Introduction & Project Background

The Residence Inn by Marriott is located at 2345 Mill Rd. Alexandria, VA. It is conveniently located near many government buildings allowing for long term guests on business to be close to work. The site is very constricted and is defined by the two streets that border the site as well as two metro tracks that cut through the Southwest side of the site. The Marriott is owned by Miller Global Properties and operated by Marriott staff. It is a 181 room, 15 story Hotel, post tensioned concrete structure, with 3 levels of underground parking on site.

In Alexandria, Virginia, every new building that is designed and built must go through a rigorous approval process. The city must approve the building use, design, façade, exterior penetrations, colors, and each building must have at least 20 LEED points. After this approval takes place the façade cannot change without re-doing the same process to evaluate the changes. The building must have minimum exterior penetrations, and they must be visually appealing or disguised in some way to hide them from the public view. The exterior colors also must consist of the very top of the building being a light beige color, with a pink / mauve brick façade in the middle, and a red brick on the base. As well as each portion of the building being distinct and identifiable as a top, middle, and bottom. The city also requires an appealing exterior walk with shade trees and wide walkways to blend each new building with the existing buildings.

This building consists of four different types of wall sections. The three walls bordering the two metro tracks consist of face brick with concrete masonry block back up and pre-cast exterior panels with thick batting insulation and drywall interior. The fourth wall on the opposite side of the metro tracks is partly made of face brick and pre-cast panels as well as some metal cladding with rigid and batting insulation back up, as well as the corner of the curtain wall system. On roof and penthouse area has an EFIS system with a pre-cast concrete back up, and rigid insulation. The roofing system is made of parapet walls with a roofing membrane, protection board, and tapered rigid insulation over a post-tensioned concrete slab.

Client Information

Miller Global Properties, LLC is a partnership between Miller Properties Group and Global Holdings. Miller Global Properties, LLC is a private equity fund corporation which develops, acquires and temporarily owns the projects they build, once stable the buildings are sold to make a profit; the operation of the building is usually contracted to the tenant. Miller Global started by leasing and selling office buildings Denver, CO but now lease and sell many types of buildings including high rises, like the 40 story Nakatomi Plaza featured in the movie Die Hard, and hotels around the world in cities like Amsterdam and London. Mickey Miller and Jim Miller are the current owners and operate the day – to – day activities. Miller Global currently has projects in progress in Alexandria, VA, Orlando, FL, Seattle, WA, San Antonio, TX, and soon to be in San Diego, CA, Hawaii and Dubai.

Miller Global has strong commitment to making the guest experience the best it can be. They do this by having high design and construction standards for all projects. Miller Global aims to out do the neighboring buildings by having more efficient installation of windows and equipment, minimizing façade penetrations, and sometimes paying an extra expense to have the latest greatest technologies and construction methods. They showed this commitment while building the Marriott Hotel on Duke St also in Alexandria, VA, by installing the most efficient mechanical system and upgrading the telecom system from the standard CAT 5 cable to fiber optics knowing that fiber optics is the best choice and will soon replace the Cat 5 cable. In Seattle, they upgraded the mechanical system from the common V-Tack system to a more efficient 2 pipe system. In the Residence Inn Marriott they are currently building they have chosen to install a more expensive but very efficient 4 pipe mechanical system that is longer lasting and more functional, and use fiber optics with CAT 5 cables for the Voice Over IP phone system and television instead of the common CAT 3 analog phone system.

Miller Global chose to build this Residence Inn Marriott in Alexandria because they have already built a Marriott on Duke St in Alexandria and have had great success with it. They know what to expect from the city requirements; they also know that they will have good returns and a constant guest flow due to being located very near the Pentagon. They also chose to take on this project after a one year delay. Marriott almost abandoned the project due to high cost and approval issues. However because of the good experience with the Duke St Marriott, Miller Global knew that this would be a successful project once approved by the city.

The key sequencing issues Miller Global is concerned with are the same for all of their projects: finishing on schedule and on budget, and maximizing the guest experience. If those key things are achieved they have built a successful project. Once Miller Global has owned the building for about 5 to 10 years they will most likely sell the building to a real-estate investment company because they have contracted the operations and maintenance to Marriott and want to sell the property to a long term owner.

Project Delivery System

A detailed hierarchy of the project team can be seen on page 8.

The delivery method for the Residence Inn Marriott was partly design-bid-build and partly design-build. The mechanical, electrical, and plumbing trades are design-build and everything else is design-bid-build. The reason for this is because Southland Industries, the mechanical and plumbing design contractor, has a very good relationship with the owner, Miller Global Properties, and after discussing the project Miller Global agreed to a design-build contract. Southland has done projects with Miller Global in the past and from their excellent reputation and design work, Miller Global knows the head engineers at Southland and felt comfortable enough to do this design-build and to also speed up the construction process. Southland holds a GMP contract with Balfour Beatty Construction with a shared savings clause that gives incentive

to bring the project in under budget and the savings would go to the owner providing that the scope does not change. Miller Global also selected Dynalectric Company for the electrical design-build for the same reasoning.

Balfour Beatty Construction was selected by Miller Global for this project also because they have a good rapport with the owner and was able to easily negotiate a GMP. The civil engineer, Christopher Consultants, was also selected by Miller Global and has a phased lump sum contract directly with them due to the many stages of work that is required for the civil work. Davis, Carter, Scott Design was selected for this project because they have done work in Alexandria, VA before and has experience with the approval board there; and through them SKA Associates was selected as the structural engineer.

During the preconstruction phase, as Balfour Beatty Construction was putting together their GMP estimate, they "bid" out all the subs including the design-build companies to get a handle on the cost of the project. During this phase all subs were required to include a bond in their estimate. From the tabulation of those numbers Balfour Beatty took out a bond that covers all of their subs. Balfour Beatty also required certificates of insurance for their subs; all other companies must present one to Miller Global.

Due to the nature of the project, and the delay in the middle of design, Davis, Carter, Scott Design holds a Cost + Fee contract directly with Miller Global. This is enables them to charge the owner with change orders because of changing the design from having a spa to have an exercise room instead. Under Davis, Carter, Scott, SKA holds a Lump Sum contract with them for the structural work. Miller Global also holds a contract directly with Riegel Consulting, they are an agent to the owner to help coordinate design and construction and are present if the owner cannot be; they act as the owner representative to help orchestrate the project.

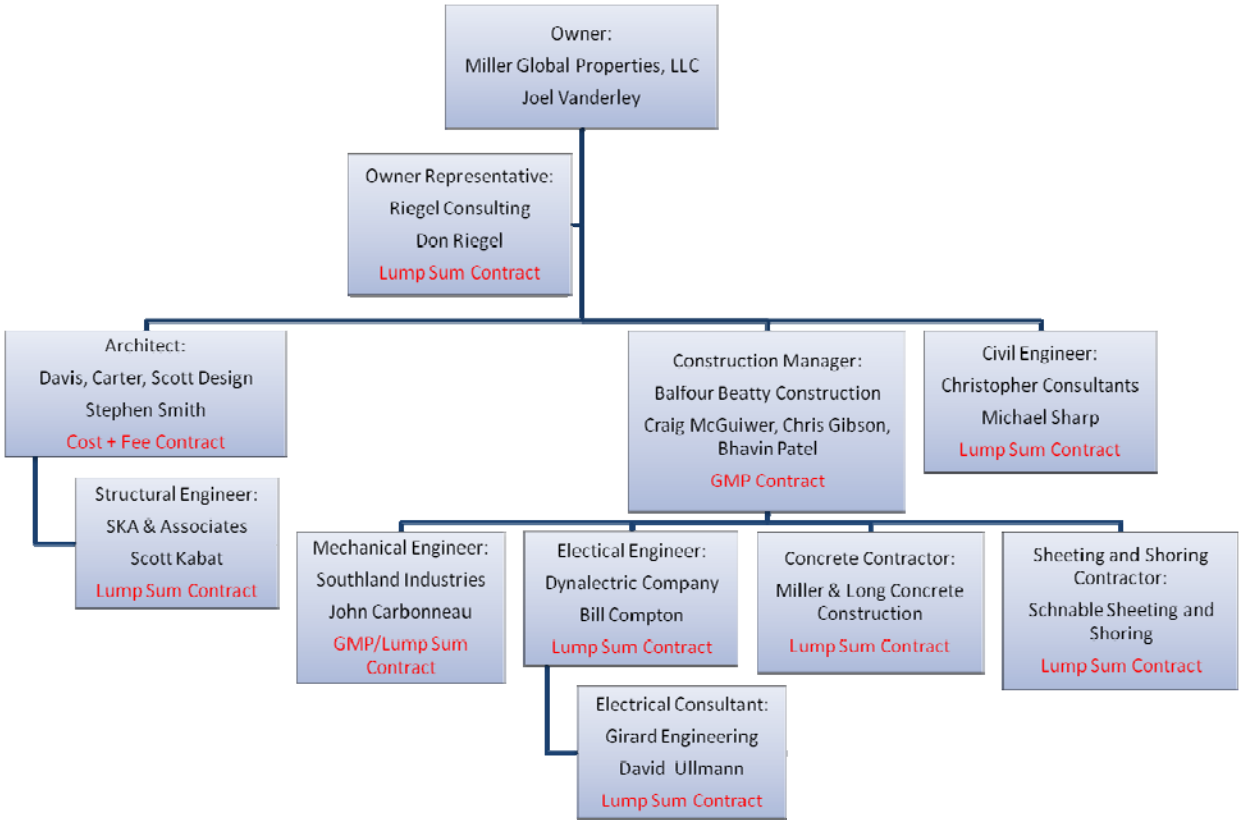

Figure 1: Project Heirearchy

Staffing Plan

Balfour Beatty Constructions Division VP and Purchasing Manager; Matt Dye and Ken Lyons are located in the Fairfax, VA office. They ensure the project was acquired correctly and helped in the pre-construction activities of negotiating the GMP contract. All other staff is located on site in the trailer. Craig McGwier coordinates the meetings for the MEP trades while Chris Gibson and Bhavin Patel organize all RFI's and weekly trade meetings on site with the superintendent Bill Carroll. The accountant Maria Serrano is also on site to help ensure that money is being spent correctly and paying the subcontractors. Chief Field Engineer, Brian Fox helps Bill Carroll handle the day to day activities of the trades on site. They make sure each trade submits daily progress reports to Balfour Beatty Construction so productivity can be tracked accurately. The hierarchy can be seen below.

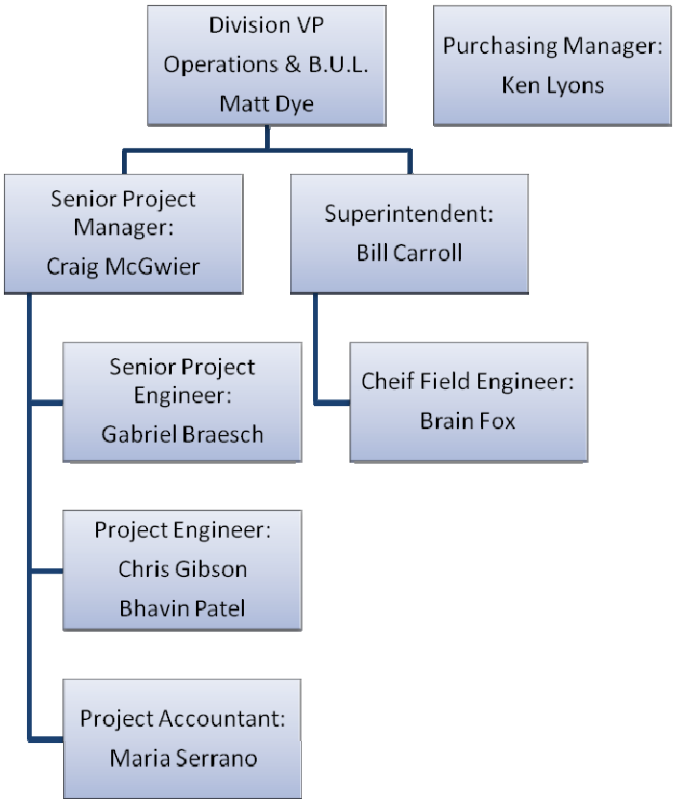

Figure 2: Balfour Beatty Project Staff

Site Plan of Existing Conditions

The site is in "Old Town" Alexandria, VA. It is neighbored by the city courthouse and other apartment buildings; it is also very close to the Pentagon. It is located just off Capital Beltway I-495 E at 2345 Mill Rd. This location enables long term guests on business for the government, and is convenient for their commute. The site is extremely restricted; it is bordered by two metro tracks and two roads. The delivery trucks must use I-495 to Telegraph Rd North, then onto Mill Rd to gain site access. All other roads in Alexandria are too constricted to use for site deliveries. There is virtually no space on site for long term storage or lay down. Mill road to the south of the site has been instituted for construction deliveries by blocking one of the two lanes available and using flaggers to direct traffic.

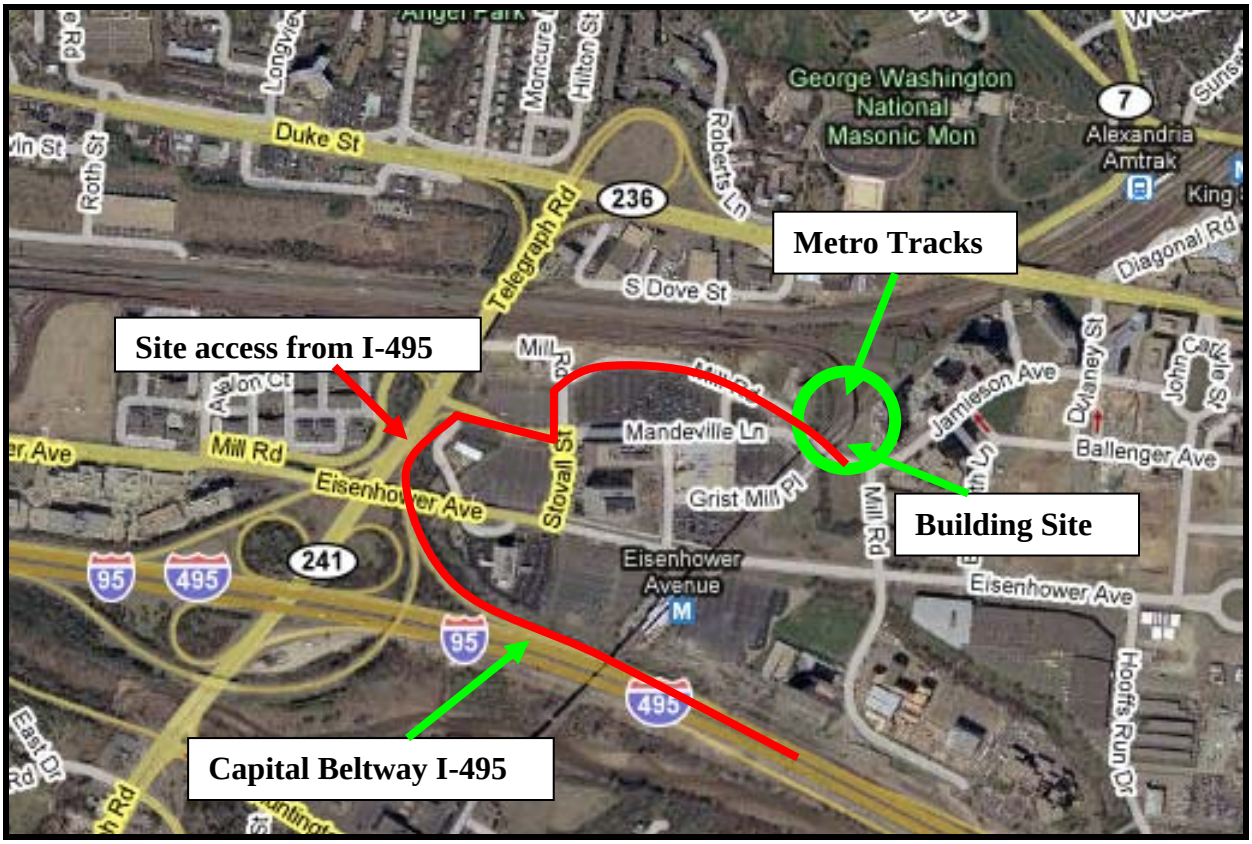

Figure 3: Road Map of Jobsite Access
Courtesy of Google Maps

Local Conditions

There are not many predetermined construction methods used in Alexandria, however concrete, pre-cast, cast in place, and post tensioned, are very common. This building uses all three types of concrete and it is possible to hire skilled workers that are comfortable working with these types of concrete, this is in part because Alexandria relies heavily on union workers. There is no on-site parking due to a constricted site; workers are expected to park in public hourly garages. The cost of parking in the nearby garages is reimbursed by Balfour Beatty for all trades, and has been accounted for in the budget. When interior construction starts there will be dumpsters on site placed under the metro track with the trailers for recycling for LEED points. The soil found on site is mostly yellow / brown fat clay in the sub-grade and silty clay with gravel near the surface. They were not expecting to encounter water problems based on the geo-tech report, but that is not the case. The excavation required is below the water table and there has been a lot of de-watering needed before pouring the mat slab foundation, as well as placing a working slab underneath the mat slab to aid in water proofing the site.

Architecture & Building Systems Summary

YES	NO	WORK SCOPE
	X	Demolition Required?
X		Architecture Features
	X	Structural Steel Frame
X		Cast in Place Concrete
X		Pre-cast Concrete
X		Mechanical System
X		Electrical System
X		Masonry
X		Curtain Wall
X		Acoustics
X		Support of Excavation
X		Transportation

❖ *Architecture*

The building consists of three levels of underground parking and 15 levels above ground. The main lobby is located on the first floor at ground level, with an exercise room and spa on the second floor. All levels above grade are post-tensioned concrete chosen to maximize the floor to floor height and enabled the design to add floors for little cost. The exterior of the building was designed to emphasize horizontal lines through the building and an offset top edge with

"punch-out" windows throughout the building. The curtain wall system spans the total height on the southeast corner of the building over the lobby entrance. It is designed to add aesthetic appeal while mimicking the glass curtain wall of the building across the street to create a "column of light" effect on either side of the street when the afternoon sun hits both buildings.

❖ *Cast in Place Concrete*

The mat slab foundation, the three underground parking levels, and the post tensioned floor decks are made of cast in place concrete. The mat slab thickness ranges from 30, 36, to 48 inches thick is 5000psi normal weight reinforced concrete and has a minimum 4" working slab of 2000psi concrete underneath it to aid in stopping water penetration. The drainage and sump pump pits were formed in the ground during pouring. The walls and columns of the parking levels are minimum 18' spans with average 10' by 10' drop panels and formed with vertical reusable formwork with 5000 psi normal weight concrete. The parking level floors are 8" thick and made of 5000 psi cast in place normal weight concrete. The typical post tensioned floors above grade are 5000psi normal weight concrete, once the strength reaches 3000 psi tensioning of the cables can occur. All exterior and exposed cast in place concrete is air entrained 3000psi concrete.

❖ *Pre-Cast Concrete*

The façade of the building above grade is comprised of pre-cast concrete with a rigid insulation and CMU backup system. The pre-cast concrete is prefabricated in panels to look like red brick to help it blend with the other buildings in Alexandria. The precast panels will be connected vertically with tee connections, and horizontally with ties imbedded in the mortar joints of the CMU block backup system.

❖ *Mechanical System*

The system is primarily a chilled fan coil unit system with electric heating coils in the fan coil units for heat. There is one air cooled chiller located on the roof that has a nominal capacity of 155 tons which pumps chilled water to the coils inside the fan coil units in each guest room. The variable air volume air handling unit located on the second floor that provides air for the lobby, offices and all other spaces on the second floor. The variable air volume boxes in the ceiling also have electric heat coils to provide heat to the spaces. There are two natural gas fired boilers that have a capacity of 1,800,000 btu input and 1,530,000 btu output. The boilers are used for domestic hot water needs and for heat inside the second floor air handling unit needs. The system also has two shell and tube heat exchanges used to generate the domestic hot water which have a capacity of 1,424,000 btu each.

The fire protection system in the building is rather complex and some aspects are added as a "code plus" to make the system more advanced. The roof top makeup air unit provides ventilation for the corridors, bathroom exhaust, and smoke ventilation. The unit normally operates at a low flow but increases once smoke has been detected by a smoke detector located in every room in the building. The smoke exhaust system is designed to provide about 12 air changes per hour, 67% of the volume on the fire floor, and pressurize the stairwells and hoistways. This is done to control the migration of smoke throughout the building, mainly focusing on the means of egress into and out of the building. While the system is in fire mode, no service will be provided through the small VAV boxes. When the smoke detectors are tripped fire dampers will open fully enabling the pressurization of the stairwells and hoistways, which means they will remain operable during a fire emergency.

❖ *Electrical System*

The switchboard is rated at 3000 amps with 480/277 volts, 3 phase, 4 wire system. A typical guest room with all equipment on draws 58 amps. Most lighting fixtures are fluorescent to add efficiency to the design and to attain the appropriate LEED points. The following transformers service the building: one 750 kva feeds the bus-duct riser, which provides 120/208 volts power to all of the guest room panels; seven other transformers provide step down voltage from 480 volts to 120/208 volt power for various areas such as the back of house outlets, low voltage kitchen equipment, corridor lighting and power, and miscellaneous garage power. The backup generator is sized at 400 kw and 480 volt would provide power to all emergency lighting, fire alarm, stair pressure fans, smoke removal fans, fire pump, emergency for elevators, selected circuits for security if the power should ever go out. The telecom load is very small and is accommodated by miscellaneous 20 amp circuits in the telecom closets to run the servers and routers. In the workout room there are 20 amp circuits for each major piece of equipment, like treadmills and plasma screen televisions.

❖ *Masonry & Curtain Wall*

There is very little masonry throughout the building; it is only in the CMU back-up wall system and on the face brick façade. The CMU is located behind the per-cast concrete panels with a full bond mortar joint and is designed to help sound attenuation and thermal insulation with the rigid insulation. There is also masonry in the brick paving on the sidewalks, but this is only for aesthetic appeal. The curtain wall system spans the total height on the southeast corner of the building over the lobby entrance is designed to add aesthetic appeal while mimicking the glass curtain wall of the building across the street to create a "column of light" effect on either side of the street when the afternoon sun hits both buildings. The curtain wall is also designed to hide the fact that there is no atrium; the lobby is only one floor in height.

❖ *Acoustics*

Shen, Milsom & Wilke performed an extensive acoustical noise study on site before construction began. This was done to learn as much as possible about the sound levels of the metro Yellow Line that runs very frequently at night, about every 5 to 10 minutes. A 24-hour measurement was conducted from 26-27 July 2005. Site measurements were also conducted on 26, 27 & 29 July 2005. Measurements were taken at the grade level and at the elevation of the raised Metro track. Metro trains traveling on the elevated track reached levels of 100 and 102 dBA. Metro trains in service traveling on the grade level tracks reached levels between 85 and 99 dBA depending on whether the operator used the horn when entering or exiting the tunnel. This research in very important to Miller Global because their main focus for every building is the guest experience. Since the World Health Organization (WHO) requires a 30 dBA level sound for good sleep the metro noise could be a large potential problem since most of the metro activity occurs at night.

Once field measurements were taken SM&W performed tests with mock up window assemblies of different STC / OITC ratings that are acceptable to the WHO. Five assemblies were tested all of which outperformed the national regulations. The third assembly proved to be the most cost effective (approximately $200 / SF) which is:

1 ¼" IGU consisting of ¼" Annealed
+ ¾" Air Space
+ ¼" Annealed with
5 3/8” air space and
3/8” laminated

This equals a total frame depth of 9”. The configuration provides an increase in performance of 3 dB at 630 Hz and 6 dB at 4000 Hz, the most critical frequency bands.
Based on this research they concluded that the appropriate window required a Sound Transmission Class (STC) of 59 and Outdoor-Indoor Transmission Class (OITC) of 46. This assembly out performs the WHO and Department of Housing and Urban Development (HUB) requirements of STC 56 and OITC 43 even without the sound barrier that will be installed. Heavy drapes will also be hung on the interior side of the windows to further help sound attenuation and increase the guest experience.

❖ *Support of Excavation*

The excavation needed support on all sides and is clear of all permanent construction work. However, due to the restrictions working around the metro tracks tie-backs were not allowed in fear of disrupting or moving the column foundations that support the metro, instead large rakers had to be installed across the site. On the other three sides that did not border the metro a regular

tie-back and lagging system was used. There were some issues during excavation with failing tie-backs; in those areas rakers were installed to support the walls. Also one raker had to be moved since it was placed on a future column line. This was done because the sheeting and shoring is to remain in place during construction.

❖ *Transportation*

There are three elevators located in one elevator bank in the southwest corner of the building. These elevators run from the lowest P-1 parking level to the highest space on the 15th floor. There are three stairwells labeled A, B, and C. Stair A is located adjacent to the elevator bank in the southwest corner and also runs from P-1 parking to the 15th floor. Stair B is located opposite Stair A in the northeast corner, and only services the underground parking levels to street level. Stair C is located adjacent to Stair B in the northeast corner, and services the first through the 15th floor.

Project Schedule Summary

Please see Appendix A for the Project Schedule Summary and Detailed Project Schedule.

Notice to Proceed was given on Friday June 9, 2006 afterward design went on as planned. However, once design just finished the 100% Design Documents there were cost and ownership issues and the project was put on hold for about nine months. After which Miller Global Properties took over the project early in 2007.

Since then, excavation has taken place from March to June 2007 and the mat slab and parking levels have been poured. During this process the concrete was poured in three phases working from North to South through the building footprint, each phase is about a third of the building footprint. There have also been some delays during excavation; the water table was much higher than expected and a great deal of de-watering had to take place. The schedule since then has been accelerated to make up for the lost time. Once the upper more typical floors are in construction the schedule will be able to catch up and make up for the time.

One of the most crucial parts of the schedule is the parking level concrete. This will determine the length of time left to complete the project. The post tensioned concrete floors above also rely on this being completed on time since they must cure to the proper strength before the cables can be tightened. Once the floors are tensioned the shoring can be removed the exterior brick and CMU backup can be installed followed by the parapet EFIS system.

After the tower is built the interior work will also be able to move quickly. This is possible because most of the guestrooms are very similar and have many typical finishes. After the

interior work is complete all that remains is testing and balancing and turning the project over to the owner.

The schedule has been accelerated more than previously to try to make up for lost time from delays while pouring the lower level parking areas. Fortunately due to a repetitive floor plan the other trades will be able to keep up with the reworked durations during the interior construction. The Residence Inn is being constructed like many other high rise repetitive buildings have been done. The excavation was first, to install the mat slab foundation and water proofing. Then the below grade concrete levels and columns were constructed followed by accelerating the upper floors easily because of a repetitive floor layout and penetrations. The tower crane is placed in an area that can be finished quickly at the end of the project (crane placement can be seen in the Detailed Site Plan Appendix C).

The interior floor construction is understood easiest by floor; however each floor is also organized logically by trade. Once interior construction starts it progresses through each floor in approximately 150 days while leaving time at the end of the schedule to close up the room that had the tower crane. The progress through each floor consists of the following sequence:

Interior Construction Sequence: 3rd Floor

Task	Duration	Start	Finish
Layout Floor	5 days	11/2/2007	11/8/2007
3rd Floor Interior Construction	153 days	11/2/2007	6/10/2008
HVAC Risers and Wall/Clg.Rough In	7 days	11/9/2007	11/19/2007
Fire Protection Rough In	3 days	11/20/2007	11/26/2007
Frame Walls, Core, Set Door Frames	5 days	11/27/2007	12/3/2007
Set Tubs, Strap Waste and Risers	4 days	12/4/2007	12/7/2007
Exterior Studs - East Side	4 days	12/7/2007	12/12/2007
CMU Exterior South	2 days	12/14/2007	12/17/2007
CMU West	2 days	1/8/2008	1/9/2008
Frame Exterior Walls	4 days	1/8/2008	1/11/2008
CMU North	2 days	1/10/2008	1/11/2008
Electrical Wall/Clg Rough In	4 days	1/10/2008	1/15/2008
Inspections, MEP, Elec, Wall Close In	5 days	1/16/2008	1/22/2008
Install Windows 3rd Floor	5 days	1/16/2008	1/22/2008
Hang Shafts (str., elev, 3 side MEP) Purple	3 days	1/23/2008	1/25/2008
Temp Dry in up to 6th Flr.	5 days	2/13/2008	2/19/2008
Hang Dry Wall & Tape except at FCU's	8 days	2/20/2008	2/29/2008

Set and Hook Up FCU / Inspect for Close In	5 days	3/3/2008	3/7/2008
Hang Drywall and Tape at FCU's	4 days	3/10/2008	3/13/2008
Temporary Conditioning	1 day	3/28/2008	3/28/2008
Install Wood Trim	4 days	3/31/2008	4/3/2008
Prime Paint and Texture Clgs	3 days	4/4/2008	4/8/2008
Point up, Reprime	3 days	4/9/2008	4/11/2008
Wall Covering and Paint, Tile	5 days	4/14/2008	4/18/2008
Install Kicthen and Bath Casework	7 days	4/21/2008	4/29/2008
Install Kitchen Sinks, and Electrical Trim	4 days	4/28/2008	5/1/2008
Final Coat Paint	3 days	5/2/2008	5/6/2008
Install Carpet	5 days	5/7/2008	5/13/2008
Start up FCU, Test MEP	5 days	5/14/2008	5/20/2008
Punch Floor	5 days	5/21/2008	5/27/2008
Complete Punch	5 days	5/28/2008	6/3/2008
Owner FFE Items	5 days	6/4/2008	6/10/2008
5 Day Stagger	5 days	6/11/2008	6/17/2008
Complete Walls and Finishes at Hoist Room	10 days	8/8/2008	8/21/2008
Owner FFE at Hoist Room	2 days	8/22/2008	8/25/2008

Figure 4: Interior Construction Schedule
Courtesy of Balfour Beatty Construction

The HVAC rough-in occurs very early in the process followed by the Fire Protection, and shortly after that the Electrical rough-in. After the rough-ins occur the systems are inspected and the rest of the interior construction can flow smoothly. As the rough-ins are taking place the masonry is being installed to help close in the building as quickly as possible. The close in of each floor occurs about half way through the interior construction of that floor. This helps the finish trades progress quickly since the environment inside the building will be more controlled for dry wall, painting, and wood trim activities. Each floor is punched when construction is completed with the exception of the hoist room, this will help when closing out the project. There will be a minimum amount of punchlist items left once the interior construction is complete and help finish on time. This also allows for the time needed at the end of the schedule to remove the tower crane and close up the room on each floor that had not been completed. Since the hoist room has its own punch and turnover process it can go very quickly because there will need to be only one room per floor punched rather than the entire floor. This enables other punchlist problems to be addressed before the hoist room is completed and possibly causing the project completion to be delayed.

Project Cost Evaluation

Total Square Footage, including underground parking: 169,205 SF

Construction Cost:	Actual: $28,587,075.00 Per SF: $168.90 / SF
Total Project Cost:	Actual: $33,500,000.00 Per SF: $197.98 / SF
Major Building Systems:	
Mechanical & Plumbing	Actual: $6,171,501.00 Per SF: $36.47 / SF
Electrical	Actual: $3,440,000.00 Per SF: $20.33 / SF
Sprinklers	Actual: $505,980.00 Per SF: $2.99 / SF
Structural	Actual: $5,628,925.00 Per SF: $33.27 / SF
Architecture / Building Skin	Actual: $3,486,828.00 Per SF: $20.61 / SF
Interior Finishes	Actual: $2,061,826.00 Per SF: $12.19 / SF
Sound Barrier	Actual: $67,080.00 Length: 325 ft. Per LF: $206.40 / LF *Exterior of Building Footprint on Metro

R.S. Means Square Foot Data: *Square Foot Cost 2007*

Please see Appendix B for reference sheets with calculations.

Total Square Footage, including underground parking: 169,205 SF
Total Building Perimeter: 451.4 LF

M.360 Hotel, 8 – 24 Story
$132.71 / SF
Location Modifier: Commercial Alexandria, VA 0.94

R.S. Means SF Estimate: $124.75 / SF

This does not include additions for the elevators with additional stops (more than 10), fire alarms and smoke detectors, plasma televisions, and washers and dryers.

***D4Cost 2002 Estimate**: a detailed print out can be found in Appendix B.*

This estimate is an average of three similar projects chosen from the available resources in D4Cost 2002.

Code	Division Name	%	Sq. Cost	Projected
00	Bidding Requirements	5.37	$9.36	$1,774,918.00
01	General Requirements	6.55	$11.42	$2,166,291.00
02	Site Work	1.55	$2.70	$511,104.00
03	Concrete	11.49	$20.03	$3,797,518.00
04	Masonry	1.87	$3.27	$619,272.00
05	Metals	2.76	$4.81	$912,652.00
06	Wood & Plastics	2.36	$4.11	$778,903.00
07	Thermal & Moisture Protection	5.32	$9.28	$1,759,242.00
08	Doors & Windows	4.94	$8.61	$1,632,106.00
09	Finishes	6.65	$11.59	$2,198,274.00
10	Specialties	0.43	$0.75	$142,659.00
11	Equipment	0.45	$0.79	$149,073.00
12	Furnishings	0.38	$0.67	$126,306.00
13	Special Construction	0.33	$0.58	$110,743.00
14	Conveying Systems	2.40	$4.19	$794,765.00
15	Mechanical	11.10	$19.35	$3,668,401.00
16	Electrical	6.09	$10.62	$2,014,298.00
21	Fire Suppression	1.65	$2.87	$544,188.00
22	Plumbing	8.53	$14.87	$2,819,289.00
23	HVAC	9.12	$15.91	$3,015,984.00
26	Electrical	9.52	$16.60	$3,147,114.00
31	Earthwork	0.87	$1.52	$288,485.00
32	Exterior Improvements	0.28	$0.48	$91,791.00
	Total Building Costs	**100.00**	**$174.37**	**$33,063,375.00**

Figure 5: Detailed Cost Breakdown from D4Cost 2002

Cost Comparison

The differences in the calculated square foot cost versus the R.S. Means square foot cost can be attributed to the fact that R.S. Means does not include additions for the elevators with additional stops (more than 10), fire alarms and smoke detectors, plasma televisions, and washers and dryers. These additions would increase the cost per square foot to $130.51 / SF with the location modification of 0.94. This is still too low, compared to the calculated $197.98 / SF because there are some project specific costs involved with the site and permitting and the nine month delay in the middle of the project that contributed to the cost increase. The R.S. Means value of $130.51 / SF is closer to the actual construction cost per square foot than the D4Cost estimate but is still too low because of the extra measures taken during excavation and foundation de-watering problems. R.S. Means also does not account for post tensioned concrete which can increase the cost as well as a very expensive window system to block out the metro noise at night.

On the other hand the D4 estimate is only off by about $450,000.00 which considering some of the complexities of the project is rather impressive. Also the three buildings chosen to average were all shorter and had larger footprints than the Residence Inn Marriott. The square foot cost is also more accurate at $174.37 / SF but still cannot account for the very constricted site and extra precautions taken to protect the metro track and sound attenuation.