2012

October 9

Technical Assignment Two

University of Maryland Physical Sciences Complex

John Melching | CM
Advisor | Anumba

EXECUTIVE SUMMARY

The content contained within this document will detail the construction of the Physical Sciences Complex at the University of Maryland. The PSC is a 160,000 square foot new structure with a project cost of $98,000,000. The building is destined to be the most advanced science laboratory in the United States and has much to live up to. The project is the second phase of a three phase plan by the University of Maryland to revitalize the sciences program over the next decade with the services of Gilbane Corp. Included in this document is a detailed analysis of the project schedule, a detailed estimate of the building façade systems, a general conditions estimate, a LEED evaluation, and a BIM evaluation.

The detailed project schedule included in this document consists of 198 activities. This schedule is organized first by zone, then by trade. In total the project duration lasts 1066 days. It was determined by Gilbane that this method of project scheduling was the most efficient as it allows for specific adjustments within zones without modifying the continuity of the rest of the project.

The next item in this document is an estimate of the building's metal and glass façade systems. The façade system for the PSC is unique. The large elliptical curtain wall that heavily defines the PSC in the public eye requires unique construction. The estimate was done using data provided by American Architectural Inc., a large ornamental metal and glass company, after an extensive Q&A with the estimating department. This data accounts for methodology, assembly prices, and take-off techniques.

Also included is a general condition estimate. This estimate accounts for numerous D1 expenses from a standard CSI format estimate. The total value for the general conditions estimate is $7,010,403.64.

A LEED evaluation is the next item. This evaluation looks at the current goals regarding sustainability of the PSC and further critiques these goals based on potential areas of improvement.

Lastly, a BIM evaluation is included. In this evaluation, the efforts behind the building information modeling implementation are analyzed and critiqued. In an interview with Josh Miller, the BIM coordinator at Gilbane, it was determined that BIM was utilized to better coordinate constructability of the PSC over coordination involving phasing.

Detailed information pertaining to all of the above can be found in the attached appendices at the end of this document.

Table of Contents

DETAILED PROJECT SCHEDULE

The schedule for the Physical Sciences Complex and the new mechanical building is organized into a zone by zone format. This method of organization is more efficient than a traditional by-trade schedule because of the complexity of the project and amount of concurrent work that takes place. Each zone is representative of a major portion of work in the building. Multiple zones are occupied at the same time with a peak of 180 workers on any given day. Below is a compressed schedule of major zones for the project.

Task Name	Duration	Start	Finish
Sitework	**751 days**	**Thu 6/3/10**	**Thu 4/18/13**
PSC Main Building	**732 days**	**Thu 8/19/10**	**Fri 6/7/13**
Excavation	**162 days**	**Thu 8/19/10**	**Fri 4/1/11**
Sub Basement	**463 days**	**Mon 6/6/11**	**Wed 3/13/13**
Basement	**570 days**	**Thu 3/3/11**	**Wed 5/8/13**
Ground Floor	**374 days**	**Mon 10/24/11**	**Thu 3/28/13**
1st Floor	**397 days**	**Thu 12/1/11**	**Fri 6/7/13**
2nd Floor	**350 days**	**Fri 12/23/11**	**Thu 4/25/13**
3rd Floor	**330 days**	**Mon 1/16/12**	**Fri 4/19/13**
Roof Level	**214 days**	**Fri 2/3/12**	**Wed 11/28/12**
Façade	**483 days**	**Mon 1/3/11**	**Wed 11/7/12**
Elevators	**114 days**	**Thu 4/19/12**	**Tue 9/25/12**
MEP Risers	**101 days**	**Tue 2/14/12**	**Tue 7/3/12**
Stairs	**187 days**	**Mon 3/5/12**	**Tue 11/20/12**
Mechanical Building	**549 days**	**Wed 4/6/11**	**Mon 5/13/13**

Site-work consists of sediment erosion control, demolition, and new utility lines. Sediment erosion control is a major factor to the success of the PSC. The current layout of the site is very compact and prone to run-off. Proper measures to reduce storm water damage and pooling of water are taken. The demolition of the existing site improvements is also key. The current parking lot, curb, and electrical shed are demolished prior to excavation. Figure.1 below shows the effects of uncontrolled sediment run-off as well as the locations of existing structures to be demolished. To the right of the image is the existing Computer and Space Sciences building which will receive a minor renovation in order to allow for multi-floor connections to the PSC.

Figure.1: Site Mobilization & Existing Area

The main building, the Science Complex its self, begins excavation August 19, 2010. Figure.2 on the next page is a series of pictures that outlines the general method and path of excavation, with each picture having roughly a month apart, starting on the first day of excavation. In the pictures it can be seen that excavation starts on the north end of the site, and proceeds southwards, where a retaining wall is constructed. The last frame includes the beginning of the caisson drilling and the placement of the tower crane. A pool of water can also be seen in frame '2'. During excavation, large dewatering wells and pumps are installed to prevent such an occurrence.

The process continues with the sub-basement and basement levels, continuing through to the ground, 1st, 2nd, and 3rd levels. Each level, after having been completed in structure begins to receive MEP work and casework. The typical flow of work begins with framing, then ductwork and piping, electrical conduit, wire pulling, fixture mounting, and then termination of MEP equipment, followed by technical and aesthetic finishes. A more detailed outline of this process is outline in Appendix A.

Figure.2: Excavation Path and Method

DETAILED METAL & GLASS CURTAIN WALL ESTIMATE

A detailed estimate of the metal and glass curtain wall system was performed for the PSC. This includes areas of the exterior that consist of metal and glass façade systems, as well as window assemblies that are embedded in the brick exterior of the East Wing. This estimate includes the take-off of the major components that make up this façade system.

Unitized Exterior

The first major component of the estimate is the unitized exterior system that runs along the North and South elevations of the building. This system is constructed in segments and lifted into place in the field. The segments are made of aluminum framing with 1" insulated glazing and have a continuous composite metal panel at each vertical break point that covers the slab edge. After being erected and secured in the field, a 1.5' continuous aluminum solar shade is mounted to the frame. Figure.3, to the right, visualizes the above description of a typical south elevation exterior. The north elevation is identical in nature but does not include an aluminum sun shade.

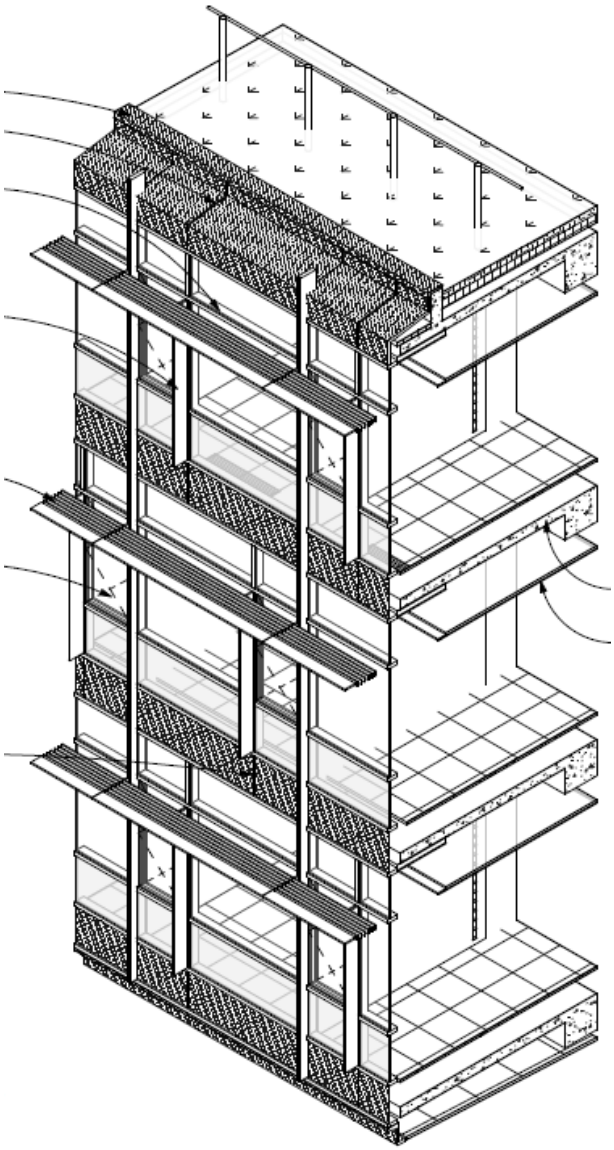


Figure.3: Typical South Façade Segment

Similar to the system for the north and south elevations, the east elevation uses a segmented, preassembled frame. It differs in the fact that it does not have operable windows, and is characterized by the use of red tinted glazing. This glazing is colored by a small adhesive film that is applied pre-shipping. The east elevation also utilizes the aluminum sun shading as seen in Figure.3.

Segmented Interior Ellipse

The next major component for the curtain wall systems is the large, intricate ellipse that is located "inside" the building as an interior façade. This system, while appearing difficult to price, is actually quite simple. The interior curtain wall is constructed the same way as the exterior. It comes in preassembled frames that all fit tightly together in a predetermined pattern. The top of the elliptical opening varies in width and location when compared to the bottom of the ellipse. This means that each vertical section of the interior façade is at a different slope and different length than the adjacent sections. The first figure below shows the plan view of the

elliptical opening from roof level, while the second is a look at the ellipse from an east-west elevation section. The complexity is easily identifiable here, but what is most important to note is the sectioning of the unitized pieces. Figure.4 shows the section labels, from E1 to E24 around the perimeter of the figure.

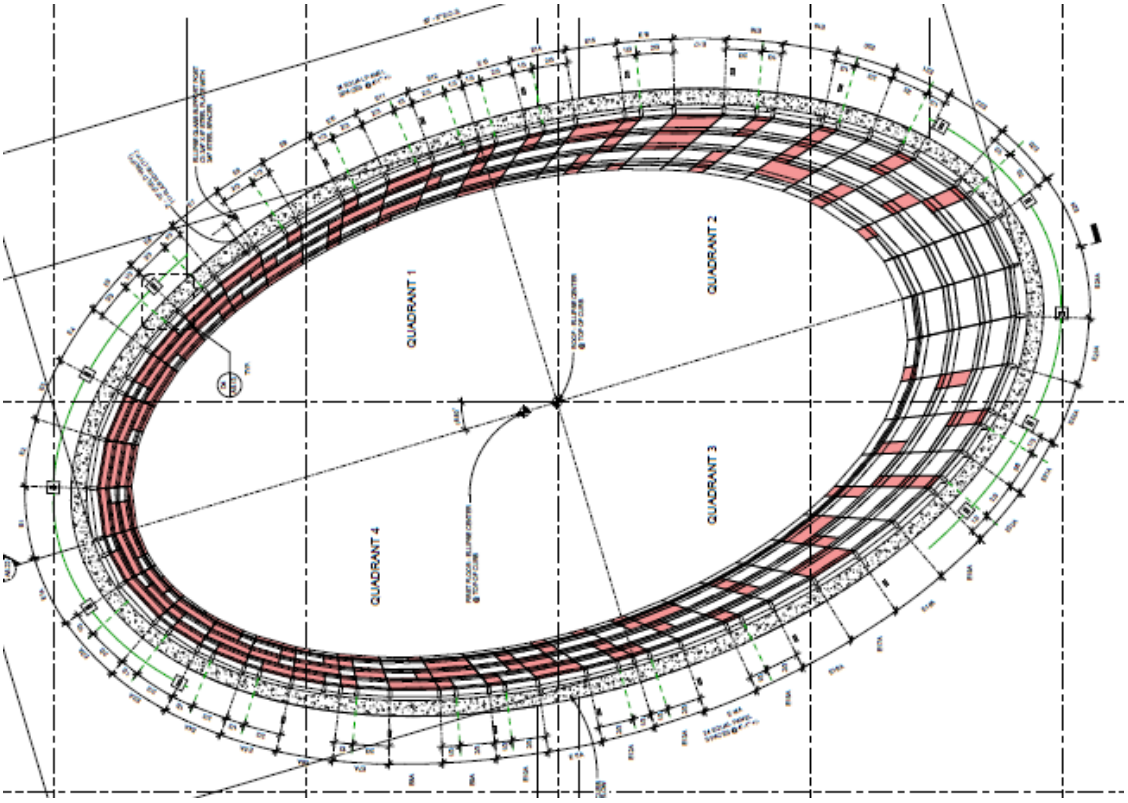


Figure.4: Plan View of Elliptical Façade

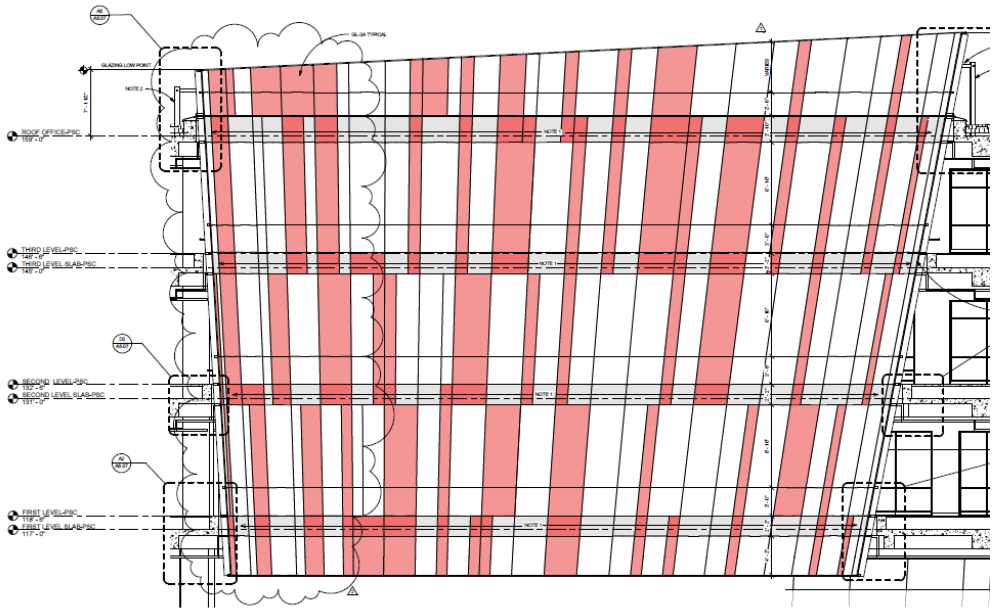


Figure.5: East Elevation Section of Elliptical Façade

Punch-in Windows

The final major component of the estimate includes preassembled window units. These units are located in the east wing of the PSC and are embedded in the brick exterior of the building. All window units are operable and are partially tinted. Figure.6, to the right, shows a typical assembly of the unitized windows. Notice the vertical aluminum fin that protrudes from the center of the unit.

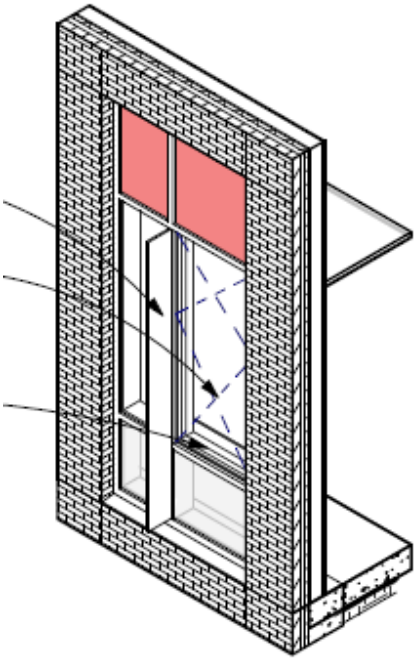


Figure.6: Typical Punch-In Window Unit

Total Estimated Cost

Below is a table which expresses the total values for each of the aforementioned components. Included in these values are the costs associated with delivery, inspections, preassembly, installation, and all materials. The take-off and estimate were performed using the business standards of American Architectural Inc. Am-Arch is an ornamental metal and glass company that deals heavily in intricate façade systems. In a discussion with the estimating department, the values for major components and the methodology for a detailed take-off was received. The table below expresses the values calculated by this estimate using the pricing data provided by Am-Arch Inc.

Estimated Costs		
Component	Subtotal Cost	Cost/SQFT
Exterior	$3,262,241	$171
Interior	$2,054,231	$205
Window	$401,830	$110
Total	**$5,718,302**	

Actual Cost & Comparison

The actual budgeted cost for the metal and glass façade systems comes to approximately $5.1 million. The estimate is slightly above that value. In a discussion with a representative at Gilbane, it was mentioned that the curtain wall systems was likely underbid. Complications in delivery and materials have been apparent in the curtain wall systems, therefore it is probable that the estimated cost more closely encompasses the true value of the façade systems.

General Conditions Estimate

A general conditions estimate was performed using information provided in RSMeans. This estimate includes costs for insurance, contingency, bonding, temporary power and utilities, cranes/hoists, inspections & testing, rubbish removal, clean-up, trailers, and field personnel. The total value of the general conditions estimate comes to $7,010,403.64 which is approximately 7% of the project cost. Gilbane holds contracts with 33 trades for construction. Many of the typical general conditions items such as small tools are handled by the subcontractor.

The personnel consists of three field engineers, four project managers, and two superintendents. The combined value comes to $3,487,250.00. This value is roughly 50% of the total general conditions estimate. The values for the contingency, insurance, and performance bonds were calculated as a percentage of the total project cost. Combined, this value comes to $2,016,000.00. Also included in the estimate is the cost for a 24/7 webcam. This webcam records live data and archives a picture of the building and site every 20 minutes. More details of the general conditions estimate and the breakdown of it can be found in Appendix C.

LEED EVALUATION

The PSC is aiming for a LEED certification and Gold rating. The current scoreboard (available in Appendix D) has a total of 41 (Gold) points out of a possible 69. Sustainability is a large factor for the PSC's success. LEED has been heavily stressed through construction and was utilized heavily in early coordination. Below is an evaluation of each major category and a summary of the point allocations.

Sustainable Sites

The PSC receives 9 of the 15 possible points in this category. The site is located atop an existing parking lot and does not disturb nature or any wild life habitats. The site is also currently part of an established commercial area. As such, points for transportation come easily. The heat island effect is overcome by the installation of a green roof on the PSC. The green roof covers roughly 75% of the roof.

Water Efficiency

The PSC scores 3 out of the possible 5 points in the water efficiency category. The potable water use for irrigation is reduced by over 50%. This is done by a system of non-potable water storage tanks that supply water to the surrounding vegetation. This water is collected and stored in these tanks from rainwater via the green roof system. The PSC also has an estimated 36% reduction of water use from the utilities. This is achieved by storm water reuse (green roof) and the partial recycling of greywater. The PSC also comes equipped with water efficient sinks and lavatories where possible.

Energy & Atmosphere

The PSC receives 5 out of 17 possible points in this category. The value for this category is lower than what many people would expect from the PSC. In reality, there is an enormous load on the building because of its purpose in laboratory testing and consistency. Energy consumption and, more importantly, energy consistency is absolutely critical. For this reason, renewable energy was not pursued. The building does, however, make use of automatic occupancy sensors to control lighting and. because of the unique interior façade, allows for an abundance of day-lighting to be utilized. This gives the PSC an optimized energy performance score of 18%.

Materials & Resources

The PSC receives 7 of the 13 possible points in this category. The PSC utilizes two 20CY comingled dumpsters that are handled by a third party, L&J Recycling. All sorting is done off site at L&J premises which allows for faster construction as sorting will not be an issue. By doing this, the PSC intends to have recycled 95% of all non-hazardous materials, 20% higher than the highest rating for LEED (75%). Of the non-hazardous materials, 5% is deemed "unrecyclable," therefore 100% of all recyclable, non-hazardous materials are recycled. This amounts to 2,217 tons of recycled waste. The PSC also utilizes a large amount of recycled

content its self. Approximately 9% of concrete is pre-consumer recycled content. Rebar is 99% recycled content and welded wire is 90% recycled while ornamental steel panels and stairs are 25% recycled.

The PSC is also constructed with local materials. 100% of all concrete on site is received from a plant 16 miles away. Although steel is imported from Canada and does not contribute to the LEED rating, the vast majority of the project is concrete and therefore is of minimal impact.

Indoor Environmental Quality

The PSC receives 12 of 15 possible points in this category. This is the strongest of all the categories. Gilbane has issued and controls an Indoor Air Quality Plan for the PSC that includes five major areas of focus. These areas of focus are HVAC Protection, Contaminant Source Control, Pathway Interruption, Housekeeping, and Scheduling. This plan includes the continued effort by Gilbane to document and record product data and operating efficiency of equipment during construction. Low emitting materials are also largely utilized in the PSC. All adhesives, sealants, paints, carpets, wood products, and concrete are required to have a volatile organic compound (VOC) content below the LEED score threshold.

Control of lighting and thermal comfort are also key points of success for the PSC. While the PSC has automatic occupancy sensors that control lighting, there are also controls that allow occupants to adjust lighting. These controls are found in labs, conference rooms, and office spaces. The PSC also has approximately 200 fan coil units that allow for modified thermal comfort in an area. On top of this, the north and south facades, as well as a partial section of the east façade, have operable windows that swing open horizontally. The thermal comfort of individual zones will be designed using BIM standards and tracked for an additional 6 months after completion using user inputs to further maximize the systems efficiency with regards to occupant comfort.

Innovation & Design Process

The PSC receives 5 of the 5 possible points in this category. The coordination behind the PSC, issued by Gilbane, is immersive. This coordination utilizes educational programs to guide contractors and to help workers provide a better, more sustainable building.

Area for Improvement

The PSC has a lot of room for improvement in the category of ‘Energy & Atmosphere.’ Energy consumption is the most important factor to the continuing growth of a civilized nation. Without an extraordinary push into the field of self-sustaining structures, we, as a people, cannot hope to ever conquer it in the near future.

BIM EVALUATION

Building information modeling was heavily used in the planning and construction of the PSC. Early on in the design process, the University of Maryland knew that BIM was beneficial to the project. Although UM realized that the sheer size and cost of the project warranted a BIM execution plan, UM was uncertain in the specific goals and benefits that BIM would provide. This is where Gilbane steps in to provide insight into the process. Gilbane is at the forefront of BIM design and has, over the years, constructed an in-house execution plan. This plan has been edited and revised after the completion of projects, one of which included the Lewis Katz Law building at the north end of the Penn State campus.

The main goals for BIM execution for the PSC can be identified in Appendix D. Included in these goals are several which are very important. Firstly, a site analysis of the existing landscape and buildings was developed. This analysis included underground utilities and basement connections for the existing Computer and Space Sciences (CSS) building. This plan allowed for precise adjustments to the connectivity between the CSS and PSC at the basement level. Furthermore, BIM is utilized to perform a structural analysis. This analysis includes locations of cast in place concrete, rebar, and post tensioning tendons. Accurate take-offs can be performed and information from the model can be used to calculate load capacities.

Another major benefit from BIM is the lighting analysis of the spaces in the building. Because of the unique implementation of the elliptical interior façade, HDR Inc. (the design firm for the PSC) was able to develop lighting schematics based off of the total level of sunlight that will be seen on each floor, and to what degree it penetrates the building. Because of the design, many offices and rooms have access to an exterior wall, allowing for a reduced level of electrical lighting to be used, and therefore a differentiated amount of lighting fixtures to be distributed through the building.

A site plan utilization model was also developed as part of the BIM package. This model helps to identify crane placement and the dimensions of the crane foundations with respect to the footprint of the building. The crane, which sits at the center of the building in the envelope created by the interior facade, has its foundation as part of the sub-basement of the PSC. The coordination introduced by the BIM execution allows for accurate and substantially easier placement of the crane. The site plan also documents caisson locations and underground plumbing so that clashes can be easily identified and dealt with.

Construction system design was another major aspect to the BIM plan. This aspect of BIM was primarily used to indicate the flow of trade-work inside the building. The 3D model indicates where field personnel can and cannot be depending on the specific phase of the schedule. This is different from a 4D model as it does not describe the phasing of the building with respect to time, but rather the location of workers with respect to what trade has priority. No 4D modeling

was utilized in the construction of the PSC. In a brief discussion with, Josh Miller, one of the BIM coordinators for the PSC, 4D modeling was determined to be an unnecessary expense of time and resources. Because of the nature of the project, the schedule shifts on a weekly basis. 4D modeling, while seemingly helpful, would result in a constant struggle to keep the documents and model up to date, consuming precious manpower.

Furthermore, 3D control and planning is also critical. Although the PSC is not identified as an IPD project, the coordination between contractors is highly encouraged. Many of the systems are collaboratively developed. One such system includes the concrete structure, floor, and elliptical façade systems, in which three contractors communicate to develop a model that precisely identifies the dimensions necessary to construct this system within production tolerances. All the MEP, equipment, and electrical is also mapped in a coordinated effort using BIM. Figure.7 shows a typical integration of systems for the third floor of the PSC.

Future Implementation

At the moment there is no strict plan to provide building maintenance scheduling, asset management, or space management integration with BIM. The current method of BIM for the PSC includes all of the necessary documentation and models to implement said strategies, but currently no word is given to follow through with it.

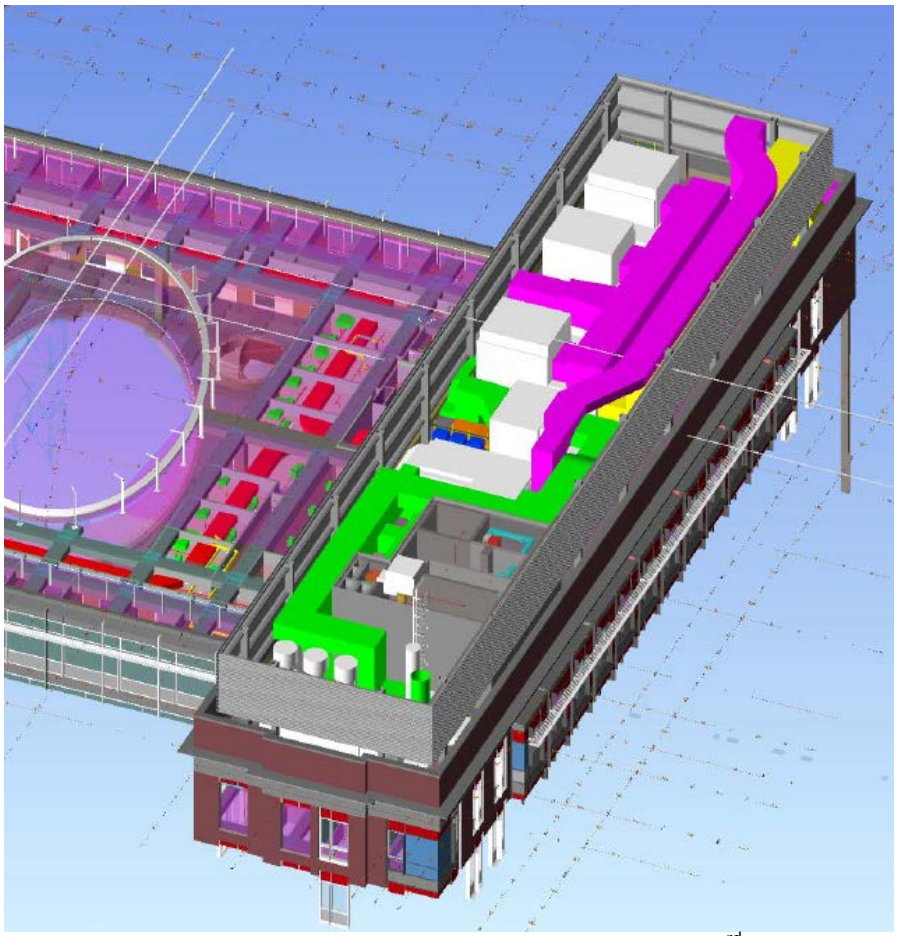
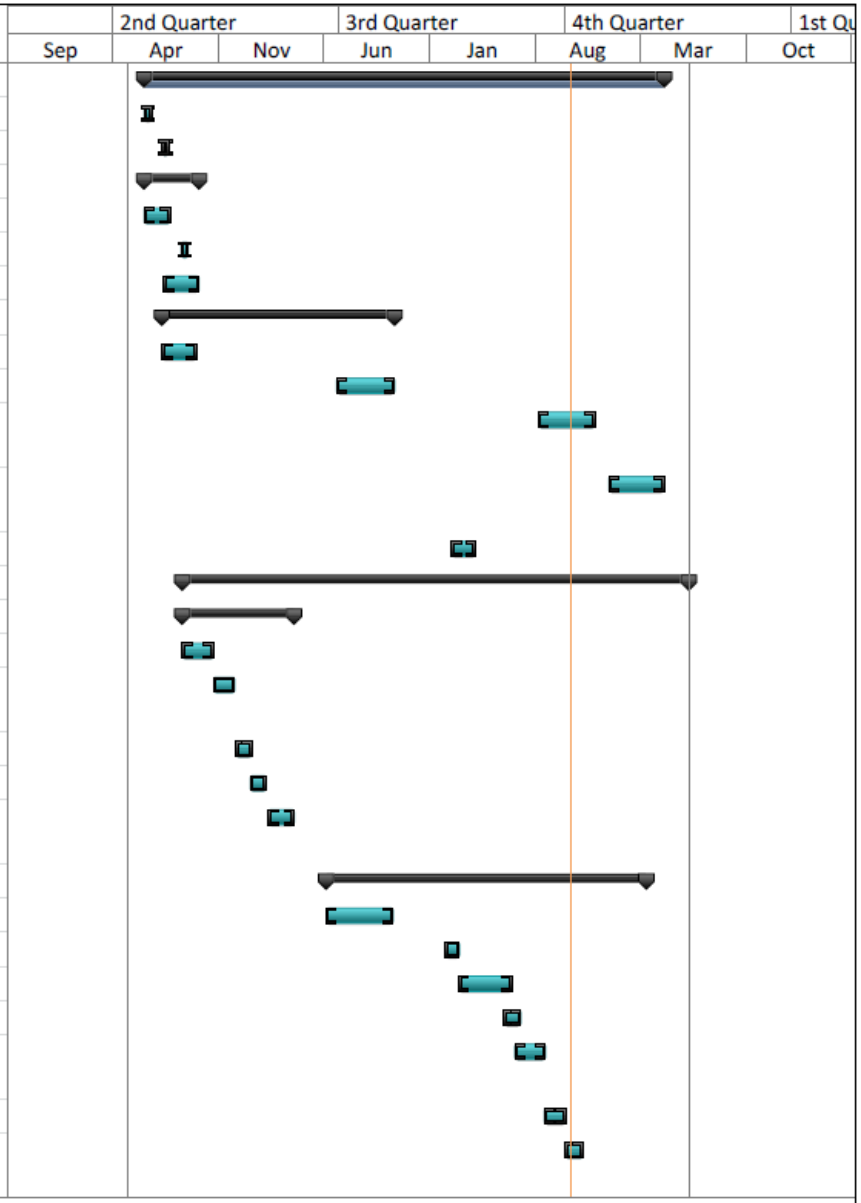


Figure.7: BIM Coordination Effort for PSC 3rd Floor and East Wing Roof

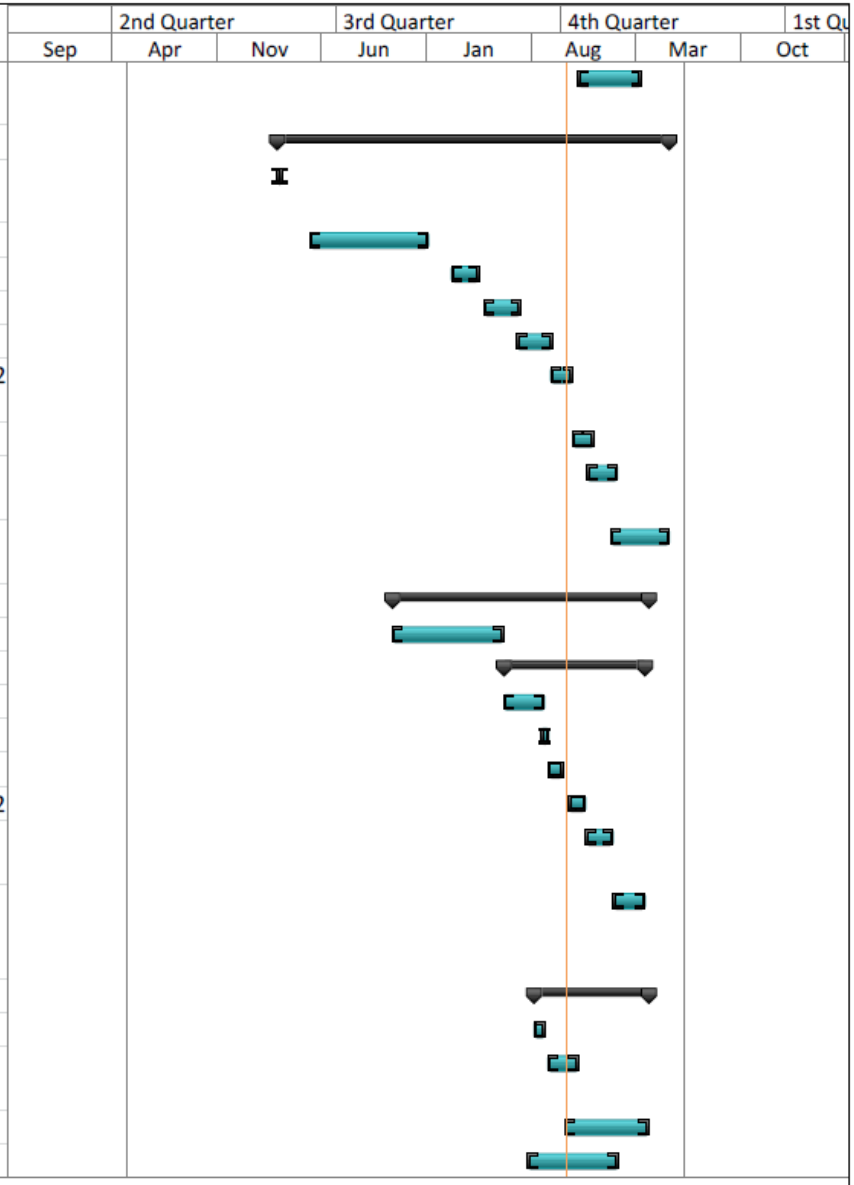
Appendix A: Project Schedule

Task Name	Duration	Start	Finish
Sitework	**751 days**	**Thu 6/3/10**	**Thu 4/18/13**
Sediment and Erosion Control	12 days	Thu 6/3/10	Fri 6/18/10
Demo Existing Improvements	10 days	Fri 7/9/10	Thu 7/22/10
North	**79 days**	**Thu 6/3/10**	**Tue 9/21/10**
Install Duct Banks	38 days	Thu 6/3/10	Sun 7/25/10
Temporary Steam	10 days	Tue 8/17/10	Mon 8/30/10
New Utility Lines	51 days	Tue 7/13/10	Tue 9/21/10
South	**336 days**	**Fri 7/9/10**	**Fri 10/21/11**
Install Duct Banks	50 days	Fri 7/9/10	Thu 9/16/10
Excavate & Install New Steam	85 days	Mon 6/27/11	Fri 10/21/11
Plaza East - Retaining wall, Paving, and finishings	82 days	Wed 8/8/12	Thu 11/29/12
Plaza West - Seat wall, paving, drains, furnishings	80 days	Fri 12/28/12	Thu 4/18/13
Permanent site lighting	35 days	Tue 2/14/12	Mon 4/2/12
PSC Main Building	**732 days**	**Thu 8/19/10**	**Fri 6/7/13**
Excavation	**162 days**	**Thu 8/19/10**	**Fri 4/1/11**
Equip. set-up & Delivery	46 days	Thu 8/19/10	Thu 10/21/10
Exc. For Piles, caissons, steam lines	30 days	Fri 10/22/10	Thu 12/2/10
Install Dewatering wells	24 days	Mon 12/6/10	Thu 1/6/11
Install Lagging & guardrail	23 days	Tue 1/4/11	Thu 2/3/11
Drill for Caissons/remove spoils	38 days	Wed 2/9/11	Fri 4/1/11
Sub Basement	**463 days**	**Mon 6/6/11**	**Wed 3/13/13**
Structure	97 days	Mon 6/6/11	Tue 10/18/11
Wall Framing	20 days	Thu 2/2/12	Wed 2/29/12
Duct and Pipe	78 days	Wed 2/29/12	Fri 6/15/12
Insulation and set Equip.	24 days	Wed 5/30/12	Mon 7/2/12
Electrical (Panel Boxes, conduit, in wall)	44 days	Thu 6/21/12	Tue 8/21/12
Finish Walls & Paint	31 days	Mon 8/20/12	Mon 10/1/12
Pull Wire and Set lighting Fixtures	26 days	Mon 10/1/12	Mon 11/5/12



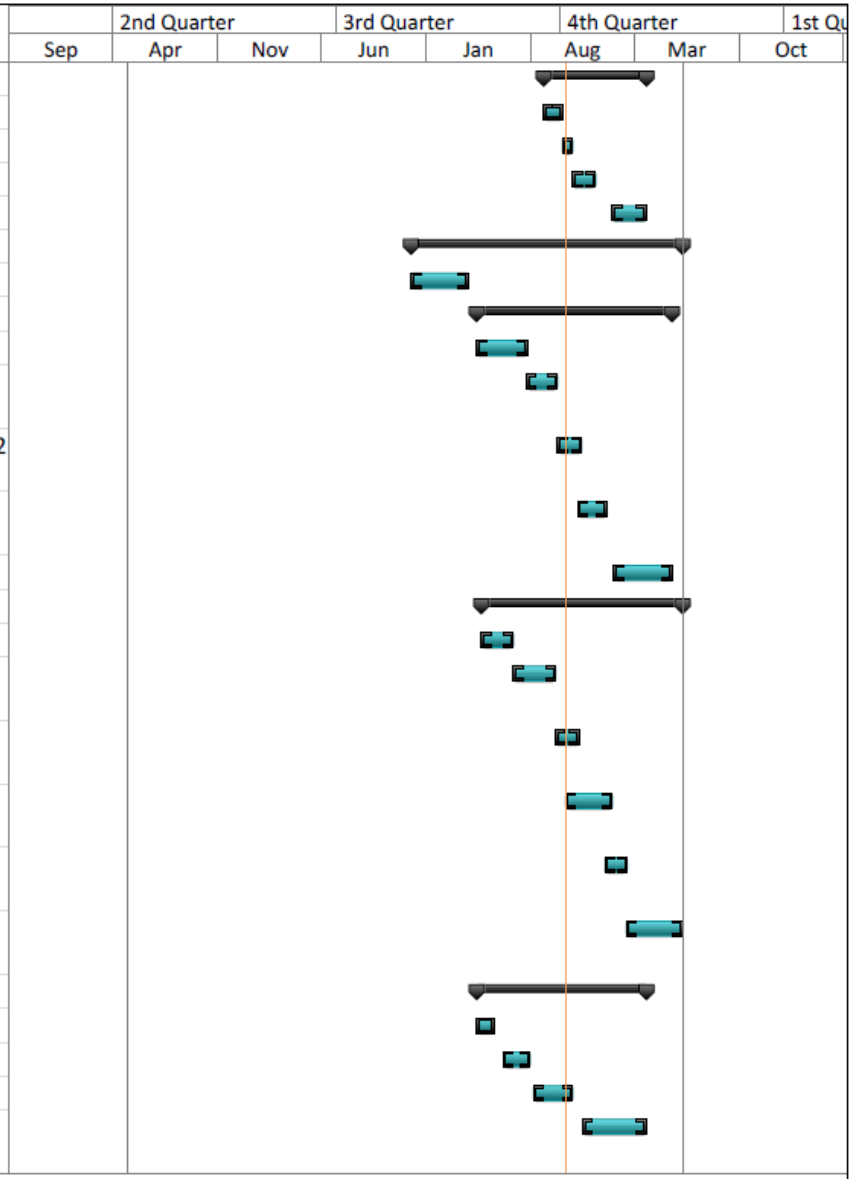
Page 1

Task Name	Duration	Start	Finish
Install Doors, Casework, and electrical finishes	94 days	Sun 11/4/12	Wed 3/13/13
Basement	**570 days**	**Thu 3/3/11**	**Wed 5/8/13**
Tower Crane Foundation/Build	8 days	Thu 3/3/11	Sat 3/12/11
Structure	173 days	Mon 5/9/11	Wed 1/4/12
Wall Framing	40 days	Tue 2/21/12	Mon 4/16/12
Duct and Pipe	53 days	Fri 4/27/12	Tue 7/10/12
Insulation and set Equip.	52 days	Tue 7/3/12	Wed 9/12/12
Electrical (Panel Boxes, conduit, in wall)	33 days	Mon 9/10/12	Wed 10/24/12
Finish Walls & Paint	31 days	Thu 10/25/12	Thu 12/6/12
Pull Wire and Set lighting Fixtures	44 days	Fri 11/23/12	Wed 1/23/13
Install Doors, Casework, and electrical finishes	85 days	Thu 1/10/13	Wed 5/8/13
Ground Floor	**374 days**	**Mon 10/24/11**	**Thu 3/28/13**
Structure	162 days	Mon 10/24/11	Tue 6/5/12
Office & Collab Space	**205 days**	**Thu 6/7/12**	**Wed 3/20/13**
Install Duct and Plumbing	58 days	Thu 6/7/12	Mon 8/27/12
Wall Framing	12 days	Tue 8/21/12	Wed 9/5/12
In-wall electrical	22 days	Wed 9/5/12	Thu 10/4/12
Finish Walls & Paint	25 days	Tue 10/16/12	Mon 11/19/12
Pull Wire and Set lighting Fixtures	40 days	Tue 11/20/12	Mon 1/14/13
Install Finishes (grills, diffusers, electrical, covers)	47 days	Tue 1/15/13	Wed 3/20/13
Lobby	**168 days**	**Tue 8/7/12**	**Thu 3/28/13**
Install Duct and Plumbing	17 days	Tue 8/7/12	Wed 8/29/12
Field measure and Fab for steel	45 days	Tue 9/4/12	Mon 11/5/12
Flooring and Finishes	123 days	Tue 10/9/12	Thu 3/28/13
Plaza Storefront & fixtures	133 days	Wed 7/25/12	Fri 1/25/13



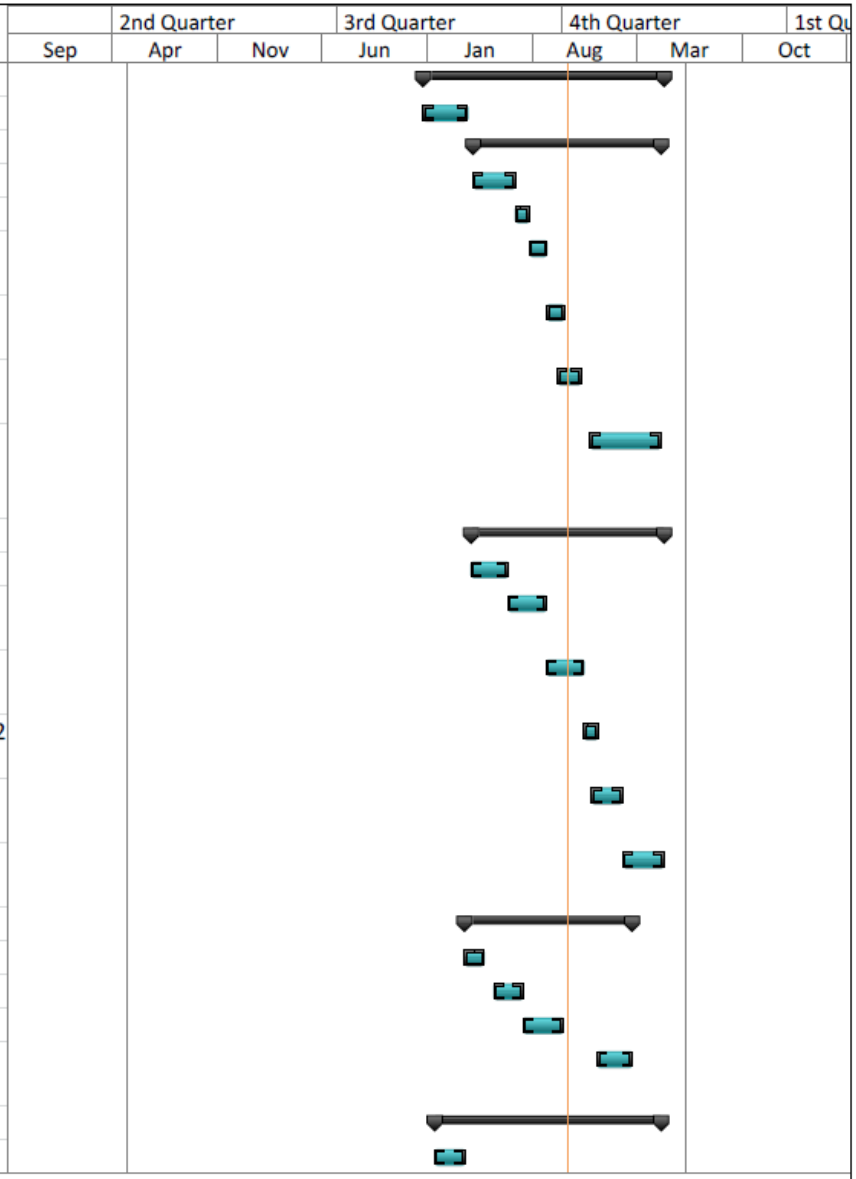
Page 2

Task Name	Duration	Start	Finish
Bathroom & Kitchen	**150 days**	**Tue 8/28/12**	**Mon 3/25/13**
Install Duct and Plumbing	28 days	Tue 8/28/12	Thu 10/4/12
Wall Framing	15 days	Fri 10/5/12	Thu 10/25/12
In-wall Electrical	33 days	Fri 10/26/12	Tue 12/11/12
Finishes	50 days	Tue 1/15/13	Mon 3/25/13
1st Floor	**397 days**	**Thu 12/1/11**	**Fri 6/7/13**
Structure	83 days	Thu 12/1/11	Mon 3/26/12
Lab Space	**285 days**	**Fri 4/13/12**	**Thu 5/16/13**
Install Duct and Plumbing	74 days	Fri 4/13/12	Wed 7/25/12
Electrical conduit/ Misc HVAC	45 days	Tue 7/24/12	Mon 9/24/12
Hang & finish walls/ finish flooring	35 days	Tue 9/25/12	Mon 11/12/12
Pull electrical and install lighting	43 days	Tue 11/6/12	Thu 1/3/13
Finishes and final Paint	85 days	Fri 1/18/13	Thu 5/16/13
Office Collab Space	**295 days**	**Mon 4/23/12**	**Fri 6/7/13**
Install Duct and Plumbing	47 days	Mon 4/23/12	Tue 6/26/12
Underfloor electrical/ Misc. HVAC	62 days	Wed 6/27/12	Thu 9/20/12
Frame walls & access flooring	35 days	Fri 9/21/12	Thu 11/8/12
Hang & Finish doors and partitions	67 days	Fri 10/12/12	Mon 1/14/13
Pull Electrical and set lighting fixtures	33 days	Mon 12/31/12	Wed 2/13/13
Finishes(ceiling tile, diffusers, coverings)	83 days	Wed 2/13/13	Fri 6/7/13
Bathrooms & MEP closets	**247 days**	**Fri 4/13/12**	**Mon 3/25/13**
Layout and Frame walls	25 days	Fri 4/13/12	Thu 5/17/12
Install Duct & Plumbing	38 days	Thu 6/7/12	Mon 7/30/12
Electrical rough-in	58 days	Tue 8/7/12	Thu 10/25/12
Finishes (grilles, fixtures, devices)	92 days	Fri 11/16/12	Mon 3/25/13



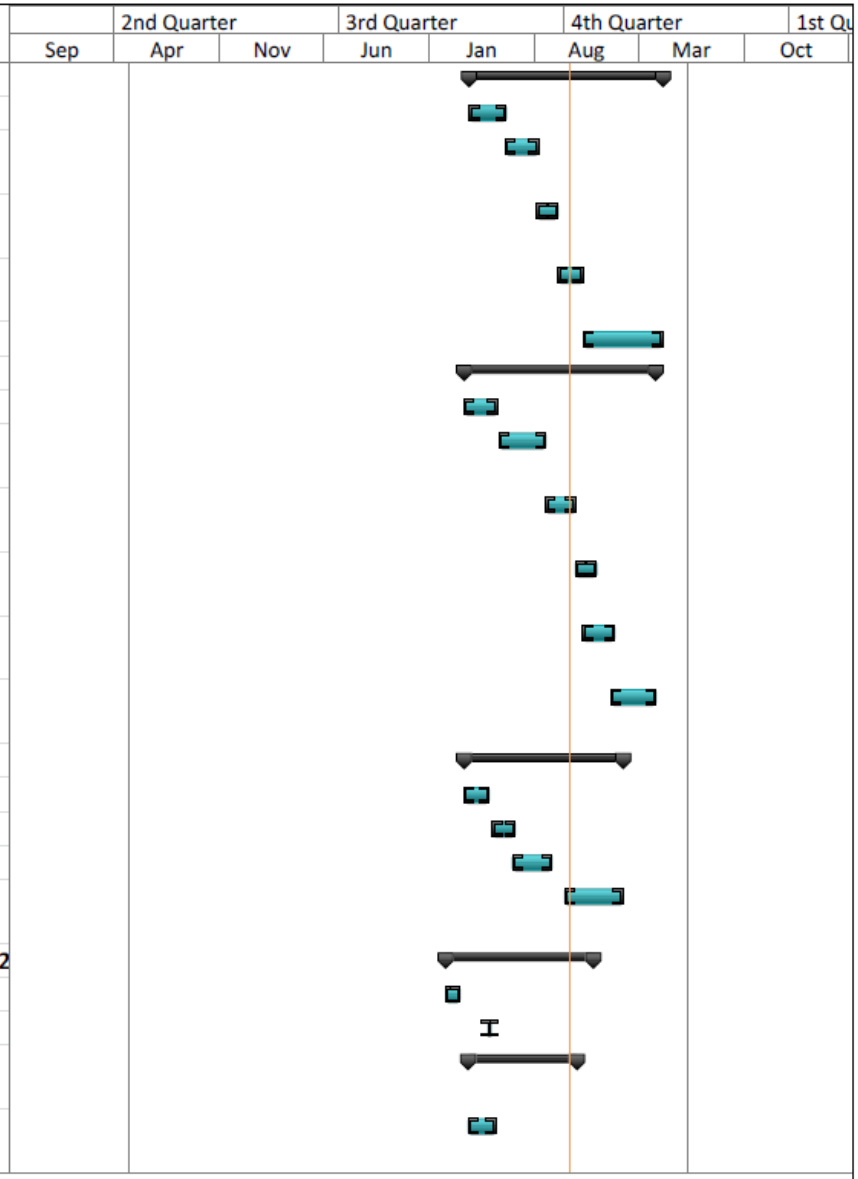
Page 3

Task Name	Duration	Start	Finish
2nd Floor	**350 days**	**Fri 12/23/11**	**Thu 4/25/13**
Structure	65 days	Fri 12/23/11	Thu 3/22/12
Lab Space	**274 days**	**Tue 4/3/12**	**Fri 4/19/13**
Install Duct and Plumbing	62 days	Tue 4/3/12	Wed 6/27/12
Framing walls & Bulkheads	21 days	Thu 6/28/12	Thu 7/26/12
In-wall electrical & Plumbing	25 days	Fri 7/27/12	Thu 8/30/12
Hang & Finish walls/ finish floor	25 days	Fri 8/31/12	Thu 10/4/12
Pull Electrical wire and install lighting	35 days	Fri 9/21/12	Thu 11/8/12
Finishes (diffusers, coverings, panels, devices)	105 days	Mon 11/26/12	Fri 4/19/13
Office and Collab Space	**280 days**	**Fri 3/30/12**	**Thu 4/25/13**
Install Duct and Plumbing	53 days	Fri 3/30/12	Tue 6/12/12
Underfloor electrical/ Misc. HVAC	56 days	Wed 6/13/12	Wed 8/29/12
Frame walls & access flooring	54 days	Thu 8/30/12	Tue 11/13/12
Hang & Finish doors and partitions	21 days	Wed 11/14/12	Wed 12/12/12
Pull Electrical and set lighting fixtures	46 days	Thu 11/29/12	Thu 1/31/13
Finishes(ceiling tile, diffusers, coverings)	60 days	Fri 2/1/13	Thu 4/25/13
Bathrooms & MEP closets	**243 days**	**Fri 3/16/12**	**Tue 2/19/13**
Layout and Frame walls	28 days	Fri 3/16/12	Tue 4/24/12
Install Duct & Plumbing	44 days	Tue 5/15/12	Fri 7/13/12
Electrical rough-in	58 days	Sat 7/14/12	Tue 10/2/12
Finishes (grilles, fixtures, devices)	51 days	Tue 12/11/12	Tue 2/19/13
3rd Floor	**330 days**	**Mon 1/16/12**	**Fri 4/19/13**
Structure	45 days	Mon 1/16/12	Fri 3/16/12



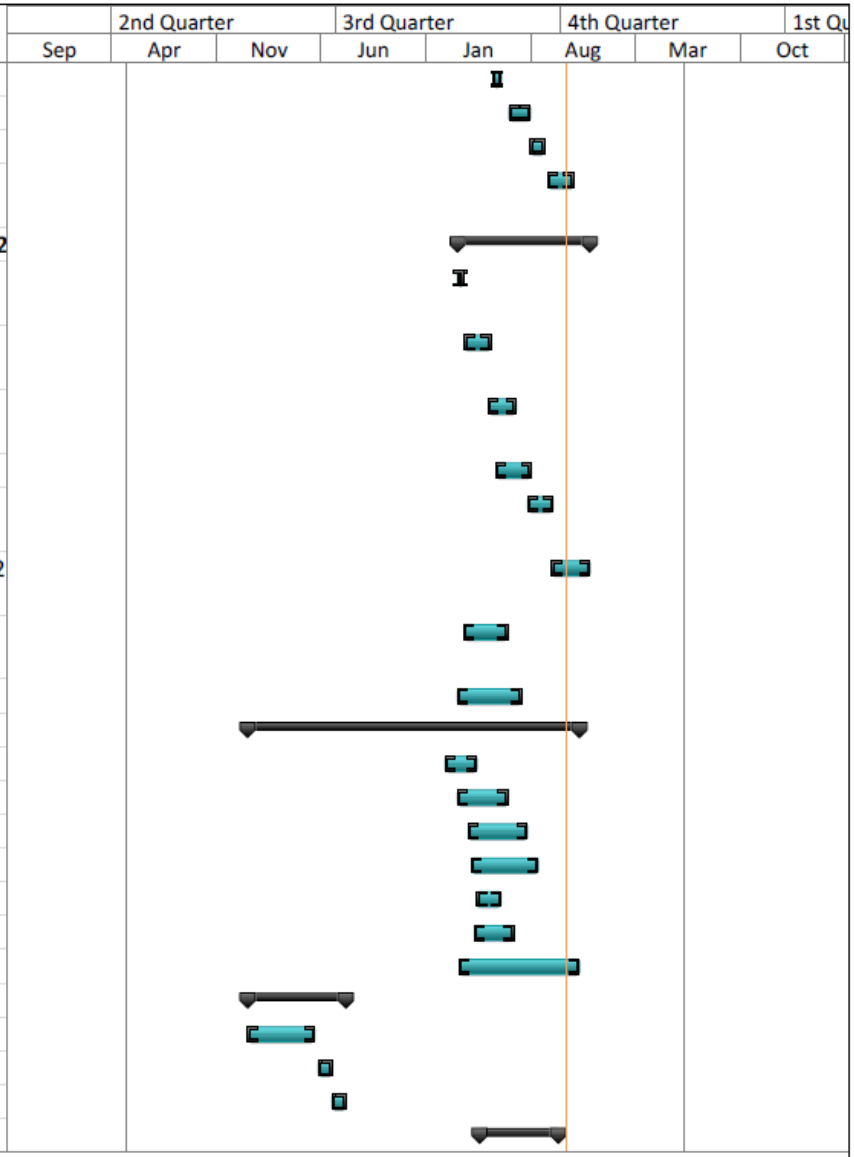
Page 4

Task Name	Duration	Start	Finish
Lab Space	**282 days**	**Thu 3/22/12**	**Fri 4/19/13**
Install Duct and Plumbing	53 days	Thu 3/22/12	Mon 6/4/12
Electrical conduit/ Misc HVAC	49 days	Mon 6/4/12	Thu 8/9/12
Hang & finish walls/ finish flooring	31 days	Mon 8/6/12	Mon 9/17/12
Pull electrical and install lighting	38 days	Tue 9/18/12	Thu 11/8/12
Finishes and final Paint	116 days	Fri 11/9/12	Fri 4/19/13
Office Collab Space	**279 days**	**Mon 3/12/12**	**Thu 4/4/13**
Install Duct and Plumbing	50 days	Mon 3/12/12	Fri 5/18/12
Underfloor electrical/ Misc. HVAC	68 days	Tue 5/22/12	Thu 8/23/12
Frame walls & access flooring	43 days	Fri 8/24/12	Tue 10/23/12
Hang & Finish doors and partitions	31 days	Wed 10/24/12	Wed 12/5/12
Pull Electrical and set lighting fixtures	47 days	Wed 11/7/12	Thu 1/10/13
Finishes(ceiling tile, diffusers, coverings)	65 days	Fri 1/4/13	Thu 4/4/13
Bathrooms & MEP closets	**231 days**	**Mon 3/12/12**	**Mon 1/28/13**
Layout and Frame walls	36 days	Mon 3/12/12	Mon 4/30/12
Install Duct & Plumbing	34 days	Tue 5/8/12	Fri 6/22/12
Electrical rough-in	58 days	Mon 6/18/12	Wed 9/5/12
Finishes (grilles, fixtures, devices)	85 days	Tue 10/2/12	Mon 1/28/13
Roof Level	**214 days**	**Fri 2/3/12**	**Wed 11/28/12**
Structure	21 days	Fri 2/3/12	Fri 3/2/12
Remove Tower Crane	5 days	Mon 4/30/12	Fri 5/4/12
Elevator Machine/ Control Room	**159 days**	**Tue 3/20/12**	**Fri 10/26/12**
Framing & Sheathing, Concrete	40 days	Tue 3/20/12	Mon 5/14/12



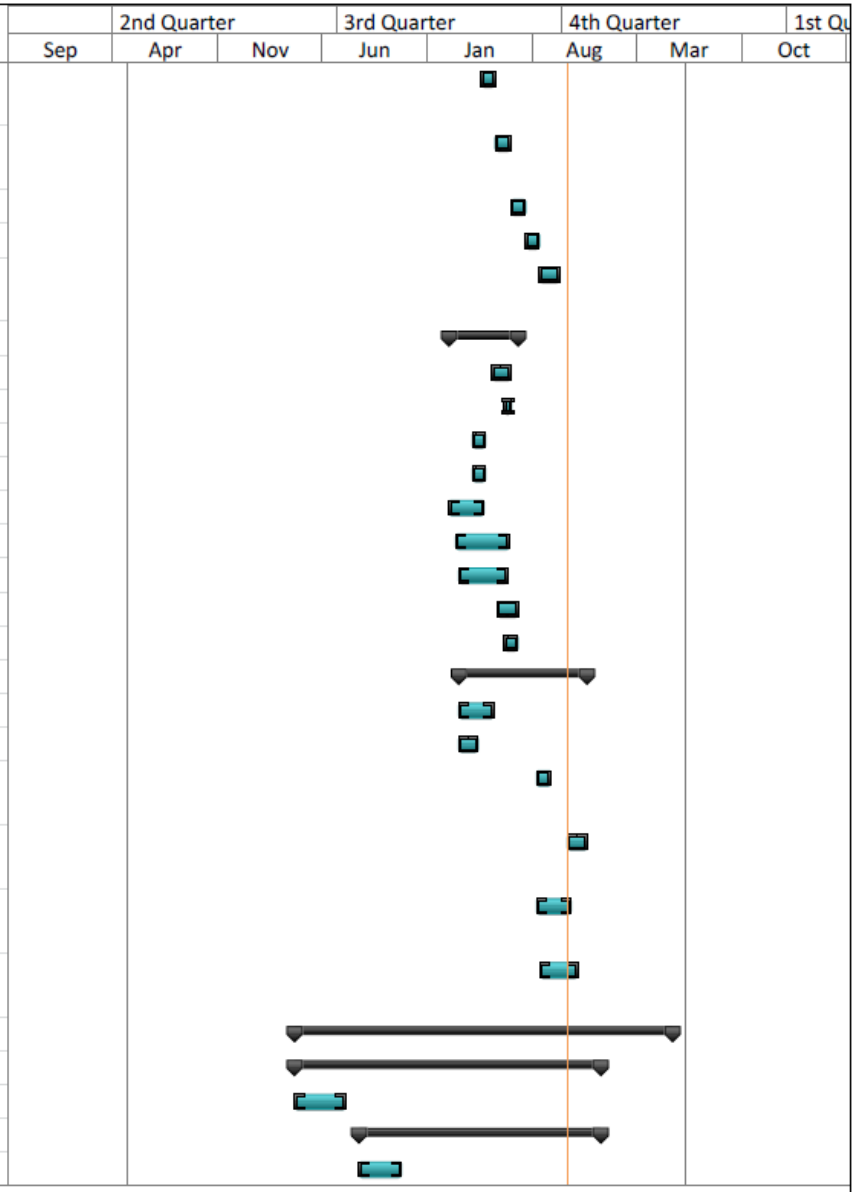
Page 5

Task Name	Duration	Start	Finish
Insulation & Metal Panels	13 days	Wed 5/16/12	Fri 6/1/12
Electrical Conduit	31 days	Mon 6/18/12	Mon 7/30/12
Pull Wire	21 days	Tue 7/31/12	Tue 8/28/12
Terminate Panels & Final Paint	38 days	Wed 9/5/12	Fri 10/26/12
Lab Roof	**193 days**	**Mon 3/5/12**	**Wed 11/28/12**
Set AHU's and other Equip.	10 days	Mon 3/5/12	Fri 3/16/12
Install Tubesteel and Roofing	40 days	Mon 3/19/12	Fri 5/11/12
Install Metal Panels & Roof Hatch	41 days	Mon 5/7/12	Sun 7/1/12
Roof Ductwork & Insulation	52 days	Tue 5/22/12	Wed 8/1/12
HVAC Connections & termination	37 days	Thu 7/26/12	Fri 9/14/12
Electrical Connections & Testing	56 days	Wed 9/12/12	Wed 11/28/12
Equipment Start-up for Construction	65 days	Sun 3/18/12	Thu 6/14/12
Office Roof	94 days	Mon 3/5/12	Thu 7/12/12
Façade	**483 days**	**Mon 1/3/11**	**Wed 11/7/12**
Structure	46 days	Thu 2/9/12	Thu 4/12/12
Column Line 8 & North El.	75 days	Mon 3/5/12	Fri 6/15/12
East El.	86 days	Tue 3/27/12	Tue 7/24/12
Column Line 8 & South El.	97 days	Tue 4/3/12	Wed 8/15/12
West El.	35 days	Fri 4/13/12	Thu 5/31/12
Ellipse/Light Shaft	58 days	Mon 4/9/12	Wed 6/27/12
Install & operate Hoist	174 days	Fri 3/9/12	Wed 11/7/12
Mock-up	**144 days**	**Mon 1/3/11**	**Thu 7/21/11**
Submittals	98 days	Mon 1/3/11	Wed 5/18/11
Construct	20 days	Fri 5/27/11	Thu 6/23/11
Review & Approve	20 days	Fri 6/24/11	Thu 7/21/11
Elevators	**114 days**	**Thu 4/19/12**	**Tue 9/25/12**



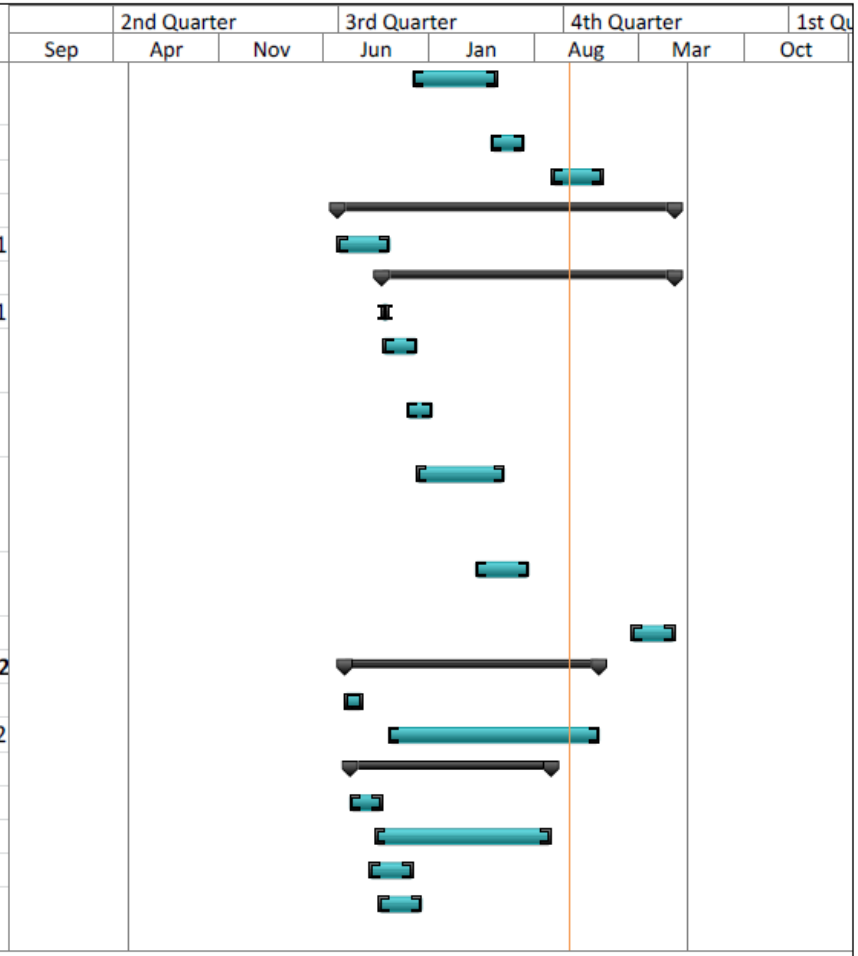
Page 6

Task Name	Duration	Start	Finish
Install EMI Shielding (shaft 1)	21 days	Thu 4/19/12	Thu 5/17/12
Install EMI Shielding (shaft 2)	22 days	Fri 5/18/12	Mon 6/18/12
Install Rails and Belts	22 days	Tue 6/19/12	Wed 7/18/12
Finish Rails & Counterweight	20 days	Thu 7/19/12	Wed 8/15/12
Build Cab & Wire (Fire Alarms etc)	29 days	Thu 8/16/12	Tue 9/25/12
MEP Risers	**101 days**	**Tue 2/14/12**	**Tue 7/3/12**
Electrical	27 days	Fri 5/11/12	Mon 6/18/12
Fire Alarm	11 days	Tue 6/5/12	Tue 6/19/12
Office Mechanical Duct	20 days	Mon 4/2/12	Fri 4/27/12
Men's Room Duct	20 days	Mon 4/2/12	Fri 4/27/12
Plumbing	51 days	Tue 2/14/12	Tue 4/24/12
Stair 1 Risers	79 days	Tue 2/28/12	Fri 6/15/12
Stair 2 Risers	71 days	Mon 3/5/12	Mon 6/11/12
Sprinkler	31 days	Tue 5/22/12	Tue 7/3/12
Security/Telecom	20 days	Tue 6/5/12	Mon 7/2/12
Stairs	**187 days**	**Mon 3/5/12**	**Tue 11/20/12**
Stair 1 Measure/Fab/Install	51 days	Mon 3/5/12	Mon 5/14/12
Stair 2 Measure/Fab/Install	29 days	Mon 3/5/12	Thu 4/12/12
Stair 3 Metal and Glass railings/treads	21 days	Fri 8/10/12	Fri 9/7/12
Stair 4 Metal and Glass railings/treads	28 days	Fri 10/12/12	Tue 11/20/12
Stair 5 Construct/Hang & Finish	50 days	Fri 8/10/12	Thu 10/18/12
Stair 6 Construct/Hang & Finish	55 days	Fri 8/17/12	Thu 11/1/12
Mechanical Building	**549 days**	**Wed 4/6/11**	**Mon 5/13/13**
Basement	**445 days**	**Wed 4/6/11**	**Tue 12/18/12**
Structure	74 days	Wed 4/6/11	Mon 7/18/11
MEP Equipment	**352 days**	**Mon 8/15/11**	**Tue 12/18/12**
Pad and Set equipment	62 days	Mon 8/15/11	Tue 11/8/11



Page 7

Task Name	Duration	Start	Finish
Connect/Conduit/pull wire	124 days	Tue 11/29/11	Fri 5/18/12
Equipment testing	49 days	Sun 5/6/12	Wed 7/11/12
Flush/Start-up/Sign-off	74 days	Thu 9/6/12	Tue 12/18/12
Upper Basement	**489 days**	**Wed 6/29/11**	**Mon 5/13/13**
Structure	76 days	Wed 6/29/11	Wed 10/12/11
MEP Equipment	**425 days**	**Tue 9/27/11**	**Mon 5/13/13**
CMU Walls	10 days	Tue 9/27/11	Mon 10/10/11
Pad and Set equipment	48 days	Fri 9/30/11	Tue 12/6/11
Conduit & Rough-in	36 days	Fri 11/18/11	Fri 1/6/12
Ductwork, Plumbing, and Insulation	127 days	Wed 12/7/11	Thu 5/31/12
Pull Wire & Terminate	77 days	Thu 4/5/12	Fri 7/20/12
Start-up/Testing/Sign-off	62 days	Fri 2/15/13	Mon 5/13/13
Ground Floor	**368 days**	**Thu 7/14/11**	**Mon 12/10/12**
Structure	26 days	Thu 7/14/11	Thu 8/18/11
MEP Equipment	305 days	Tue 10/11/11	Mon 12/10/12
2nd Floor	**292 days**	**Mon 7/25/11**	**Tue 9/4/12**
Structure	47 days	Mon 7/25/11	Tue 9/27/11
MEP Equipment	255 days	Wed 9/14/11	Tue 9/4/12
Roofing & roof Hatch	63 days	Fri 9/2/11	Tue 11/29/11
CMU/Brick Façade & waterproofing	63 days	Wed 9/21/11	Fri 12/16/11



Page 8

Appendix B: Detailed Façade Systems Estimate

SQFT Quantities														
		Framing					Installation		Glass (Insulated)					
Zone	Influence SQFT	Straight	Segmented	Gasket/Seal	Unitize	Delivery	Interior	Exterior	1" Clear/Vision	1" Color	Alum. Metal Panel	Alum. Sunshade	Operable Windows	Final Seal/ Inspection
1	6500	6500	0	6500	6500	6500	0	6500	3600	1200	1600	630	700	6500
2	6500	6500	0	6500	6500	6500	0	6500	3600	1200	1600	0	700	6500
3	2400	0	2300	2300	2300	2300	2400	0	1035	1265	0	0	0	2400
4	2400	0	2300	2300	2300	2300	2400	0	1080	1320	0	0	0	2400
5	2600	0	2600	2600	2600	2600	2600	0	1508	1092	0	0	0	2600
6	2600	0	2600	2600	2600	2600	2600	0	1690	910	0	0	0	2600
7	6030	6030	0	6030	6030	6030	0	6030	2715	2109	1206	585	120	6030

Zone	Influence SQFT	Cost/SQFT of Component													Subtotal Cost	Subtotal Cost/SQFT
		$36	$58	$9	$45	$6	$59	$36	$18	$31	$27	$108	$32	$7		
1,2	13000	$468,000	$0	$117,000	$585,000	$78,000	$0	$468,000	$129,600	$74,400	$86,400	$68,040	$44,800	$91,000	$2,210,240	$170
3,4,5,6	10000	$0	$568,400	$88,200	$441,000	$58,800	$590,000	$0	$95,634	$142,197	$0	$0	$0	$70,000	$2,054,231	$205
7	6030	$217,080	$0	$54,270	$271,350	$36,180	$0	$217,080	$48,870	$65,379	$32,562	$63,180	$3,840	$42,210	$1,052,001	$174
Punch-in Windows	3653														$401,830	$110
Total Cost	**32683**	**$468,000**	**$568,400**	**$205,200**	**$1,026,000**	**$136,800**	**$590,000**	**$468,000**	**$225,234**	**$216,597**	**$86,400**	**$68,040**	**$44,800**	**$161,000**	**$5,718,302**	**$175**

Zone	Description
1	South elevation, metal and glass curtainwall
2	North elevation, metal and glass curtainwall
3	Interior, elliptical curtain wall. Quadrant 1 on sheet A5.23
4	Interior, elliptical curtain wall. Quadrant 4 on sheet A5.23
5	Interior, elliptical curtain wall. Quadrant 2 on sheet A5.23
6	Interior, elliptical curtain wall. Quadrant 3 on sheet A5.23
7	East Elevation, metal and glass curtainwall (includes wrap around)

Punch-in window type	Count	SQFT/Window	Subtotal SQFT
W1	27	63	1701
W2	23	74	1702
W4	2	125	250
		Total SQFT	3653
		Cost/SQFT	$110
		Total Cost	**$401,830**

Appendix C: General Conditions Estimate

General Conditions Estimate					
Line Number	Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
13113200120	Field engineer, average	145	Week	$1,875.00	$271,875.00
13113200120	Field engineer, average	145	Week	$1,875.00	$271,875.00
13113200120	Field engineer, average	145	Week	$1,875.00	$271,875.00
13113200200	Field Personnel, project manager, average	145	Week	$3,075.00	$445,875.00
13113200200	Field Personnel, project manager, average	145	Week	$3,075.00	$445,875.00
13113200200	Field Personnel, project manager, average	145	Week	$3,075.00	$445,875.00
13113200220	Field Personnel, project manager, maximum	145	Week	$3,500.00	$507,500.00
13113200260	Field Personnel, superintendent, average	145	Week	$2,850.00	$413,250.00
13113200260	Field Personnel, superintendent, average	145	Week	$2,850.00	$413,250.00
14523500020	Field Testing, for concrete building, costing $1,000,000, maximum	1	Project	$39,166.60	$39,166.60
14523500082	Testing and Inspecting, quality control of earthwork	240	Day	$350.96	$84,230.40
15113800450	Temporary Power, for temp lighting only, 23.6 KWH/month, max	158000	CSF Flr	$3.40	$537,200.00
15213200350	Office Trailer, furnished, rent per month, 32' x 8', excl. hookups	74	Ea.	$213.21	$15,777.54
15419600100	Crane crew, tower crane, static, 130' high, 106' jib, 6200 lb. capacity, monthly use, excludes concrete footing	15	Month	$36,812.20	$552,183.00
15426500030	Hand Operated steel cable hoist, 500lbs capacity	18	Month	$445.45	$8,018.10
15626500250	Temporary Fencing, chain link, rented up to 12 months, 6' high, 11 ga, over 1000'	1800	L.F.	$6.71	$12,078.00
24119230725	Selective demolition, rubbish handling, dumpster, 20 C.Y., 8 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost.	155	Week	$770.00	$119,350.00
24119230725	Selective demolition, rubbish handling, dumpster, 20 C.Y., 8 ton capacity, weekly rental, includes one dump per week, cost to be added to demolition cost.	155	Week	$770.00	$119,350.00
	Webcam Services by OxBlue	36	Month	$550.00	$19,800.00
13113300010	Insurance				$936,000.00
13113900010	CM Bonding				$757,000.00
12116000000	CM Contingency				$323,000.00
				Total	**$7,010,403.64**

Appendix D: LEED Evaluation Checklist

LEED-NC

LEED-NC Version 2.2 Registered Project Checklist

University of Maryland Physical Sciences Complex
College Park, MD

Yes	?	No			
9		5	**Sustainable Sites**		14 Points
Y			Prereq 1	**Construction Activity Pollution Prevention**	Required
1			Credit 1	**Site Selection**	1
1			Credit 2	**Development Density & Community Connectivity**	1
		1	Credit 3	**Brownfield Redevelopment**	1
1			Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1			Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1			Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	1
1			Credit 4.4	**Alternative Transportation**, Parking Capacity	1
		1	Credit 5.1	**Site Development**, Protect of Restore Habitat	1
1			Credit 5.2	**Site Development**, Maximize Open Space	1
		1	Credit 6.1	**Stormwater Design**, Quantity Control	1
		1	Credit 6.2	**Stormwater Design**, Quality Control	1
1			Credit 7.1	**Heat Island Effect**, Non-Roof	1
1			Credit 7.2	**Heat Island Effect**, Roof	1
		1	Credit 8	**Light Pollution Reduction**	1

Yes	?	No			
3		2	**Water Efficiency**		5 Points
1			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
		1	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		1	Credit 2	**Innovative Wastewater Technologies**	1
1			Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1			Credit 3.2	**Water Use Reduction**, 30% Reduction	1

Yes	?	No			
5		5	**Energy & Atmosphere**		17 Points
Y			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			Prereq 2	**Minimum Energy Performance**	Required
Y			Prereq 3	**Fundamental Refrigerant Management**	Required
3			Credit 1	**Optimize Energy Performance**	1 to 10
		3	Credit 2	**On-Site Renewable Energy**	1 to 3
1			Credit 3	**Enhanced Commissioning**	1
		1	Credit 4	**Enhanced Refrigerant Management**	1
1			Credit 5	**Measurement & Verification**	1
		1	Credit 6	**Green Power**	1

continued...

Yes	?	No	Materials & Resources	13 Points
7		6		

Y			Prereq 1	**Storage & Collection of Recyclables**	Required
		1	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		1	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		1	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
1			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
1			Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
		1	Credit 3.1	**Materials Reuse**, 5%	1
		1	Credit 3.2	**Materials Reuse**,10%	1
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
1			Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regic	1
1			Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regic	1
		1	Credit 6	**Rapidly Renewable Materials**	1
1			Credit 7	**Certified Wood**	1

Yes	?	No	Indoor Environmental Quality	15 Points
12		3		

Y			Prereq 1	**Minimum IAQ Performance**	Required
Y			Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
		1	Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1			Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
1			Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			Credit 6.1	**Controllability of Systems**, Lighting	1
1			Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
1			Credit 7.1	**Thermal Comfort**, Design	1
1			Credit 7.2	**Thermal Comfort**, Verification	1
		1	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		1	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1

Yes	?	No	Innovation & Design Process	5 Points
5				

1			Credit 1.1	**Innovation in Design**: Provide Specific Title	1
1			Credit 1.2	**Innovation in Design**: Provide Specific Title	1
1			Credit 1.3	**Innovation in Design**: Provide Specific Title	1
1			Credit 1.4	**Innovation in Design**: Provide Specific Title	1
1			Credit 2	**LEED® Accredited Professional**	1

Yes	?	No	Project Totals (pre-certification estimates)	69 Points
41				

Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

Appendix E: BIM Evaluation Documents

BIM Use Priorities Chart:

PRIORITY (HIGH/ MED/ LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES
High	Increase productivity in the field	3D Coordination Construction Systems Design 3D Control and Planning
High	Eliminate conflicts in the field	3D Coordination Construction Systems Design
High	Increase the effectiveness of the design	3D Coordination Construction System Design Programming Design Authoring Cost Estimation
High	Improve site planning and logistics	4D Modeling Site Utilization Planning
High	Identify conflicts between existing and new zones	4D Modeling Site Utilization Planning
Med	Provide the owner with functional maintenance program	Building Maintenance Scheduling Asset Management Record Modeling
Med	Review design process	Design Review Programming
Low	Improve efforts to reach sustainable goals	LEED Evaluation

BIM Selective Use Implementation:

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
	PROGRAMMING	X	DESIGN AUTHORING	X	SITE UTILIZATION PLANNING		BUILDING MAINTENANCE SCHEDULING
X	SITE ANALYSIS	X	DESIGN REVIEWS	X	CONSTRUCTION SYSTEM DESIGN		BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
		X	STRUCTURAL ANALYSIS	X	DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
		X	LIGHTING ANALYSIS	X	3D CONTROL AND PLANNING		DISASTER PLANNING
			ENERGY ANALYSIS	X	RECORD MODELING	x	RECORD MODELING
			MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
			SUSTAINABLITY (LEED) EVALUATION				
		X	CODE VALIDATION				
	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION		COST ESTIMATION		COST ESTIMATION		COST ESTIMATION
x	EXISTING CONDITIONS MODELING	x	EXISTING CONDITIONS MODELING	x	EXISTING CONDITIONS MODELING	x	EXISTING CONDITIONS MODELING