Interaction between the Air Barrier System and HVAC in Natatoriums

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Outline

- Natatorium considerations
- Optimization thru computer modelling
- HVAC and pressurization considerations
- Case Study 1: Natural Ventilation of an Indoor Pool
- Case Study 2: Pool Install within a Historic Building
- Case Study 3: Pan Am Aquatics Centre
- Conclusion/Reiteration of key points

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Natatoriums

Fundamental Considerations

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Natatoriums – things to consider

- Giant body of water INSIDE a building
- Waterproofing concepts
- Indoor Air Quality
  - Air temperature, relative humidity
  - Contaminant risk
  - Proper ventilation of space
- Pool Water Quality
  - Pool water temperature
  - Evaporative risk
  - Pool water chemistry

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Natatoriums – things to consider

- Occupant Comfort and Health
  - Bather and spectator
- Condensation Considerations
  - Thermal bridges
  - Moisture and chloramine laden air
- Air tightness and Vapor control
  - Pool-to-Exterior
  - Pool-to-Interior spaces
- HVAC
  - Ventilation Strategy, Pressurization, Dehumidification, Purge cycle

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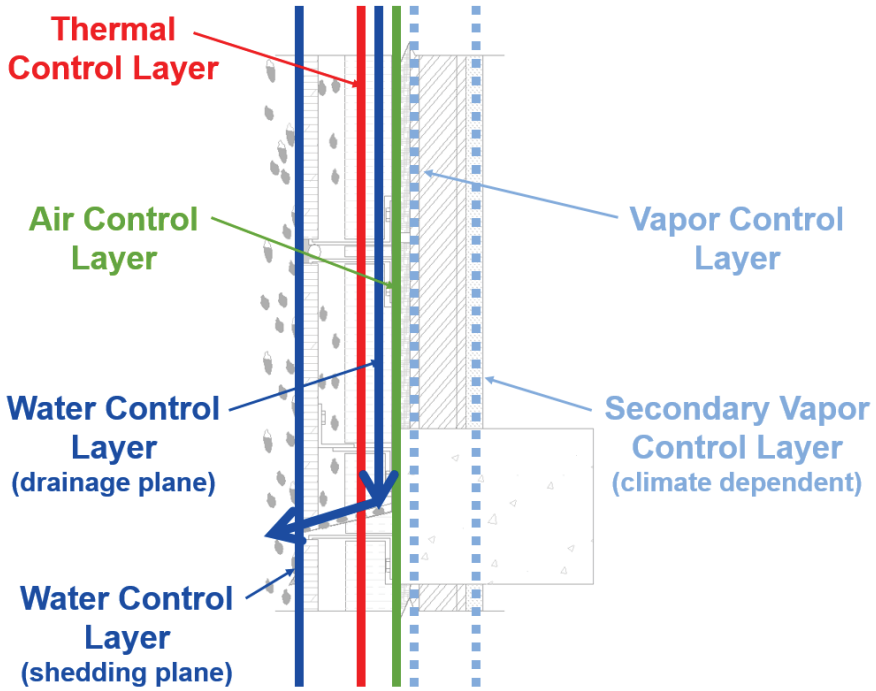
Natatorium Enclosure Considerations

- Reduce thermal bridges and enhance insulation
- Air tighten and provide vapor control
- Fenestration placement
  - Interface with thermal barrier
  - Tie-ins with adjacent systems
- Interaction between mechanical system and building enclosure
  - Heat washing exterior glazing to minimize condensation



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Natatorium Enclosure Considerations

Additional considerations for existing structures:

- Understand how the previous design worked
- How to improve through alterations
- Integrate new systems with original structure
- Skills of construction trades

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ASHRAE Recommended Design Conditions

Space Type	Water Temperature	Air Temperature	Relative Humidity
Recreational Pools	75°F - 85°F	75°F - 85°F	50% RH - 60% RH
Competition	76°F - 82°F	78°F - 85°F	50% RH - 60% RH
Diving	80°F - 90°F	80°F - 85°F	50% RH - 60% RH
Offices, Conference Rooms, Common Areas	n/a	Winter: 70°F - 74°F Summer: 74°F - 78°F	Winter: 20% RH - 30% RH Summer: 50% RH - 60% RH

Source: 2015 ASHRAE Handbook – HVAC Applications

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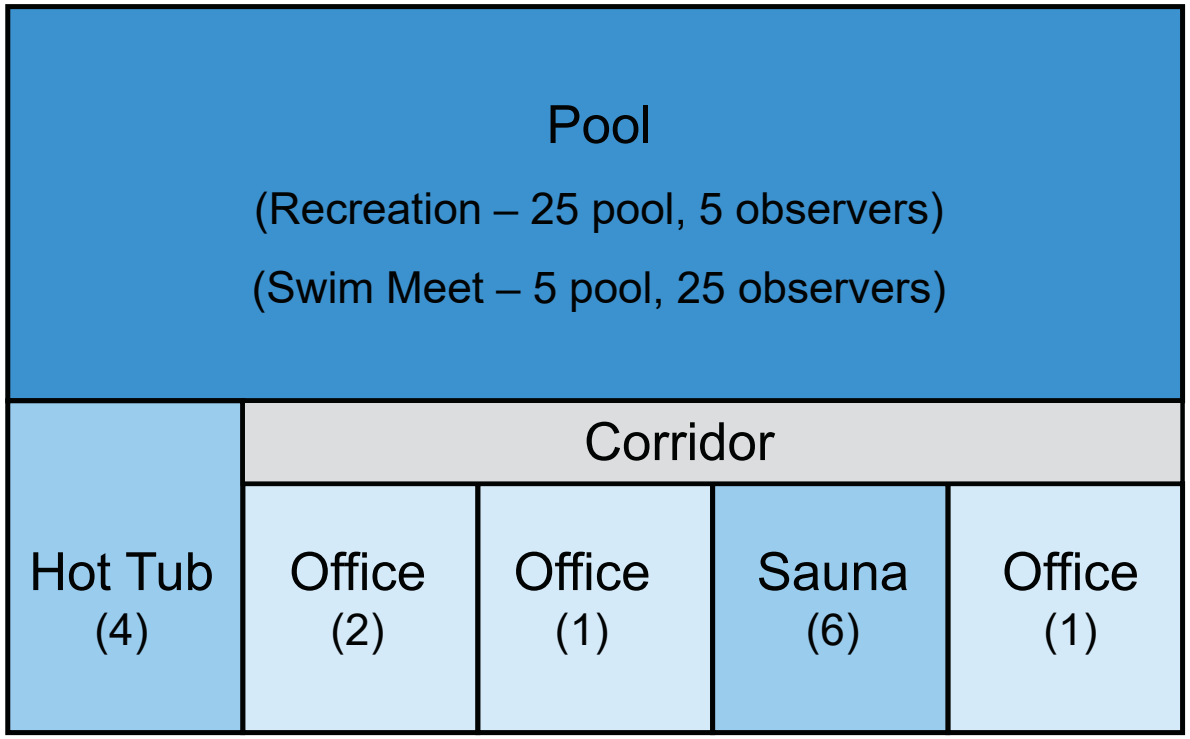
Interior Enclosures – Occupancy and Comfort



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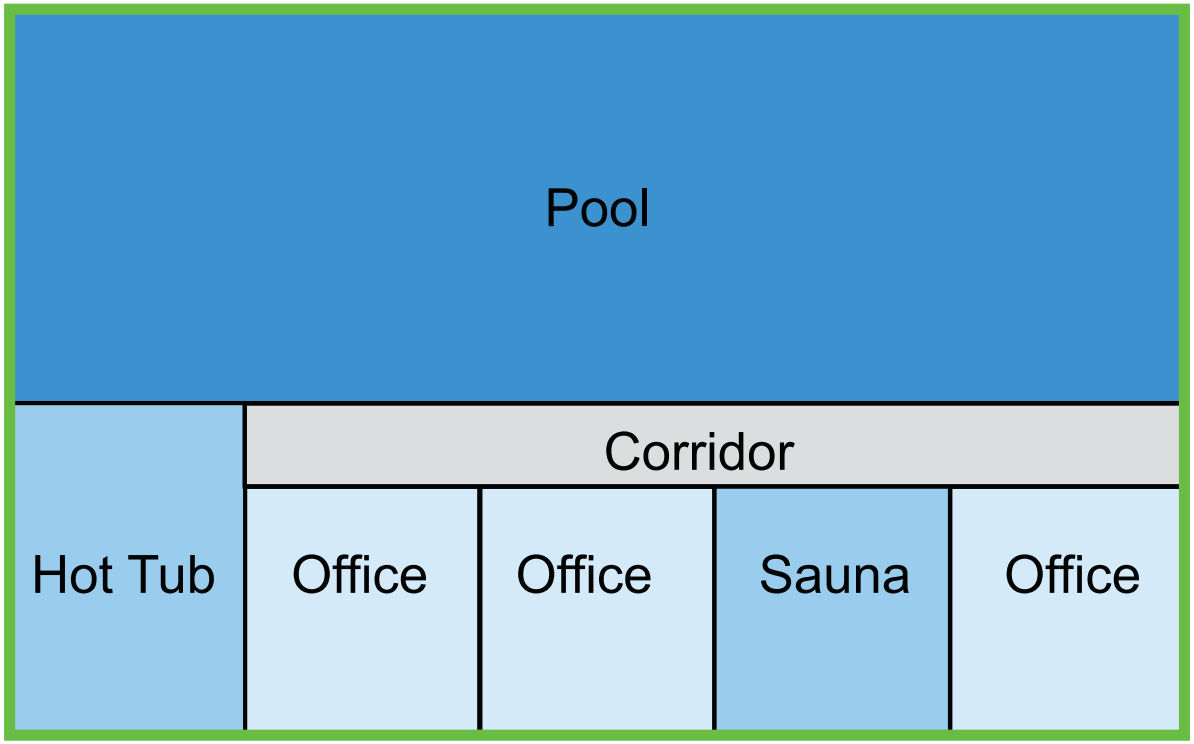
Air Barrier Zones - Exterior



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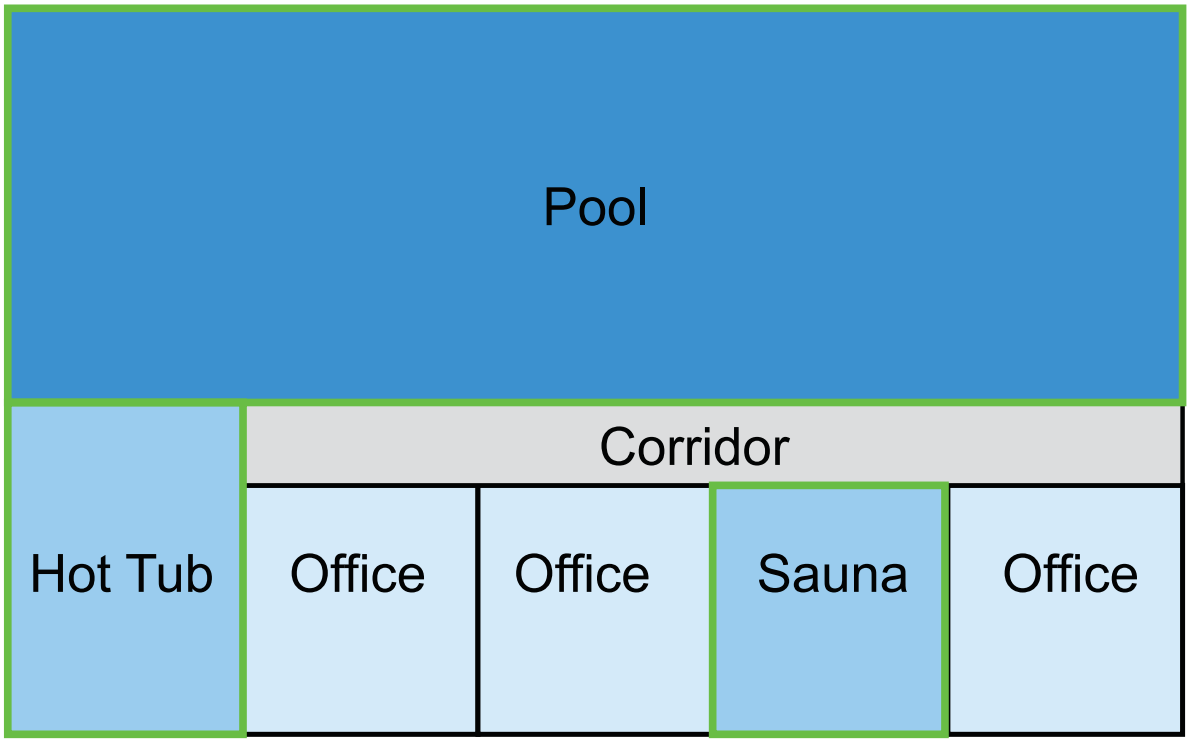
Air Barrier Zones - Interior



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Critical Air Tightness Details

Improve thermal, air, and vapor tightness at interface conditions:

- Interior pool-to-exterior
- Interior pool-to-interior spaces
- Wall-to-window
  - Curtain wall and other fenestration
- Wall-to-roof/slab
- Wall-to-foundation
- Penetrations
- Framing/structural, MEP

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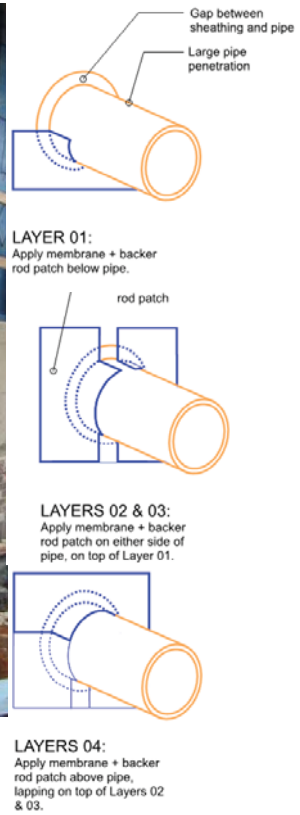

Computer Models

- Provide a feasible and reliable approach to optimize energy and thermal performance
- Consider psychrometrics and mechanical buffer zones
  - Difference between interior/exterior conditions
  - Condensation risk
- Optimize/validate using computer models
  - Thermal and hygrothermal
- Optimize building enclosure, then the mechanical systems

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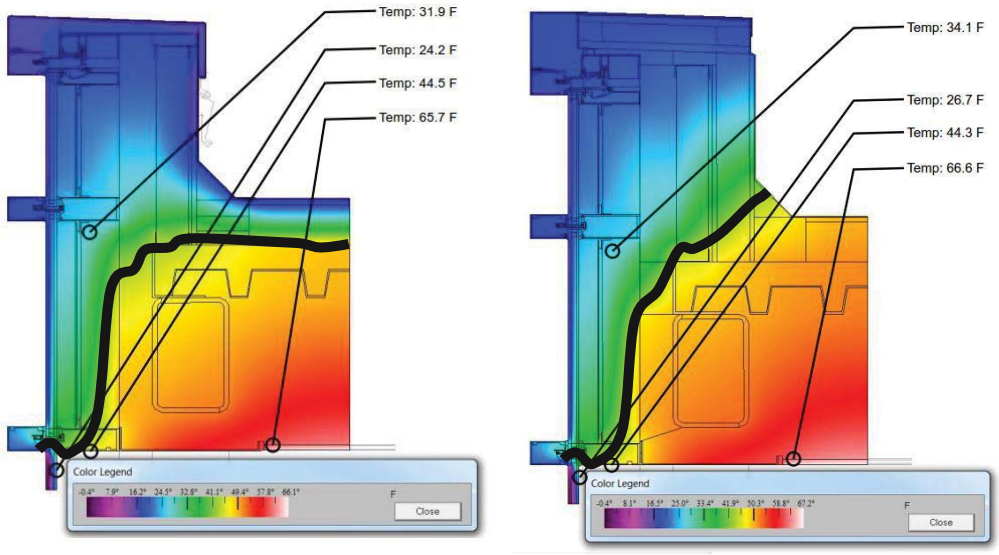
Computer Modeling – Thermal Analysis

- Evaluate critical thermal aspects and heat transfer
- Material type/thickness and configuration
- Localized thermal bridge effects
- Dew point location and condensation potential
- Air barrier location



Thermal Analysis

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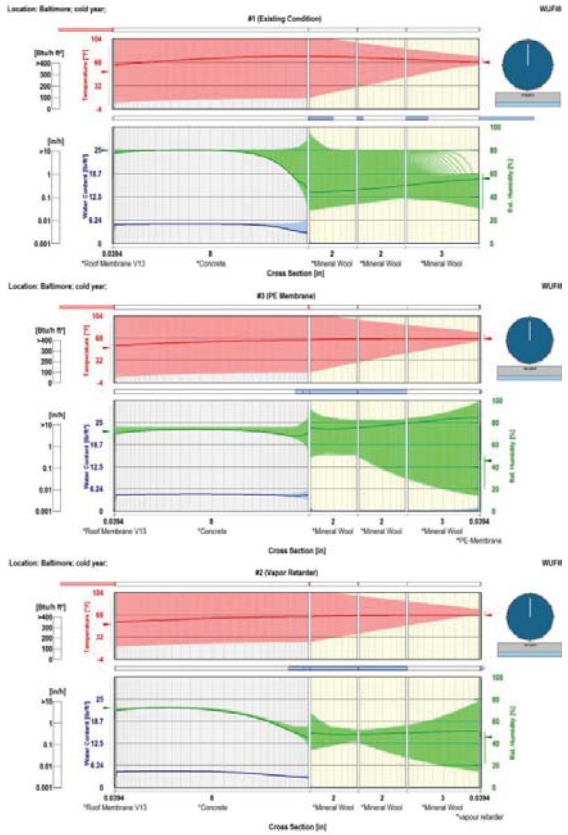
Computer Models - Hygrothermal

- Depending on exterior environment, vapor diffusion rates differ
- Summer and winter concerns as well as swing seasons
- Consider spaces adjacent to pool
- Condensation potential and vapor barrier location



Hygrothermal Analysis

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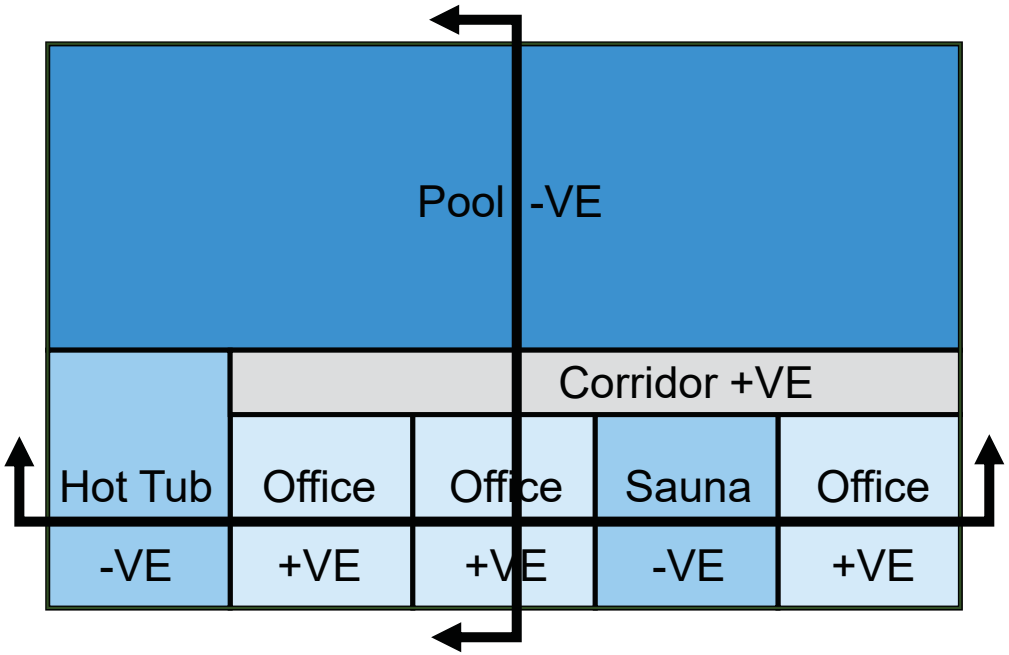
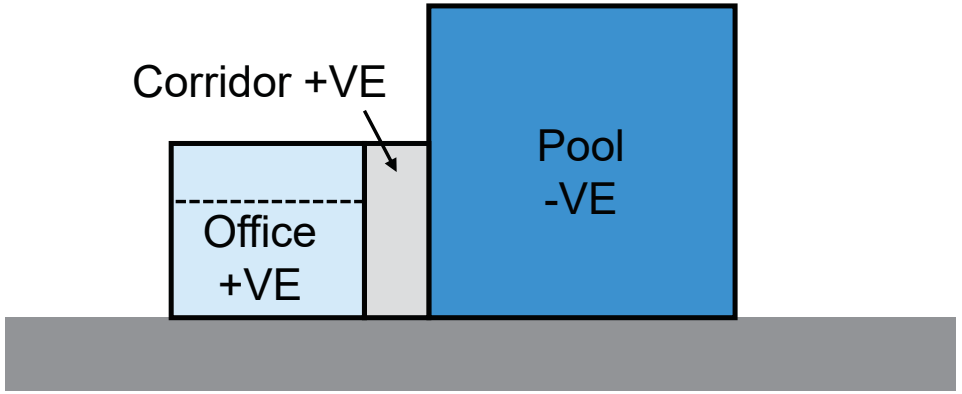
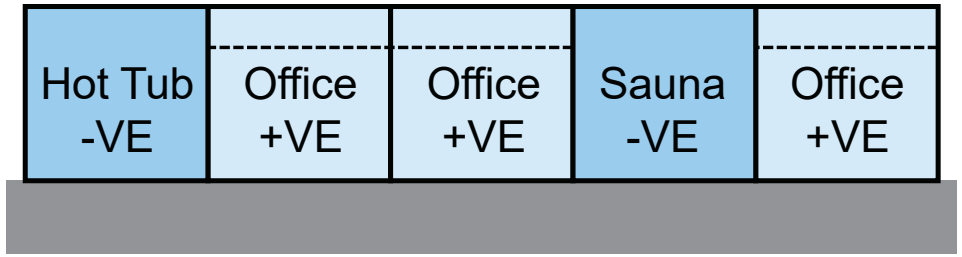
HVAC and Pressurization







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Case Study 1

Natural Ventilation of an Indoor Pool Space

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Case Study 1

Natural Ventilation of a Pool Space

- Indoor pool is open all 12-months of year
- Outdoor pool is open Memorial Day to Labor Day
- High occupancy of outdoor pool expected late morning until before dinnertime

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Case Study 1

Natural Ventilation of a Pool Space

- Large natatorium doors on east elevation
- Operable windows on west elevation
- Outdoor pool on east side of building
- Risk for higher energy usage and moisture accumulation

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Case Study 1: HVAC Operation Mode

RETURN
high at middle, but below ceiling.

SUPPLY
at perimeter

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Case Study 1: HVAC Operation Mode

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Case Study 1: Natural Ventilation Mode

Band of **OPERABLE DOORS** on east elevation.

Band of **OPERABLE WINDOWS** on west elevation.

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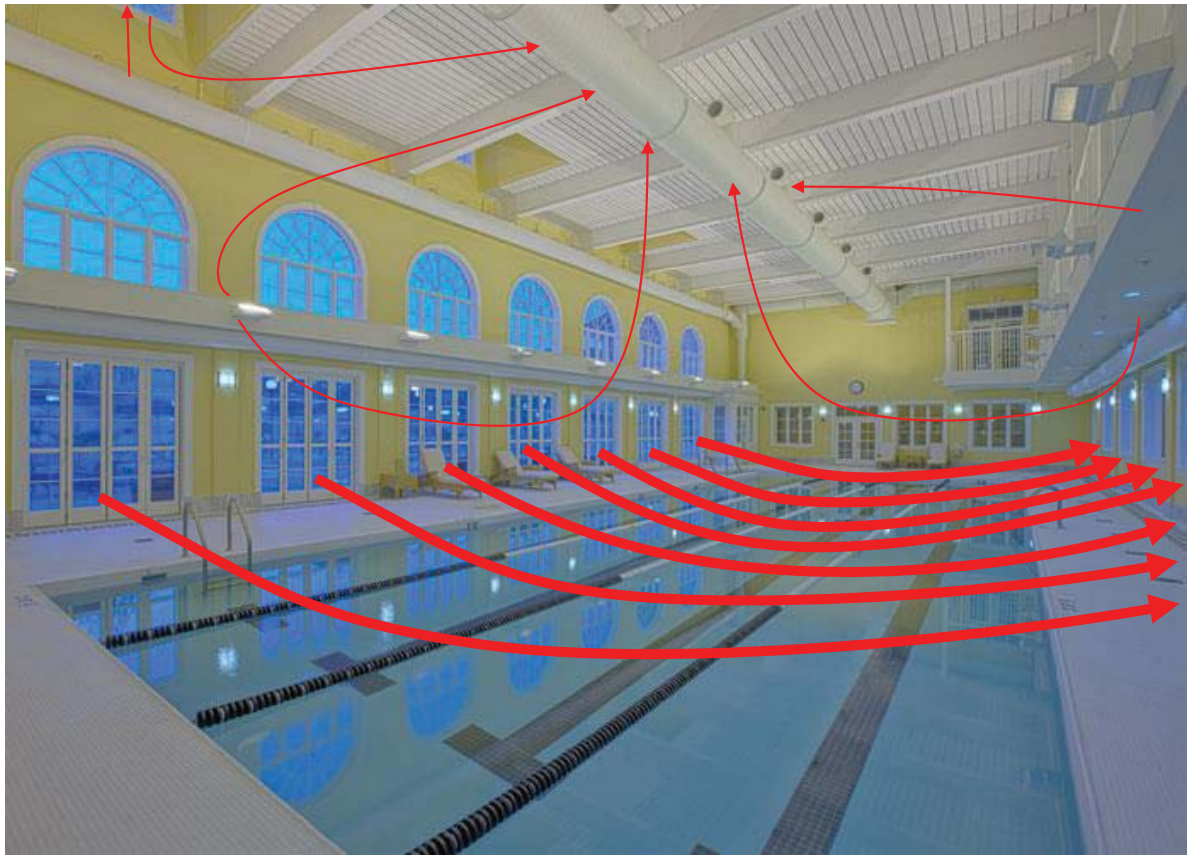
Case Study 1: Natural Ventilation Mode



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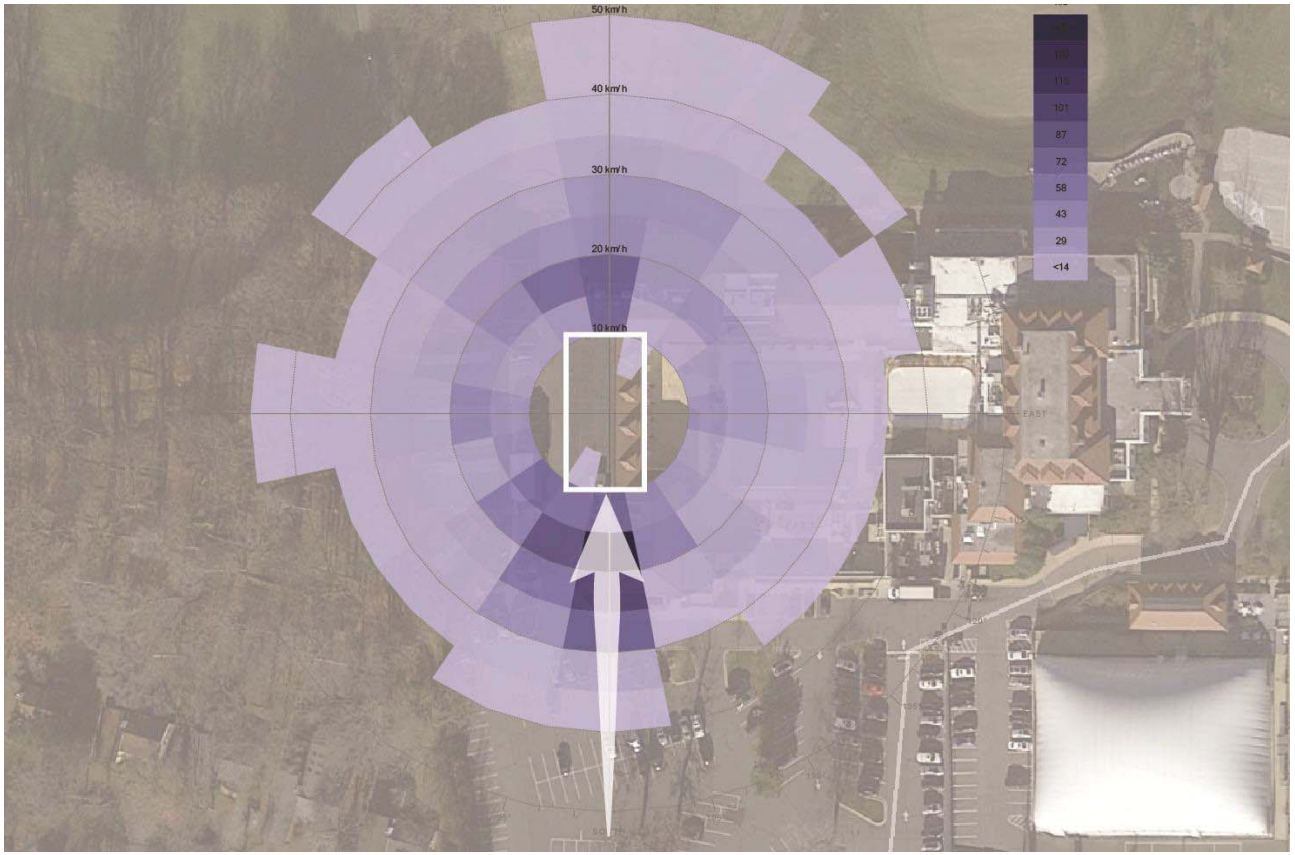
Case Study 1: Climate Considerations

Wind Rose Summer Months



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Case Study 1: Key Findings

- Issues Arise when Outdoor Air Conditions Fall Outside ASHRAE Recommended Values

Space Type	Air Temperature	Relative Humidity
Recreational Pools	75°F - 85°F	50% RH - 60% RH
Current Operating Conditions for Pool	80°F - 85°F	50% RH - 60% RH

Source: 2015 ASHRAE Handbook – HVAC Applications

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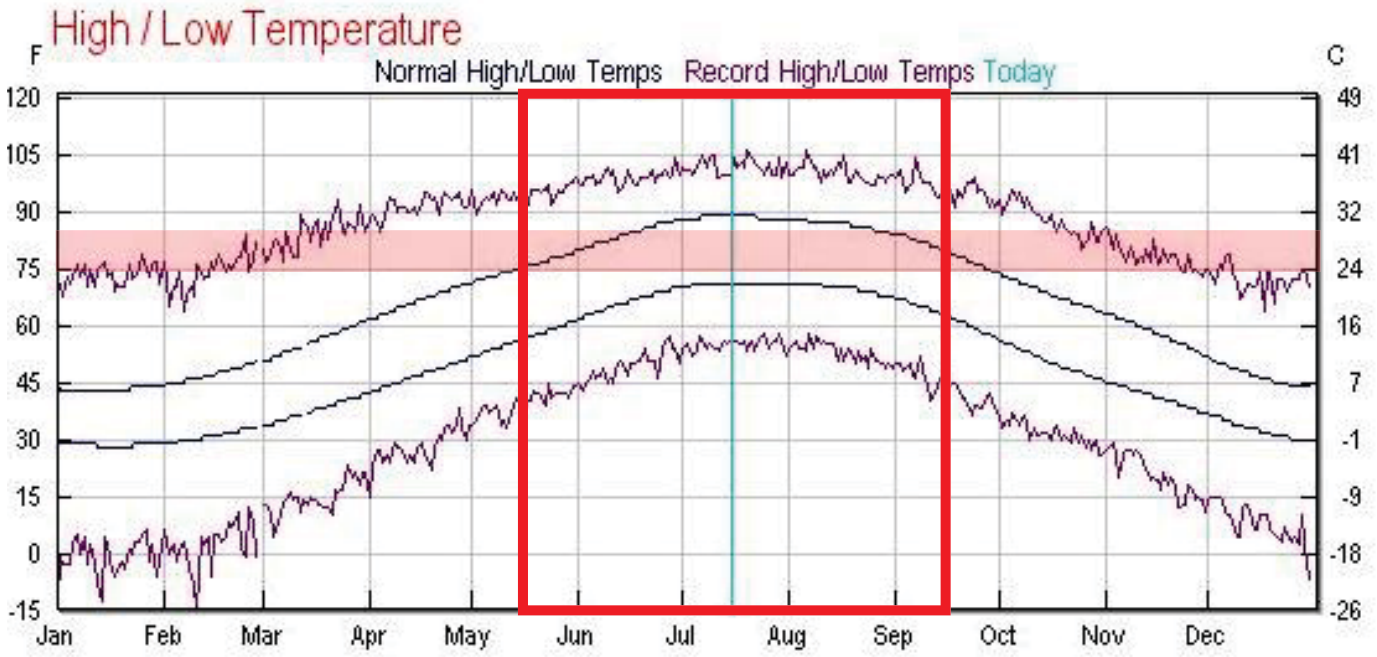
Operating Condition Dew Point
Ranges from = 59.7°F to **69.5°F**

Case Study 1: Key Findings

- Issues Arise when Outdoor Air Conditions Fall Outside ASHRAE Recommended Values (75°F - 85°F, 50% to 60% RH)



Temperature Average Ranges from = **55°F** to **90°F**

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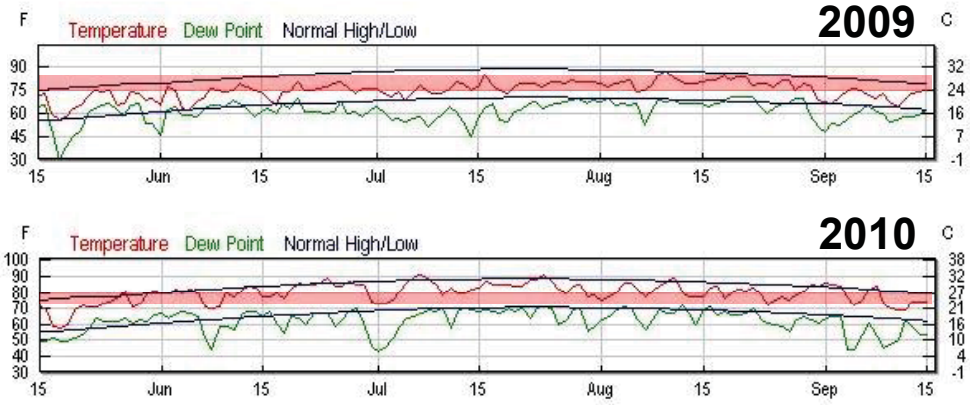
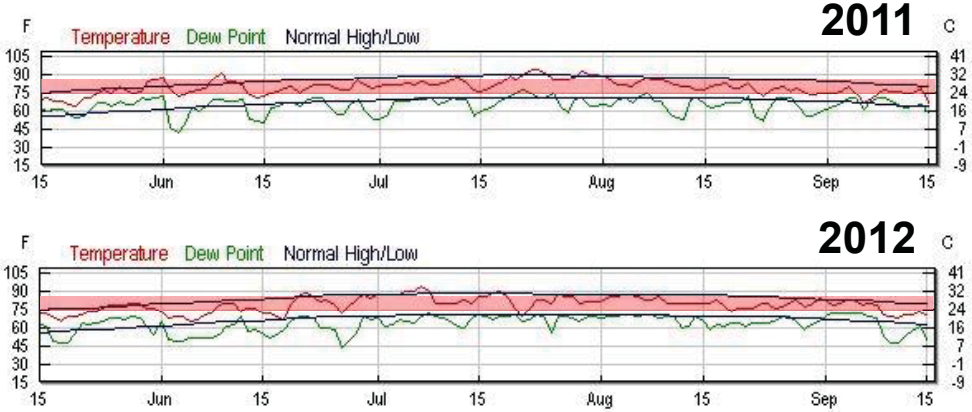
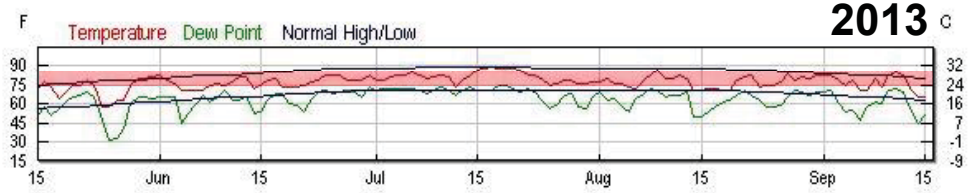
Case Study 1: Key Findings

- Issues Arise when Outdoor Air Conditions Fall Outside ASHRAE Recommended Values







May 15 through September 15

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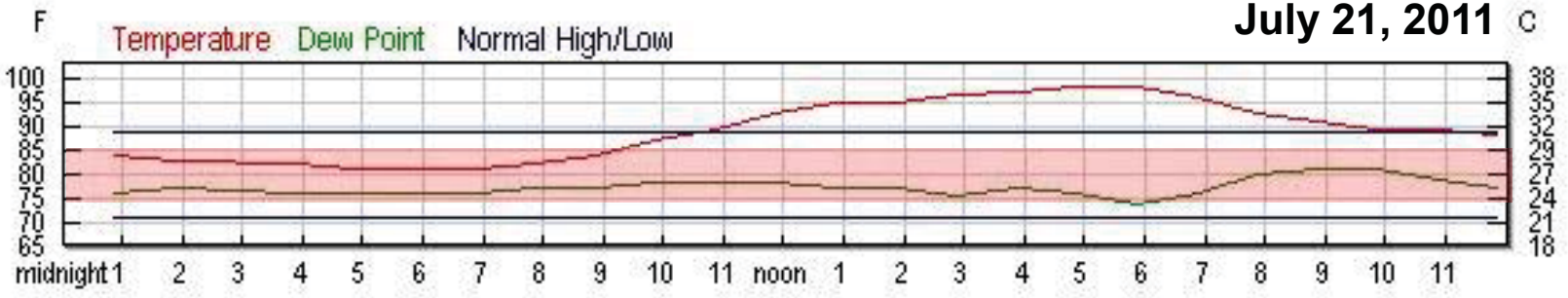
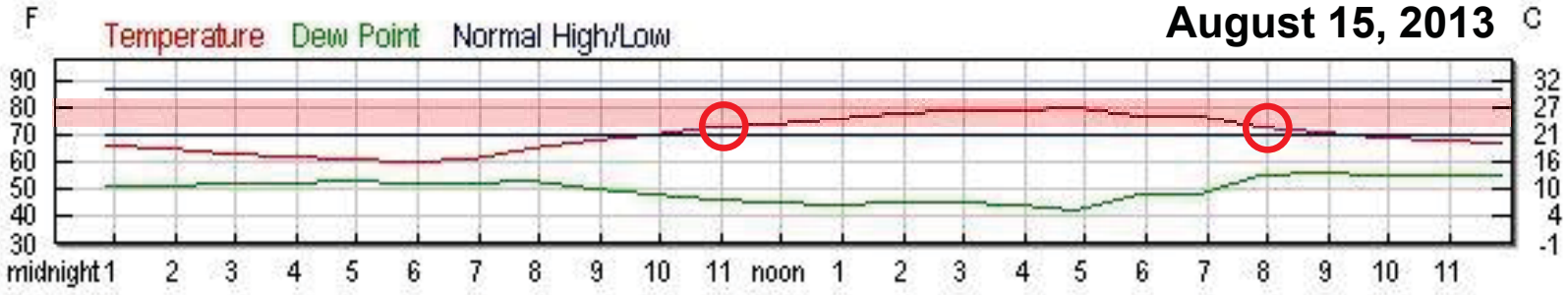
Case Study 1: Key Findings

- Issues Arise from Outdoor Air Conditions that Fall Outside the Range of ASHRAE Recommended Values (75°F - 85°F, 50% to 60% RH)





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Case Study 1: Key Findings

- Weather Events Including Precipitation, Fog, and High Velocity Wind Flows Can Increase Risk

Note that these images are from other projects.

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Case Study 1: Recommendations

- Open/Close Doors and Windows at Specific Conditions to Minimize Energy Impact and Condensation Risk

- Pool staff operate doors/windows on a consistent schedule:
  - OPERATE doors/windows between Memorial Day and Labor Day.
  - OPEN doors/windows at 11am and CLOSE by 4:30pm.
  - Unless:

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Case Study 1: Recommendations

Outdoor Air Conditions To Open Doors and Windows Operating Conditions: 80°F - 85°F, 50% - 60% RH (69.5°F Dew Point)					
Outdoor	**Outdoor Relative Humidity**				
Temp (F)	75%	80%	85%	90%	95%
75	66.5	68.4	70.2	71.9	73.5
80	71.3	73.3	75.1	76.8	78.4
85	76.2	78.1	80	81.7	83.4
90	81	83	84.9	86.7	88.4
95	85.8	87.8	89.8	91.6	93.3
Legend					
DO Open Windows		CAUTION Opening Windows		DO NOT Open Windows	

- OPEN doors/windows,
  once OA temperature raises to 75°F.
- CLOSE doors/windows,
  before OA temperature lowers to 75°F.
- Keep doors/windows CLOSED:
  - If OA will be greater than 90°F and greater than 85% RH.
  - If precipitation or fog is predicted.
  - If wind flows greater than 15 mph are predicted.

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Case Study 2

Pool in Historic Building – Using Garage Ramp for Pool Slope

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Case Study 2: Historic Building

- Historic building in Midwest
- Brick masonry and concrete accents
- Re-purposing of parking garage at one floor for pool amenity

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Case Study 2

Water Tightness

- Pool slab and below pool, two critical planes for waterproofing
- Redundancy is key
- Deck to wall critical

Air Tightness

- Use one layer of water tightness as air tight plane
- Make sure to tie floor to wall to ceiling
- Carefully pick insulation strategies

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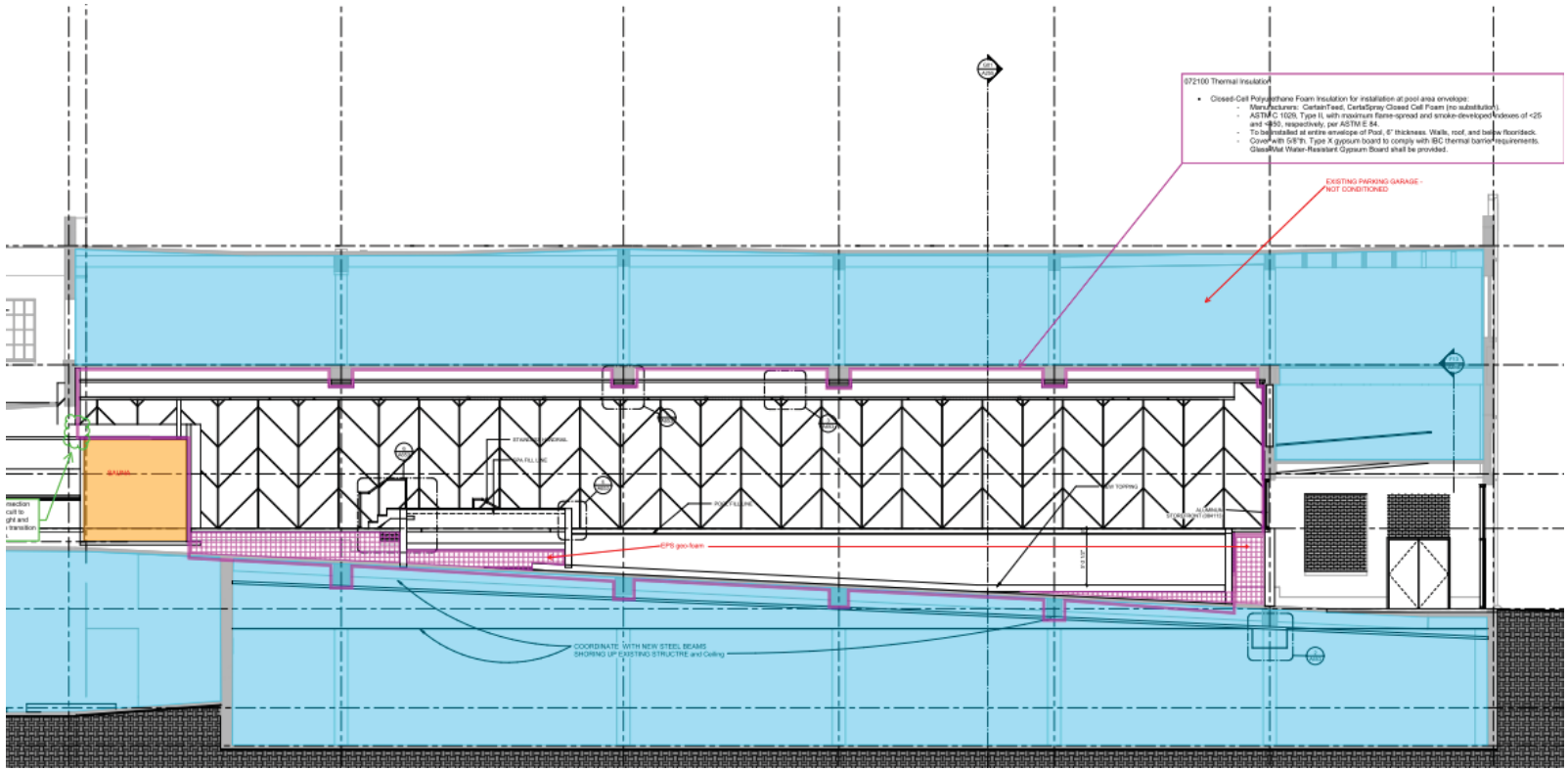
Case Study 2



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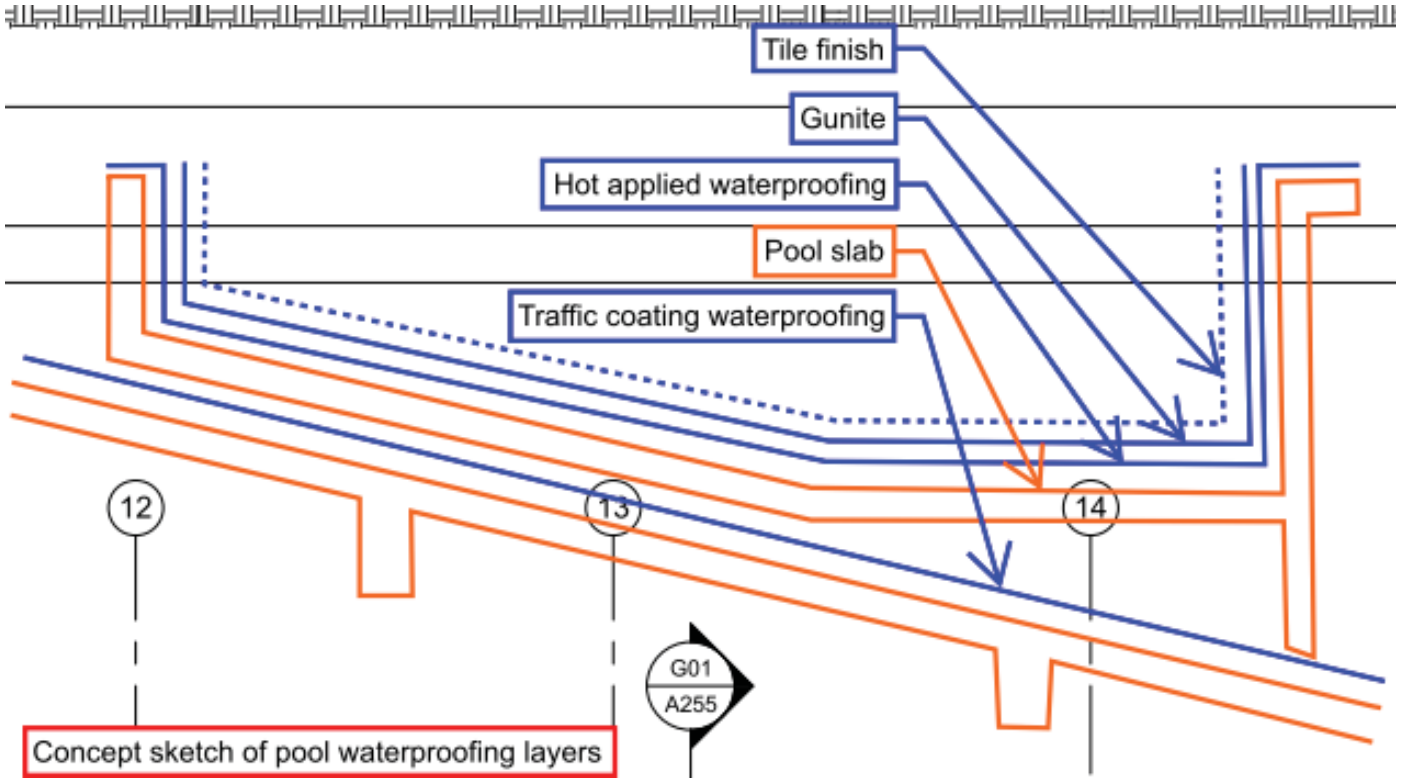

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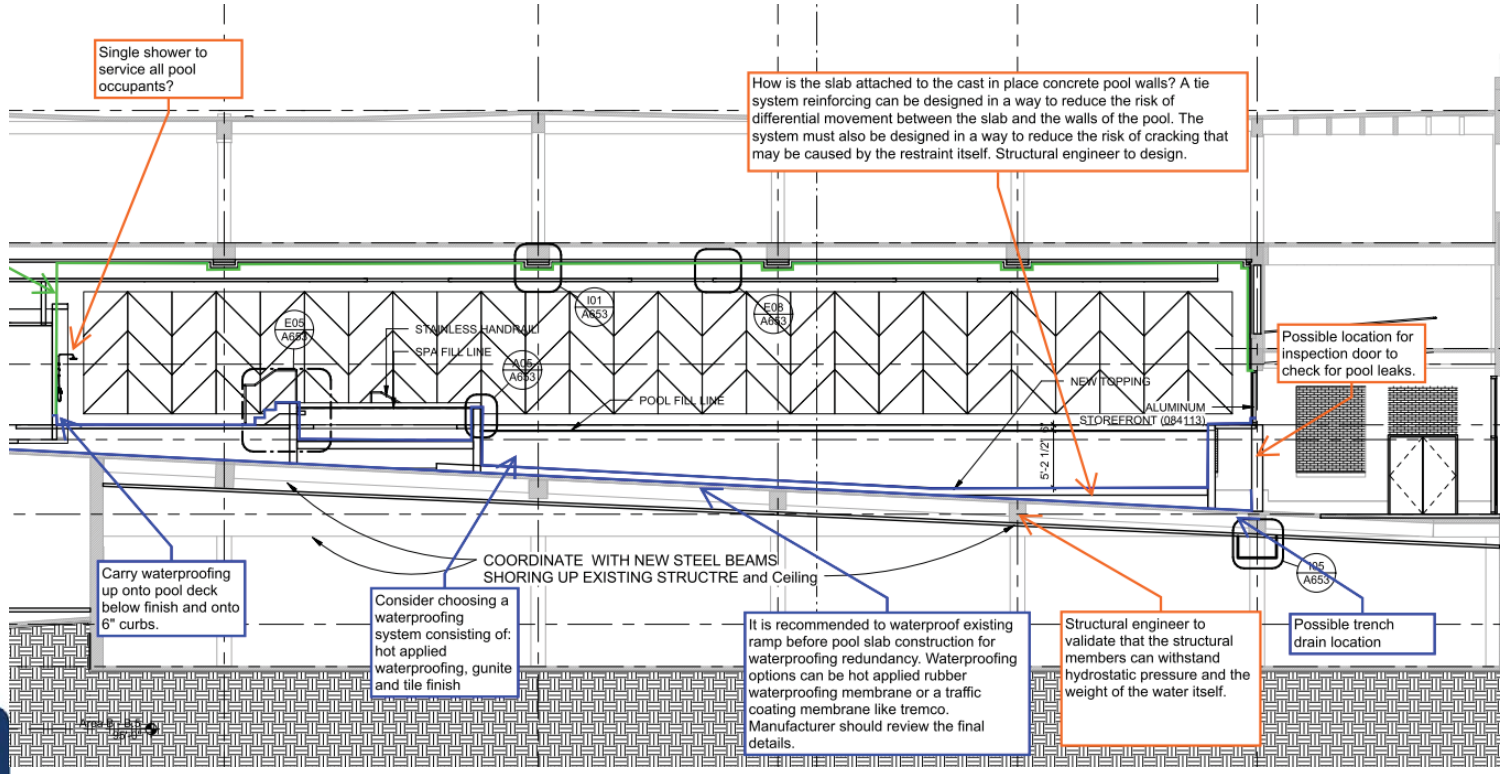

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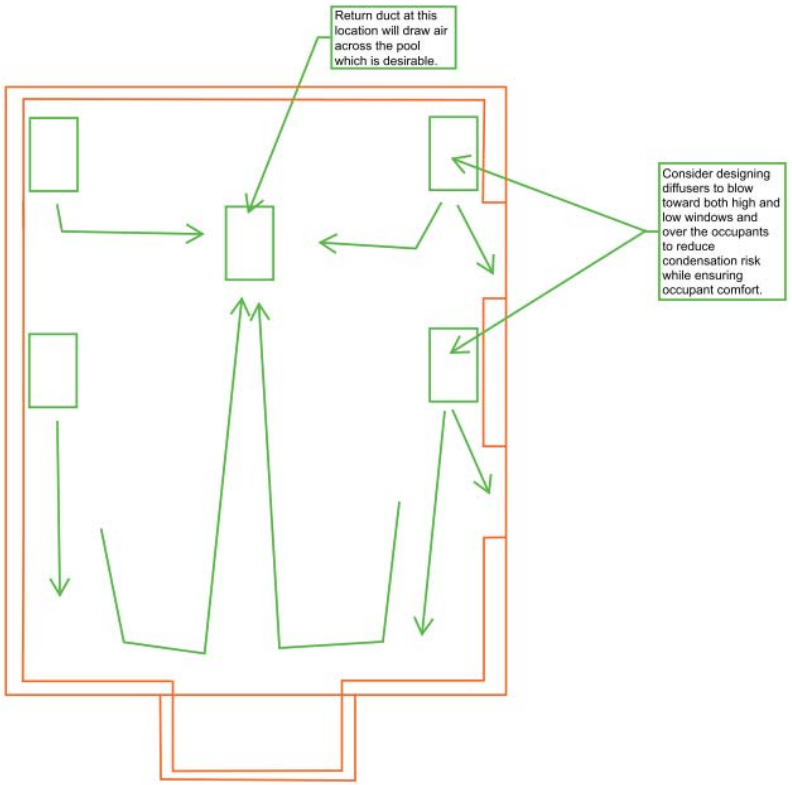

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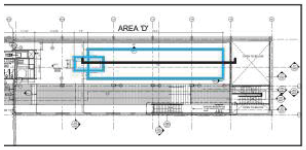

REFERENCE KEY FOR LONGITUDINAL SECTION THROUGH POOL DECK
(From Helix Preliminary Set, Sheet A122)

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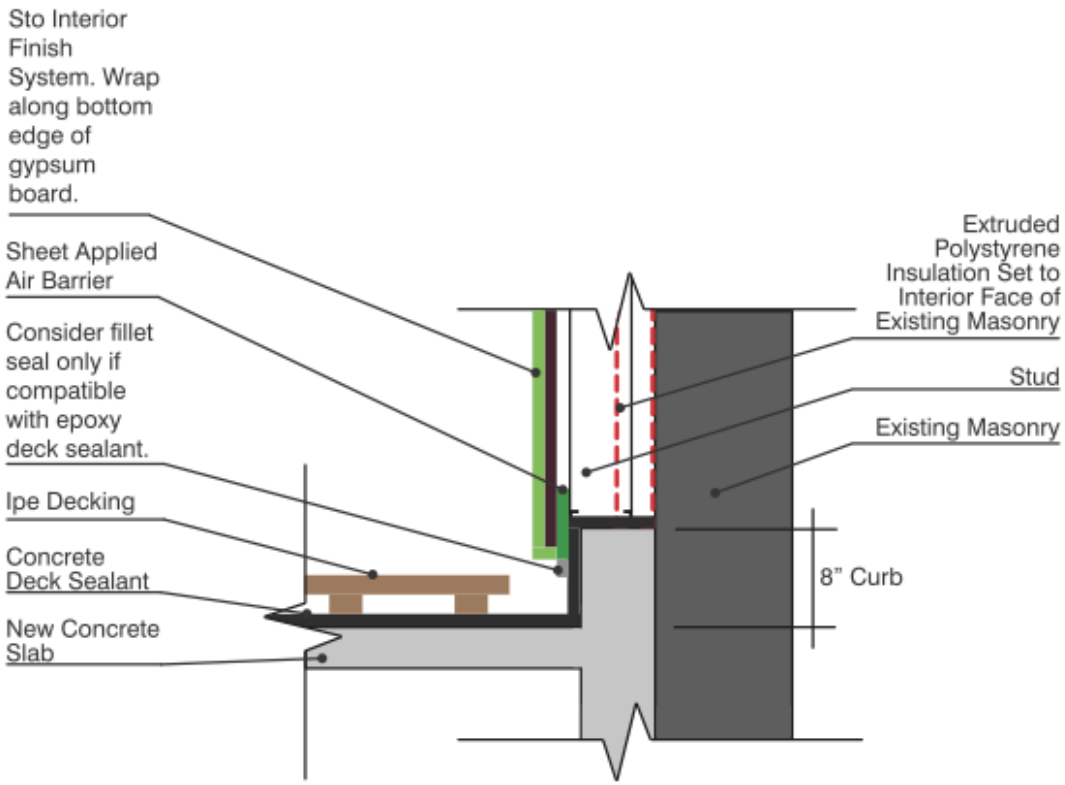
Case Study 2



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Case Study 3

Pan Am Aquatics Center and Field House

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Case Study 3: Pan Am Aquatics Center

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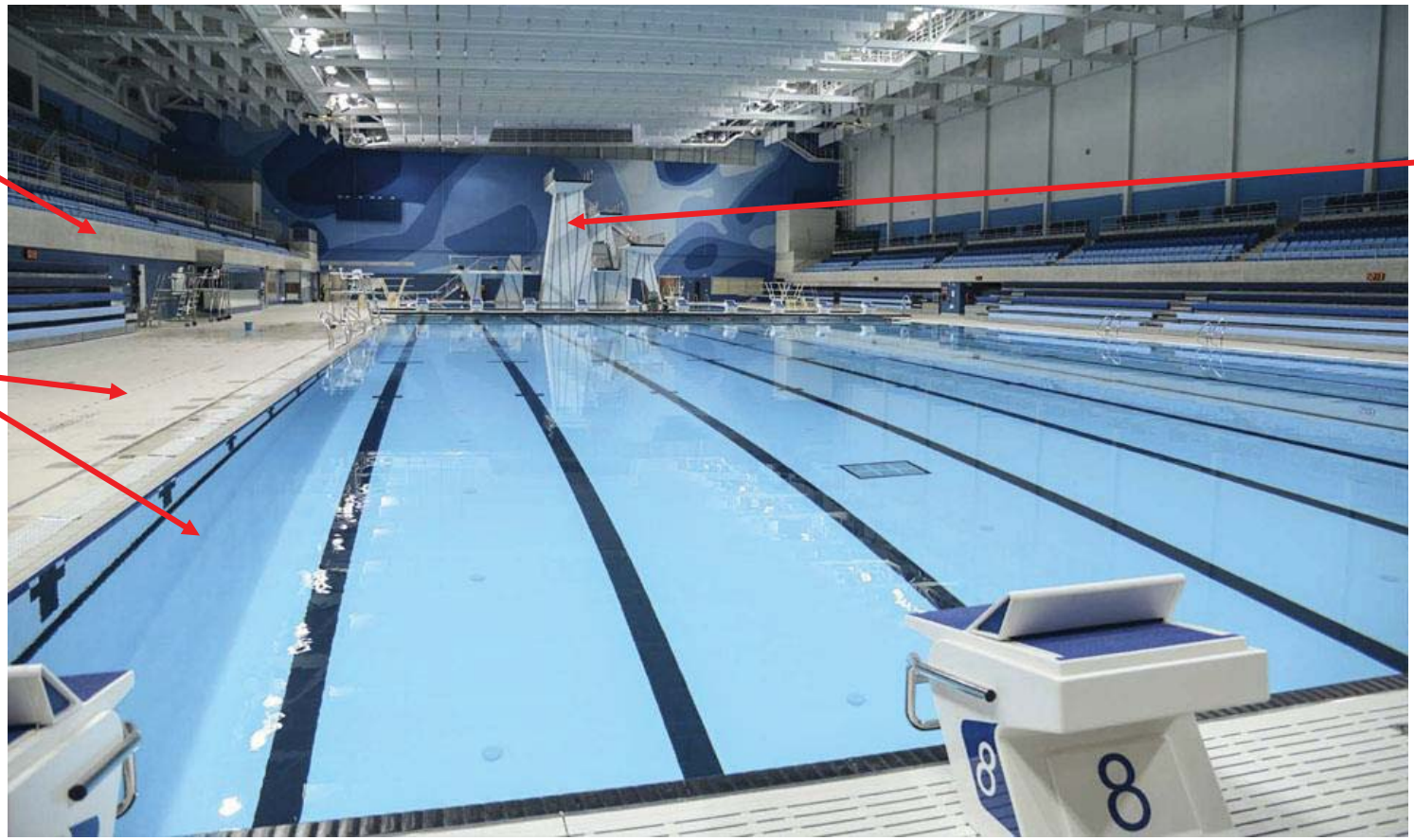
Case Study 3: Pan Am Aquatics Center

Observation and stands on both sides of pool

Pool deck and competition pool



Diving competition

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Case Study 3

Athlete Considerations

- Limit risk for cramping – better air flow at deck and up towers
- Platform divers and swimmers – different considerations

Fan and Family Experience

- Pool smell limited based on return layout
- Fans at ceiling – push air down but also sound – cheering is louder
- Better athlete performance – better experience

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Case Study 3

Atmospheric Acclimation Chamber

- Air tightening walls – isolates zone
- Provides better acclimation
- Ventilation in small air tightened space – needs more air

Field House and Other Space Isolation

- Pool smell limited based on air tightness and zone pressure
- Each zone has own experience
- Fieldhouse athletes not impacted by pool smell

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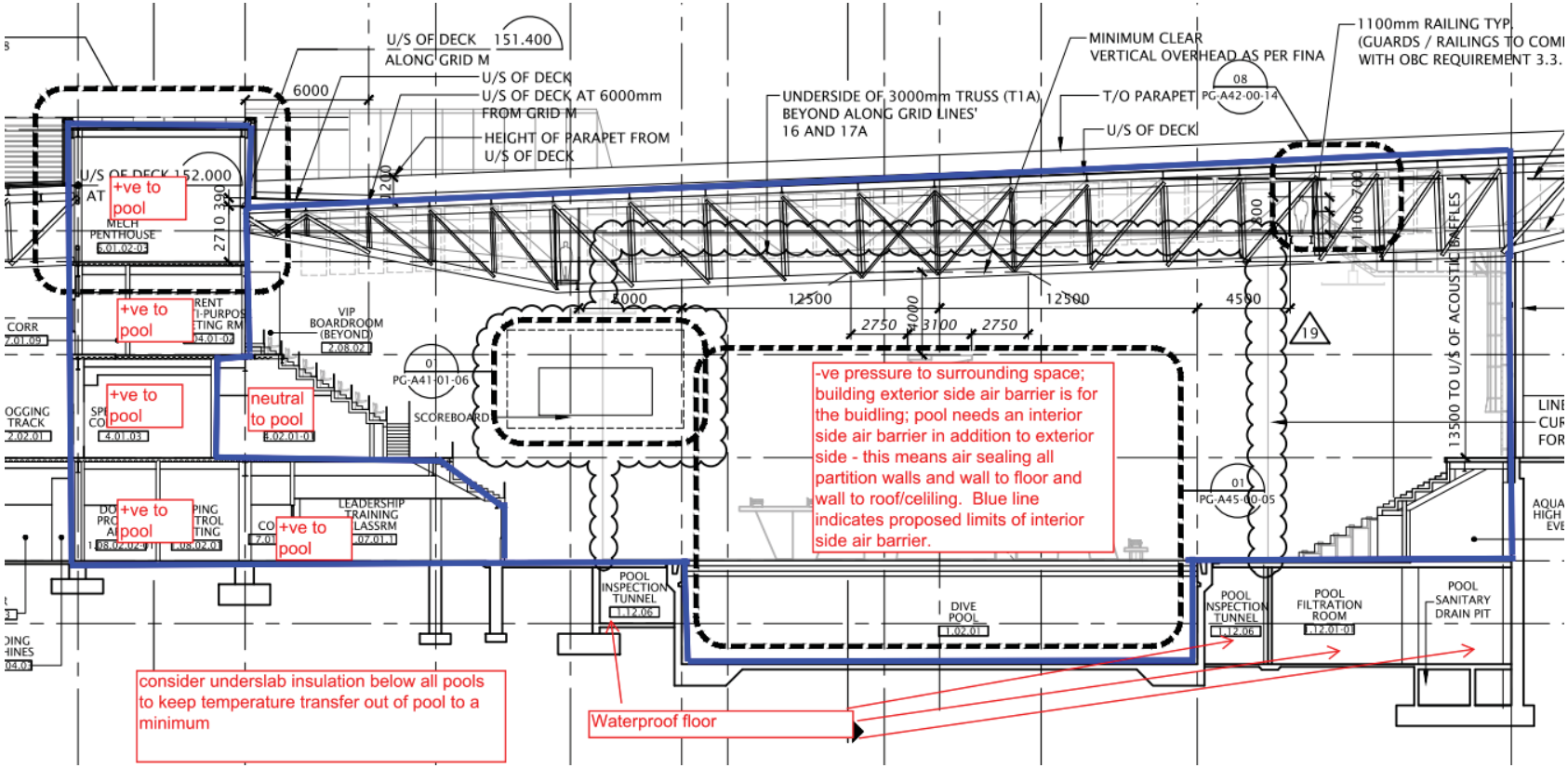
Case Study 3: Pan Am Aquatics Center



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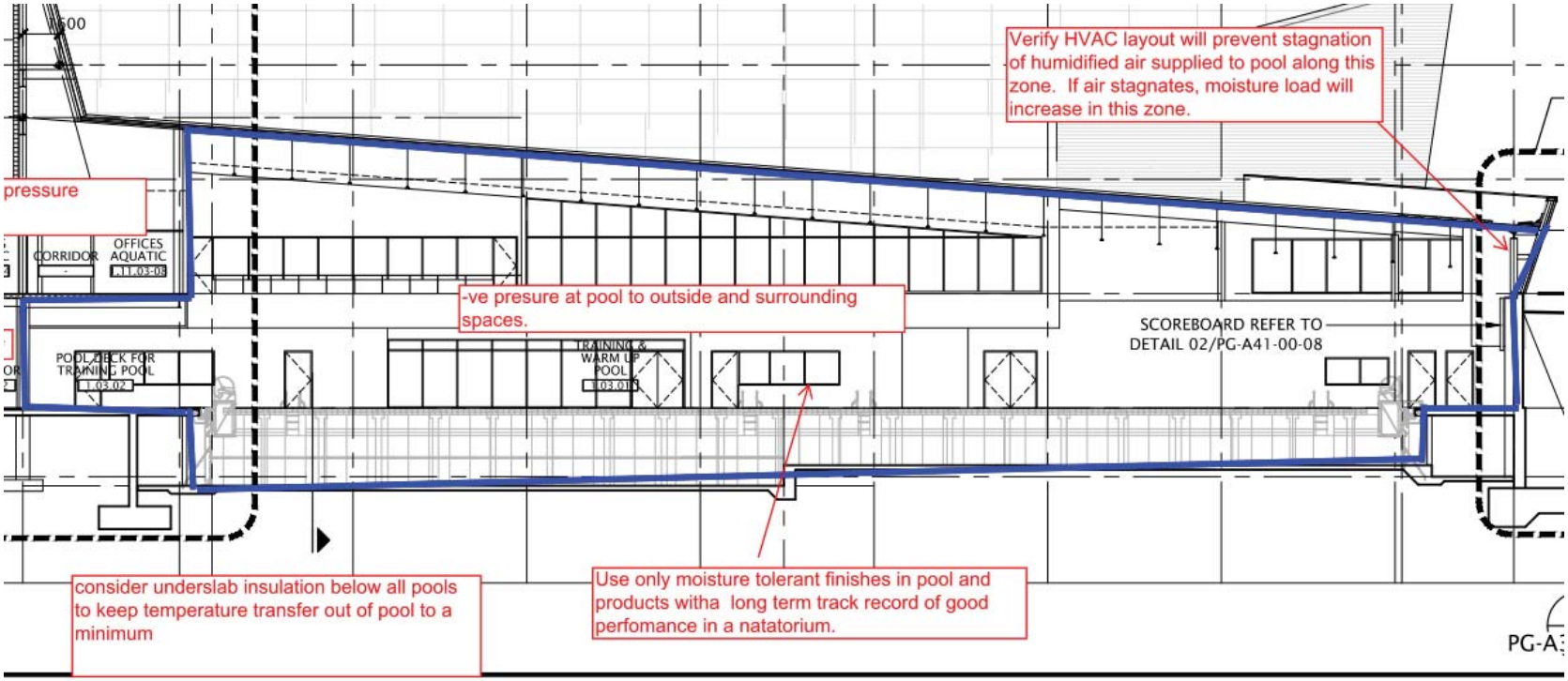

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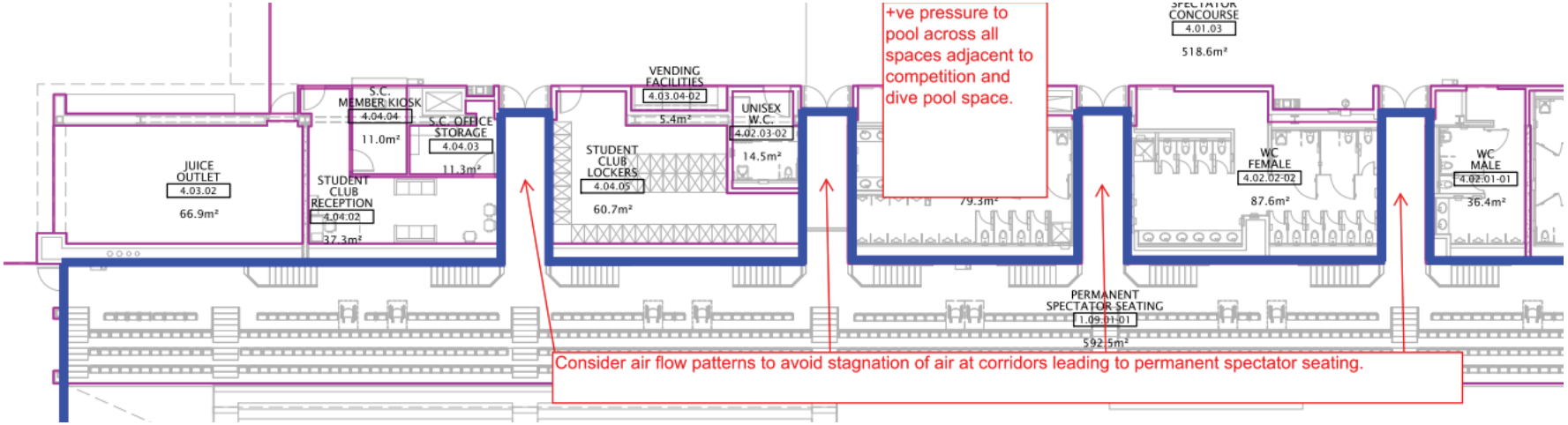

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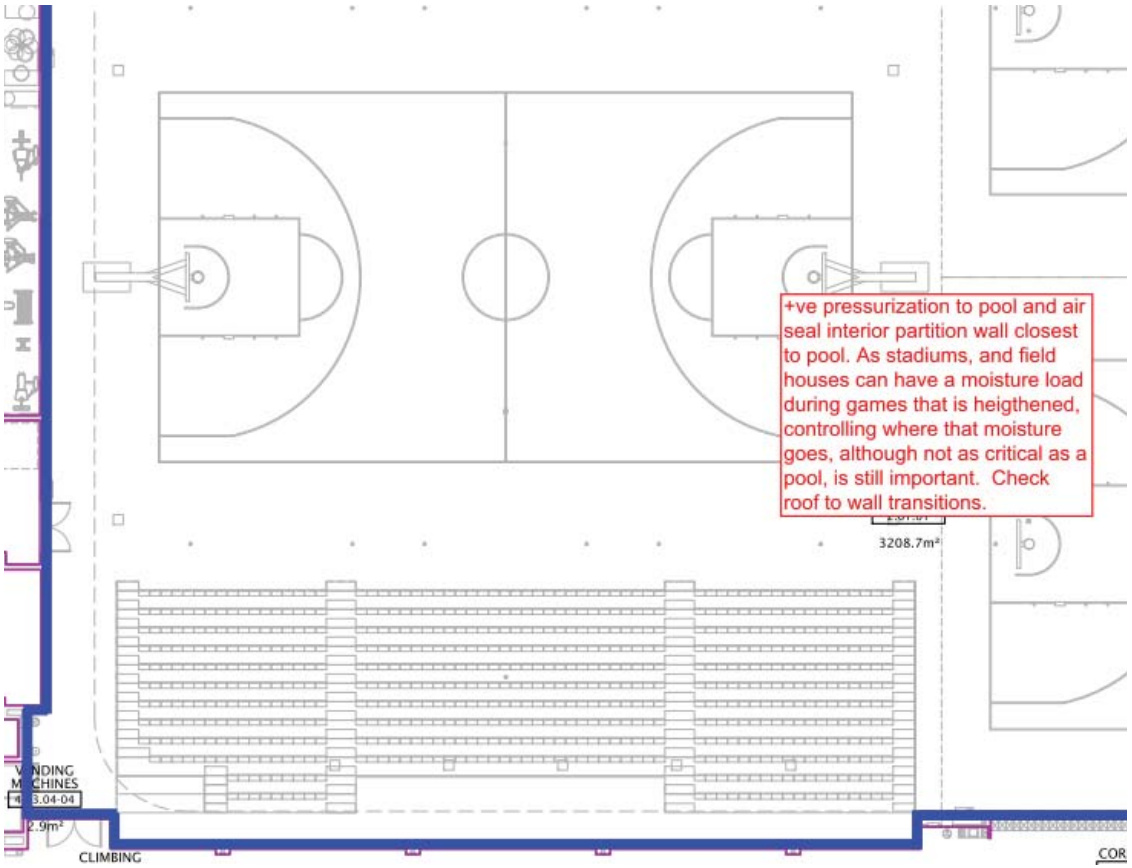

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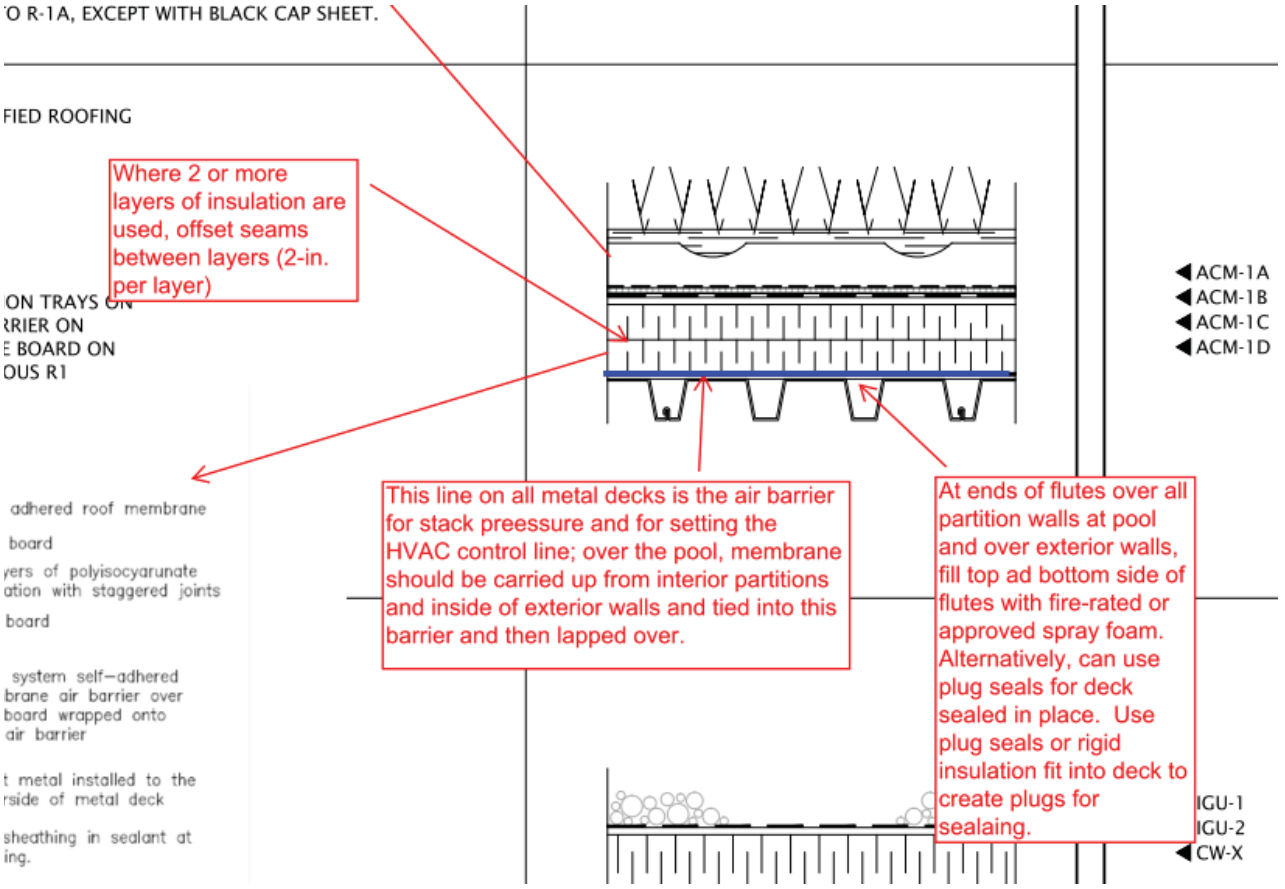

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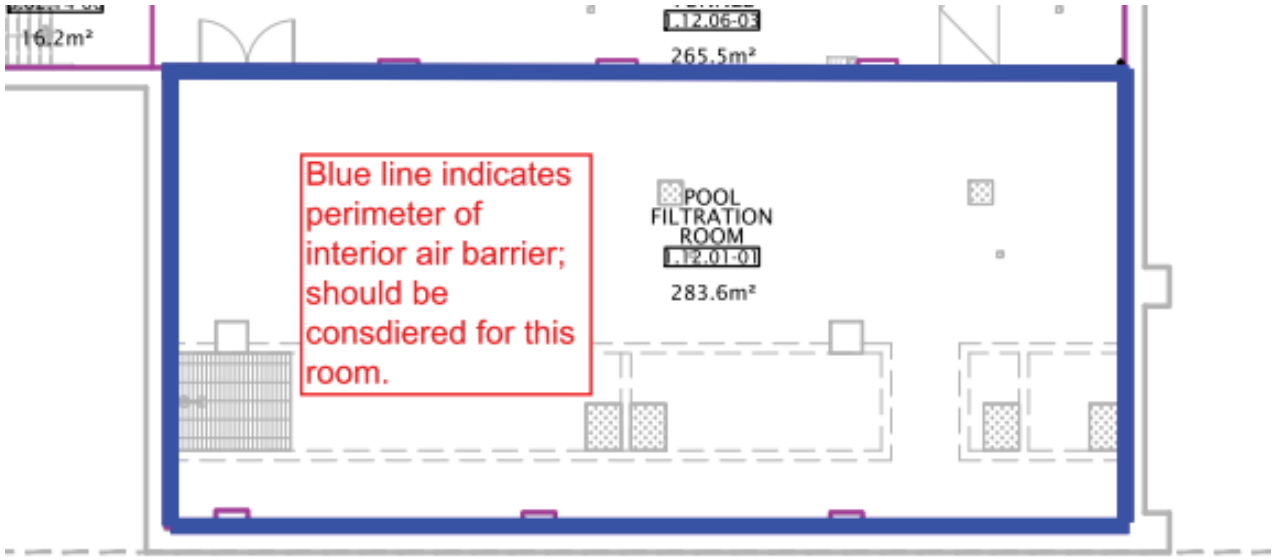

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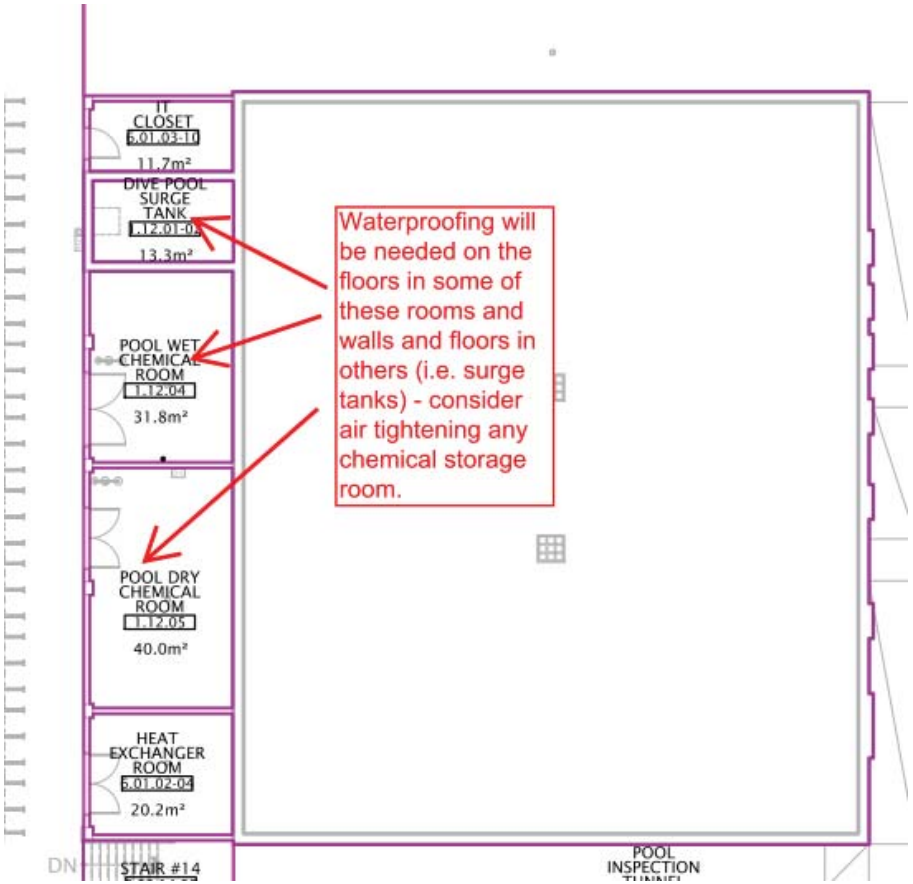

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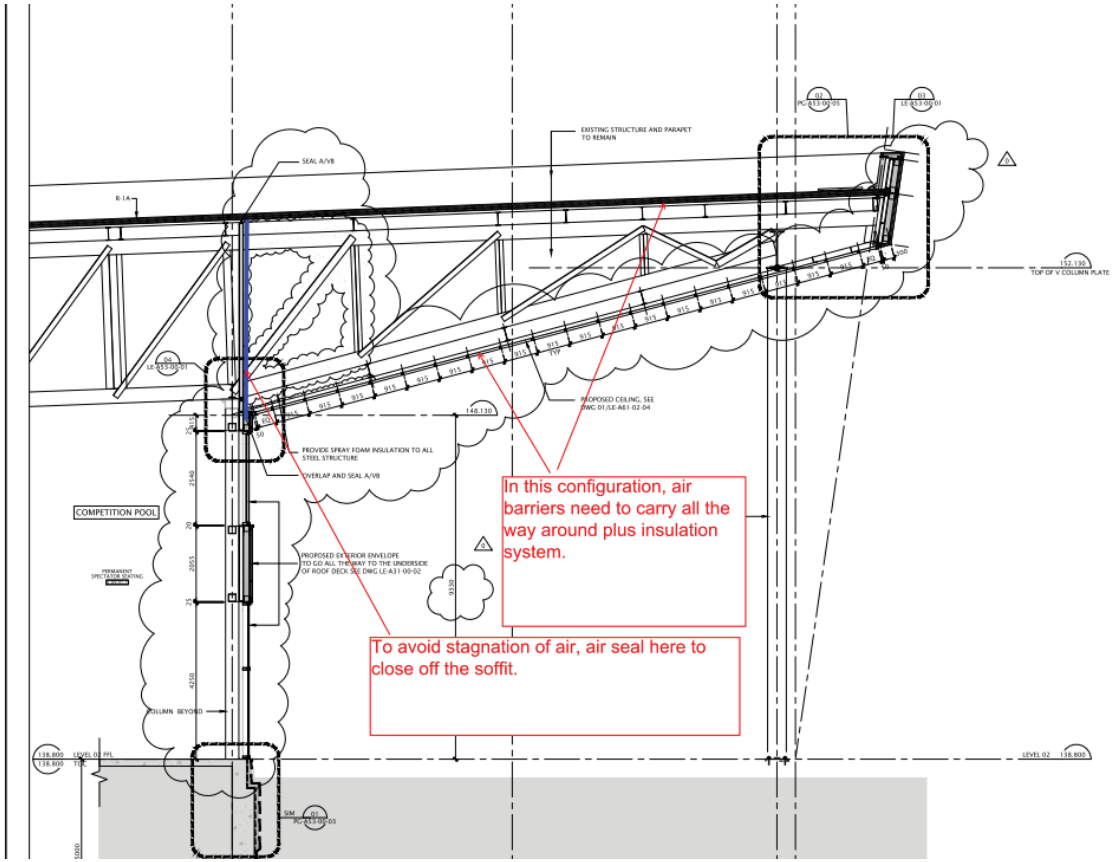

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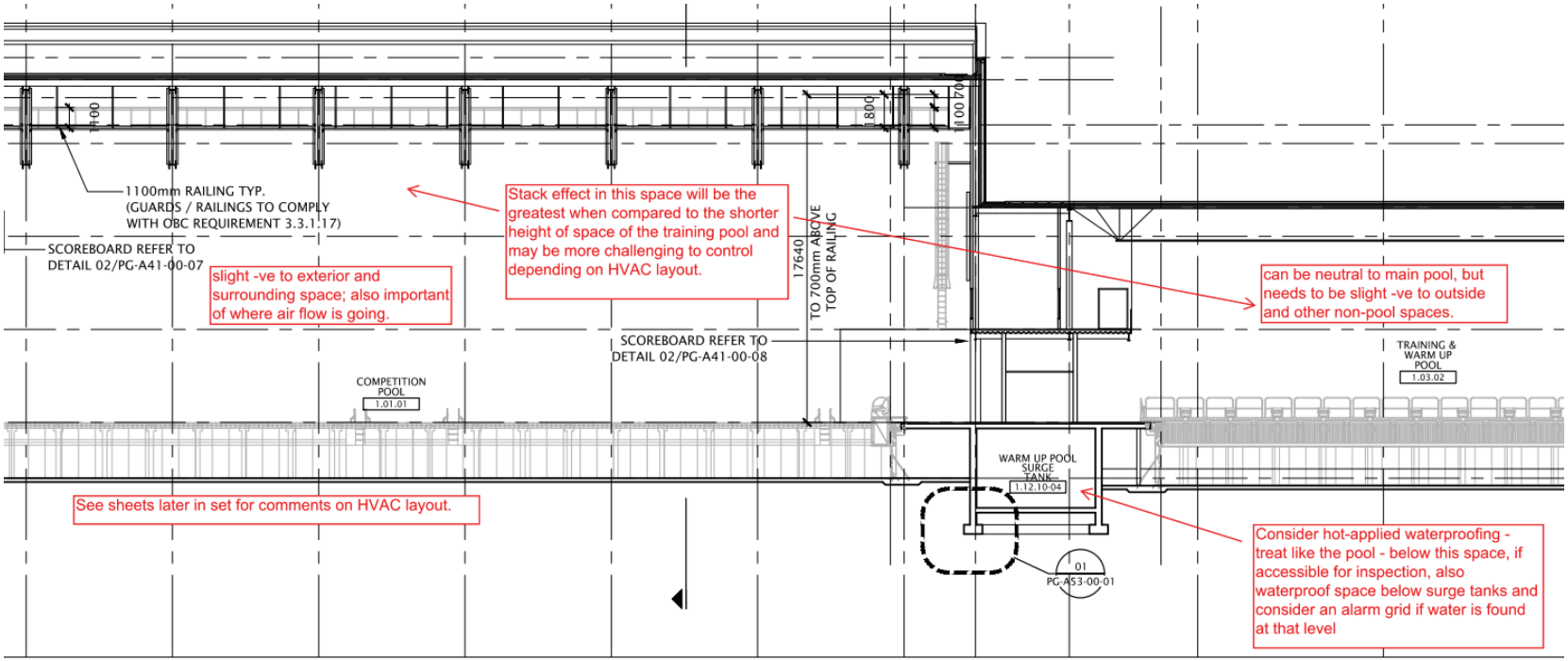
Case Study 3: Pan Am Aquatics Center



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Summary

Air Tightness

- Air tightening exterior walls, roof and below-grade, and slab on grade
- Air tighten interior between spaces
- Air tighten transitions to isolate

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HVAC

- Pressure in spaces understood
- Design layout for good flow of supply and return
- Care when using natural ventilation
- Fieldhouse athletes not impacted by pool smell
- Interaction with enclosure important

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