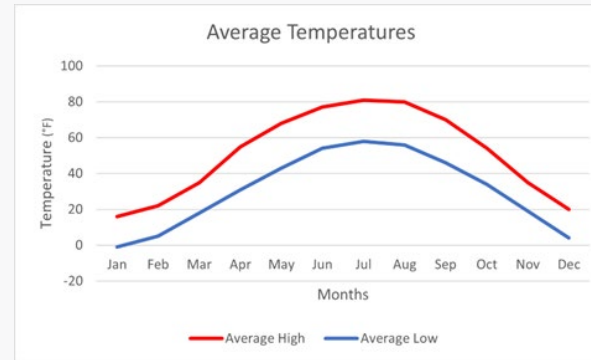|	
▮	SUPPLY AIR: 75 ft/s
▮	SUPPLY AIR: 50 ft/s
▮	EXHAUST: 30ft/s
▮	RETURN

GRAND FORKS
AQUATIC CENTER
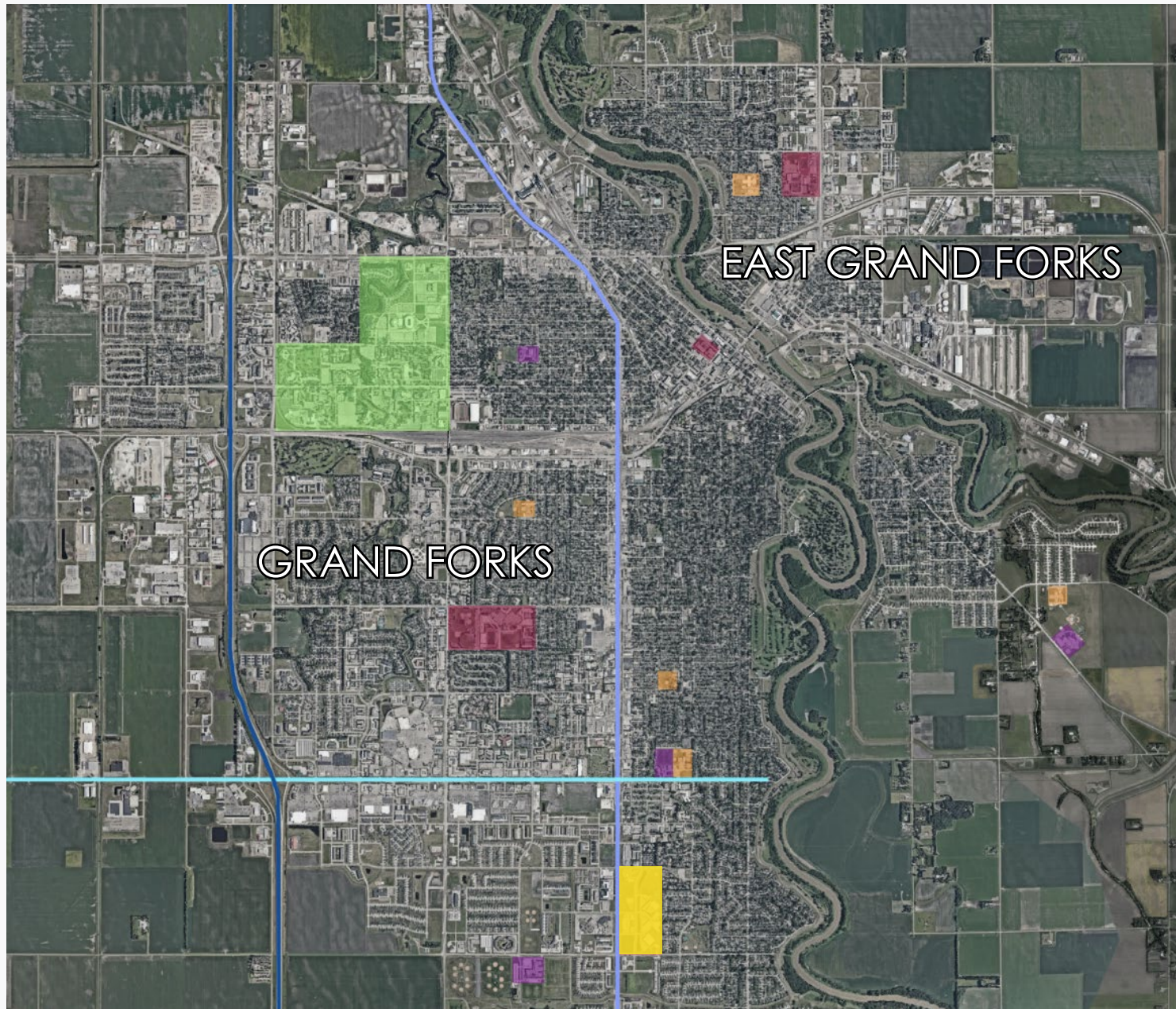
Legend:
- I-29
- S WAHSINGTON ST.
- 32nd AVE S.
- UND CAMPUS
- HIGH SCHOOL
- MIDDLE SCHOOL
- ELEMENTARY SCHOOL
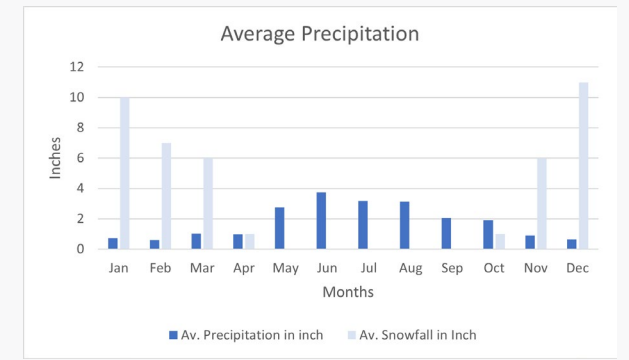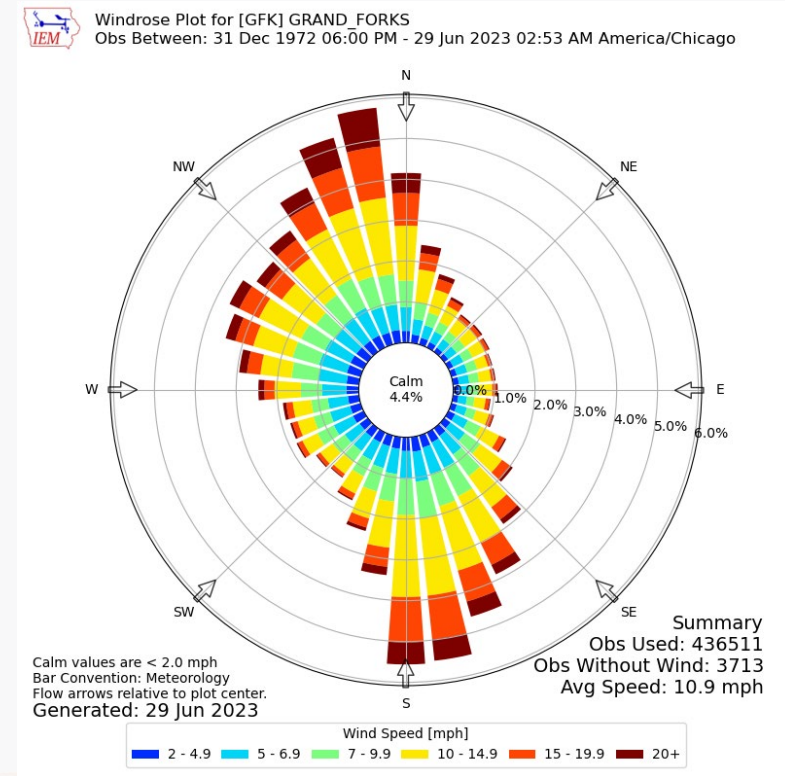- SITE

EAST GRAND FORKS

GRAND FORKS

N

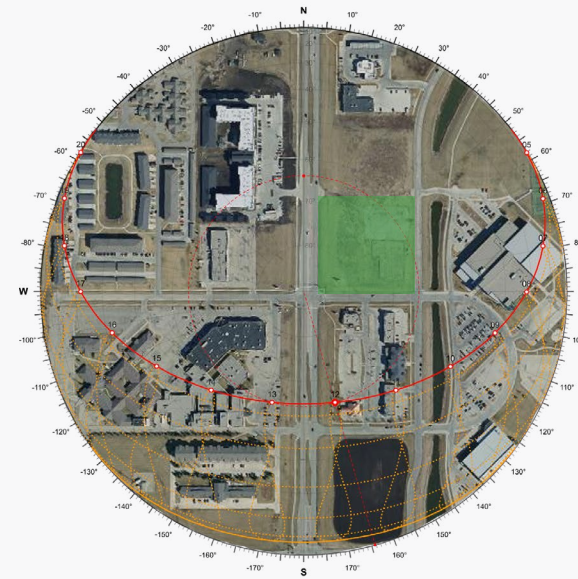CITY CONTEXT

SITE PLAN

TEMPERATURE

PRECIPITATION

WINDROSE

SITE PLAN

S WAHSINGTON St.

S 11th St.

44th Ave S.

N

SUMMER SOLSTICE

SOLAR INFORMATION

Solar Time:	11:30
Azi / Alt:	163.82° / 64.74°
Hour Angle:	7.45°
Declination:	23.44°
Rise / Set:	04:28 / 20:31
Daylight:	16:03 Hrs

TWILIGHT TIMES

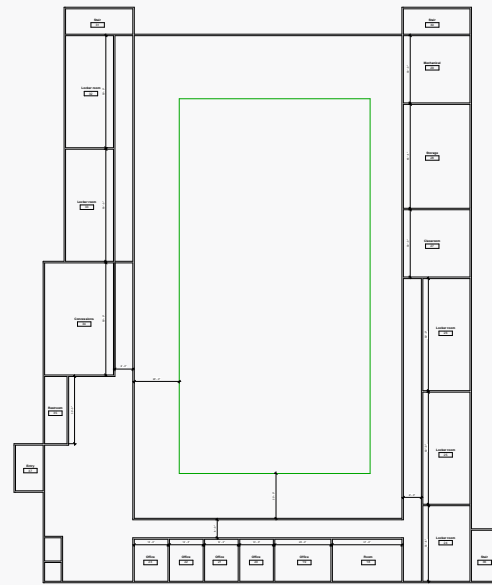| Civil: | 03:47 / 21:12 |
| Nautical: | 02:49 / 22:10 |
| Astronomical: | 01:10 / 23:50 |
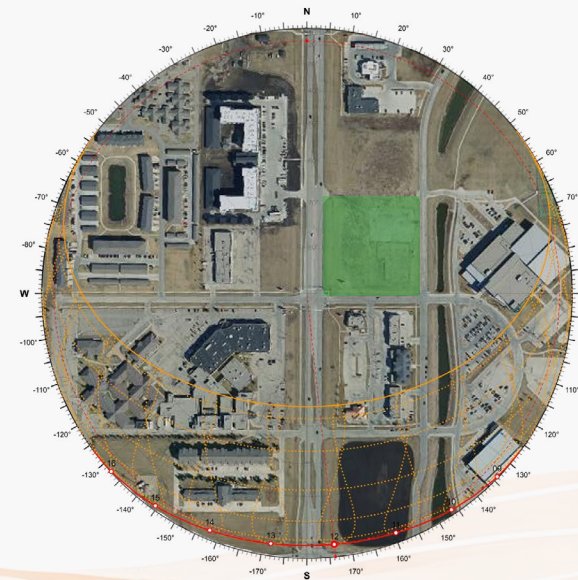
WINTER SOLSTICE

SOLAR INFORMATION

Solar Time:	11:34
Azi / Alt:	173.76° / 18.38°
Hour Angle:	6.46°
Declination:	-23.43°
Rise / Set:	08:15 / 16:37
Daylight:	08:22 Hrs

TWILIGHT TIMES

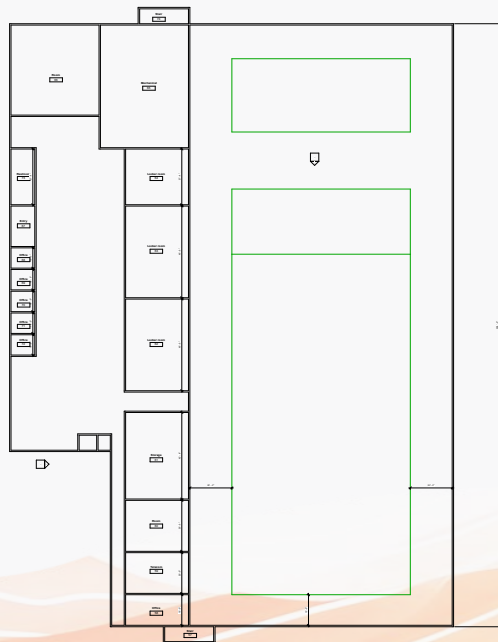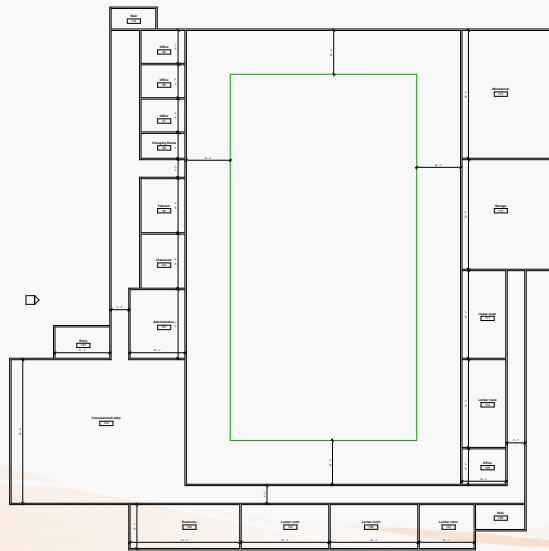| Civil: | 07:38 / 17:13 |
| Nautical: | 06:59 / 17:53 |
| Astronomical: | 06:21 / 18:31 |
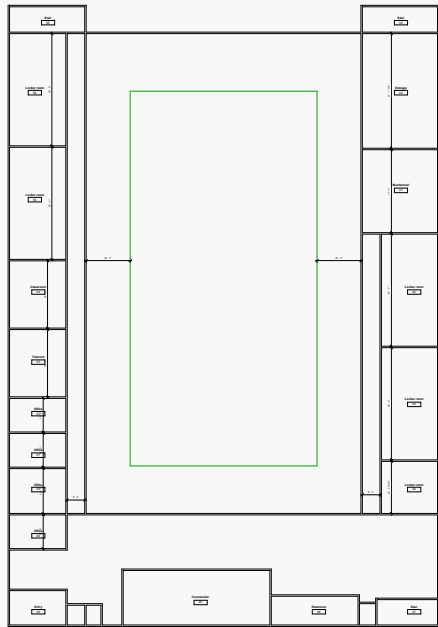
OPTION 1

OPTION 2
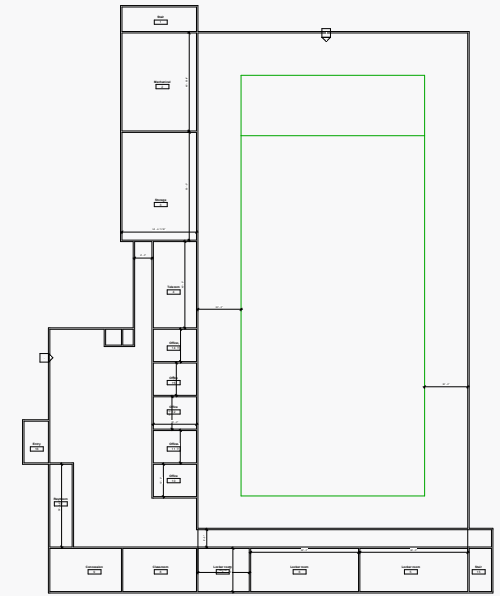
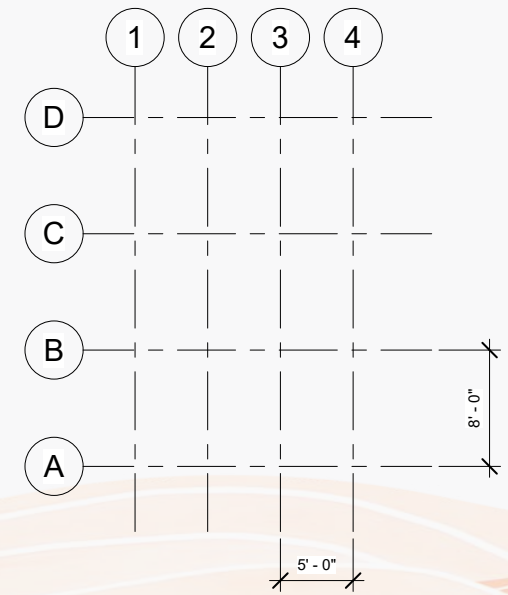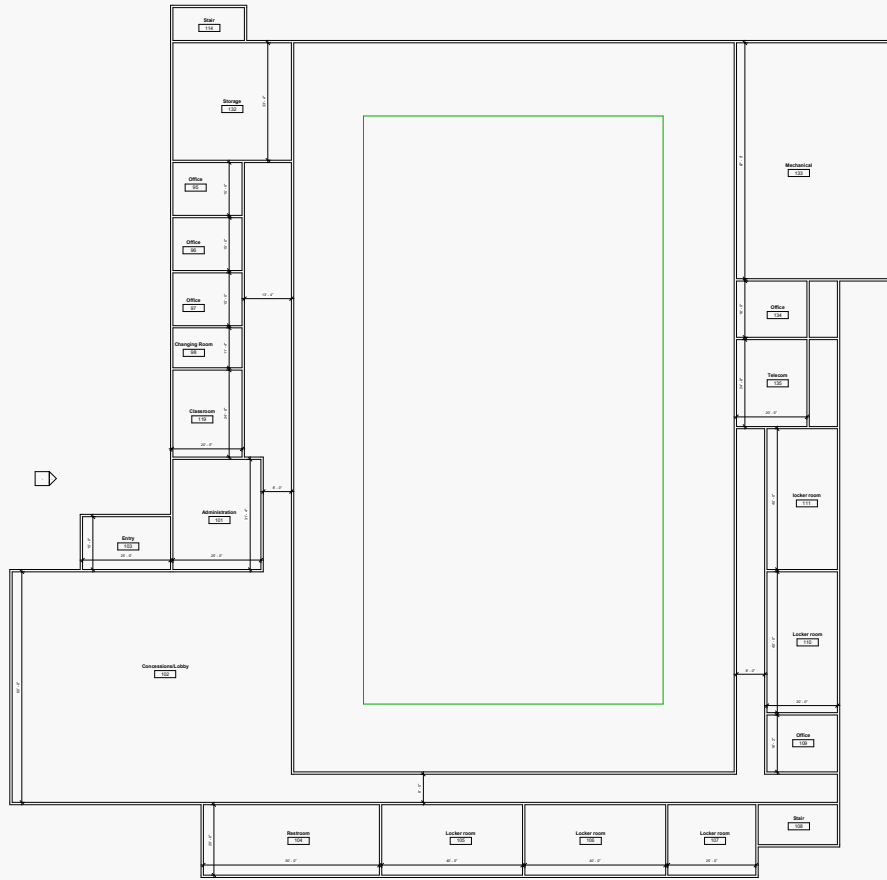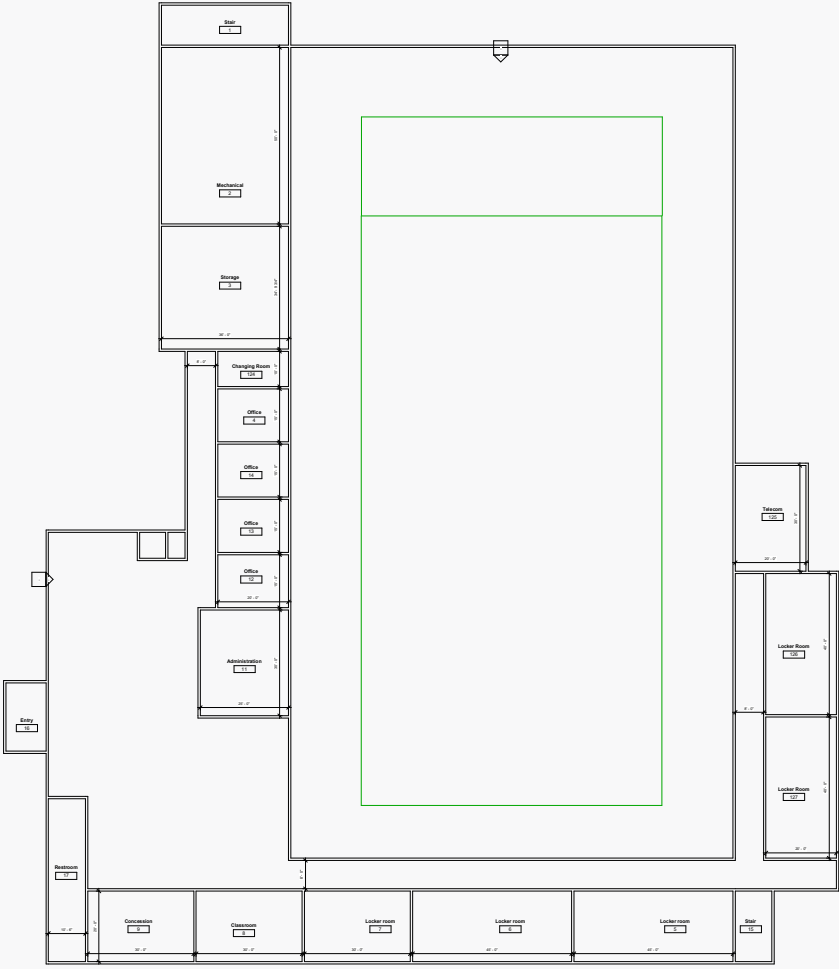OPTION 3

OPTION 4

OPTION 5

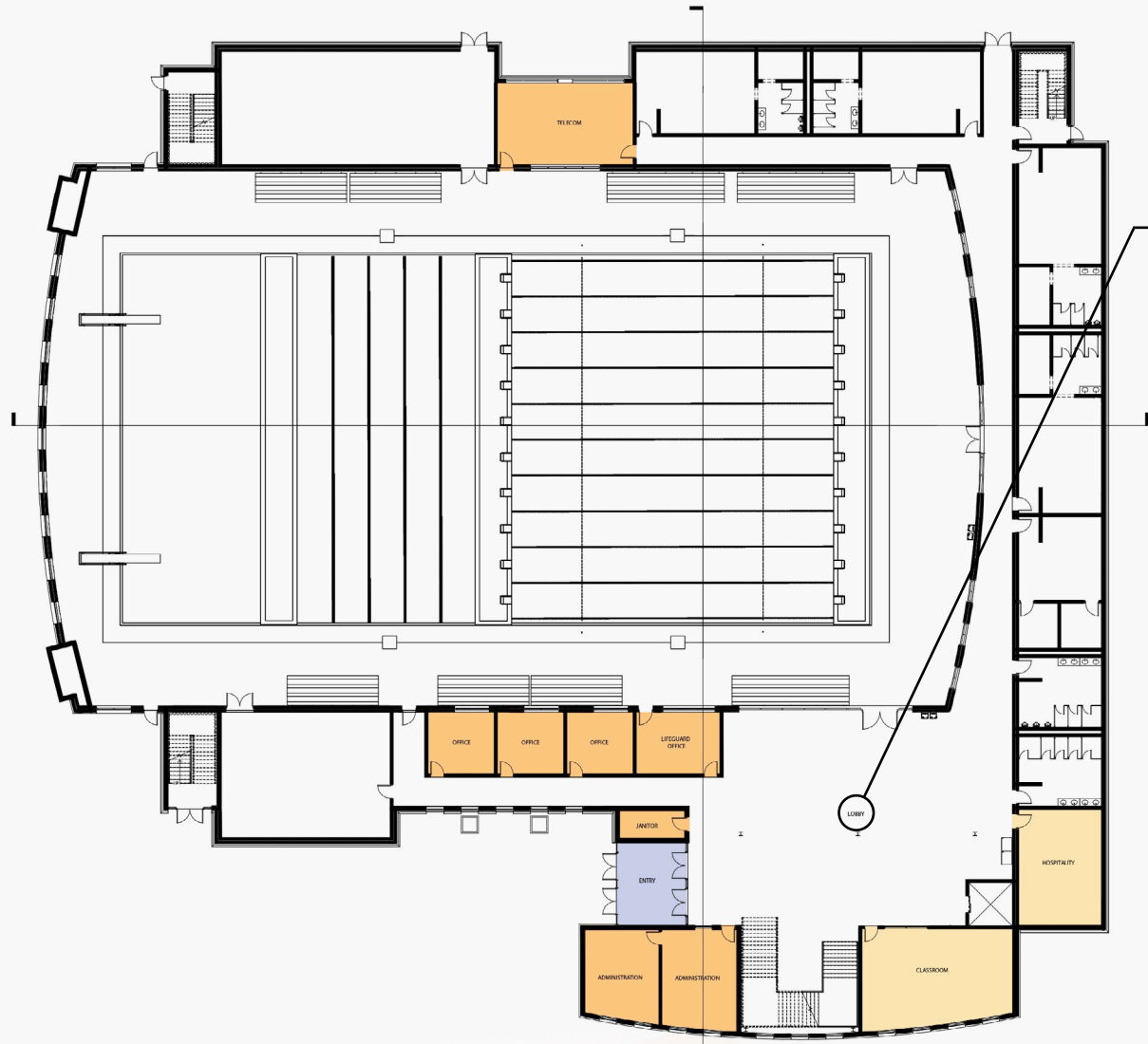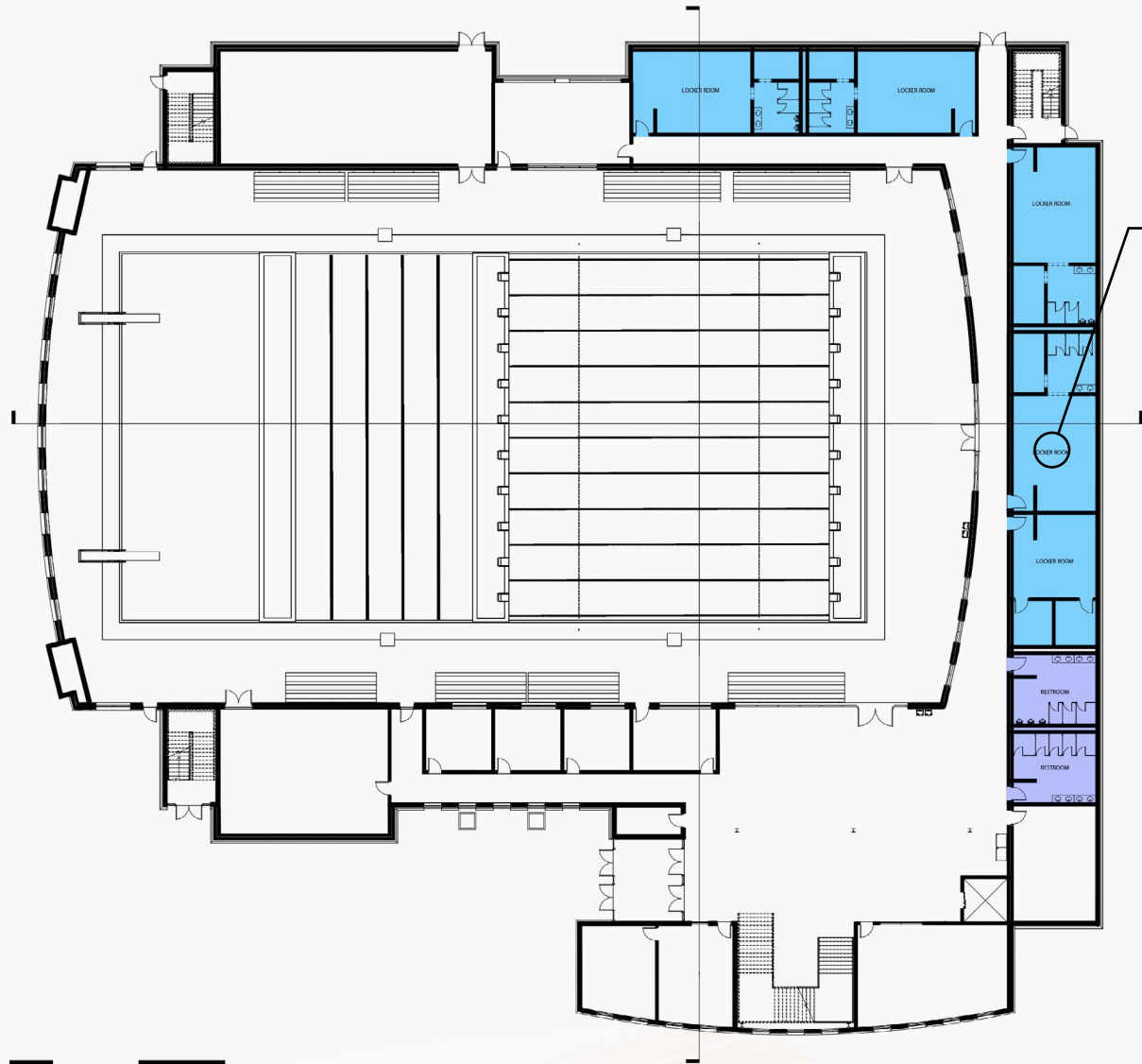ORGANIZATION SYSTEM

8' - 0"

5' - 0"

OPTION 6

OPTION 7

LOBBY

- ENTRANCE
- FACULTY
- CLASSROOM/HOSPITALITY

0 10 30 50 100

LOCKER ROOM

LOCKER ROOM

RESTROOM
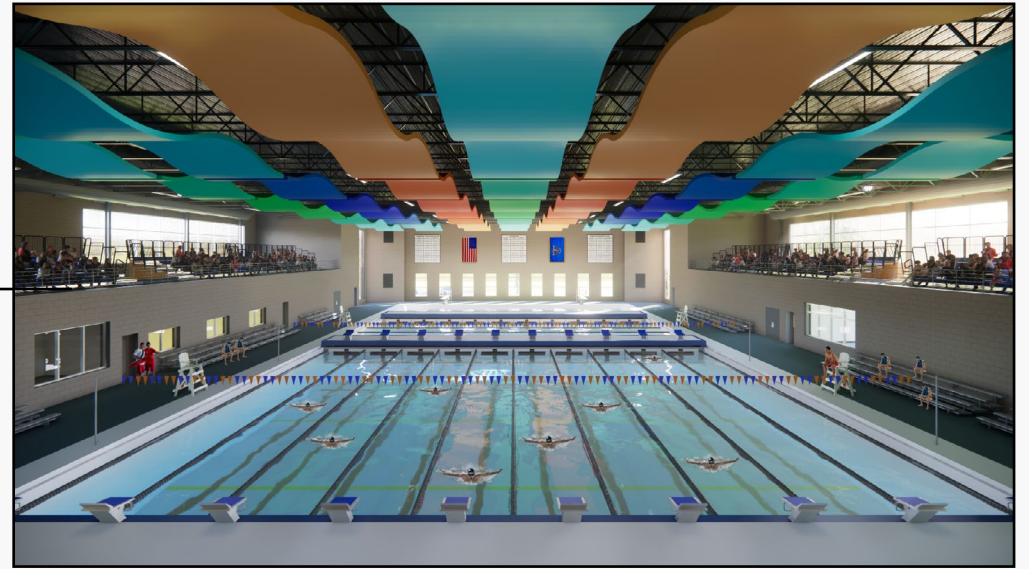
COMPETITION POOL

MECHANICAL/STORAGE

EGRESS

MECHANICAL

STORAGE
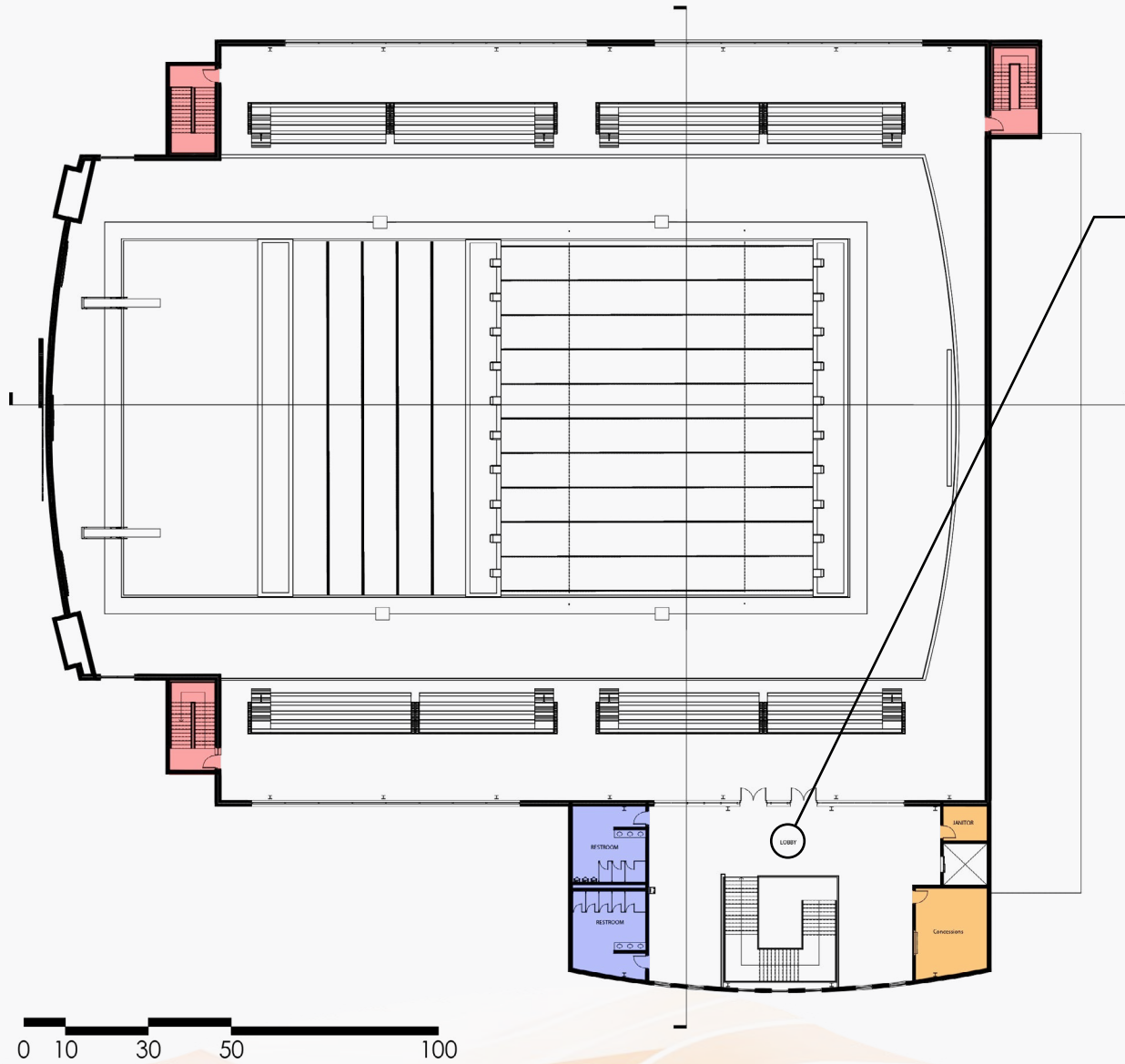
0 10 30 50 100

UPPER LOBBY

FACULTY

RESTROOM

EGRESS
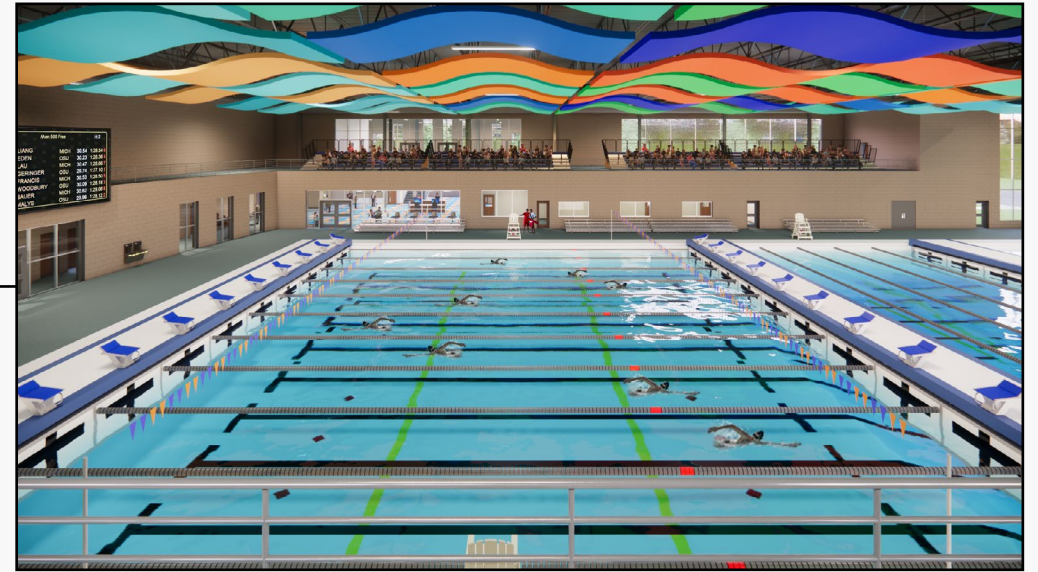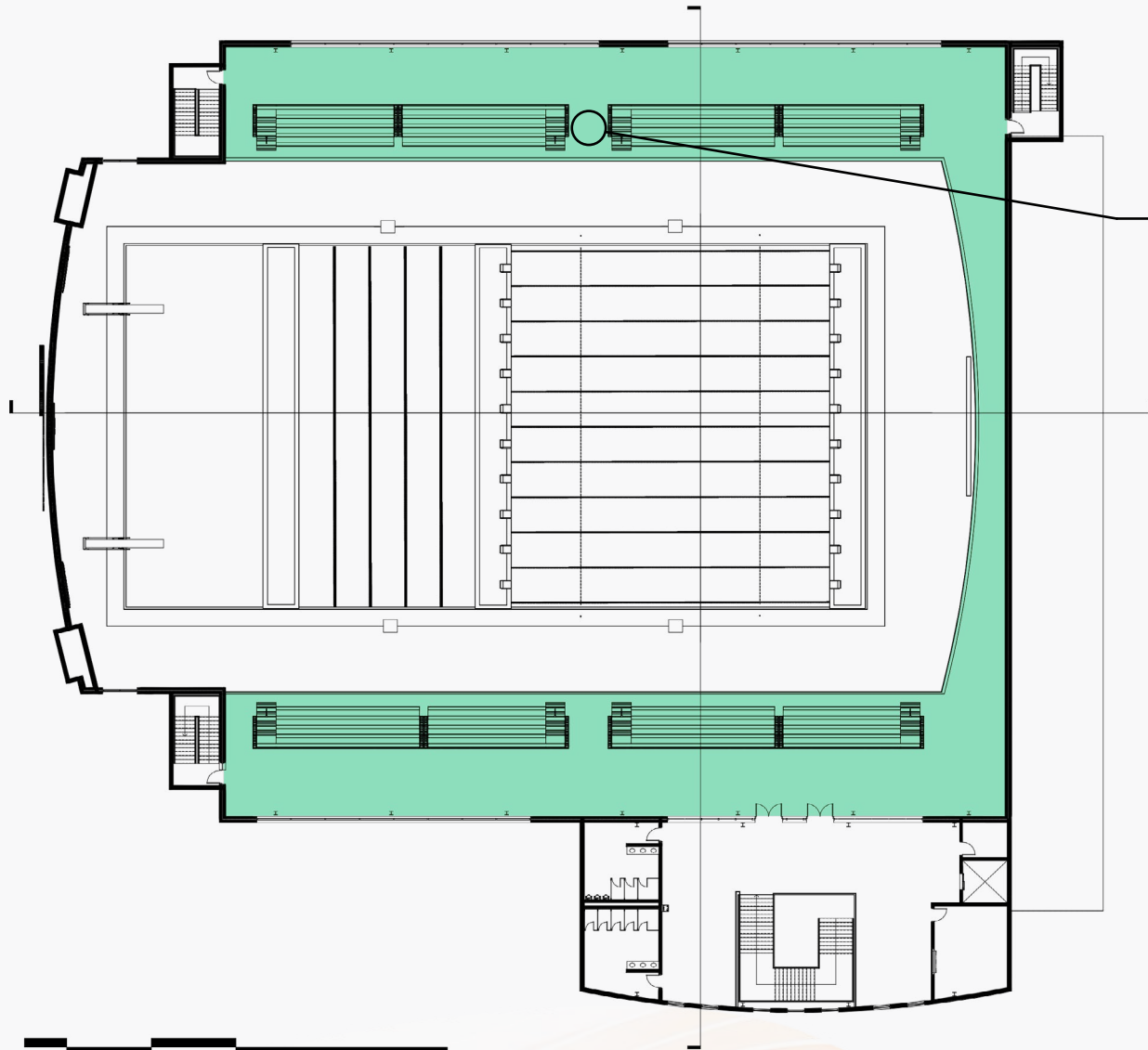
0 10 30 50 100

COMPETITION POOL

 SPECTATOR SEATING

0 10   30   50   100

SOUTH ELEVATION

0   10   30   50   100

GRAND FORKS
AQUATIC CENTER

WEST ELEVATION

NORTH ELEVATION

0   10   30   50   100
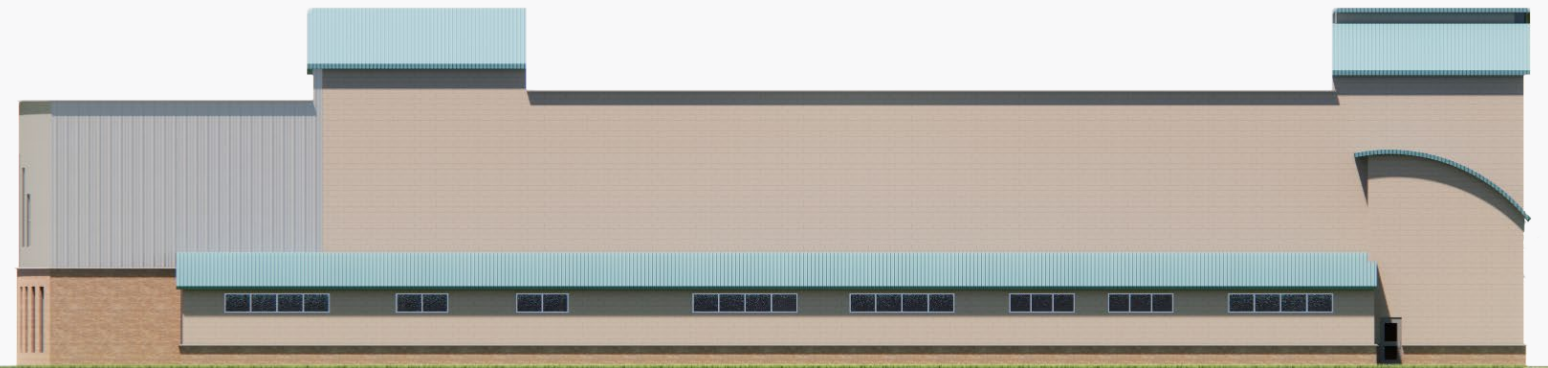
EAST ELEVATION
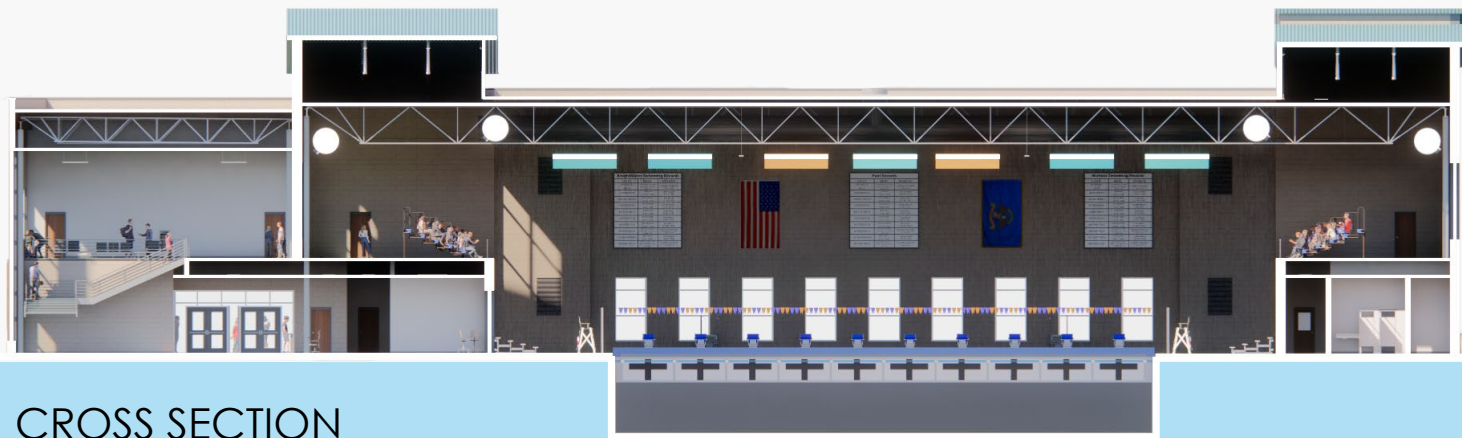
CROSS SECTION

SECTION CUT

STRUCTURE DIAGRAM

■ PRIMARY STRUCTURE ■ SECONDARY STRUCTURE

STEEL DECKING
STEEL BEAM
STEEL COLUMN
OPEN WEB TRUSS
AIR DUCT
EXTERIOR WALL
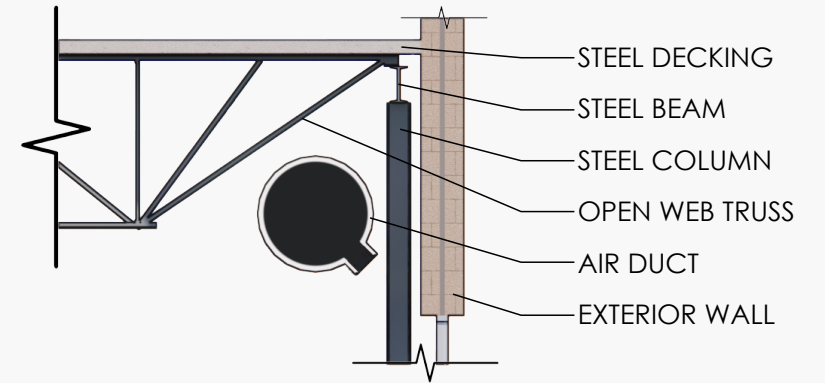
TRUSS DETAIL

SECTION CUT

HVAC DIAGRAM

- 🟧 PRIMARY AIR CIRCULATION
- 🟨 SECONDARY AIR CIRCULATION
- 🟩 RETURN
- 🟦 EXHAUST FLOW

No Vapor Retarder

Room Air

Dew Point location moves inward as insulation gets wet

Condensation Results in Soggy Insulation

Vapor Retarder
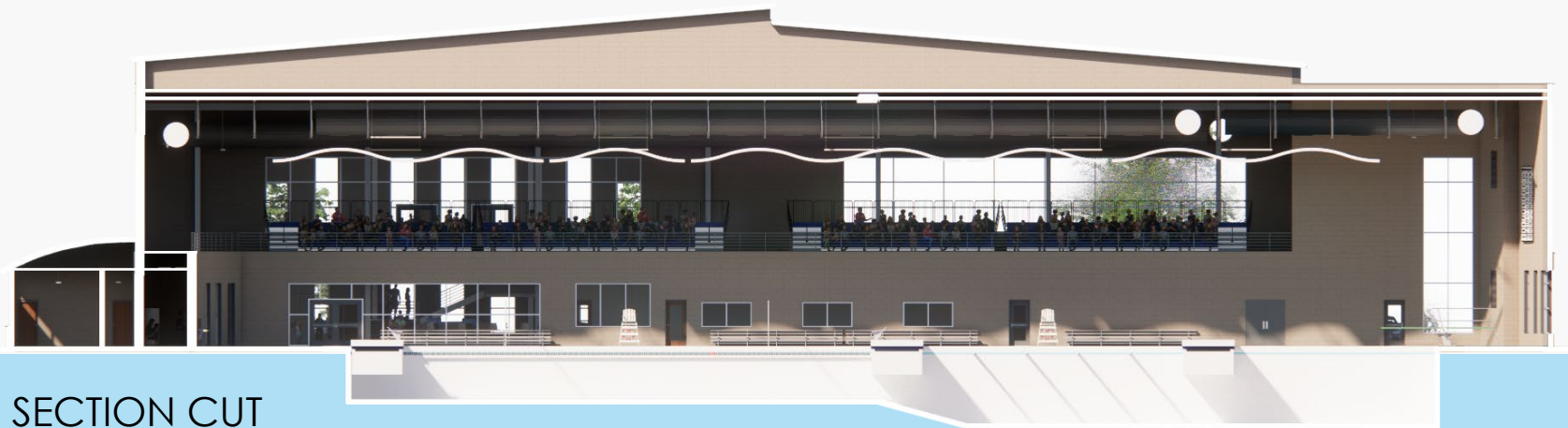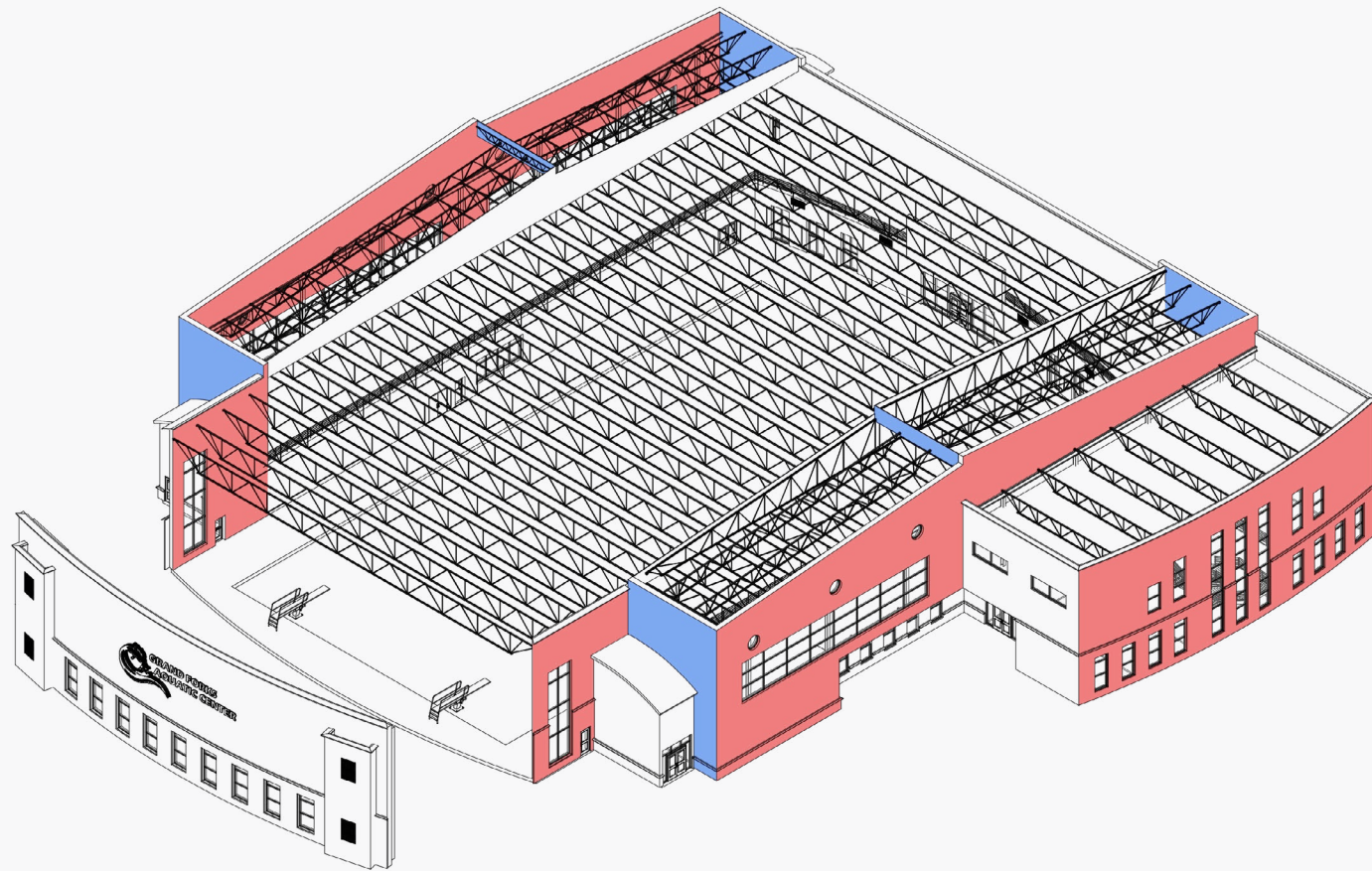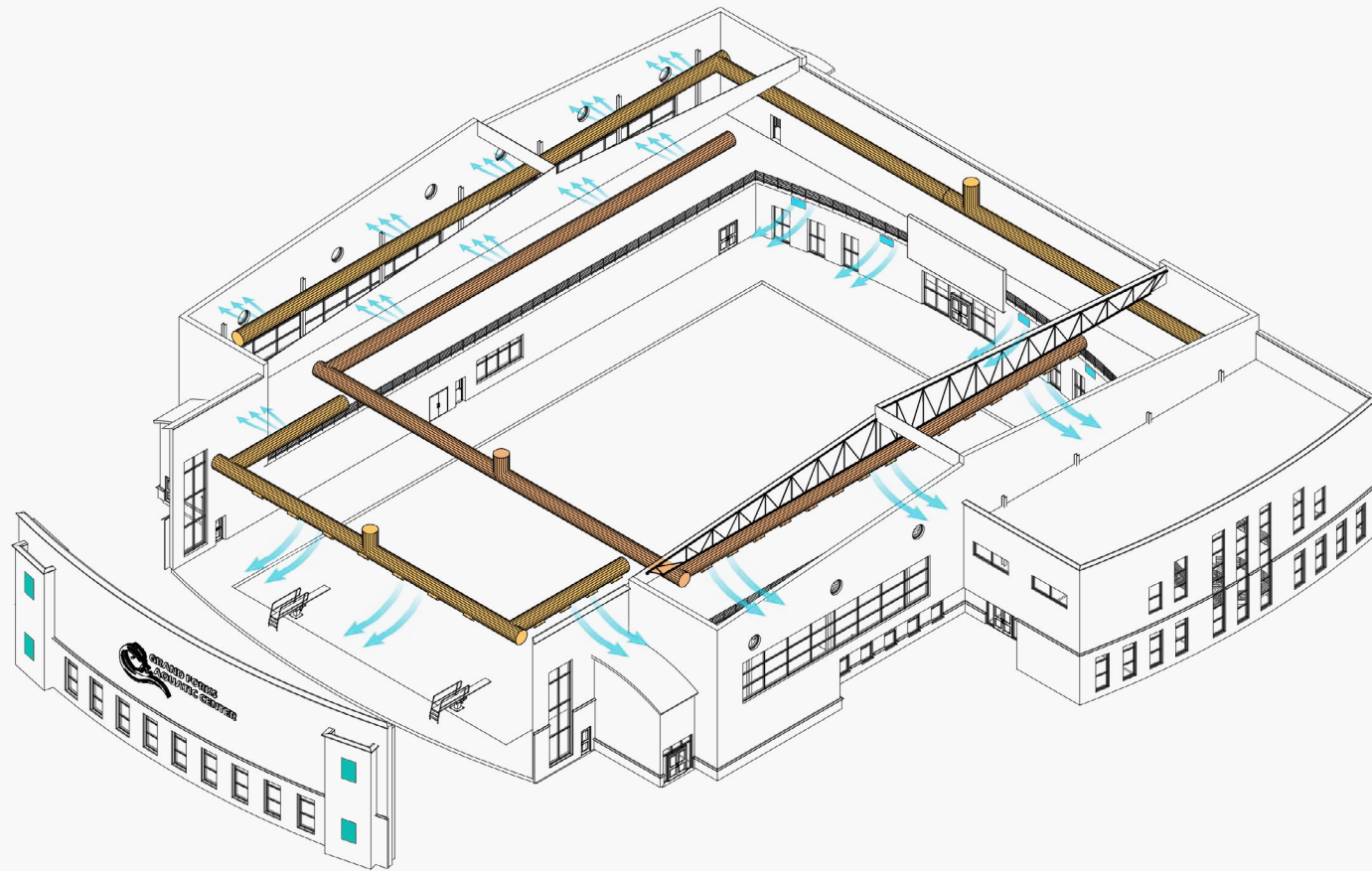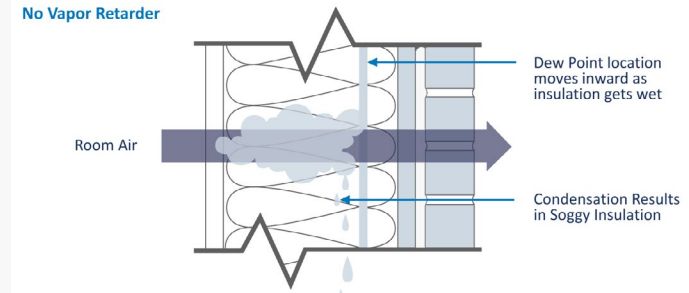
Room Air

Vapor Retarder

Dew Point location

Dry Insulation

Do not build an indoor pool without a vapor retarder.

VAPOR RETARDER DETAIL

Figure 1: https://dehumidifiedairsolutions.com/natatorium-design-guide/

Temperature Gradient Through Wall

85°F 70°F

64.5°F

4°F

0°F

Vapor Retarder Location

Dew Point Location

Exterior Wall Detail

Natatorium Pool Space Condition 85°F DB, 50% RH. Dew Point is 64.5°F

Outside Air Film (15 MPH Wind)

Face Brick 4"

Rigid Polystyrene 2"

Vapor Retarder

Concrete Block 8"

Inside Air Film (Still Air)

Inside   Outside

Wall

Note: Install vapor retarder on the warm side of the dew point location.

WALL DETAIL

Figure 2: https://dehumidifiedairsolutions.com/natatorium-design-guide/

AIR CIRCULATION SIMULATION

■ SUPPLY AIR: 75 ft/s

■ SUPPLY AIR: 50ft/s

■ EXHAUST: 30ft/s

■ RETURN

PARAMETERS

Temperature:
- Water: 80-84
- Air: 84

Humidity:
- Relative: 55%
- Summer: 60%
- Winter: 50%

Air Change Rate:
- Minimum of 6-8 per hour

Air Flow Rate:
- Regular Air Flow: 50-100 ft/s
- Air Flow Across the Water: 10-30 ft/s

SHALLOW END

DEEP END

POOL LENGTH

Resources
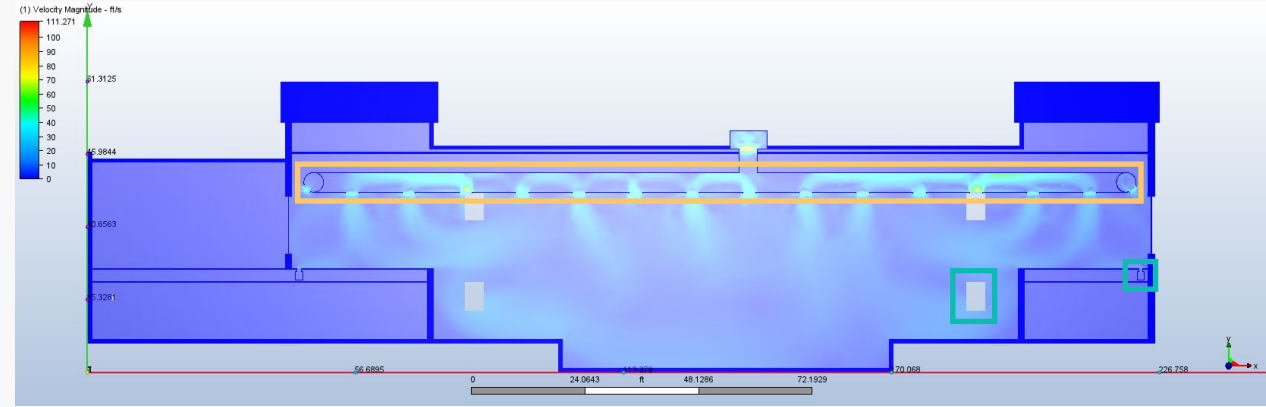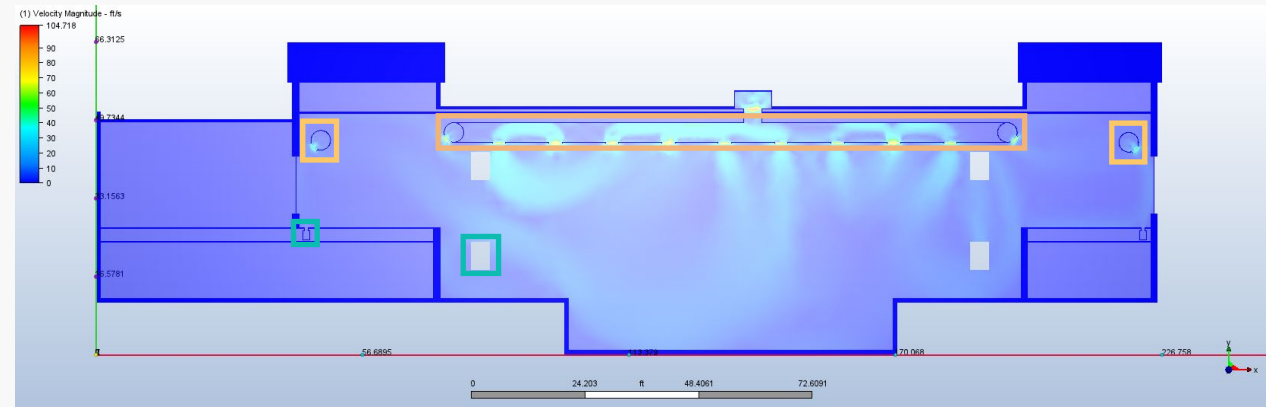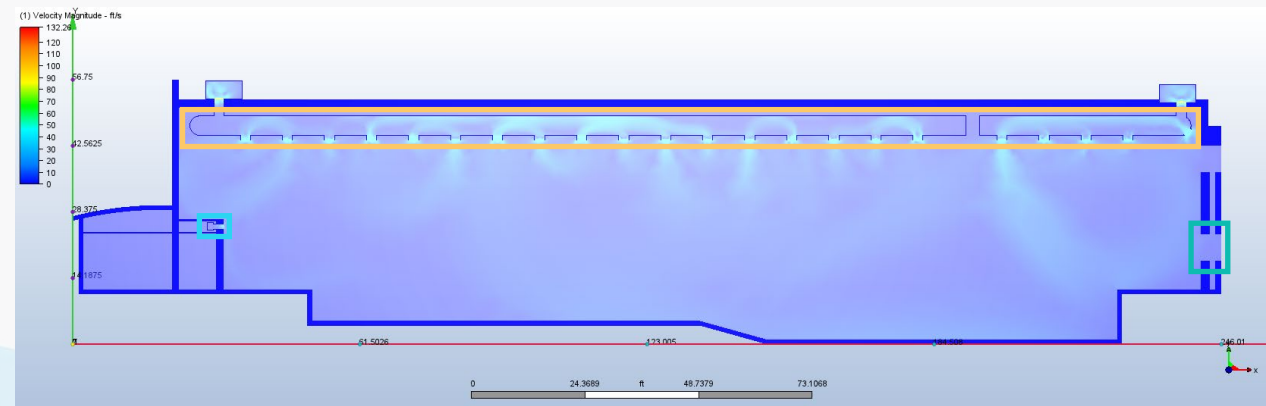
2D Sun-Path. (n.d.). Retrieved May 5, 2024, from https://andrewmarsh.com/apps/releases/sunpath2d.html

akrherz@iastate.edu, daryl herzmann. (n.d.). IEM: Site Wind Roses. Retrieved May 5, 2024, from https://mesonet.agron.iastate.edu/sites/windrose.phtml?station=GFK&network=ND_ASOS

Brochure-21st-Century-Pool-Design-Guide-DA030.pdf. (n.d.). Retrieved November 25, 2023, from https://www.desert-aire.com/sites/default/files/Brochure-21st-Century-Pool-Design-Guide-DA030.pdf

Natatorium Design Guide. (n.d.). Dehumidified Air Solutions. Retrieved August 30, 2023, from https://dehumidifiedairsolutions.com/natatorium-design-guide/
UP Aquatics. (n.d.). Retrieved May 5, 2024, from https://www.swimwestfargo.com/plan.html

Weather averages Grand Forks, North Dakota. (n.d.). Retrieved May 5, 2024, from https://www.usclimatedata.com/climate/grand-forks/north-dakota/united-states/usnd0476