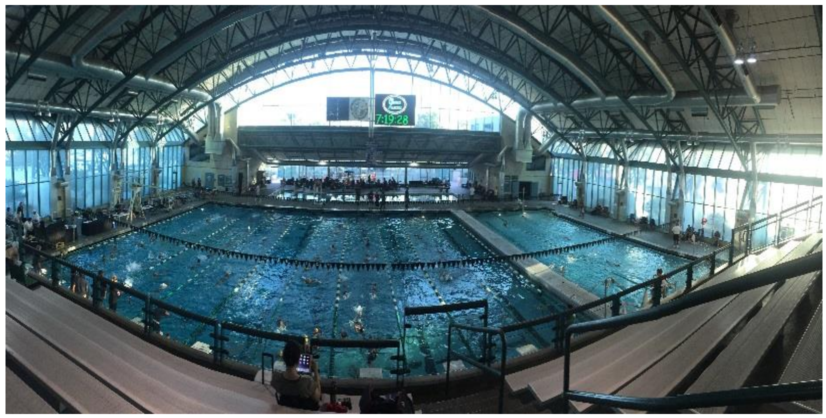
Brenda Villa Aquatics Center
City of Commerce
Commerce, California
Air Quality Evaluation

March 14, 2016



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SCOPE OF WORK

BOA Architecture and Dewberry were contracted by the City of Commerce to investigate air quality issues at the Brenda Villa Aquatics Center in Commerce, CA. The aquatics center is operated by the City of Commerce. This contract was solicited by the city in a Request for Proposal (RFP) dated May 18, 2015. In addition to air quality issues the study includes ingress and egress issues and an option for natural ventilation.

Since construction in 2001 the aquatics center has experienced issues with poor ventilation, high temperature and humidity levels, and excessive chloramine gas levels. In March of 2006 EMC Engineers completed an Indoor Air Quality Study. All recommendations in this report were implemented with the exception of 5b (Increase Outdoor Air Using Operable Windows). The aquatics center has also installed UV water treatment equipment. Conditions have improved considerably but the complaints over excessive temperature and humidity remain. The city also is aware of the existing equipment is approaching the end of its expected life. The scope of this study included the following tasks:

1. Review existing drawings and reports.
2. Conduct 2 day site visit included one day during and active swim meet. Site visit to include inspections of existing equipment, interviews with pool staff and maintenance personnel.
3. Install temperature and humidity data loggers at selected areas. Record conditions for two weeks.
4. Review information from site investigation, consider planned projects, develop alternatives to improve air quality and humidity conditions. Provide ROI cost estimates for solutions.
5. Provide recommendations for improving ability to access the site by film crews for filming.
6. Provide recommendations for natural ventilation systems.
7. Provide recommendations for modification or expansion of mechanical rooms to improve equipment access.
8. Prepare a report to present proposed solutions including economic analysis and system schematics.

FACILITY AND SYSTEM DESCRIPTION

The Brenda Villa Aquatics center was constructed in 2001. The building consists of two levels with approximately 42,915 sf on the first level and 10,925 sf on the second level for a total building area of 53,840 sf. The building houses swimming pools, a workout room, spectator seating, classrooms, a snack-bar/kitchen, and offices. The scope of this study was limited to the swimming pool and spectator seating area.

The aquatics center houses two indoor swimming pools, a 9,126 sf competition pool and a 1,500 sf training pool. **Figure 1** shows the ground floor pool area layout and **Figure 2** shows the second floor pool area layout.

The warm-up pool is maintained at 88 – 89 degrees F. The competition pool is maintained at 80 degrees F. Occasionally this temperature is lowered to 77-78 degrees F for collegiate meets.

The pool area is heated and cooled by two30,000 cfm Dectron pool dehumidification units located in second level mechanical rooms on the north end of the building. **Figure 3** shows a schematic of one of the pool dehumidification units. These units utilize a DX refrigerant coil to cool and dehumidify the air. The heat removed from the air can be rejected to the pool water to heat the pool, used as reheat in the unit, or rejected to an outdoor condenser. A hot water reheat coil supplied with hot water from the building boiler provides re-heat when the DX reheat is insufficient or needed for pool heating. The original indoor design conditions for the pool space were 82 degrees at 50 – 60% relative humidity (RH).

Additional heating for the pool water is provided by natural gas fired pool heating boilers located in the pool equipment room. There is a dedicated boiler for the warm-up pool and a dedicated boiler for the competition pool. Re-heat water to the De-humidifier units is provided by a building boiler which provides heating water to the remainder of the building.

In order to improve ventilation in the pool area a new exhaust/ventilation system was installed a few years ago. Low returns pull air from the pool surface which is exhausted by two in-line exhaust fans located in the second level mechanical rooms. Both fans are controlled by variable frequency drives which are indexed to building static pressure. During events the pool staff opens the exterior doors to the pool area in order to create a “purge” effect. This results in a drop of the building static pressure causing the fans to speed up and increase the exhaust rate.

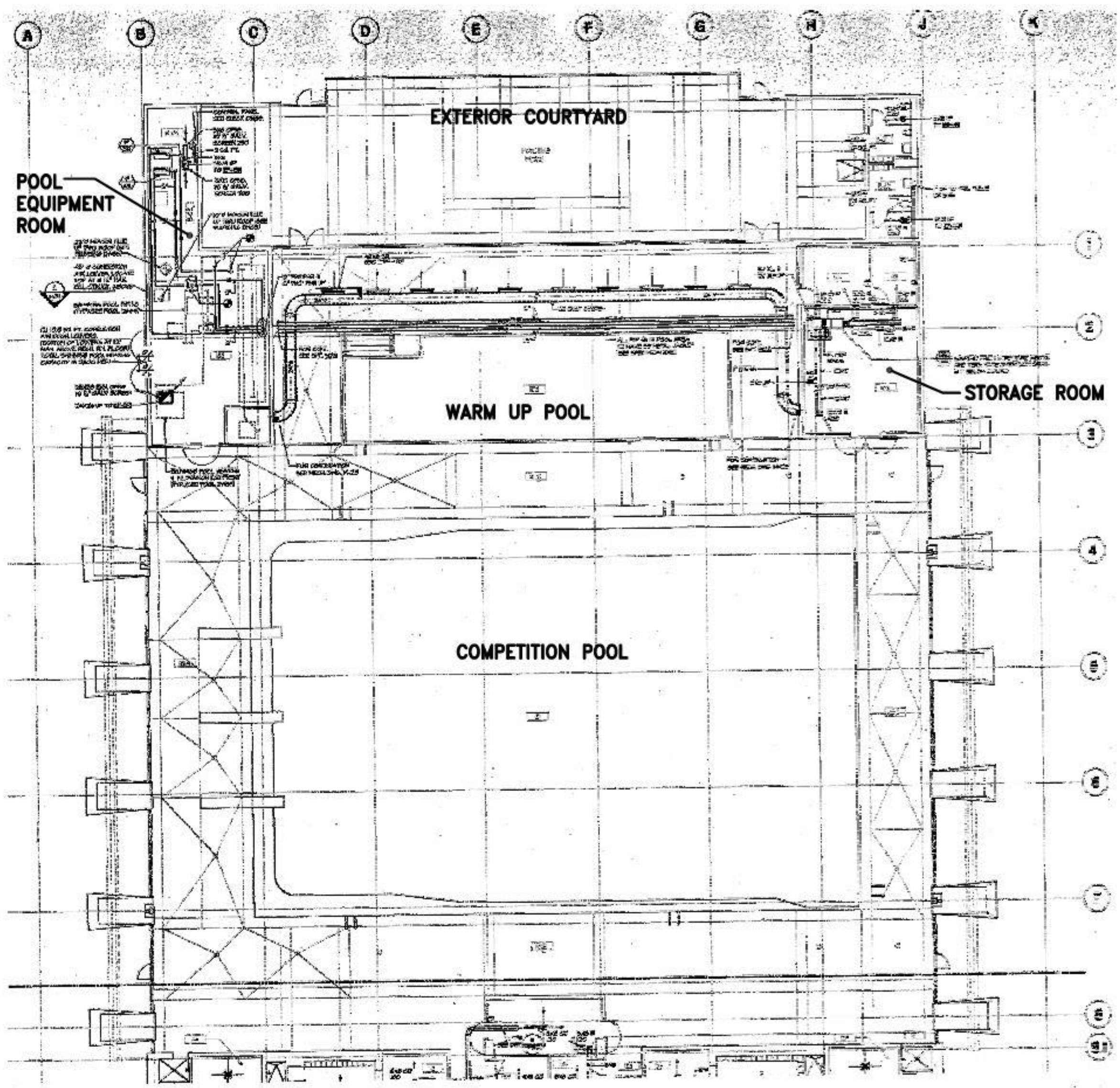

FIGURE 1 – POOL AREA LEVEL 1

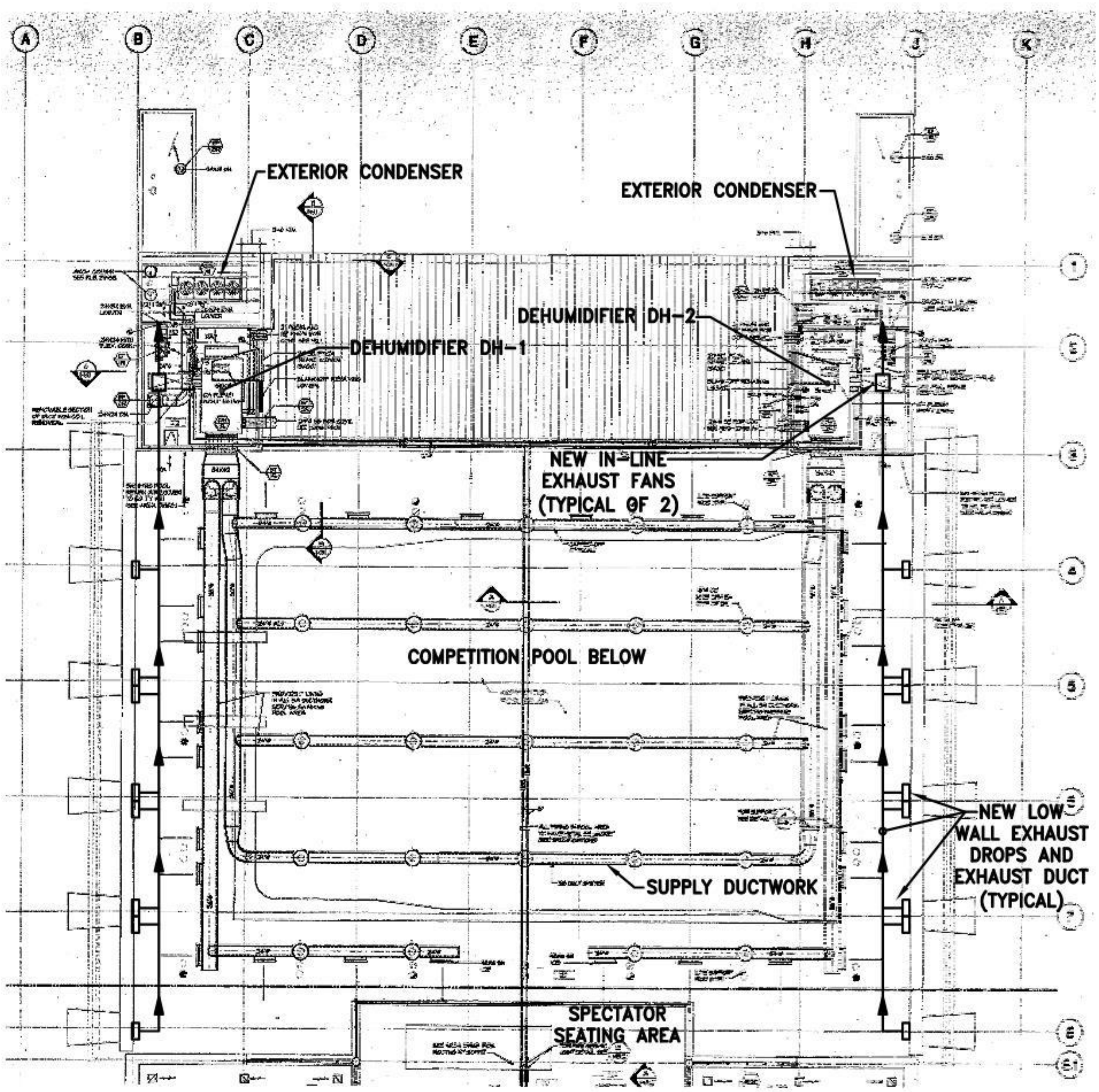

FIGURE 2 – POOL AREA LEVEL 2

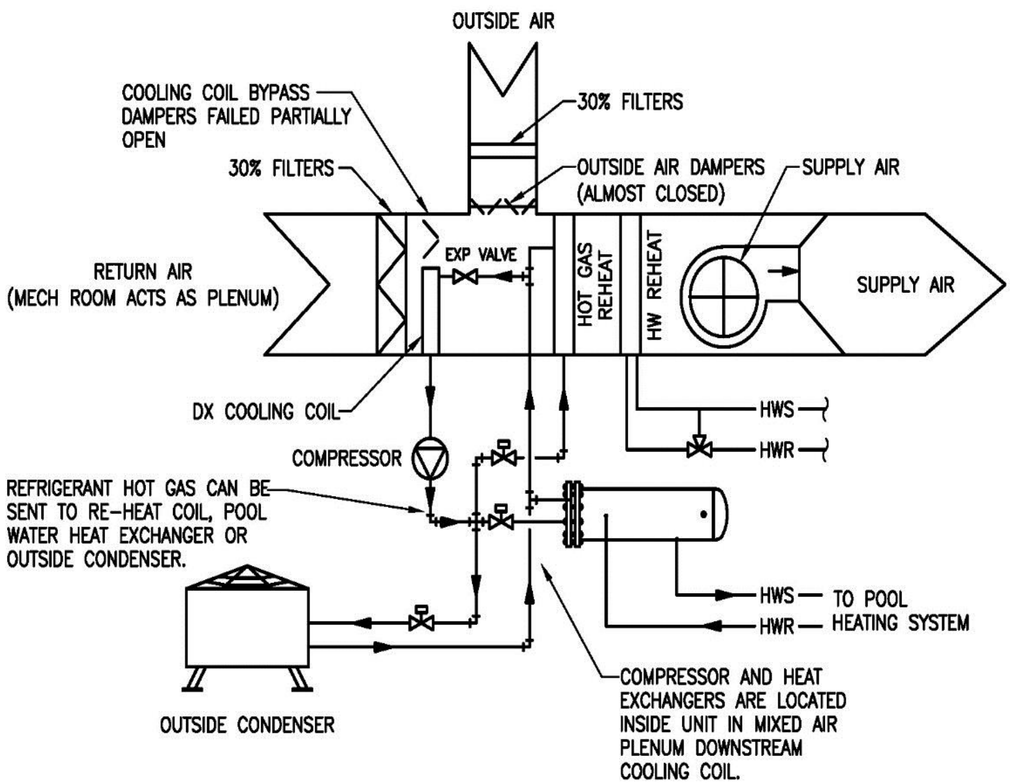

FIGURE 3, POOL DEHUMIDIFICATION UNIT SCHEMATIC

SITE VISIT OBSERVATIONS AND TEST RESULTS

BOA Architecture and Dewberry representatives visited the site on September 18, 2015. Dewberry representatives returned to the site on September 19, 2005 to observe the system during a swim meet event. The swim meet on this date was a large youth event consisting of multiple swim teams resulting in occupancy at peak capacity. In addition the outdoor temperatures for this day reached 91 degrees dry bulb and 71 degrees wet bulb substantially exceeding design conditions. The ASHRAE 0.4 % design condition for Los Angeles is 83.7 degrees dry bulb and 64.3 degrees wet bulb. The ASHRAE 1.0% design condition for Los Angeles is 80.4 degrees dry bulb and 64.7 degrees wet bulb.

Data loggers were installed by Dewberry personnel to record selected events, temperatures, and humidity levels. These devices were left in place until September 30, 2015 and recorded data at 15 minute intervals. Table 1 summarizes the low and high readings recorded for each of these points during this time period.

Table 1 - Summary of Data Logger Readings

Data Point	Lowest Reading			Highest Reading		
	Temp (deg F)	RH (%)	Dewpoint (deg F)	Temp (deg F)	RH (%)	Dewpoint (deg F)
Warm-up Pool Water Temp	80			90		
Competition Pool Water Temp	77			85		
Pool Area Ambient Air	77	60	62.0	85	60	69.6
Spectator Area Ambient Air	77	58	61.1	84	59	68.1
Dehumidifier 1 Supply Air	74	59	58.8	95	40	66.9
Dehumidifier 1 Cooling Coil Lvg	57	87	53.1	69	95	67.5
Dehumidifier 1 Return Air	77			85		
Dehumidifier 2 Supply Air	65	71	55.4	88	47	65.2
Dehumidifier 2 Cooling Coil Lvg	51	100	51.0	73	100	73.0
Dehumidifier 2 Return Air	76			87		
Design Conditions (Ambient Air)	82	50	61.5	82	60	66.8

A data logger was also placed on the variable speed drive for exhaust Fan #2. These values ranged from 0.2 amps to 7.3 amps. During the time of our site visit the drive for exhaust Fan #1 was in hand or manual mode awaiting repairs.

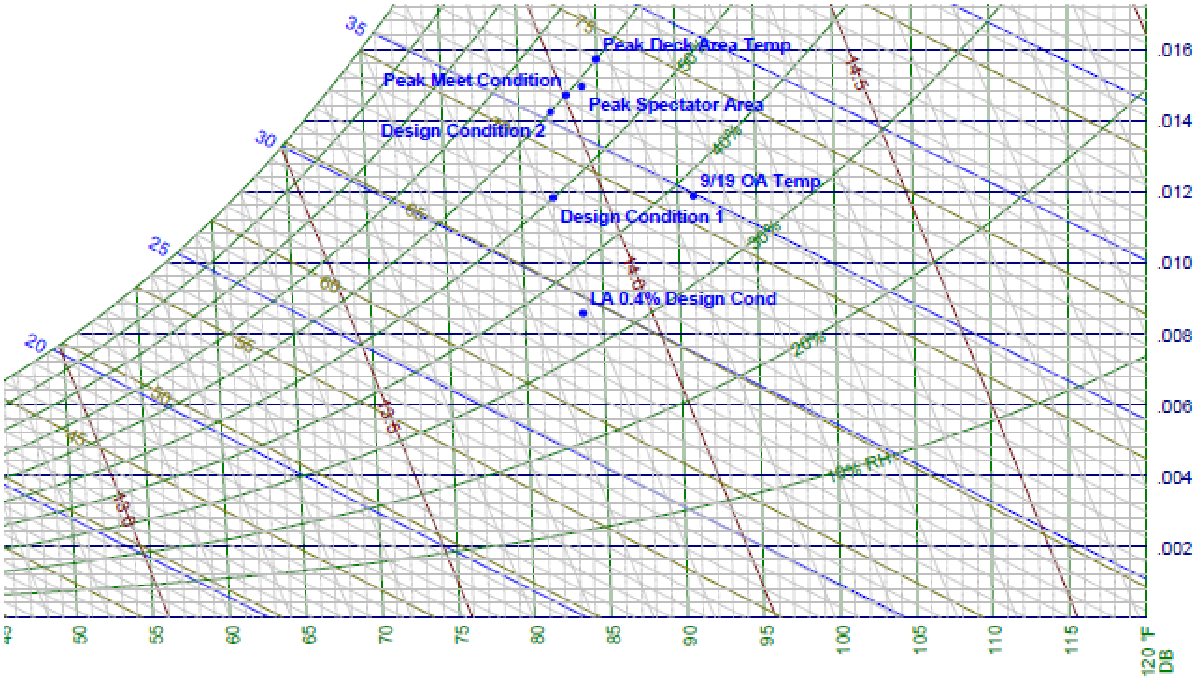

Figure 4 – Peak Conditions and Design Conditions Psychrometrics

As seen in Table 1 and Figure 4 the ambient air conditions are exceeding the design values. The highest readings for the pool area and spectator seating area were recorded during later periods when the set-points may have been higher. During the September 19, 2015 swim meet the highest conditions recorded were approximately 83 degrees, 60% RH in the spectator seating area and 84 degrees, 60 % RH at the pool deck. During this period maintenance personnel turned set-points down. While the system was not able to meet set-point it should be noted the indoor conditions were only slightly above the design condition even though the outside air conditions were significantly above design.

During the swim meet it was observed that the exhaust fan controls were not operating per design. This is discussed more under system deficiencies. The dehumidifiers were showing signs of advanced age. Several issues are discussed under system deficiencies.

The previously reported chloramine gas issues did not seem to be an issue during the swim meet. Staff reported that new ventilation system had improved this. Ultraviolet Light (UV) systems were recently added to the pool filtration equipment. This produced the most dramatic improvement in reducing chloramine levels. Staff noted this had not been a problem recently but space comfort conditions remain an issue.

During the swim event both pool heating boilers were off. All pool water heating needs were being met by the dehumidification units.

SYSTEM DEFICIENCIES

After our site visit, review of the system design, and our test results we identified the following system deficiencies:

1. As noted earlier during the time of our visit exhaust fan #1 variable speed drive was in hand or manual mode. Maintenance staff were aware of this condition and had scheduled repair of the unit. The fan was running at approximately 48 Hz or 80% speed.

2. While exhaust fan #2 was running in automatic mode the fan controls were not operating per design. The fan continued to run in slower speeds during 9/18/15 even after exterior doors were opened which should have caused the fan speed to increase. During the day of the event on 9/18/15 the fan run in low speed for much of the morning then sped up to 100% (60 Hz) in the afternoon for no apparent reason. During this period closing doors in an attempt to slow the fan down had no effect. Later in the day the fan returned to slow speed. When running at 60 Hz or 100% speed the fan was running at an unstable point on the fan curve. The fan was observed surging.

3. The outside air dampers for the de-humidifiers are closed or nearly closed. The dampers do not have automatic operation to allow the use of outside air for economizer operation when conditions permit.

4. Maintenance staff expressed concern that the outside air for the dehumidifiers is introduced down-stream from the cooling coil into the mixed air section. With this design only the return air is passed over the cooling coil prohibiting dehumidification or cooling of the outside air. This is common for pool dehumidifier units. A review of temperature and humidity data for Los Angeles shows that outside air conditions are typically lower than the indoor pool design conditions thus is not necessary to run the outside air through the cooling coil.

5. The dehumidifiers have bypass dampers around the cooling coils which are not operational but are locked in a partially open position. This is allowing unconditioned air to bypass the coil.

6. The reheat coil control valve for dehumidifier number 1 appeared to be leaking. The coil remained warm during periods when the unit was not meeting cooling set-point.

7. The dehumidifiers are able to meet space design conditions. This seems to be primarily due to the condition of the units and other deficiencies noted above. The units are showing signs of advanced age and are at the end of the life expectancy for this type of equipment. While the cooling coils appeared to be relatively clean both coils had a static pressure drop of approximately 1.3 inches w.g. indicating the coils may have fouling deep within the fins from the advanced age. A review of the data logger information indicated the lowest discharge temperature recorded off the coils was 53.1 degrees. The coils were designed to have a discharge temperature of 45 degrees. The broken bypass dampers may be partially responsible for this higher temperature but readings were taken near the center of the coil. The coils and compressors may not be producing full capacity due to the advanced age.

8. Several control points were identified that are in need of calibration.

9. The dehumidifier units utilize R-22 refrigerant which is being phased out as it does not meet current environmental standards for non-ozone depleting refrigerants. As this refrigerant gas is phased out the only R-22 available for recharging the units will be reclaimed gas which will become increasingly expensive.

10. The existing de-humidifiers were installed in mechanical rooms surrounded by cast-in-place concrete walls. The roof of the mechanical room is concrete as well. The louvers to the rooms are not large enough to move new equipment through. The existing mechanical rooms are also small and must be accessed through a ladder and small trap door in the floor.

Dehumidifier outside air dampers in closed position

Open bypass dampers around cooling coil

Interior rust, deteriorating coil fins

Pool Dehumidifier Unit

Exterior condensing unit

View of northwest corner of building showing concrete walls and roofof mechanical room

RECOMMENDED IMPROVEMENTS

First Priority Repairs (Phase 1)

1. Re-commission the existing pool ventilation fan system. Repair control functions to maintain the building static pressure as designed. Re-balance the system and confirm the desired building static pressure set-points for the fan system. Limit the maximum fan speed for both exhaust fan units to a value that will prevent operation at an unstable fan curve point. **Approximate Cost = $25,000.**

2. Repair the hot water reheat coil control valve on dehumidifier unit 1. **Approximate Cost = $1500.**

3. Repair the Dehumidifier bypass dampers or block the dampers openings to increase airflow over the cooling coil. Re-balance the outside air and adjust the outside air dampers in each unit. Generally outside air conditions for this area will be at lower dew-points than the return air thus a higher outside air setting is recommended.**Approximate Cost = $20,000.**

4. Install a pool cover system over the warm-up pool. Pool covers significantly reduce evaporation off the pool surface which is the primary source of heat loss from the pool water and a significant vapor or humidification load to the space. Covering the warm-up pool during events can help reduce indoor loads. There is no cost, as the City already owns such a pool cover but has not been using it.**Approximate Cost = $0.**

5. Install dedicated spot cooling for the spectator area. While the spectator area only slightly exceeded design conditions there were considerable complaints from spectators during the event. A lower design condition for this area should be considered. This area could be cooled by ducting air from existing rooftop unit 1R if the unit is upsized when replacement is required. It is assumed that based on the age of the equipment this unit would also need to be replaced in the near future. Other options for spot cooling would include mini-split units installed in the spectator areas with condensers located on the roof near unit 1R. **Approximate Cost = $50,000.**

This recommended HVAC equipment cost is included in the overall Phase 1 cost estimate. See Figure 8.

Second Priority Repairs (Phase 2)

1. Replace each of the two de-humidification units. The new units should include outside air economizer function. This will require new mechanical rooms be created on the north end of the building. One possibility may be relocating the exterior condensers and opening the north wall of the mechanical room allowing expansion to the north. This is an expensive repair due to the extensive general construction that is required to accomplish installation of new units. While expensive this will eventually need to be done as the units are already near the end of expected life and are not currently meeting design conditions.**Approximate Cost = $3,000,000 - $4,000,000.**

This recommended HVAC equipment cost is included in the overall Phase 2 cost estimate. See Figure 9.

THE NATURAL VENTILATION OPTION

Southern California has one of the best weather conditions in the whole world. Those that live here, enjoy mild climate for the majority of the year. It is not uncommon for many residences to not have air conditioning in their homes. So why not use our great weather as an asset for this indoor pool project to achieve great indoor air quality. And an added bonus, save a lot of money on air conditioning cost.

As part of our report and recommendations, we propose to create openings at the East/West/North sides, and at the upper East/West/North window walls, to promote natural ventilation. During mild climate conditions, the HVAC system could be totally shutdown, and new slide-up doors at the East/West/North sides can be drawn open to allow the prevailing winds to naturally ventilate the interior quickly. Indoor air temperature and air speed can be (relatively) controlled by increasing or decreasing the size of the open area of the slide up doors, or by sliding up or down the new slide-up doors.

This natural ventilation option will no doubt save money on air conditioning cost. A review of climate data for the area shows that outside air conditions are lower than the indoor design conditions most of the year. This does not mean that outdoor air can be used for all cooling as the ventilation air must be lower than the indoor design condition in order to offset the space loads from people and pool water evaporation. Natural ventilation could reduce the equivalent full load cooling hours for the space by 50% for a savings of approximately $45,000 per year. This would equate to a simple payback of 20.7 years. While the simple payback may seem long this improvement would last for the life of the building thus it would still have a positive savings investment ratio. This would also reduce operational time on the HVAC equipment resulting in lower maintenance costs and extended equipment life. Factoring in these additional savings would reduce to the simple payback to less than 20 years.

The existing Brenda Villa Aquatic Center building already has a very good orientation to promote natural ventilation. It allows for an abundance of openings on the West and East side of the aquatic center to take advantage of the prevailing westerly winds for good air flow. Three side of aquatic center can have large openings to allow wind to enter and exit quickly to expel chlorine air and moisture. Another good feature of the existing building is that, the curve barrel vaulted roofs is a very good shapes to enhance natural ventilation. The rising curve on the West side of the aquatic center roof will increase wind velocity as air flows from West to East. The curved roof creates a good micro-environment for natural ventilation to prosper, which is extremely important for interior environmental/temperature control.

How does the location and placement of the opening enhance natural ventilation? Does it matter where the opening are located? What are the factors that impact natural ventilation? BOA's research (from the book "Tropical Architecture by C. P. Kukreja) resulted in the following factors used to design and locate new openings.

- **Factor #1:** A larger ratio of outlets to inlets in terms of size will facilitate the speediest, and hence the most cooling, air flow within a building.

  Design Response: The outlets on the leeward East and windward West sides of the aquatic center are proposed to be adjustable to promote air andfacilitate the speediest air flow as needed.

- **Factor #2:** Changes in the directions of the air flow tend to retard wind speed therefore, abrupt changes in the direction of the air flow should be avoided as much as possible.

  Design Response: In all interior spaces, there will no interior walls or obstructions between openings to block wind speed as wind passes through the interior of the aquatic center.

- **Factor #3:** The temperature difference that exist between warm air and cool air due to the weight disparity, cause the warmer air column to rise by displacement. This is more commonly known as the "stack effect".

  Design Response: We propose a large, window opening at the upper north window wall (above the score board) to encourage warm air, and chemical smells to rise up and exit the building through the upper clearstory as quick as possible. We also propose new upperEast/West window walls closest to the spectator bleacher to provide natural ventilation relief for spectators sitting in the upper bleachers.

We have provided renderings of floor plans, and section diagrams of our proposed design modifications to your existing aquatic center to promote natural ventilation. See Figures 4 thru 7 on the following pages.

Cost Estimate for Proposed Aquatic Center Modifications

The cost estimate of the natural ventilation option for modification of the existing window walls and new slide-up doors and new openable upper windows, along with architectural and engineering design fees and contingency is approximately $750,000. See Figure 8 and Figure 9 for cost estimate spreadsheet. As stated earlier this improvement will reduce cooling costs by approximately $45,000 per year. This would equate to a simple payback of 16.7 years. While the simple payback may seem long this improvement would last for the life of the building thus it would still have a positive savings investment ratio. This would also reduce operational time on the HVAC equipment resulting in lower maintenance costs and extended equipment life. Factoring in these additional savings would reduce to the simple payback to less than 16 years.

Should the proposed upper openings at East/West/North be permanent/y open?

We understand there is interest in utilizing a fixed opening for the natural ventilation in the pool area.The design condition for the pool area is 82 degrees dry bulb, 50-60% RH. For most of the warm weather or summer season the Los Angeles weather conditions are actually below this design point thus an open vent is a benefit and does not induce additional cooling load on the system. A review of average annual weather conditions shows the summer outdoor conditions will exceed the desired indoor condition only 120 hours per year with the majority of those hours falling between the hours of 9am – 4pm. During those 120 hours there would be additional cooling load on the system by having the open vents.

Of more concern is the effect the open vent would create during cooler weather. Even during the winter season it is generally preferable to maintain pool spaces at higher temperatures. Lower temperatures increase evaporation rates on the pool surface resulting in higher rates of heat loss and swimmers will be uncomfortable when exiting the water in a cooler environment. A review of average annual weather data shows a large number of hours per year when an open vent could significantly increase heating loads for the space. This would be less of an issue during large swim meets when there is more internal loads to offset this additional heat loss but would represent a considerable increase in heating load during normal operation.

Average annual weather conditions for Los Angeles show the outside temperature is between 55 – 59 degrees for over 1880 hours per year. Temperatures drop below 55 degrees over 1160 hours per year. This represents a total of 3040 hours per year when an open vent could add additional heating load. The majority of these conditions occur in the months from October – May. Closing the vents manually during this period might be a consideration but it should be noted there are a significant number of more moderate hours during those months when the natural ventilation would be desired.

For this reason we would not recommend a permanently fixed opening. We recommend that the opening be operable for staff to open and close the opening as needed.

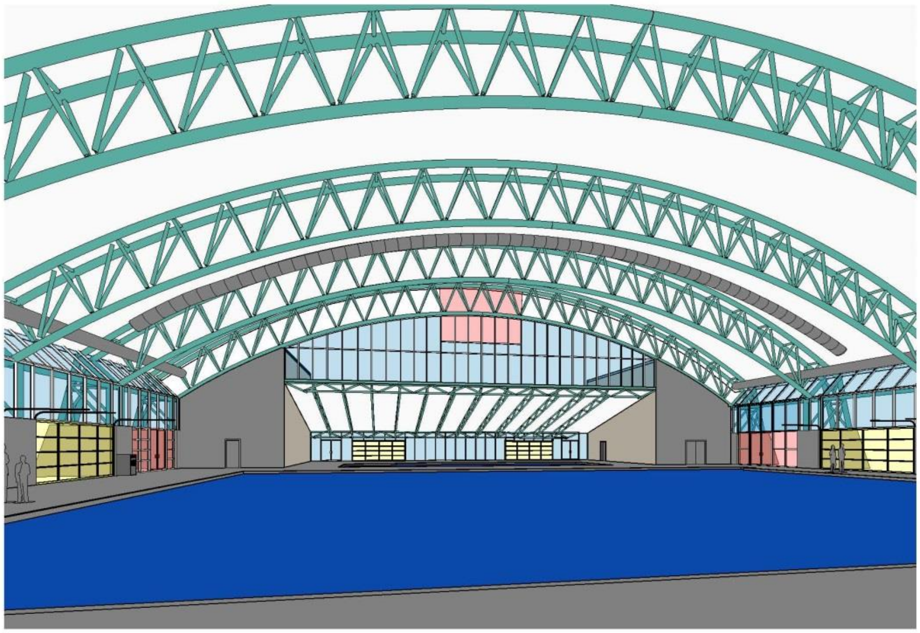

FIGURE 4 - INTERIOR RENDERING

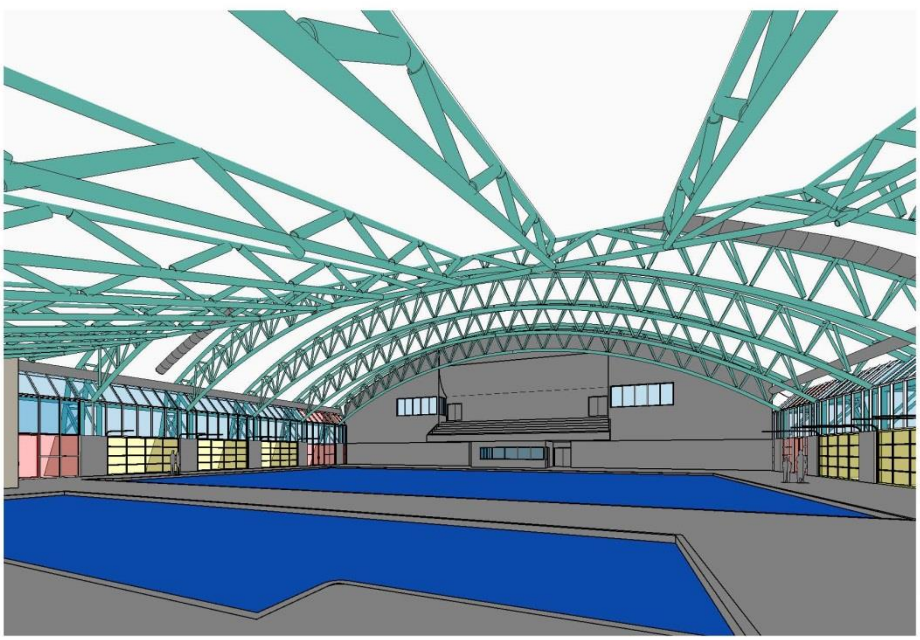

FIGURE 4.1 - INTERIOR RENDERING

RED INDICATES PHASE 1

YELLOW INDICATES PHASE 2

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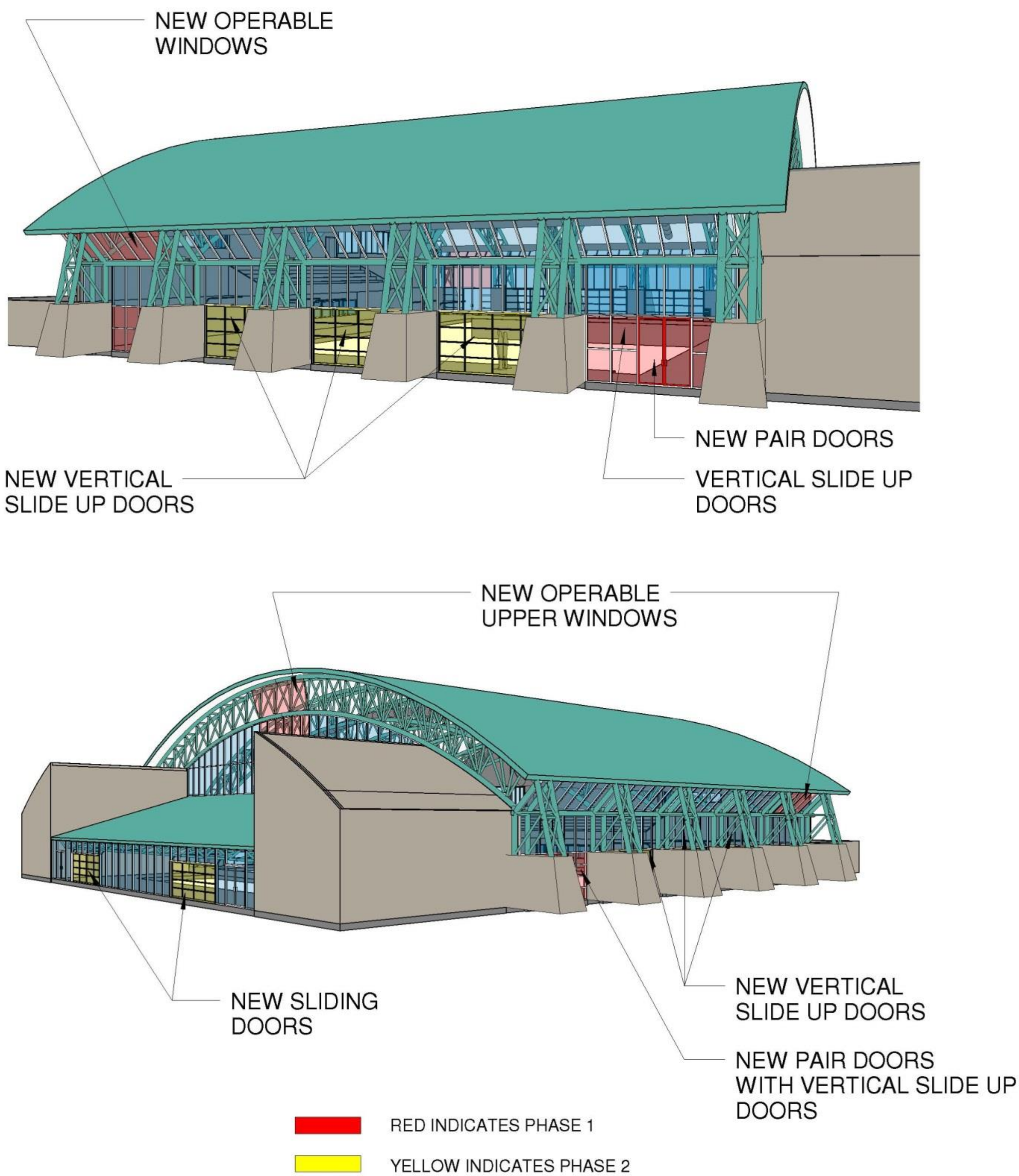

FIGURE 5 - EXTERIOR RENDERING

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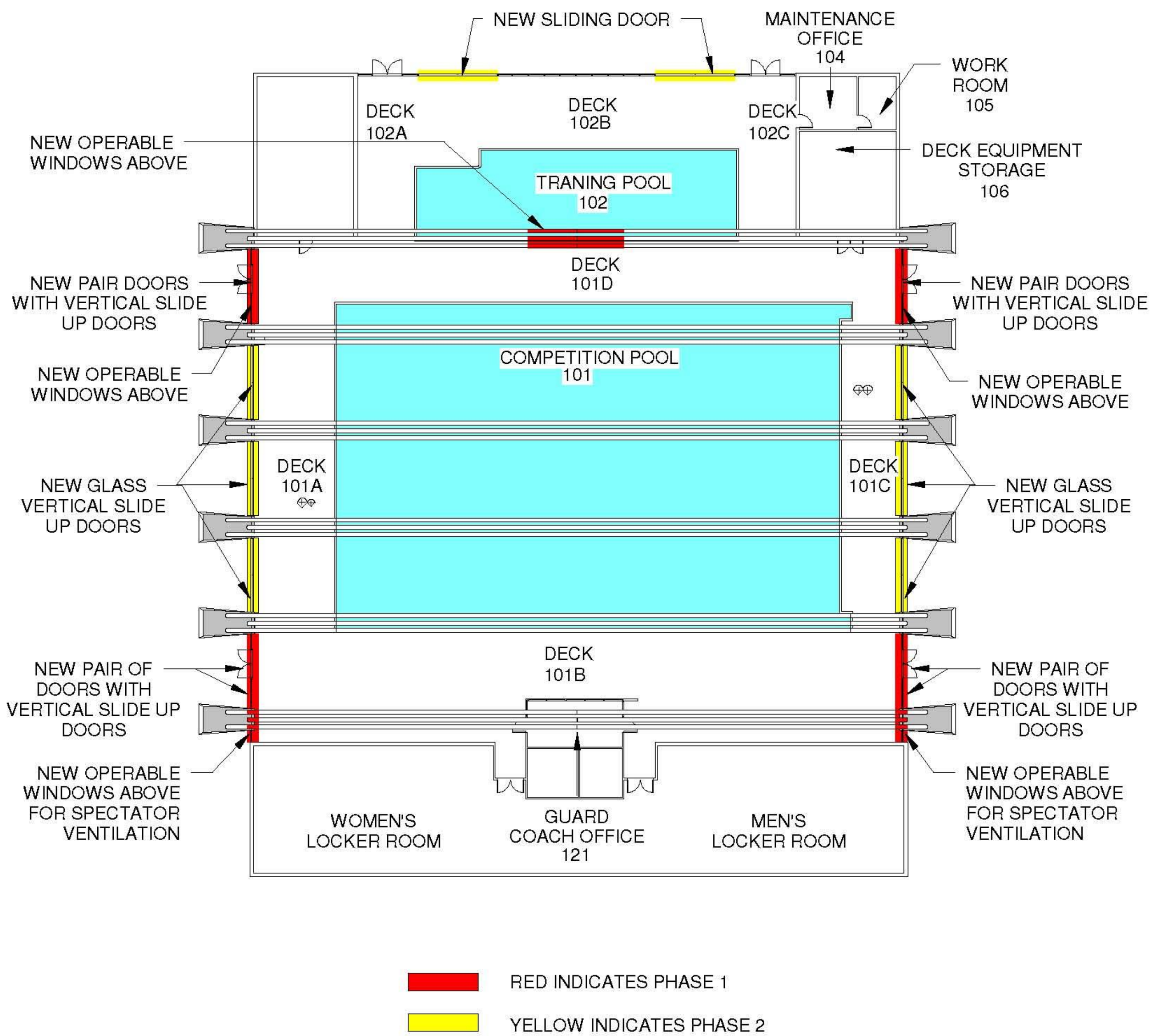

FIGURE 6 - FIRST FLOOR

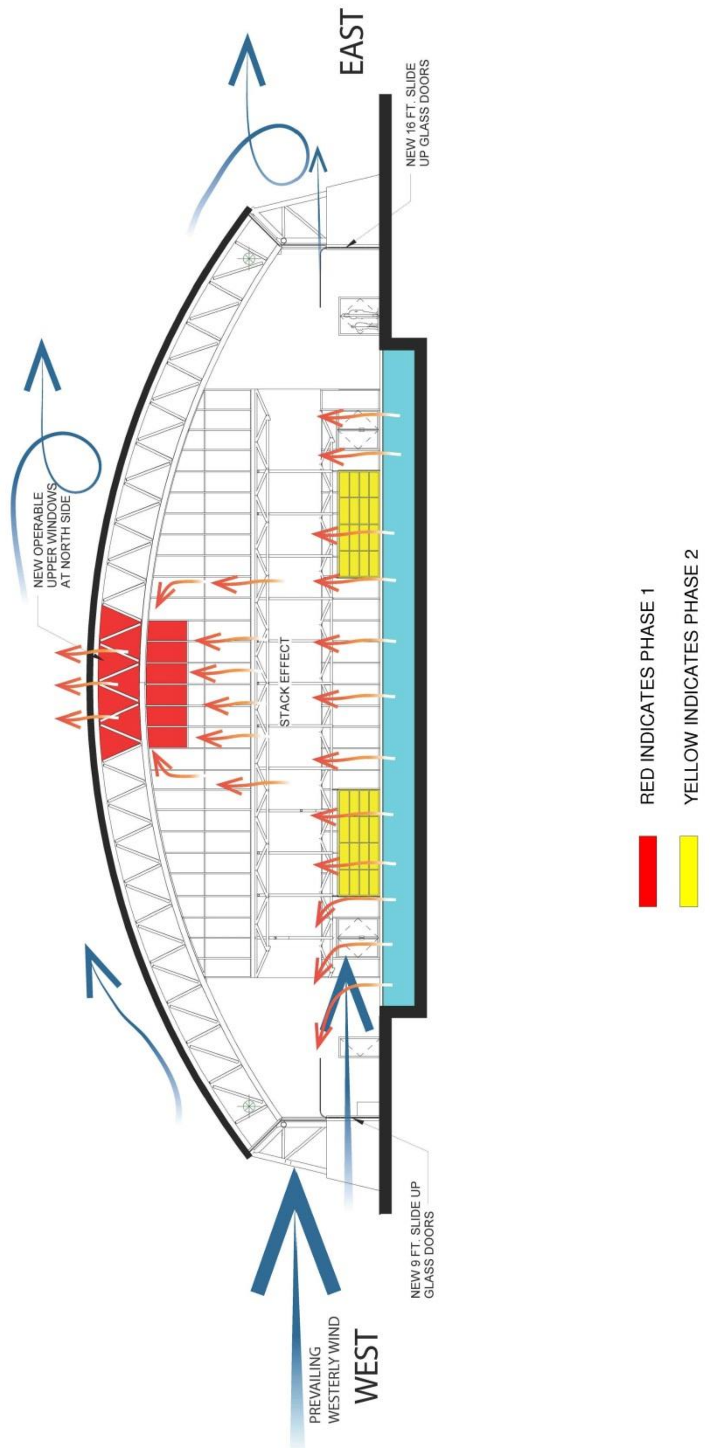

FIGURE 7- NATURAL VENTILATION CONCEPT

City of Commerce

Aquatic Center Natural Ventilation Option

Statement of Probable Construction Cost at Conceptual Design Phase

Contract #	Project Manager	Capital Project No.	Specifications No.	Date
	City of Commerce			3.14.16

Work Description	Facility Location
Modify storefront w new slide-up doors&win	Commerce, CA

Work Description	Units	Qty.	Unit	Subtotal	Total
PHASE 1					
Demoliton of part of existing storefront doors and windows	s.f.	1600	$40	$64,000	
Demoliton of part of existing storefront concrete curbs					
General Conditions					
Subtotal for general conditions and demolition					$64,000
Some new paved areas with concrete walkways	sf	500	$15	$7,500	
New glass and aluminum vertical slide-up doors	ea	4	$15,000	$60,000	
New glass&aluminum upper E/W/N side operable windows	sf	700	$200	$140,000	
New glass and aluminum pair doors	ea	4	$8,000	$32,000	
ADA compliant parking, ramps, and path-of-travel	l.s.	1	$8,000	$8,000	
Subtotal Modifications for slide-up doors					$247,500
Recommission/repair HVAC system				$25,000	
Repair hot water control valve at DH1				$1,500	
Repair DH bypass dampers, rebalance w more outside air				$20,000	
Install cover at warm-up pool w existing pool cover				$0	
New mini-split HVAC system for spectator area				$50,000	
Subtotal HVAC system					$96,500
Subtotal					$408,000
Architectural and Engineering Design Cost @ 15%				$61,200	
Subtotal, including Design Cost					$469,200
Contingency @ 20%				$93,840	
TOTAL, INCLUDING DESIGN COST & CONTINGENCY					**$563,040**

Figure 8

BOA Architecture Dewberry

City of Commerce
Aquatic Center Natural Ventilation Option
Statement of Probable Construction Cost at Conceptual Design Phase

Contract #	Project Manager	Capital Project No.	Specifications No.	Date
	City of Commerce			3.14.16

Work Description	Facility Location
Modify storefront w new slide-up doors&win	Commerce, CA

Work Description	Unit	Qty.	Unit	Subtotal	Total
PHASE 2					
Demoliton of part of existing storefront doors and windows	s.f.	1000	$40	$40,000	
Demoliton of part of existing storefront concrete curbs					
General Conditions					
Subtotal for general conditions and demolition					$40,000
Some new paved areas with concrete walkways	sf	700	$15	$10,500	
New glass and aluminum vertical slide-up doors	ea	6	$15,000	$90,000	
New glass and aluminum sliding doors at warm-up pool	ea	2	$15,000	$30,000	
New glass and aluminum pair doors	ea	0	$8,000	$0	
ADA compliant parking, ramps, and path-of-travel	l.s.	0	$8,000	$0	
Subtotal Modifications for slide-up doors					$130,500
Recommission/reprogram HVAC system				$25,000	
Replace existing w 2 new DH units, demo., replace roof, expand mech room				$3,000,000	
Subtotal HVAC system					$3,025,000
Subtotal					$3,195,500
Architectural and Engineering Design Cost @ 15%				$479,325	
Subtotal, including Design Cost					$3,674,825
Contingency @ 20%				$734,965	
TOTAL, INCLUDING DESIGN COST & CONTINGENCY					**$4,409,790**

Figure 9

BOA Architecture Dewberry