Senior Thesis Final Report

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Turner

h|c|m

General Building Data

- Building name : **Susquehanna Sports Center**
- Location and site: **Bel Air, MD**
- Building Occupant **Harford Community College**
- Size: **106,955 SF**
- Dates of construction: **5/23/2011-11/07/12**
- Overall project cost: **$26.7 Million**
- Project delivery method: **Design-Bid-Build**

Primary project team

- Owner: **Harford Community College**
- CM: **Turner Construction**
- Architect: **Hord | Coplan | Macht**
- Civil: **Site Resources, Inc.**
- MEP: **BKM & Associates, Inc.**
- Structural: **CMJ Structural Engineering, Inc.**
- Natatorium: **Counsilman Hunsaker**

Architecture

- The renovation of the existing Susquehanna Center includes an expanded fitness center with a new façade that provides filtered, natural, indirect light into the space.
- The administrative offices for the athletics department and physical education faculty and staff have been also upgraded.
- The existing 25-yard swimming pool will be refurbished and fitted with new equipment.
- The new construction includes a 2,500 seat arena with wood athletic floor, concessions, ticket windows, and public toilet rooms.

Structure

- The structure of this building compromised of both structural steel and cast in place concrete. The new arena is supported by 153' long trusses spaced 8' apart.
- Cast in place concrete has been used in the main lobby area connecting the basketball arena with the Susquehanna center.

Mechanical

- All existing HVAC systems are demolished and removed except for HVAC hot water boilers.
- New HVAC hot water pumps and hot water distribution along with a new 340 ton air-cooled chiller are included.
- The existing building is served by 4 rooftop air-handling units with chilled water and hot water coils along with a dedicated DX rooftop unit for the pool area.
- The new addition is served by (4) rooftop DX air-handling units with hot water preheat coils and heat recovery wheels.

Electrical

- The secondary service will provide the buildings with 277/480 voltage power. Local dry transformers will be used to provide 120/208 voltage power for receptacles and low voltage loads.
- A diesel generator will provide emergency power to support the fire alarm system as well as life safety lighting.

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http://www.engr.psu.edu/ae/thesis/portfolios/2013/haa133/index.html

000. Executive Summary

This AE Senior Thesis is about The Susquehanna Center Renovation and Addition project, which consists of a renovation of 49,159 square feet and an addition of 58,640 square feet and costs $26.7M. It walks through a design and construction overview of the project to prep for four diverse, yet comprehensive analyses discussed right after.

Analysis 1: Reduction of weather impact on the foundation schedule

The first analysis explored how weather impacts the construction of a foundation and how that affects the scheduling process. Also, this research helped find out how much a construction team relies on weather forecasts and what techniques can be used in order to prevent weather damages. It was evident toward the end of this analysis that the construction team made the best decisions related to weather impact actions, which was proven throughout this analysis.

Analysis 2: BIM Use in the Susquehanna Center renovation project

The second analysis found the best way to make this project eligible and feasible to use BIM. A study was done in the most efficient ways to convert the documentation of the old building into a BIM friendly format. Also, it sought to find how to go about educating other parties in the project about BIM and its importance in an efficient manner. Those were the two main obstacles in the path of BIM implementation along with the cost concern. At the end, the cost analysis proved that the BIM uses suggested are actually worth implementing and would incur 44% to 140% Return Of Investment.

Analysis 3: Alternative façade system (Architectural and Mechanical Breadths)

The third analysis included architectural and mechanical breadths and its goal was to bring a better alternative façade design for the owner. Through this interesting combination of architecture and value engineering, the old and current façade systems were studied, and value engineered modifications were made based on the owner's requirements. Cost and schedule analyses determined to what extent the alternative façade system is a better option. While schedule would not be affected by the alternative façade design, $85,178 was estimated to be saved. The mechanical breadth analyzed fitness center’s cooling load and utilized Trane Trace™700 to see how it would the window type change would affect the cooling load. It indicated that the cooling load would be less by 0.7 tons which was not enough to change the chiller type.

001. Acknowledgments

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Rebecca Koch and Lutz Engineering's Project Team

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Dr. Moses Ling

My Family and Friends

002. Table of Contents

010. Project Background

011. Introduction

The Susquehanna Center Renovation and Addition, Harford Community College in Bel Air, MD includes a renovation of a 49,159 square feet and an addition of a 58,640 square feet, which adds up to 106,955 square feet. Having a project that includes both a renovation and an addition required intensive collaboration and coordination between all parties involved in this project.

This project started construction on May 23rd, 2011 and was originally planned to finish on September 17th, 2012. However, due to weather related impacts, Turner has been granted a 38 working day extension for the Arena Addition. The addition part was then turned over beginning of November and the first basketball game was held November 15th. The Renovation portion of the project has not been affected by the weather impact and already was turned over on September 17th. The total cost of the project was $26.7M after about $1.65M worth of value engineering savings.

Figure 1 shows a view of both the renovation and addition parts of the project. The canopy of the façade is shown at the left and it extends till it reaches the basketball arena addition at the right, which has a greater height. The photo was taken during construction in early September.

The new addition has 153' steel trusses that span through the new basketball arena addition. Figure 1 shows that it has a beautifully designed curtain wall at the top portion of the walls, which increases the usage of natural light. The owner, Harford Community College, had a goal to make the campus more environmentally friendly and this is one the projects that they had in their master plan. They were originally planning on getting Silver LEED certification for this project. However, the owner decided not to strive for it right before construction started, but still the environment is one of the main components to care about in this project.

The project went through several construction management issues which some of them were utilized in this proposal for the analyses. Other than the weather impact on schedule,

Figure 1: The facade's canopy of the Susquehanna Center is shown at the left, and the basketball arena addition is shown at the right. The photo was taken during construction in early September.

the pool restoration was one of the main problems. The pool was over 30 years old and the owner wanted to completely restore it. The pool was tested beginning of September prior to installation of pool tiles and it turned out it was leaking. The site team was not surprised; leakage is very possible given that the pool is relatively old. That caused a delay to the project as well.

Overall, the Susquehanna Sports Center is a great project for a construction management study as it contains both an addition and a renovation. The fact that it has a renovation part has been directly used in Analysis 2, *BIM Use in the Susquehanna Center project*, and Analysis 4, *Commissioning mechanical systems in renovation projects*.

020. Construction Overview

021. Detailed Project Schedule*

The Susquehanna Center Project started construction on the 23rd of May, 2011. Before that, the preconstruction services started back on 11th of February 2011. This project was originally planned to be completed on the 17th of September 2012, but due to unforeseen conditions a 38 working days extension has been granted to the construction team for the addition part of it, the basketball arena. The renovation part, however, has been already turned over to the owner, HCC, by the beginning of the fall 2012 semester, the 4th of September 2012. Although the Susquehanna Center has already been turned over, it has not been completely finished. The only work left is the pool restoration work, which is estimated to finish sometime by the end of the year. That is why it can be noticed that the "Commissioning, Testing, & Balancing" task is 220 days long to account for the delay it had. The Susquehanna center "final cleaning" and "substantial completion" tasks in the project schedule attached do not include the completion of the pool.

Table 1. **Project Schedule Overview***

	Duration	Start Date	Finish Date
Preconstruction	179 days	4/25/2011	12/29/2011
Susquehanna Center's Arena (Addition)	407 days	5/23/2011	12/6/2012
Site work	407 days	5/23/2011	12/6/2012
Structure	107 days	8/10/2011	1/5/2012
Building Envelope	81 days	11/10/2011	3/1/2012
Rough-in	70 days	12/9/2011	3/15/2012
Finishes	237 days	11/23/2011	11/7/2012
Susquehanna Center's Renovation	193 days	5/31/2011	2/23/2012
Demolition	36 days	5/31/2011	7/19/2011
Fit Out	132 days	7/20/2011	1/19/2012
Pool Restoration	280 days	8/17/2011	9/11/2012
Commissioning, Testing, & Balancing	220 days	11/29/2011	10/1/2012
Susquehanna Center Substantial Completion	0 days	12/6/2012	12/6/2012
Total	**424 days**	**4/25/2011**	**12/6/2012**

**Please refer to Appendix A for the Detailed Project Schedule.*

Table 1 in the previous page shows an overview of whole project schedule including the preconstruction period. This project is estimated to take about 424 business days in total, about a year and 7 months. It would have taken about a year and 5 months if everything was according to the original schedule. The site work tasks include "Site Utilities" and "Tennis Courts" tasks as well. You will notice that it took the whole period of construction, because that Tennis Courts did not start construction until the end of the project, which is estimated to finish by the project completes.

Preconstruction services took about 2 months and a half. It included an engineering and shop drawing period, submitting them, and getting them approved. Material lead times were to do a part of the preconstruction services where the construction team made sure all the materials arrive on time to avoid any delays. Also included are all the critical submittals for the project, permits, and other typical preconstruction services. The detailed project schedule attached shows the preconstruction services tasks first and then it is followed up by the MEP coordination tasks. Those are put in there to show an example of coordination for one aspect of the project to help visualize its relation to the actual project construction tasks. After that the "Susquehanna Center's Arena Addition" tasks come right before the "Renovation of Susquehanna Center" tasks. Each of the two project parts, addition and renovation, are broken down into the different phases that it includes to make it easier to follow.

As can be noticed, a big gap between the "Tennis court Earthwork" and the "Retaining Walls & Steps" tasks under the Tennis Court section in Appendix A, Detailed Project Schedule. That is because it has been delayed due to weather impacts. Tennis courts need a consistent dry weather to construct. It will not take long, but the problem in Maryland is that weather is not consistent. It kept raining in April quite much that the tennis court construction has to be rescheduled to the fall. The old tennis courts have been completely demolished, but the new courts which are to be located to the east of the Susquehanna center will be constructed sometime at the end of September.

The Project Schedule is based on normal weather conditions for this area of the country. The cost to make up lost time due to inclement weather is included in the work. Work hours are from 7:30 AM to 5:00 PM Monday through Friday. With pre-approval by Turner and Owner's Harford Community College, the Subcontractor may work ten (10) hour days at its own expense to maintain the Project Schedule, if required must also notify Turner forty-eight (48) hours in advance. There will be times in keeping with the College annual schedule when quiet times will be observed such as before and during finals. These times are coordinated with Turner Project Superintendent and all impacts to comply with these times are included with the Scope of Work.

022. Project Cost Evaluation

The total cost for the project was estimated to be $26.7M. The cost estimate was prepared by Turner. This section evaluated the total project cost and compared it to actual costs and R.S.Means estimate.

Actual Building Costs

	Cost	Cost / SF
Construction Cost (CC)	$24,572,180	$229.74
Total Cost (TC)	$26,700,000	$249.64

Table 2. **Actual Building Cost Data**

Building Systems Costs

System	Total Cost	Cost / SF
Concrete	$1,895,530	$17.72
Masonry	$1,596,620	$14.93
Structural Steel	$1,048,791	$9.81
Plumbing and HVAC	$4,740,908	$44.33
Electrical and Fire Alarm	$1,723,183	$16.11
Glass systems	$1,145,650	$10.71

Table 3. **Major Building Systems Costs**

*Square Foot Estimate**

A square foot estimate has been prepared for this project using R.S.Means data. The cost came to be significantly lower than the actual cost because R.S.Means did not count for the long-span basketball arena trusses. It has been assumed that the arena is among the gymnasium building category.

Arena Addition Cost: $8,199,500

Susquehanna Center Renovation Cost: $8,273,000

**Please refer to Appendix B for a detailed breakdown for the Square Foot Estimate.*

*Assemblies Cost Estimate**

A mechanical system cost estimate has been prepared which came out to a total of $1,369,401.35 which is also less than the actual cost. The actual cost for mechanical and plumbing systems together is well above $4M. The reason behind that is the assemblies estimate was done for the addition only, so it is extra for the renovation part. Renovation part came out to be much more expensive because they demolished the old system and renewed it with another brand new mechanical system. Not to mention that the $4M assemblies cost does not have the value engineering value subtracted.

**Please refer to Appendix C for Mechanical assemblies cost*

General Conditions

In the Susquehanna Center Renovation and Addition project, the general conditions costs were split into four main categories: Project Staffing, Temporary Facilities, Temporary Utilities, and Protection and Safety. The home office overhead and contingency are not included. The total of general conditions came to a total of $907,645.54, which means a total weekly rate of $11,345.57.

Table 4. **General Conditions Estimate Overview****

Categories	Unit Rate	Unit	Quantity	Total Cost
Staffing	$6,889.82	Week	80	$551,185.74
Temporary Facilities	$1,593.23	Week	80	$127,458.40
Temporary Utilities	$1,397.69	Week	80	$111,815.00
Protection and Safety	$1,464.83	Week	80	$117,186.40
TOTAL	**$11,345.57**		**80**	**$907,645.54**

Staffing*** includes the fee for the staff for both the preconstruction and construction phases. The divisions involved in this are the Management, Estimating/Purchasing, Superintendence, Engineering, Financial, and Administration. While developing the General Conditions Estimate, it was taken into account that there was a time extension, so the total would be less if it was to finish on time. Temporary Facilities and Temporary Utilities* include all the costs related to mobilization, maintenance, temporary heat, light, plumbing, etc. Protection and Safety category includes anything related to safety in general such as sidewalk fences, safety program, railing, etc.

***Please refer to Appendix D for the General Conditions Estimate.*

****Please refer to Appendix E for a detailed Staffing plan.*

The percentage of general conditions to the total project cost is about %3.3. This is lower than what typically seen in construction. The reason behind this is that contingency, home overhead and general requirements are not included. General requirements include general cleaning, general office expenses, financing processing fee, etc.

023. LEED Evaluation*

LEED, Leadership in Energy and Environmental Design, is a program that promotes sustainable and green building through a verification point system run by U. S. Green Building Council (USGBC). The most up to date LEED point system is LEED version 3 which has total points of 110 points distributed between its different topics. Its topics are Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, Innovation in Design, and Regional Priority.

The Susquehanna Center initial design was targeting a LEED Silver Certification. The owner, Harford Community College, decided not to chase it in order to cut down short term costs. In this section, it is assumed that the project went according to the initial plans and it strived for LEED Silver Certification. Each one of the topics will be evaluated accordingly using LEED rating system version 3.

Sustainable Sites

In order to gain points in each of the 7 topics introduced by the LEED rating system, the building has to meet the prerequisites each one requires. For the Sustainable Sites topic, the building has to have a Construction Activity Pollution Prevention Plan. The Susquehanna Center does meet this prerequisite by creating and implementing an erosion and sedimentation control plan for all of the project's construction activities. That was done by stockpiling topsoil for reuse which also prevents its loss by rain or wind. In addition, sediment traps have been made to prevent sedimentation of storm sewers or receiving streams.

Points can be gained in the LEED system after the building meets the prerequisite for a particular topic, if there are any, and meets credits prescribed by the topic. The more credits it meets, the more points it gains. The Susquehanna Center is in an area that meets all the requirements to gain a point for the Site Selection credit, which is a not a farmland, previously undeveloped land, land within 100 feet of any wetlands…etc. It also has bicycle racks, changing rooms close to entrance, 5% parking for low-emitting and fuel efficient vehicles, and another 5% for vanpools and carpools.

**Please refer to Appendix F for the LEED Checklist*

Water Efficiency

Water Efficiency topic requires Water Use Reduction plan as a prerequisite before it can receive any points for the topic. It requires employing strategies that decrease the water use baseline calculated for the building by 20%.

The building is actually designed for 30% water use reduction by providing more efficient toilets, urinals, faucets and showerheads. That qualifies it for 2 points in addition to meeting the prerequisite. This percentage may increase to 40% which could add 2 more points.

The landscape irrigation in the project uses 100% treated water rather than potable water which qualifies it for full 4 points for the Water Efficient Landscaping section. Moreover, the project introduces an innovative wastewater technology that captures rainwater and uses it in the building as seen in **Figure 2**. This has been actually implemented in the project at the south side of the Arena Addition right below the roof cantilever despite the fact the project is not chasing LEED.

Figure 2: Drainage pipes along the south side of the basketball arena. The pipes create an architectural feature and functions as a roof rainwater collector.

Energy and Atmosphere

Energy and Atmosphere requires 3 prerequisites which are: Fundamental Commissioning of Building Energy Systems, Minimum Energy Performance, and Fundamental Refrigerant Management. Fundamental Commissioning of Building Energy Systems is to make sure certain building energy systems are going to be commissioned. Minimum Energy Performance is to establish a minimum level of energy efficiency for the building. Fundamental Refrigerant Management is to reduce stratospheric ozone depletion by not using CFC based refrigerants in HVAC systems. All the prerequisites are met in this project.

The first points that could be gained in this topic are from optimizing energy performance. The design team has to demonstrate a percentage improvement in the proposed building performance rating compared with the baseline building performance rating. The new addition showed 14% and the existing showed 10% at least. That qualifies the building for 2 LEED points. That percentage could increase to 18%/14% after the building is constructed and the actual testing is done, which could add 2 more points.

Materials and Resources

The prerequisite for Materials and Resources topic is to provide an easily-accessible dedicated area for the collection of recycling materials for the entire building. Despite the fact that the project is not going for LEED anymore, the construction team still recycles materials as per the owner recycling requirements. Since this project is a renovation and an addition project, more than 55% of the projects structure was reused. This qualifies the project for one LEED point in this topic. Also, more than 75% of the waste is recycled or salvaged, more than 20% of project contents are recycled, and more than 20% of the materials are extracted or manufactured within the region. All that adds up to 8 points in this topic.

Indoor Environmental Quality

LEED also promotes increasing indoor environmental quality and that has two prerequisites: Minimum Indoor Quality Performance and Environmental Tobacco Smoke (ETS) Control. The first prerequisite is to establish a minimum IAQ performance to contribute in the comfort and well-being of occupants. That is done by meeting the minimum requirements of ASHRAE Standard 62.1-2007. The second prerequisite is to prevent or minimize exposure of building occupants, indoor surfaces and ventilation air distribution systems to tobacco smoke.

That is done in this project by prohibiting smoking in the building. The first point that the project was trying to earn is from providing natural ventilated space. That is done by providing a really nice patio space in the arena addition which has a view over the tennis courts and the beautiful landscape around the building. There was a construction indoor air quality management plan during construction and before occupancy that enhanced the overall IAQ. In addition, it was planned to use low-emitting materials, and use adhesives, sealants, and paints, flooring systems that comply with the volatile organic compound (VOC) limits. For instance, terrazzo has been used, which has low VOC number. Moreover, Controllability of systems in lighting and thermal comfort weighs more LEED points. For example, the project was designed to have light sensors, LEDs.

Innovation in Design

The Innovation in Design topic give the opportunity to achieve exceptional performance above the requirements set by the LEED rating system. The project team is targeting 45% water use reduction, 95% in building material re-use, and 95% recycled or salvaged waste during construction. At the time of design, the team was still not sure whether they would be able to get points out of this or not. It all depends on what will turn out after the building is actually constructed. Also, one point could be gained because one of participant in the architect team is a LEED accredited professional. This helps support and encourage the design integration required by LEED.

Regional Priority

The Regional Priority topic is to provide an incentive for the achievement of credits that address geographically specific environmental priorities. For the projects specific zip code, three more points could be earned because of site selection, controllability of lighting systems, and thermal comfort design.

024. Existing Conditions

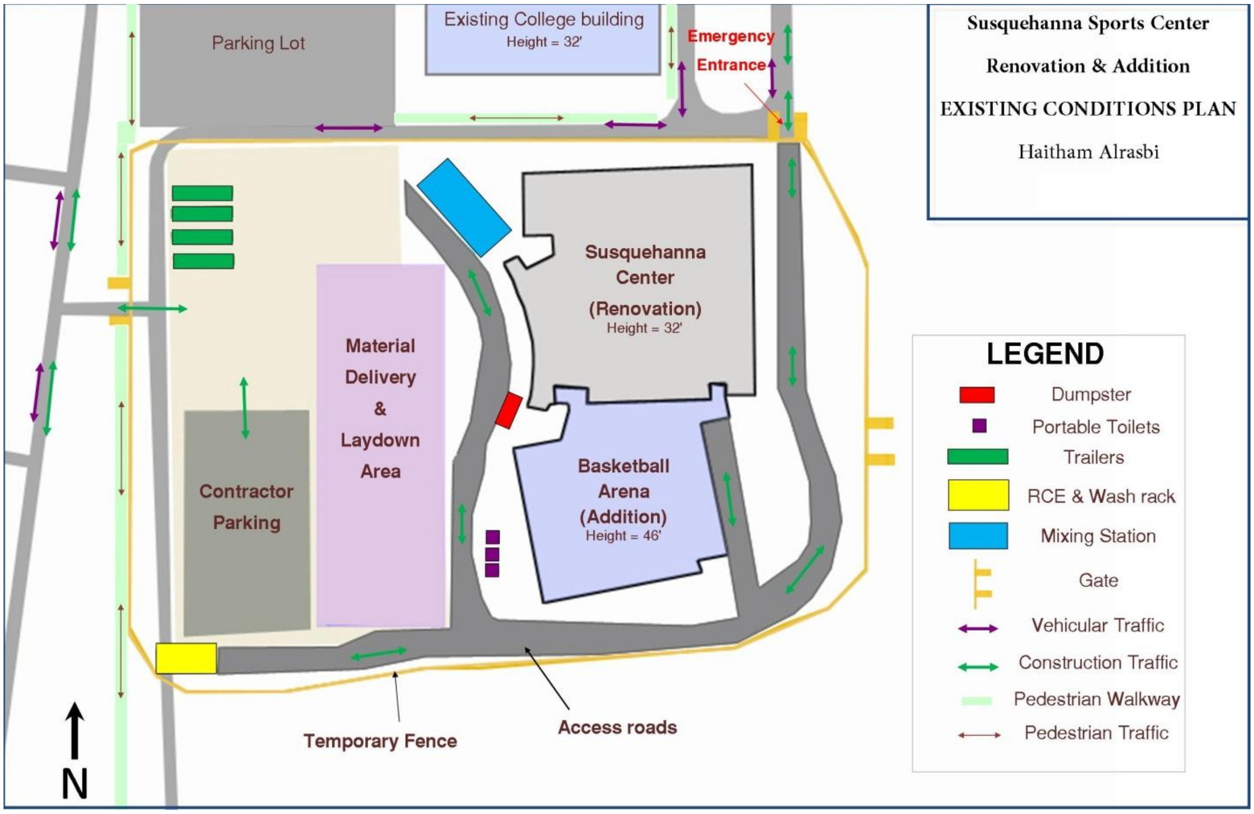

Figure 3: Existing conditions site plan

Figure 4 shows an existing conditions site plan of the Susquehanna Sports Center. Susquehanna Center Renovation part is at the north of the Basketball Arena Addition. The site could be entered from both the west side and from the north-east. The west side is mainly used by contractors and employees who work at the trailer offices. The north-east entrance is mainly used by material delivery trucks, construction worker, etc. The site plan shows how construction, vehicular, and pedestrian traffic flows. All of this was taken under account to construct the best and the safest site logistic plan for students, construction workers, and everybody else.

**Please refer to Appendix G for a better resolution Existing Conditions Site Plan and for the Site Logistics plan provided by Turner.*

025. Site Layout

For the site layout plans, site plans are phased into three phases: Excavation, Superstructure, and Finishes. Each phase is explained and walked through in the sections related to each one below:

*Excavation phase**

Before the excavation began, workers started mobilization into the site and setting up the fence, trailers, mixing stations, dumpsters, toilets, equipment, and everything that will help them get the excavation phase started. The Susquehanna Center has been closed completely for renovations, which means students are not permitted to access it until construction finishes. The north-east entrance is determined as the emergency entrance.

**Please refer to Appendix H for Excavation phase site layout*

*Superstructure phase***

The superstructure phase consisted of constructing the building using cast in place and structural steel frames. As discussed before, the basketball arena is designed to have 153' trusses which hold the cantilevered roof. Taking into account the shape and perimeter of the site, and both time and cost efficiency, 150' Krupp mobile is chosen.

***Please refer to Appendix H for Superstructure phase site layout*

*Finishes phase****

In the finishing phase, a lot of material is transported into the building, so most of the time both material hoists are being used. The pool inside of the Susquehanna center is being restored so materials are needed to transport into there too.

****Please refer to Appendix H for Finishes phase site layout*

026. Local conditions

Site description

The Harford Community College campus is located in the Churchville area of central Harford County. The Susquehanna Center athletic building is located on the east side of the campus east of Thomas Run Road.

The ground surfaces south and west of the existing building are irregular and indicate extensive grading. To the east of the proposed addition, the ground surface forms a swale running into the wooded area east of the property. The large open grassed area to the east of the existing Susquehanna Center is likely closer to original grade. In the outside paved and athletic field areas, the ground is generally grass covered with intermittent landscaped clusters of trees.

*Subsurface material**

Topsoil was found at the surface of all borings except P-1 and P-4 in pavement areas. The pavement encountered in the both borings was composed of 6 inches of hot-mix asphalt over a 6-inch crushed stone base.

Existing fill was found in borings B-1, B-3, B-4, B-5, and B-7 within the proposed building area. These fills, particularly in boring B-7, are likely the result of filling the former swale or intermittent stream as shown on the previously referenced USDA Soil Survey running west to east through the center of the proposed building addition. The fill generally consisted of loose sandy silt or silty sand or medium stiff, low plasticity sandy silt & clay.

Existing fill was also found sometimes in the site borings. SWM-5 encountered 6 feet of loose sandy silt which, given it position, likely represents filling of the original swale. Fill was also found in SWM-1 to a depth of 6 feet; in pavement boring P-5 to at least 5 feet; and SWM-4 to a depth of 3 feet. The possible fill designation in B-7 indicates that a definite conclusion could not be made as to whether the soil layer was fill or original ground.

*Groundwater conditions**

Groundwater was encountered within all the borings drilled within the proposed south building addition area, as well as in two of the three SWM borings south of the proposed building addition. Groundwater was encountered one day following completion of drilling operations in borings B-1 through B-7, SWM-3 and SWM-5 above borehole cave-in depth.

**Please refer to Appendix I for Boring and Test Pit Location Plan*

Groundwater levels ranged from as deep as 23.3 feet in B-3 to as shallow as 7.5 feet in boring SWM-5; however, when comparing groundwater elevations, it was found that groundwater levels were very uniform within most of the building area ranging in elevation from 364 to 366.5 in borings B-1 through B-6 and elevation 370 in B-7. In SWM-3 and SWM-5, groundwater levels range in approximate elevation from 362 to 365.

Recycling and tipping fees

This project was at some point in the design phase striving for Silver LEED certification, but then the owner decided not to do it before the project started. However, recycling service is maintained in this project. There is a dumpster service on site which collects combined trash and then sorts it. Percentages of how much recycling has to be done are provided to the construction team, and that has been set as goal for the team.

Parking

The Susquehanna Center did not have sufficient parking, so it was within the scope of work to add parking spaces which could be used for the Susquehanna Center, the added basketball arena, the soccer fields, and the surrounding Harford Community college buildings. There were about 200 parking spaces for the Susquehanna center. The tennis courts were removed from the front the Susquehanna Center and replaced by an additional 400 parking spaces. The tennis courts will be moved to the back (East) of the Susquehanna Center. Since the parking spaces are taking a large space in the construction site, some of it was used for trailer space and storage before the parking was constructed. After it was constructed, it was used sometimes for storage space. The construction team and workers used the existing parking spaces throughout the timeline of the project.

Permitting

The construction team did not face any problems prior to construction regarding local conditions and permits. Submittals and approvals were all done well before the construction start date to allow for material lead time, engineering/shop drawing period, and other typical preconstruction activities. All that leads to having everything in the preconstruction period go smooth and as planned. Construction started May 23rd, 2011 as initially planned.

027. Client Information

Harford Community College (HCC) is the owner of this project. It is located in Bel Air, Harford County, Maryland. It was founded in 1957. Their mission is to provide high quality educational experience for the community through a dynamic, open-access institution along with promoting lifelong learning, workforce development, and social and cultural enrichment. Their most fundamental values are Lifelong Learning, Integrity, Excellence, Diversity, Communication and Collaboration, and Service.

Figure 4: HCC's mascot (blog.sidearmsports.com, 2011)

The Susquehanna Sports Center Expansion and Renovation is a part of Master Plan adopted by the Board of Trustees for fall 2008 – fall 2012. There was a former plan developed in the late 1980s, but it became outdated as the current president states so they needed a new plan. There are many reasons for this plan. It creates more green area that helps protect the environment and makes the college more livable. It reconfigures walkways and roads, and creates more parking spaces.

HCC is not only open for students, staff, faculty; it also has many events open for the community of Harford County. It is considered as the educational, cultural, and recreational center of the county. A cultural events program and a community theater produce a full series of offerings each year. Thomas Run Park on the College campus offers a lighted artificial turf field for lacrosse and soccer, and several baseball and softball fields serving adult athletic needs for tournaments, evening activities and special events. Other indoor and outdoor athletic and recreation facilities open to the community include the gym, fitness center, pool, tennis courts, basketball, and sand volleyball.

All in all, This Facilities Master Plan will guide the expansion and renovation of HCC's facilities to meet programmatic needs, restore satisfactory physical condition, meet regulatory requirements, implement the College's Strategic Plan, and maintain alignment with a campus-wide sustainability initiative that encourages environmentally responsible plans, services, operations, and curricula. (hardford.edu, 2008)

028. Project Delivery System

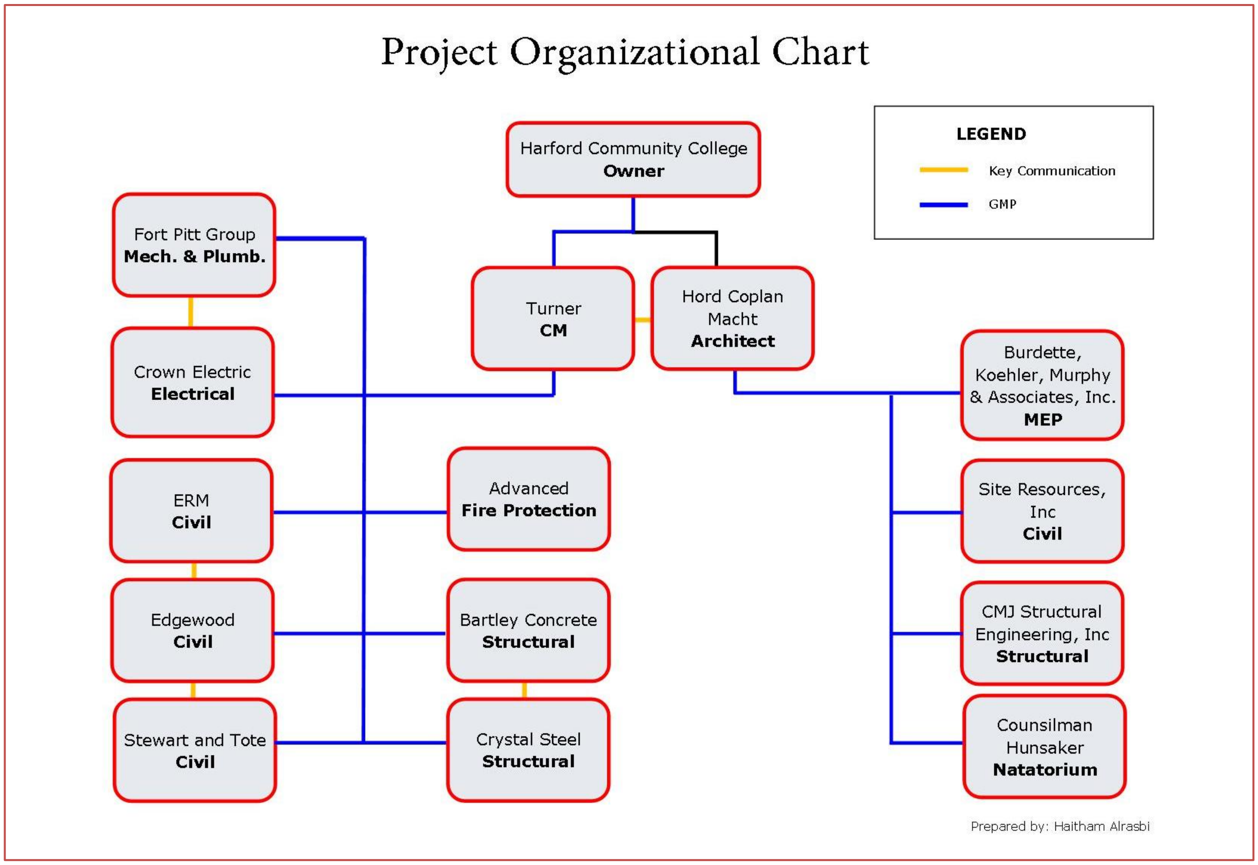

Figure 5: Project Organizational Chart

The owner, Harford Community College, and Turner have both agreed on a Guaranteed Maximum Price (GMP) contract in order to execute this project. Turner holds the subcontracts for the Civil, Structural, MEP, Fire protection contractors along with others. Figure 5 better describes the relationship between the key parties in this project. Hord Coplan Macht has MEP, Civil, Structural and Natatorium designers that work under their umbrella.

029. Staffing Plan

The staffing for Turner in this project is Doug Belling as a Project Manager, John Ricketts as Lead Superintendent, Brendan Kerin as Engineer. Just last spring Rick Sopala was added as a Renovation Superintendent to the project. This adds up to four employees working full-time at the site. Table 4 below shows the breakdown for Turner's other employees that work back at Philadelphia's main office along with the construction team at site. It also shows the time duration of work they spent on the project.

Staff	Duration	
Preconstruction		
Estimating/Purchasing		
Chief Estimator	5	months
Secretary	5	months
Sr. Estimator	5	months
Superintendent	5	months
Sr. Mechanical Estimator	3	months
Project Manager	5	months
Superintendent	5	months
Construction		
Management		
Operations Manager	16	months
Project Executive	16	months
Project Manager (D.Belling)	16	months
Estimating/Purchasing		
Purchasing Manager	3	months
Purchasing Agent	2	months
Purchasing Clerical	2	months
Superintendence		
Project Superintendent (J.Ricketts)	14	months
PM MEP / Commissioning	1	months
Asst Super /Engineer	14	months
Safety Director	14	months
Engineering		
Project Engineer (B.Kerin)	16	months
Financial		
Accountant	16	months
Cost Engineer	16	months
Other		
Administrative Assistant	14	months

Table 5: **Staffing Plan**

030. Design Overview

031. Architecture

The renovation of the existing Susquehanna Center includes an updated and expanded fitness center with a new façade that provides filtered, natural, indirect light into the space. The administrative offices for the athletics department and physical education faculty and staff will also be upgraded. The existing gymnasium will be updated and retained as an all-purpose auxiliary gym with studios for martial arts, yoga, Pilates, and other fitness classes. The existing 25-yard swimming pool will be refurbished and fitted with new equipment and the athletic training facility, locker and team rooms will be renovated. The new construction includes a 2,500 seat arena with wood athletic floor, concessions, ticket windows, and public toilet rooms. The facility is designed to accommodate locally televised basketball games as well as large public concerts and events.

Figure 6: A rendering of the Susquehanna Center's facade

032. Building Systems

Demolition

For the western building addition, all vegetation, topsoil, existing fill and otherwise unsuitable materials within the building pad area extending to about 5 feet beyond the exterior wall lines were removed to expose undisturbed native soils. All existing utility trench backfill was removed. After performing the necessary underpinning*, the building pad area was cut to grade.

Structural Steel Frame

What is interesting about the usage of the structural steel in this project is that they used (23) 153' 96SLHSP trusses spaced 8' apart that span through the new basketball arena addition (Figure 1). W6x25 are also used at the south and north sides of the arena to hold the cantilevered roof. W10x12, W16x31, and W12x14 are used at the Susquehanna Center addition along with HSS6x3x5/16 used in the façade of the center. Cast in Place concrete has been used in the main lobby area connecting the new basketball arena with the Susquehanna center. All structural steel are obtained from a domestic origin and meet all requirements of "Maryland Buy American Steel Act."

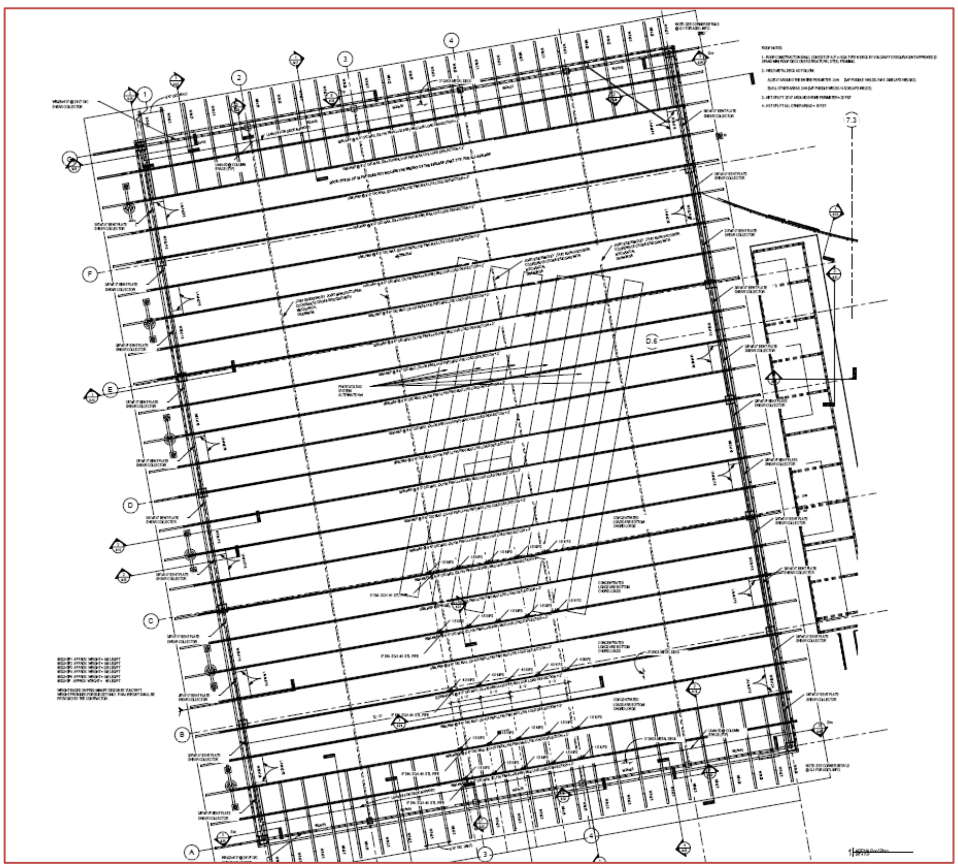

FIGURE 7. STRUCTURAL DRAWING OF THE ARENA ADDITION

**Please refer to Appendix J for a better resolution drawing of the basketball arena*

Cast in Place concrete

Cast in place concrete is used in all concrete construction in this project. No precast concrete has been used. Common or Utility grade formwork used for non-exposed surfaces. Structural or Construction grades are used for wales, braces, and supports. All lumber used for formwork are either Western Wood Products or Southern Forest Products grading. Plywood is APA PS-I, B-B, or Exterior Grade MDO. Glass fiber reinforced forms are used for cylindrical columns, pedestals, and supports with smooth surfaces that will produce surfaces without seams or irregularities which exceed specified formwork surface class. As for concrete placement methods, a concrete pump truck is used to pump concrete.

Mechanical System

All existing HVAC systems will be demolished and removed except for HVAC hot water boilers. New HVAC hot water pumps and hot water distribution along with a new 340 ton air-cooled chiller are included. The existing building is served by 4 rooftop air-handling units with chilled water and hot water coils along with a dedicated DX rooftop unit for the pool area. The new addition is served by (4) rooftop DX air-handling units with hot water preheat coils and heat recovery wheels.

Electrical System

The power distribution system is serviced from the North-West portion of the existing building on the main level. Baltimore Gas and Electric supplied a 2000kVA transformer that the building is fed by. The secondary service will provide the buildings with 277/480 voltage power. Local dry transformers will be used to provide 120/208 voltage power for receptacles and low voltage loads. The service entrance point is on the North-West portion of the building on the main level. A diesel generator will provide emergency power to support the fire alarm system as well as life safety lighting.

Masonry

The typical exterior finish is brick veneer with masonry backup walls. Veneer wall ties are used to hold up it up with the brick (Figure 2). The materials included in the masonry are: water, Portland cement, hydrated lime, aggregate for mortar, water repellent admixtures, accelerators and retarders, and color additives. Aggregate are stockpiled from same quarry to insure consistency in color. Masonry, mortar, and blended cements are not permitted in this project.

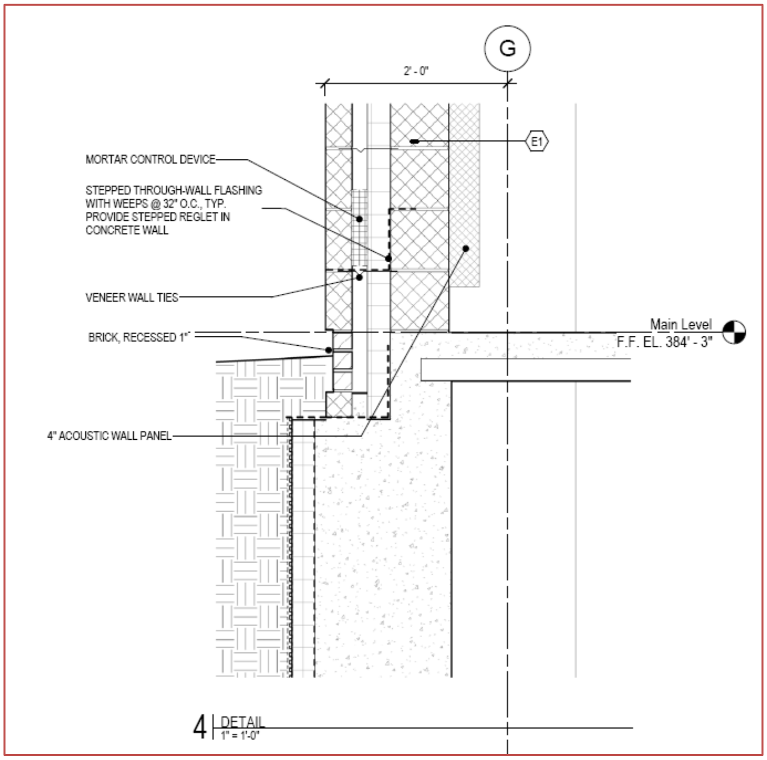

Figure 8. Brick veneer connection detail

Curtain Wall

Hord, Coplan, & Macht were the main architects for this project, therefore they designed the curtain wall. The Curtain wall is located above the arena masonry wall. A mix of blue, green, and clear insulated glass has been used along with 7” x 2 ½” aluminum curtain wall frames which creates this aesthetically pleasing look to the arena. It drops down to the entrance of the arena. The glass there is tampered to allow for doors to be installed.

Figure 9. Rendering of the Susquehanna Center Project

Support of Excavation

The existing south wall loads of the Susquehanna Center will have to be carried below the founding elevation of the new arena addition which will be as much as 9 to 10 feet deep below the existing footing. Since the proposed building addition wall will directly correspond to the existing wall, it will not be possible to construct a permanent soldier pile or lagging wall to support the existing construction and founding soils as could be possible if the new addition wall was slightly offset from the original. Given the configuration, it has been decided to underpin footings in a series of pits to extend sufficiently below the proposed building addition excavation.

100. Analysis 1:
Reduction of weather impact on the foundation schedule

101. Problem Identification

The project team has asked for a total of 38 working days as an extension mainly because of the rain impact on the foundation phase. The construction stopped as pouring concrete for footings was in the critical path. The scheduler for this project added 7 working days as a float, but it was not enough. After many discussions between the owner and Turner, they approved the extension. This Analysis analyzed the incident that happened in the project and explored what could have been done differently in both preconstruction and construction phases in to minimize or eliminate the delay.

102. Research Goal

The goal of this research is to analyze how weather impacts the construction of a foundation and how does it impacts the scheduling process. Also, this research helped identify to what extent the construction team relied on weather forecasts and what techniques were used in order to prevent weather damages. That should reflect on the scheduling process and the duration of the respective tasks. The Susquehanna Center will be taken as an example and as a basis of the research.

103. Potential Solutions

In order to minimize the damage of weather in a foundation system, it needs to be analyzed from two different aspects: physical techniques and predicted schedule duration. The physical techniques are all the physical means possible to prevent the foundation system from any weather damages. All that should reflect on schedule as well, which is the second aspect that needs to be analyzed. Depending on the weather predictions and physical means used, a float will be added to the foundation schedule activities. The task duration has to be just right, neither too small that the project team has to deal with a delay if it went over the allocated duration, nor too large that it will take a much longer duration than desired.

104. Expected Outcome

This research topic seems to have a great potential as weather could have a severe damage and it is sometimes underrated because extra weather precautions mean extra money and time spent. This research aims to provide affordable weather precautions that would prevent the majority of weather damages that could happen without having to pay heavily for advanced techniques or having to put long floats on critical construction activities.

110. Background Research

Weather plays an important role in every construction project. It has to be taken into deep consideration in order to achieve project completion with minimal implications. Weather can take any shape of influence and it has a wide range of effects. It could be anything from worker discomfort to delay in major critical path activities. Figure 10 below shows a small example of how worker's discomfort may become a problem. Real Estate Economics has published a study that identifies two different ways that weather impacts can take. The first one is seasonal effects, which are the weather effects caused by different seasons. Contactors tend to account for different seasons, but it is impossible to predict the exact weather conditions. The second influence is unseasonable effects, which are even harder to predict. They can come anytime with short or no notice. (myweather2.com, 2012)

The cause of weather is the reaction to changes in atmospheric pressure. Pressure would make air move and change its temperature and humidity. The more dramatic the change is, the more severe the rain will be. Many attempts have been made by human to control climate, but all of them have concluded that it is impossible, so that is not an option. Meteorologists can predict these changes with limitation in short-term accuracy. Those are what are called weather forecasts, which are what construction managers mainly rely on when scheduling their construction projects. (Crissinger, 2005)

The impact of weather can differ greatly in severity based on many factors. Two example factors would be construction phase and the type of weather that causes the impact. Generally, weather would have less impact if the building was enclosed and all the materials inside are secured. Also, wet weather tends to carry more damage than dry weather. For the scope of this thesis analysis, the main focus will be rain damage on the foundation phase.

Figure 10: A picture of the back of the Basketball Arena where some landscape work is taking place. It shows that rain made the site muddy, which could contribute to discomforting the workers when maneuvering around. (Photo taken: September 28th, 2012)

120. The Susquehanna Center weather impact case

The rain during the foundation phase was a great challenge to the construction team. It was the main cause for the schedule delay which has put back the completion date until mid-November 2012. It was originally scheduled to complete on September 17th, 2012. The only part that was affected by the delay is the basketball arena. The renovation was already turned over to the owner on the 4th of September 2012.

Once the campus re-feed of the domestic water was finished to remove the existing domestic line that ran along the south end of the building (shown in Figure 11 below), there was an underpinning work scheduled to start at August 4th 2011. Footing excavation along the south face and extended up the west face of the arena addition was scheduled on August 16th. A 10" rainfall had fallen into the site while 3" of rain was anticipated which caused a delay in placement of footings. Only the south spread footing had been placed by the end of August. [Belling, Doug (Project Manager), Sep. 19th, 2011]

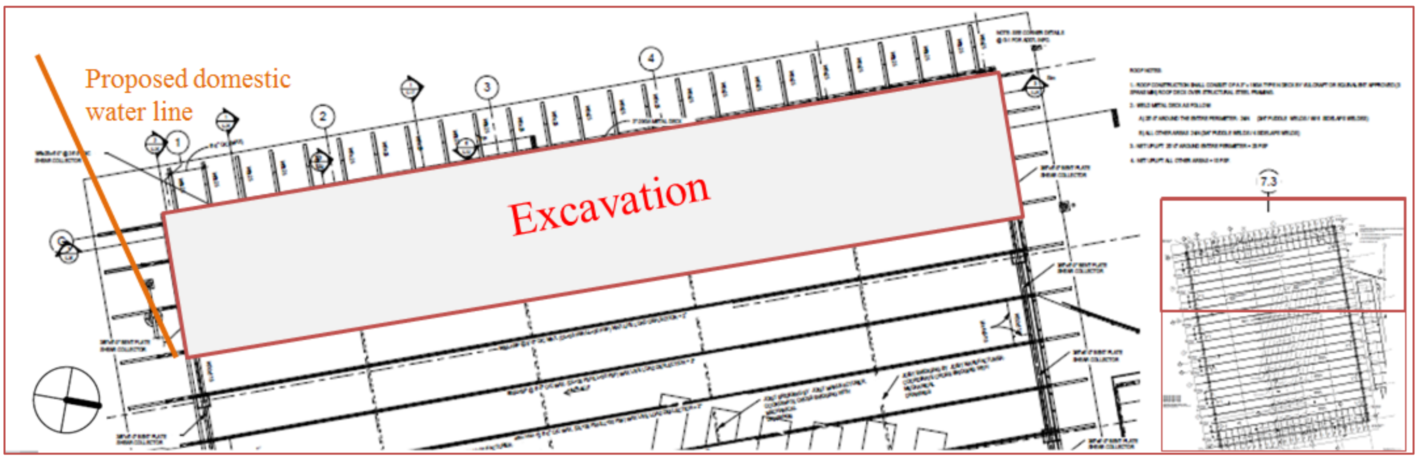

Figure 11: The South-West side of the Basketball arena (Addition) where the excavation started, and where the domestic water line feed into the building is located. Appendix J includes a better resolution drawing of the close up basketball structural drawing.

Turner had been in contact with the owner about the issue. They explained everything to the owner and requested 32 days extension which is a sum of 17 days for removal of accumulated water and wet material and 15 days to get back into construction activities. At first, the owner agreed on the 17 days only, but then they granted Turner what they requested.

Turner has also considered working overtime in some critical path activities and usage of concrete accelerators to make up for the schedule delay. It is very evident from the communication between the CM and the owner that negotiation skills are of high importance in the construction industry in general. If the project manager did not explain the situation properly, they might not have gotten the extension.

130. Means and Methods

In the "Means and methods" section, different ways of how to prevent and deal with weather delays are analyzed. First, accounting for weather in scheduling is discussed along with the different methods to implement it. Second, physical techniques to prevent whether from affecting construction (foundation) activities are investigated and whether they were viable in the Susquehanna Center project. Third, importance of negotiation and coordination with other parties in the project about the case with the case are discussed along with the legal aspect of it.

Accounting for weather in scheduling

Weather causes construction delays in many cases and in order to analyze that construction delays and studied along with the ways to account for them in general when scheduling. The component of each activity that corresponds to accounting for construction delay is the float. It is a leeway assigned to schedule activities according to historic information, scheduler's judgment, weather data, etc. Incorporating float into activities can take many ways, two of which are "early start" and "late start." An "early start" schedule contains controllable float where there is no float in the "late start" schedule, which means all activities are critical in a "late start" schedule. An "early start" schedule activities are mostly not critical. Owners prefer to use "late start" schedules because contractors do not have that much flexibility. This is specially the case when the owner owns the float. (Hinze, 2010)

In the Susquehanna Center project, an early start schedule has been utilized throughout the lifetime of the project, because Turner was responsible of 7 days of the float. This gives them some flexibility on the schedule and allows them to cut time in some activities if they were late in others.

After a general schedule has been developed, activities should be examined one by one. This is particularly important for accounting for weather impact because this helps determine at which time of the year a certain activity is going to occur in order to prepare for weather accordingly. This should help the scheduler and the project manager anticipate problems such as delayed shop drawing approvals, delay in material deliveries, the expiration of labor agreements, and deficiencies in the cash position on the project. The project manager should also try to anticipate some rework and the loss of sometime due to inspections. (Hinze, 2010)

This indicates the high importance of the schedulers' experience while scheduling and anticipating the various events that may occur. The Susquehanna Center project is a great example of this because of the many unpredictable events that happened as implications of the schedule delay. When it was raining during the foundation phase in August 2011, it was obvious that it had direct impact to the schedule. What was not so obvious is the amount of time the construction team needs in order for the construction site to get back on track. Some materials got wet and excavation hole needed drainage. The implication this had on the project schedule that the October activities were pushed to November when weather got even worse and that meant even more time lost.

Weather-dependent activities should be scheduled before doing the network calculations. During scheduling weather-dependent activities, their duration would be increased to accommodate for a float based on the likelihood that a delay would occur and the extent of the delay. A basic example would be if history indicated that rainfall would occur 10% of the time, the duration would be increased by 10%. A second way to accommodate for weather when scheduling is to insert "weather delays" activities. Those activities would be inserted next to weather-dependent activities. An advantage of this is the duration of time added as "weather delay" would be clearer. However, adding extra activities into each weather-dependent activity would make the schedule look tight and contain more critical activities. (Hinze, 2010)

In the Susquehanna Center project case, a method similar to the first method was followed. A climatological report provided by National Climatic Data Center (NCDC) was used in the scheduling process. Rain of about 4" was anticipated, which should not affect foundation activities. The scheduling team, though, decided to add 7 days of total float to the foundation activities as a precaution. However, about 11" of rain had fallen when footing concrete pouring was about to start which caused a direct delay of 15 days to the project, which is beyond the 7 days accounted for. The total delay actually came out to be 32 days. The construction team was granted a 38 day extension after a series of meetings and negotiations with the owner. The owner-CM negotiations are further discussed in the "legal" section of this analysis.

The unit of time used is another scheduling consideration that should be taken under account when accounting for weather. Units of time used in construction schedules are usually either working days or calendar days. In the Susquehanna Center project, calendar days are used because they are more commonly used for building construction and are easier to deal with in case the project did not go as planned.

Weather could be very difficult to predict, but it is not impossible. The construction team always tries to estimate the lowest cost and the shortest schedule possible with the lowest risks involved. Sometimes things do not go according to plan, and that is when other options are looked at. In the Susquehanna Center project, the construction team tried their best to finish construction by the beginning of fall 2012, as the owner, Harford Community College, wished. However, it did not go according to plan and they had to act accordingly.

Physical techniques to minimize weather impact

Generally, there is not much that can be done physically during the foundation phase to avoid rain impact. One direct physical way of minimizing rainfall impact is by actually covering the excavation site to prevent rain from getting in the way of foundation activities. However, this is not feasible due to the large area of the site. The damage could be minimized by figuring out a way to drain the water out of the excavation though. If the temperature goes below zero Celsius, the water could freeze which makes it even much more difficult to deal with. In the Susquehanna Center project, drainage was not a problem because water was removed right away from the excavation using drainage pumps.

In order to minimize the overall impact of weather, there are some considerations that could be taken into account. The use of concrete accelerators helps concrete to cure quickly therefore saves some time. Working overtime for critical path trades and activities helps accelerate the schedule and bring it back to normal. In the Susquehanna Center project, the construction team worked longer days and on Saturdays during the foundation phase. That allowed them to get some preliminary work done before they increase manpower for regular hour trades.

Negotiation

If different techniques, either physical or related to schedule, did not work, a schedule extension should be requested. Requesting a schedule requires very developed negotiation skills, with either the owner or the general contractor. In the Susquehanna Center project case, Turner's Project Manager and the owner were negotiating the schedule extension till Turner got it. The owner was questioning Turner's performance as a CM at risk, but Turner responded that they treat the project as if it was their own by representing Harford Community College (owner) and Hord Coplan Macht (Architect) to the best they can. Turner's Project Manager proceeded by saying, if you [the owner] are still in doubt, then we are not effectively communicating with each other. This went on until the project manager succeeded on getting the required extension, 38 working days.

Legal

Construction delays can be categorized by their excusableness and compensability. An excusable delay is caused by an unforeseeable event beyond the contractor's control. A compensable delay is a delay where the contractor is entitled to a time extension and/or to additional compensation. Whether or not the delay is compensable depends on the terms of the contract. A No-Damage-for-Delay clause explains the responsibility of a particular party in a given delay and its liability. Generally, it states that for any excusable delay the contractor may be granted a time extension, but no additional compensation will be paid. (Trauner, Manginelli, Lower, Nagata, and Furniss, 2009)

In the Susquehanna Center project, the weather delay was excusable for sure, but was not clear whether it was compensable or not. The CM discussed that with the owner until they got it and it was determined it was compensable by a time extension. There was no specific No-Damage-for-Delay clause in the contract. Instead, it was stated that Turner will be responsible for 7 days in case an excusable delay occurs.

It is very critical for all parties to understand the contract, particularly delays and time extensions. If a contractor does not have much experience with construction law, they can consult a qualified counsel who is familiar with it prior to signing a contract, as it could be complicated sometimes. For example, a contract may say "inclement weather" is excusable and noncompensable delay. "Inclement" here can have different meanings. Inclement could technically be anything from a weather that discomforts the construction worker to a weather that destroys the building. Therefore, all parties should carefully understand the contract and its wording. (Trauner, Manginelli, Lower, Nagata, and Furniss, 2009)

Turner has done a good job defining different types of delays in their contract. That was used in their favor when negotiating with the owner about the schedule extension. For example, the contract specified that Turner is only responsible for 7 days. Turner will do their best on gaining back any time lost beyond the 7 days. That means if somehow it was not possible to stay within the 7 days buffer, the owner has to step in. The wording in the contract made the owner obliged to grant Turner the required extension time.

140. Analysis

Looking at the data gathered from the incident and from various references, it looks like all parties involved have done a good job doing their best avoiding weather impact and any consequences may occur. The major cause of the delay was the rainstorm that happened which is beyond the control of anybody. However, this incident surely contains many lessons learned which can be found if it was analyzed more thoroughly. The "Analysis" section includes a further study of each aspect of the incident.

Schedule

Weather was fairly well taken under account when scheduling for the Susquehanna Center project. Turner is responsible of 7 days of weather damage which would seem fair to the owner. However, in reality if weather continuously damaged an activity as critical as the foundation, 7 days will not be enough. Turner in turn based its weather predictions on the National Oceanic and Atmospheric Administration (NOAA) climatological report, which reduced their risk, but did not eliminate it.

According to the NOAA report (attached in Appendix K, the referred data is also shown in the next page in Figure 12), the normal value of anticipated rainfall is 3.39”. The amount of rainfall that would cause problems is 8” which far from what was anticipated. The departure from normal value is 8.58” which is unlikely. However, the rainfall came out to be 11.97” which is more than 3 times the anticipated rainfall value! It was not possible for Turner to add enough time to schedule beforehand without any justifiable reason in order to stay in competition. This suggests that there was not much could be done before to account for the weather delay in schedule without any certain data about the occurrence of the weather delay.

...THE BALTIMORE INNER HARBOR MD CLIMATE SUMMARY FOR AUGUST 31 2011...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 9999 TO 9999

WEATHER ITEM	OBSERVED VALUE	TIME (LST)	RECORD VALUE	YEAR	NORMAL VALUE	DEPARTURE FROM NORMAL	LAST YEAR
TEMPERATURE (F)							
YESTERDAY							
MAXIMUM	85	335 PM	MM	MM	85	0	96
MINIMUM	67	601 AM	MM	MM	69	-2	75
AVERAGE	76				77	-1	86
PRECIPITATION (IN)							
YESTERDAY	0.00		MM	MM	0.11	-0.11	0.00
MONTH TO DATE	11.97				3.39	8.58	4.41
SINCE JUN 1	17.07				11.28	5.79	11.42
SINCE JAN 1	33.18				27.37	5.81	27.11

Figure 12: An excerpt from the NOAA climatological report. Both observed and normal values related to the weather delay are highlighted.

Physical techniques

The construction team tried to use every possible physical solution available. During the rain, they used drainage pumps to remove water out of the excavation as quickly as possible. If it sat there for a long time, it could freeze and it would be more problematic. Concrete accelerators were also used whenever possible. Concrete accelerators cost an average of $1200/ ton, so that would be $39,000 for 32.5 concrete accelerator tons. However, this was not used mainly because the owner was more worried about cost rather than schedule. If the owner was interested though, concrete accelerators would save a week of curing and setting time out of the 41 days long foundation activities.

Additionally, the project manager used construction workers more efficiently by letting them work overtime before it was possible to increase manpower. All that helped the construction team get back on track. That did not carry any additional costs to the owner or the project manager as per an agreement between the project manager and the subcontractors.

Negotiation

The construction manager in this project was at some point held responsible for all weather damages that occurred. The construction manager tried their best to avoid any additional costs charged to either themselves or the owner, but they reached a point where they were behind on schedule and there is no way around it. Luckily the construction manager was able to negotiate their way through in this project and get the required extension. This made both the construction manager and the owner avoid any additional charges by postponing the completion date.

Legal

The project contract clearly defined weather construction delays for the most part. If it was looked at from a critical view, there was not a direct mention of "concurrent delays" in the project's contract. The rain directly impacted the concrete pouring, but it also resulted in impacting the placing of masonry activity and the cleanliness of the job site. Having all those concurrent delays makes it more difficult to determine the responsibility for each activity as there was more than one contract involved.

Concurrent delays are common in many projects, although few contracts specify anything about concurrent delays clearly. It is critical to address it, especially when determining damages responsibilities if they happened. Later on, "concurrent delays" may become a reason for contractors to be granted a time extension. On the other hand, owners might see it as reason to assess liquidated damages to contractors. In addition, many companies out there do not fully understand the concept of "concurrent delays." (Trauner, Manginelli, Lower, Nagata, and Furniss, 2009) The contract between the owner and the construction manager did not include specifications about "concurrent delays." Luckily, the project did not have an extreme case of it, otherwise it may have been more difficult to resolve.

150. Proposed solution

The analysis shows that the construction team has done everything possible to reduce the weather impact. Each aspect of the weather impact seems to be having taken into thorough consideration beforehand. The schedule was based on a NOAA climatological report which is what is normally done. The NOAA report is usually accurate, but sometimes it is not, and The Susquehanna Center is the best example of this. It is hereby proposed to not rely 100% on the NOAA report, and try the best to always be on the lookout for any serious weather changes. The second aspect is the physical techniques such as: drainage pumps and concrete accelerators. The third aspect is the legal aspect of the issue. All parties involved should coordinate together to solve the problem from all aspects mentioned. The solution employed in this project and explained in this analysis is the proposed solution as well. It is believed that it was the best approach for the good of all parties involved in it. However, this was a good case to study, which includes many lessons learned (mentioned in the next section, "Conclusion".)

160. Conclusion

Weather can have a big impact in construction projects, so construction managers are always on the lookout for any ways to minimize its risk. Through this analysis, it appears that there are many aspects in a project that can be looked at from a construction management perspective in order reduce weather impact. Examples discussed in this analysis are scheduling, physical techniques, negotiation, and construction contracts. Scheduling is where the weather may have the biggest impact on, so it is essential to shape it according the best judgment based on experience, weather forecast, etc. There are not many physical techniques where rain or snow can be completely avoided. It is more about the physical method to recover from any damages weather may incur. If there appeared to be still some schedule delay after all this, the contractor may negotiate the contract with the owner about time extension and damages responsibility.

The Susquehanna Center was a great example of weather impact on construction because it went through all the aspects of weather impact discussed. Also, it contains many lessons learned:

- Floats added to weather-dependent activities should neither be too short that is weather damage would be risky, nor too long that puts the CM's bid out of the competition.
- NOAA climatological reports are what are relied on in construction scheduling which reduces the risk of weather impact by putting an educated guess for the best float possible in weather-dependent activities. It does not completely eliminate the risk though, so it is highly recommended to closely watch out for any weather changes especially for critical construction activities.
- It is not physically possible to stop weather from directly impacting foundation construction. However, it is possible to recover from it by some other techniques such as: concrete accelerators. This means it is always important to keep back up physical strategy that can help reducing the weather impact on schedule.
- Sometimes it reaches a point where there is no way around a schedule delay. In this case, negotiation skills are very important to convey the whole situation to the owner from the contractor (or vice-versa).
- Wording can be fairly complicated in construction contracts and specifications, so all parties should pay special attention to that.

200. Analysis 2:
BIM use in the Susquehanna Center renovation project

201. Problem Identification

BIM was minimally used in the Susquehanna Center Project. One of the main reasons is the cost of using it. Although it should pay itself in the long run, it was decided not to use BIM. Being a donation dependent project is another factor. Despite the fact that BIM is now very widely spread in the building industry around the nation, some marketplaces lack sufficient knowledge about it. So was the case with some subcontractors in this project. Moreover, since the existing building dates back to 1966, its documentation was not available in a format that would make the BIM process run smoothly.

202. Research Goal

The goal of this research is to find the best way to make this project eligible and feasible to use BIM. A study will be done in the most efficient ways to convert the documentation of the old building into a BIM friendly format. Also, it will aim to find how to go about educating other parties in the project about BIM and the importance of it in an efficient manner. Cost, schedule, and constructability studies at the end will determine whether or not it is worth it.

203. Potential Solutions

A potential solution for this problem is 3D scanning surveying instruments. 3D laser scanning could be incorporated with BIM by scanning the building periodically and sending the information to a database accessible by the respective parties. Those tools could also be used to provide BIM friendly format of construction documents. That is of course to create CDs and models from scratch, but the available documentation for the old building could be used for verification. To ensure the feasibility of this solution, a cost analysis has to be done to it and see whether it could be actually used in the Susquehanna Center project.

As for how to implement BIM in a marketplace that lacks the knowledge of it, a planned coordination has to be done with all parties. This is a problem that comes across in a lot of the projects. It is difficult to bring subcontractors that all know BIM sometimes, and if they do, they might charge a lot extra. A potential solution for this would be to put some requirements for subcontractors in order to get awarded the job. Using a particular software program for drawings is one example. Early involvement with subcontractors especially those who do not use BIM is critical as well. All this could be labeled as different ways to coordinate with other parties in the project, but they need to be researched and experimented in order to know whether they would work or not.

204. Expected Outcome

By the end of this research, it is expected that it will provide a good guidance to contractors on how to implement BIM when it seems that there is no place for it in the project. This research also aimed to help find the best and most up-to-date techniques for creating the required CDs and models for BIM. BIM will also include many potential improvements to coordination, costs, schedule, safety, etc.

210. Background Research

One of BIM's objectives is to digitally represent the physical and functional characteristic of a facility. It also can act as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle, which is defined as existing conditions from earliest conception to demolition. BIM includes a whole process that integrates different building systems into shared building information models between the involved parties in a project. BIM includes a wide range of uses which has to be defined in the BIM execution plan specified for the project. Examples for BIM uses would be 3D Coordination, Record Modeling, Space Management and Tracking, etc. There are many benefits of using BIM such as:

- Increased design quality through effective analysis cycles
- Greater prefabrication due to predictable field conditions
- Improved field efficiency by visualizing the planned construction schedule
- Increased Innovation through the use of digital design applications

Although it might seem the path of BIM is flawless and it is always a win-win scenario for everybody involved, it is actually not. If BIM is not properly implemented, it may not be worth it. When there is a lack of knowledge, information, or coordination between the parties involved, it may incur schedule delays and increased costs. (BIM Execution Guide, 2010)

220. The Susquehanna Center BIM case

There was no intentional use of BIM in the Susquehanna Center project. The primary two obstacles that were in the way of using BIM are: the lack of subcontractors' BIM knowledge, and BIM documentation format. Both of them made the BIM option seem costly to the project manager, so they decided not to go with it. This analysis aimed to find out whether the BIM option could have been feasible if the project manager was to avoid the two obstacles. Before that, suggestions were made to avoid the obstacles, and the BIM Execution Plan was created accordingly.

221. Subcontractors lack BIM knowledge

Research

Joseph Joseph in his seminar, *BIM: A Business Decision*, has discussed some BIM failing examples and shared the reason why some fail to implement BIM properly: "One of the main facts that continue to slow the progress of BIM in the AEC industry is the many failure stories reported by firms. This includes firms that attempt to implement a BIM solution, loose significantly on projects and decide to withdraw their attempt and go back to doing the work in CAD." He thinks that the main reason for these failed BIM attempts is the lack of knowledge in multiple areas such as:

- "Vision: The evolution of BIM
- Understanding that BIM isn't simply a technology.
- Lack of education: what is BIM exactly? Everyone thinks it is a 3D Model.
- No BIM maturity and/or leadership within firms.
- No BIM business plan and strategy in approach.
- Push back from management, staff and communities.
- Firms agree to use BIM / REVIT due to mandate of clients without understanding the scope."

All the aforementioned areas are related to basic BIM understanding and perception, which are important at first. After that the company can move on and create a BIM Movement within a company towards their end goal. Joseph continues by suggesting several considerations that companies should put in their mind for a successful BIM Movement:

- "Customizing your approach: Addressing groups at their level.
- Create a strategy based on driving factors and BIM Stage.
- Assess the scope and types of projects that your company goes after.
- Elevate the level of BIM understanding among principals and leaders.
- Asses the risks of BIM Implementation and discuss them proactively."

Suggested solutions

Joseph's advice is more related to companies that want to move to BIM *internally* without any *external* forces, unlike the Susquehanna Center case. However, we can deduce from that some general strategies that Turner could follow in order to avoid the subcontractors' lack of BIM knowledge issue.

First, the project manager should define their goals and BIM scope and make it very easy for other parties to follow. That is best done by following the BIM Project Execution Planning Guide by CIC Research Group, Department of Architectural Engineering, The Pennsylvania State University (http://bim.psu.edu).

Second, a CM or a GC that wants to use BIM should choose subcontractors that use BIM too. This is best way to avoid the problem. In an interview with DeShawn Alexander from Limbach, Inc, he said that Limbach always strives to use BIM and they always try their best to choose subcontractors that use BIM as well.

However, they work with other parties that do not use BIM every once in a while. The usually get around that effectively by training the other contractors on how to do BIM. If they were not interested in that, they would offer the company to do their BIM work as an additional service they provide for them.

222. Construction Documents format problem

Another challenge that the construction team may face when implementing BIM in a renovation project is the availability of the construction documents in a BIM friendly format. Also, since the building is old, it might have gone through a series of changes that make its construction documents not valid anymore.

A solution to this is the use of 3D Laser Scanning technologies that will easily help take the first steps to obtain and generate an accurate data set for creating the 3D model for the renovation project. There are already many different technologies that can be used as 3D scanning devices. Laser scanning instruments collect high accuracy data providing millions of measurements in 3 dimensions called point clouds and the result is an organized 3D digital representation of an object which is delivered efficiently, quickly and accurately. (architecturalevangelist.com, 2012)

230. BIM Execution Plan

"BIM Project Execution Planning Guide" by Computer Integrated Construction Research Group, Department of Architectural Engineering, The Pennsylvania State University is a great reference for executing BIM in different kinds of project. It offers a complete package for various BIM uses in detail. The BIM Execution Guide states "Teams should not focus on whether or not to use BIM in general, but instead they need to define the specific implementation areas and uses." Not all BIM uses can be implemented in one single project. Instead, BIM uses that carry the most value to the project should be implemented. It should be developed early on in the project to get the most out of it. The BIM Execution Guide states that the plan must do the following:

- Define the scope of BIM implementation on the project
- Identify the process flow for BIM tasks
- Define the information exchanges between parties
- Describe the required project and company infrastructure needed to support the implementation.

Defining the scope of BIM implementation can be done by choosing the BIM uses first. The strategic goals, and roles and responsibilities of each party involved should also be defined. BIM is all about coordination, so every participant should understand every input and output clearly in the BIM process. That should help achieve the owner's and construction team's goals and help deliver the project more efficiently.

231. BIM Uses

For the purpose of defining the cost of tackling the BIM challenges in this project, the potential BIM uses for this project are explained. Appendix L contains 7 BIM uses that thought to be most relevant and useful to the project along with their value to the respective parties. Also included is Appendix M which has a proposed BIM Execution Plan. The suggest BIM Uses are Existing Conditions Modeling, Cost Estimation, Design Reviews, 3D Coordination, Record Model, Maintenance Scheduling, Space Management/Tracking, and Design Authoring. Each one is explained separately below:

Existing Conditions Modeling

This BIM Use primarily helps create a 3D model of the existing conditions in the project. It can be developed using many tools such as 3D laser scanning or conventional surveying techniques. This is particularly helpful for the Susquehanna Center project as it acts as a prerequisite for other BIM uses. By using it, a 3D model will be developed that should be handy for other parties involved in the project. This could be as a stepping stone for other BIM uses, and does not really contribute to any of the owner's goals directly, so its cost could be considered as an added cost. It is considered in the "Cost Analysis" to decide whether it is worth or not.

Cost Estimation

The Cost Estimation BIM Use allows for accurate cost estimates throughout the lifecycle of a project. It allows accounting for any changes that may occur quickly and incorporate that into the cost estimate. This helps avoiding going excessively over budget due to change of orders and project modifications. The Susquehanna Center project has been through many changes of orders and it would save time and money if this BIM use was implemented.

3D Coordination

It is a process where parties involved in the project conduct a clash detection to determine any field conflicts. This saves so much time by avoiding potential change of orders that would have caused delays. The Susquehanna Center project has had some problems and change of orders which could have been avoided using clash detection software.

Design Authoring

It is a process where 3D software is utilized to develop a BIM model. It has two groups of applications which are design authoring tools and audit and analysis tools. It is essential to run through both because authoring tools create models while audit and analysis tools add richness of information in the model. This is particularly important to the Susquehanna Center project as the next step after creating the 3D model using 3D laser scanning tools.

Record Model

It is a process used to represent the physical conditions and environment of the building. It contains information about the different building systems in the building. This helps with future modeling and improves documentation for future uses. For this project, Design Authoring and 3D Coordination BIM uses would be sufficient and it is thought that there is no need to create a Record Model.

Building Maintenance Scheduling

It is a process where the function of the building structure and equipment serving the building are maintained over the operational life of a facility. This will help track maintenance history, reduce corrective maintenance and emergency maintenance repairs, and increase the productivity of the maintenance staff. All this contribute to reduced repairs and reduced overall maintenance costs. This BIM use seems helpful, but not very much for the Susquehanna Center project. The Harford Community College has its own building maintenance scheduling and facility management program, so this BIM use does not look will be of great benefit to the project. Also, in order to utilize this BIM use, a Record Model has to be created which means increased costs.

240. Proposed Solution to initiate BIM

The Susquehanna Center project did not actually use BIM, but this analysis is investigating what was BIM feasibility and how to start the BIM process despite the challenges it went through. The three main challenges were construction documents format, subcontractor's lack of knowledge, and cost of BIM concern. A 3D model will be created as a result of the "Existing Conditions Modeling" BIM Use, so there should not be a problem with construction documentation if this BIM Use was utilized. Some suggested solutions for the subcontractor's lack of knowledge challenge, as discussed in the "Background Information" section, are training subcontractors and offering BIM service. The cost of these two options are analyzed along with the cost of BIM uses to determine whether usage of BIM in this project is feasible or not.

Training subcontractors

All the designers of the Susquehanna Center project do have BIM capabilities, but two of the installing contractors do not. They are electrical and fire protection installing contractors. From the design standpoint, BIM is going to be ready for implementation and the model will be passed to installing contractors in order to build it. The model will be converted back to 2D if the installing contractors prefer that. Since two out of at least 10 contractors do not how to use BIM, then it should not be a problem. The project engineer and project manager from Turner will be assigned to help the installing contractors if needed. Throughout construction, there will be bi-weekly BIM meetings between all parties involved. Representatives from both the electrical and fire protection installing contractors will be present and will have the opportunity to engage into the process. During the meeting, everyone will learn about any coordination issues and any clashes detected. All this will help installers install equipment correctly and familiarize them with the BIM process, and it should get easier for them for the rest of the project and for the following projects.

Offering BIM service

Offering BIM service to subcontractors without BIM capabilities works only with design subcontractors. In that case, the project manager, the designer, or any other third party can take the 2D designs and convert them into 3D designs all ready for BIM use. However, in the Susquehanna Center project case, all the designers do have BIM capabilities, but two of the installing contractors do not. The only two ways around that is training them to use BIM or replacing them. Replacing them would not work because they are the only ones available around the area, and because of the owner's relationship with them. Training them will be the best choice as the learning curve here is low. As far as cost and feasibility go, training subcontractors (or familiarizing them) with the BIM process is the most feasible choice between the two, which does not carry any significant additional costs.

Existing Conditions Modeling

As for the construction documentation format problem, "Existing Conditions Modeling" is the way to go. This integrated part of BIM will help initiate BIM while being a part of BIM itself. However, it will be looked at as an additional cost. The most common way to model existing conditions nowadays is 3D laser scanning. According to "3deling 3d scanning services" database, it is estimated to take about 2 days for a 2 operators (scanner and total station) to 3D scan the building on site. It would take about 2 weeks for draftsman to convert the input and the raw images into a BIM ready 3D model.

241. Cost Analysis of proposed solution

The last obstacle that is on the way of implementing BIM is the costs associated with it. As mentioned in the "Background Information" section, BIM costs might not always be outweighed by BIM savings. BIM Uses choices have to be just right that potential savings would incur from doing so.

BIM Prerequisites	Labor	Equipment	Total
Training subcontractors	$4,800	-	$4,800
BIM Use	**Labor**	**Equipment**	**Total**
Existing Conditions Modeling	$10,240	$2,560	$12,800
Cost Estimation	$8,100	-	$8,100
3D Coordination	$11,200	-	$11,200
Design Authoring	$36,160	$10,300	$46,460
TOTAL	**$70,500**	**$12,860**	**$83,360**

Table 6: BIM Use costs breakdown

Table 6 shows the total cost of initiating and using BIM is about $83,360. It was mostly based on the estimated man hours spent on each BIM Use. Training subcontractors through the coordination meetings and the project engineer on site would add a cost of around $4,800. Existing Conditions Modeling labor cost was based on a quote from 3deling 3D laser scanning services. It came out to be $12,800 and it was estimated that %20 of that would be equipment costs. Cost Estimation BIM Use added about $8,100 accounts for additional hours required to incorporate any cost changes into the master cost estimate. 3D Coordination would require additional coordination meetings, which are estimated to add $11,200. Design Authoring would cost the most out of all suggested BIM uses because it accounts for the whole process that converts the existing conditions model into a model ready for 3D coordination.

The next step is to calculate BIM savings. Autodesk published an article about BIM's Return on Investment and provided a formula to calculate first-year ROI. Figure 13 below shows the formula with its variables. After experimenting with this formula, it turned out that it always gives a positive ROI. This will not help answer the question about whether BIM is worth implementing in this project or not. It is not a matter of how much ROI this project gets. Instead, it is a matter of whether there will be a return on investment at all.

$$\frac{\left(B-\left(\frac{B}{1+E}\right)\right)\times(12-C)}{A+(B\times C\times D)} = \text{First Year ROI}$$

The formula variables are:

A = cost of hardware and software (pounds)
B = monthly labor cost (pounds)
C = training time (months)
D = productivity lost during training (percentage)
E = productivity gain after training (percentage)

Figure 13: Autodesk's BIM ROI formula

Cost ($M)	Project	BIM Cost ($)	Direct BIM savings ($)	Net BIM savings ($)	BIM ROI (%)
54	Progressive Data Center	120,000	(395,000)	(232,000)	140
82	HP Data Center	20,000	(67,500)	(47,500)	240
16	GSU Library	10,000	(74,120)	(64,120)	640
47	Aquarium Hilton	90,000	(800,000)	(710,000)	780
88	Mansion on Peachtree	1,440	(15,000)	(6,850)	940
30	Ashley Overlook	5,000	(135,000)	(130,000)	2600
58	1515 Wynkoop	3,800	(200,000)	(196,200)	5160
47	Raleigh Marriott	4,288	(500,000)	(495,712)	11560
32	NAU Sciences Lab	1,000	(330,000)	(329,000)	32900
14	Savannah State	5,000	(2,000,000)	(1,995,000)	39900

Table 7: BIM costs and savings for previous projects (Azhar, Hein, and Sketo, 2007)

Table 6 shows BIM costs and the corresponding savings to similar projects to the Susquehanna Center project. It is noticed that BIM Return Of Investment varies very much from 140% all the way to 399000% in the examples shown. The average of Return in Investment is $9486, while the standard deviation is more than $14600. This means that the data here varies very much and the average cannot be simply used even though they are all similar projects. In order to estimate the savings here, it is best to look at individual projects more closely. The two most similar projects are Ashley Overlook and 1515 Wynkoop, because both carry similar scope of BIM as the Susquehanna Center would. The Ashley Overlook had 3D coordination and existing conditions analysis BIM uses. The 1515 Wynkoop had 3D coordination and cost estimation BIM uses. Both projects are relatively low in BIM cost, because the construction manager, Holder, have adopted BIM many years ago that it became the norm now. It would not cost them as much extra to implement the BIM uses mentioned as they are used in most of their projects. Also, the BIM costs noted do not include equipment cost. The direct BIM savings for Ashley Overlook and 1515 Wynkoop are $135,000 and 200,000 respectively. Therefore, the minimum cost savings for the Susquehanna Center would be $135,000*(26.7/30)= $120,000, where $26.7M is Susquehanna Center project's total cost and $30M is Ashley Overlook project's total cost. This is to account for project size proportion with the assumption that the BIM will go according to plan. This suggests that the Susquehanna Center project will have direct BIM savings in the range of $120,000 to $200,000. Net savings would be in the range of $36,000 to $116,640 and a return of investment range of 44% to 140%. Indirect savings sometimes can be even more than the direct savings. All that being said, it is safe to say that the BIM uses chosen are worth implementing in the Susquehanna Center project.

242. Effect on schedule and construction

Schedule

The total duration added for BIM implementation is about 2050 man-hours split up between all subcontractors. Figure 13 shows a snippet from the Proposed BIM Execution Plan (Appendix M) that shows the BIM Use staffing and how it breaks down in terms of worker duration. It also shows that implementation of BIM all together will take no more than 5 weeks which can be incorporated into other activities as well. 3D coordination will minimize the RFIs and ASIs exchanged between the owner and the designer. The owner and the designer themselves exchanged more than 80 RFIs and ASIs. The pool restoration RFI alone took almost a month and put the whole pool restoration activity behind which was on the critical path. The project manager asked the designer and the owner about whether it is acceptable to add a layer to the pool in order to fix the pool leakage. Another issue which got resolved after two RFIs that took a whole month is the drainage pipes detail drawing RFI along the south face of the basketball arena. All these RFIs and delays would be minimized if 3D coordination was implemented, which will overweight the time spent in BIM implementation. The two mentioned RFIs alone took two months. If they were to be avoided, the construction team would have avoided at a month of delay. If the other RFIs were to be avoided, they would add at least a 2 weeks of schedule savings. All this means 6 weeks of schedule reduction at least. That is a net of one week of schedule reduction after the 5 weeks spent on BIM implementation. Not to mention that BIM implementation activities could overlap with other activities. In order to further assure that BIM implementation would not affect the schedule negatively, the two projects used earlier for the cost analysis have been look at more carefully. According to Holder, they have been able to save at least 3 weeks in the mentioned projects.

BIM Use	Organization(s)	Staff Required for BIM Use	Worker Duration
Existing Conditions Modeling	Site Resources, Inc / HCM	Site Resources, Inc: (1) Surveyor and (1) Civil Engineer HCM: (2) Architects	(1) week each
Cost Estimation	Turner / HCM	Turner: (2) Estimators HCM: (2) Architects	(3) weeks for estimators (1) week for architects
3D Coordination	Turner / HCM / Subcontractors	Turner: (2) Project Managers HCM: (1) Project Architect and (1) Architect Subcontractors: 1 from each sub = (3) + 1 = 4 total	(1) week each
Design Authoring	Turner / HCM / Subcontractors	Turner: (2) Project Managers HCM: (1) Project Architect and (1) Architect Subcontractors: 1 from each sub = (3) + 1 = 4 total	(3) weeks for project managers (5) weeks for architects (4) weeks for subs

BIM Use	Organization(s)	Number of Total Staff for BIM Use	Estimated Worker Hours	Location(s)	Lead Contact
Existing Conditions Modeling	Site Resources, Inc / HCM	4	160	Jobsite	Site Resources, Inc
Cost Estimation	Turner / HCM	4	320	Office and Jobsite	Turner
3D Coordination	Turner / HCM / Subcontractors	7	280	Accessible from anywhere	Turner
Design Authoring	Turner / HCM / Subcontractors	7	1280	HCM office, Turner offices, and jobsite	HCM

Figure 14: BIM Uses tables from the proposed BIM Execution Plan (Appendix M)

Construction

Most of the BIM Uses are done within the planning and design stage and does not really affect construction in a negative way. Figure 14 shows the various BIM Uses on the different project phases from the Proposed BIM Execution Plan (Appendix M). 3D Coordination allows all parties to work better together into constructing the building and reduces the number of RFIs through detailed 3D models and clash detection. Cost estimation carries the most work during planning and design phase by doing the actual cost estimate of the building. In the construction and operation phases, it only consists of recording and cost changes and incorporates that into the master cost estimate, which does not interfere with construction activities at all. The owner was more concerned about the cost of implementing BIM rather than schedule or constructability aspects. A cost analysis was conducted in the next section.

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

Figure 15: BIM Uses by phase table from the proposed BIM Execution Plan (Appendix M)

250. Conclusion

In conclusion, BIM is spreading around very fast around the nation and the globe, and it is almost always a great investment. The Susquehanna Center project sets a great example of that where it faces great challenges that seem infeasible, yet BIM is still a feasible investment. The subcontractors that lack BIM knowledge and the construction documents format are two of the biggest obstacles in the path of implementing BIM in this project. However, after conducting cost, constructability and schedule analyses, it came out that BIM will most likely benefit the project and all the aforementioned aspects. The most important recommendation here is that BIM should be seriously considered in every project no matter how many challenges may be faced. However, in order to get the most out it (and actually maintain its feasibility) is by implementing BIM very early in the project as early as the first meeting of the planning phase. The direct BIM savings are estimated to be in the range of $120,000 to $200,000 which would result a return of investment between 44% and 140%.

300. Analysis 3: Alternative façade system

301. Problem Identification

The façade of the existing Susquehanna Center has been completely redesigned and renovated which greatly impacted the structural system. The owner wanted a better looking facade than the fitness center brick wall and also wanted bigger windows to let more light in. He wanted all that for the lowest price possible. The fitness center was enclosed by a brick wall with small windows. By renovating it, it made the fitness center bigger using a curved shape curtain wall instead of the brick wall. In addition to the structural system, the mechanical and lighting systems were also affected. Although the owner was satisfied with the design, it was expected to be cheaper than this.

302. Research Goal

The goal of this research is to design a more cost effective alternative façade system that still meets the owner's requirements. This requires a value engineering study for the old and current façade systems and a new alternative façade system proposal which includes a new architectural design. The cooling load required for the new façade was also analyzed to see whether it got affected by the new design.

303. Potential Solutions

It is possible to design an alternative façade system but it might not be better in all aspects considered. In all cases if the owner wanted to save money in the project, he/she is better off changing the design early than late, otherwise it would cost even more. This research analysis is here just to see what different options the owner had prior to construction and what the value engineering potential areas in this project are.

304. Expected Outcome

Upon completion of this research, it is expected to have an alternative façade system design that is better in terms of cost, and meets all the owner requirements at the same time. Potential improvements in schedule and constructability are also possible. The alternative design was compared with the old and current systems to see what the different options the owner had in the beginning of the project.

310. Old facade

The old façade used to be a brick wall, which does not even deserve the word façade. It was the western wall shown in the photo below which is one of the men's locker room walls. It was just a straight wall with absolutely no windows in it.

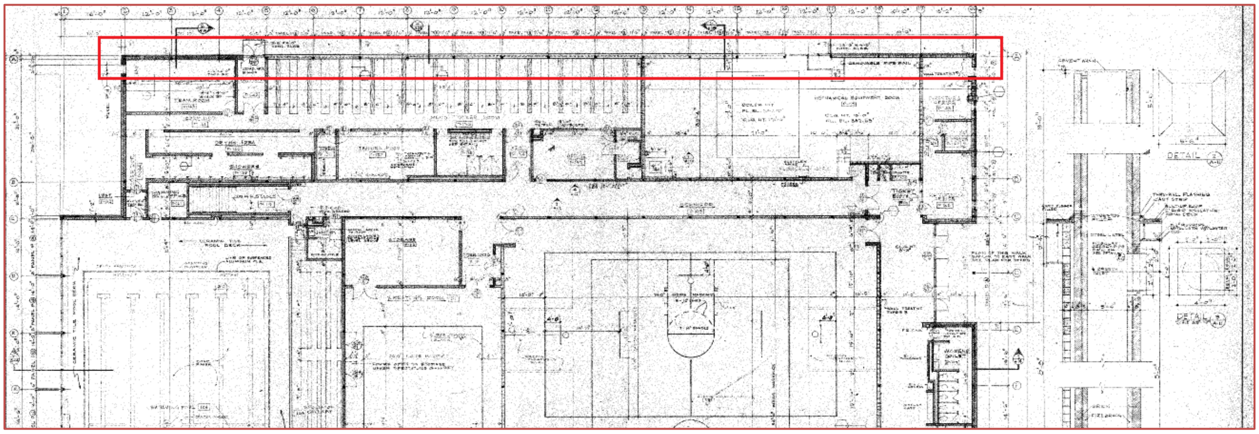

Figure 16: A portion from the old floor plan of the Susquehanna Center (prior to renovation). The old facade is shown in the red square.

The building used to face North, where the main entrance is located and where the rest of the campus buildings are. Now that the campus is expanding, and a soccer field had been added later south of the building, it makes more sense to have the main entrance to the west of the building.

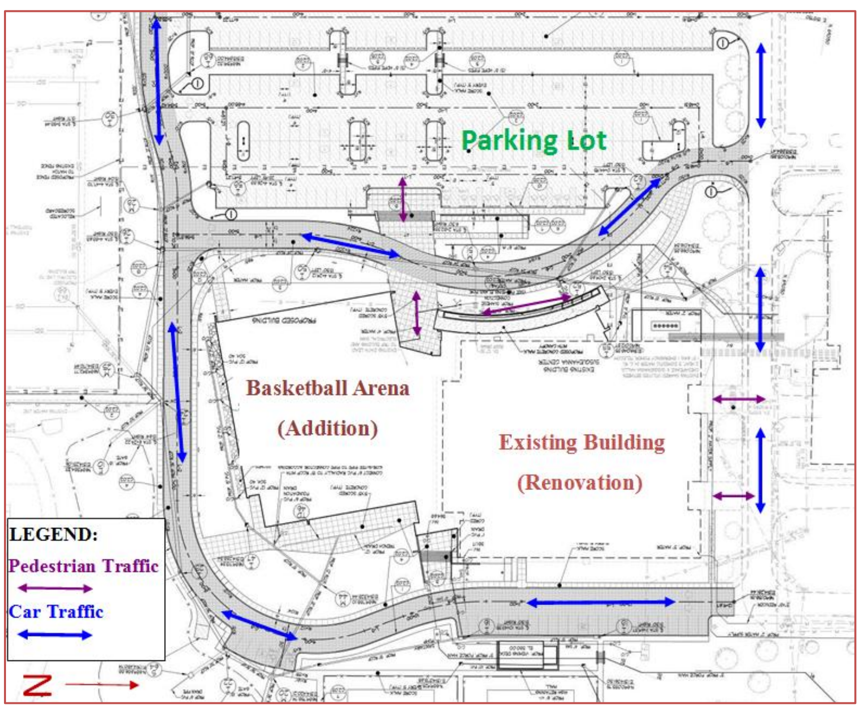

Figure 17: A site plan that shows pedestrian and car traffic. Most students come from the North side of the building. (Appendix N includes a better resolution of Figure 16)

311. Current facade

The current façade houses the fitness center and of a much better aesthetics. Instead of a straight brick wall, it is now a curtain wall curved outward. The canopy underlines a walkway underneath it which leads to other campus buildings north wise. This makes it keep the function of the old main entrance while facing at a completely different direction.

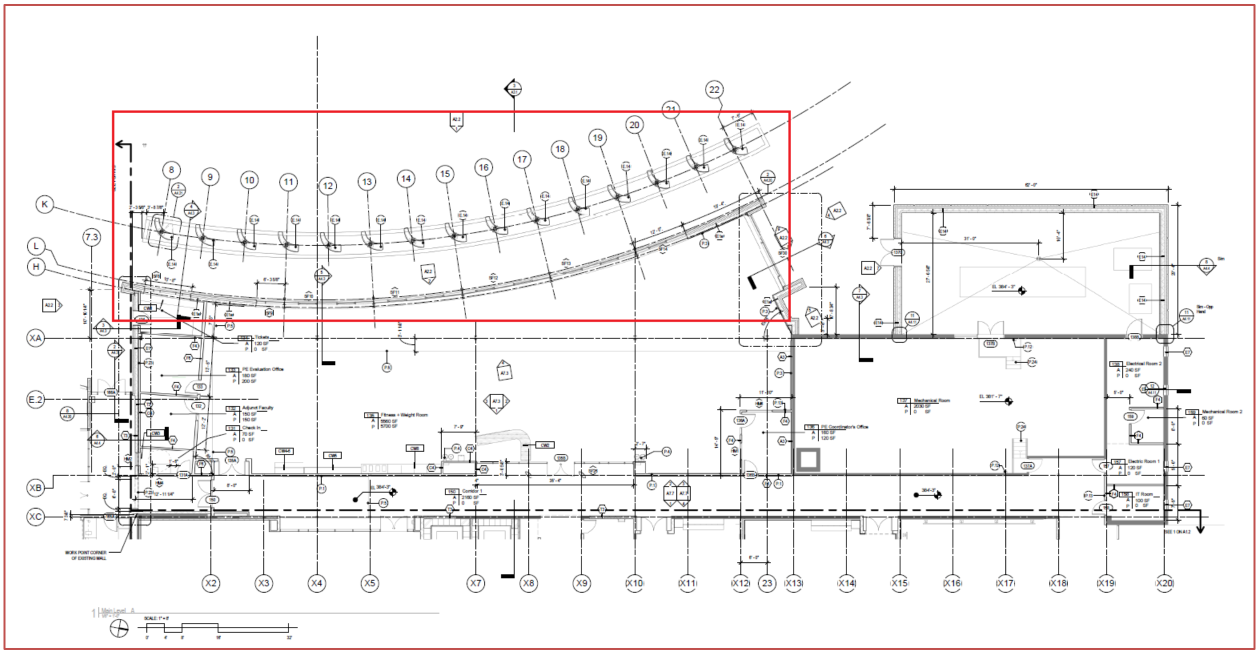

Figure 18: A portion from the current floor plan of the Susquehanna Center (After completion of construction). The current façade is shown in the red square.

Adding the basketball arena to the Susquehanna Center makes it a necessity to move the main entrance closer to it. It was moved to the west side of the building right between the old Susquehanna Center part and the addition. This helped integrate the two parts together into one building.

320. Relationship with other building systems

Mechanical

The mechanical room has been extended because of the increased load due to the increased size of the building. The additional portion of it is located outdoors and contains an air cooled chiller mounted on a concrete pad. As noticed in Figure 18 below, having the wall curve outwards makes the pedestrian walk a little bit away from the mechanical room just north of the fitness room. Most of the mechanical system components have been demolished in the early stage of construction. Ductworks have been completely removed from the new fitness center area and replaced with a mechanical system that meets the set mechanical requirements for the fitness center. Some of the insulated glass that has been chosen for the fitness center curtain wall has 62% VLT (Visible Light Transmitted) to minimize the air conditioning energy lost.

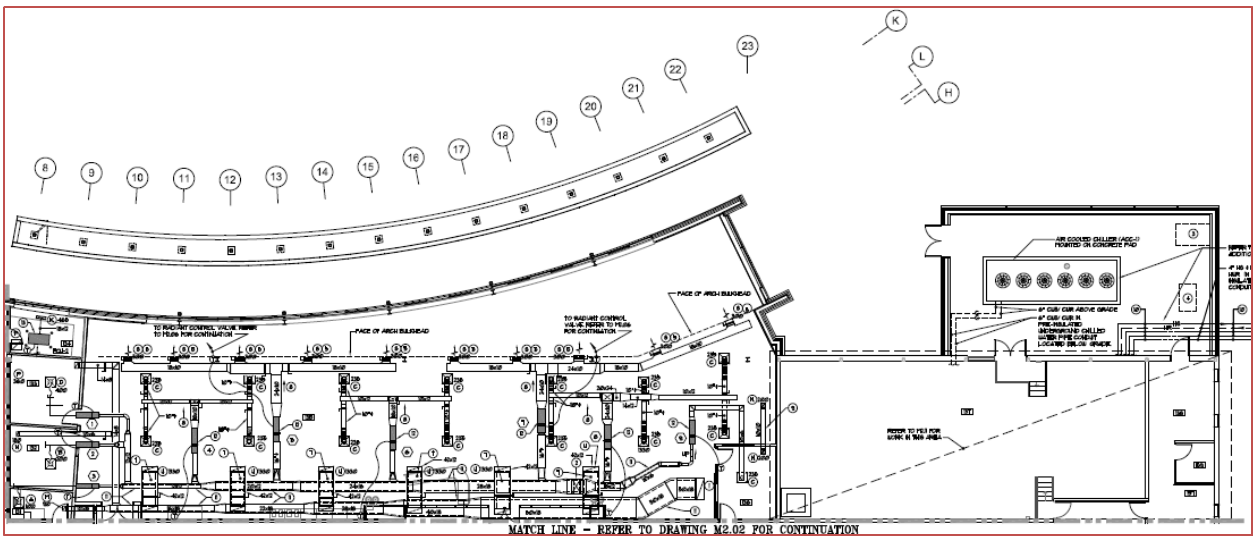

Figure 19: The HVAC ductwork drawing of the facade portion of the building. The box at the right is an added space to house an air-cooled chiller. The canopy attached to the façade allows pedestrians to walk away from the added portion of the mechanical room.

Lighting

The current façade avoids the entrance of direct sunlight to the fitness center because of the canopy that acts like an overhang. At the same time though, the fitness center benefits from indirect sunlight which is important there.

Figure 20: The current facade is shown in this picture at the left while the basketball arena is located right next to it in the far center.

Structural

The west brick wall used to be a load bearing wall, but now the west portion's weight of the Susquehanna Center is carried by (15) canopy steel columns, HSS 6x6x1/2, as well as (9) steel columns in the curtain wall and next to it, W10x33. As for beams, HSS6x4x3/16 had been mostly used for the canopy portion of the façade, and W12x14 for the fitness center addition.

330. Architectural Breadth: Alternative façade design

After careful review of both the old and current façade designs, a new alternative façade design is being proposed. The design went through a series of alterations until it settled on one design. This section will go through the most significant design steps.

The biggest change that this alternative façade design suggests is the removal of the canopy attached to the façade. From an architectural perspective, the current façade and the canopy are screaming if they are isolated from the whole building. It is the only part curved in the building is not homogenous. From the functional perspective, It was noticed in figure # most students come from the North side of the building through the Susquehanna Center. In my visit to the project after it got completed in February, 2013, I observed the building for a while and did not notice a single person walking through the canopy during peak hours of a week day. Other than acting as a shade for the sidewalk, the canopy serves as an overhang for the curtain wall to limit direct sun light. Instead, a triple-glazed, medium-solar-gain Low-E glass will be used in the curtain wall. This is used in the Rec hall building in The Pennsylvania State University. It effectively limits direct sun light without the need of an overhang.

Another value engineering change that has been made is making the façade wall straight rather than curved. The first reason for that is this is the only curved wall in the building and it would not fit very well if it was curved and did not have a canopy. More importantly, it will save costs in both the wall construction and procurement of custom curved windows.

Design #1:

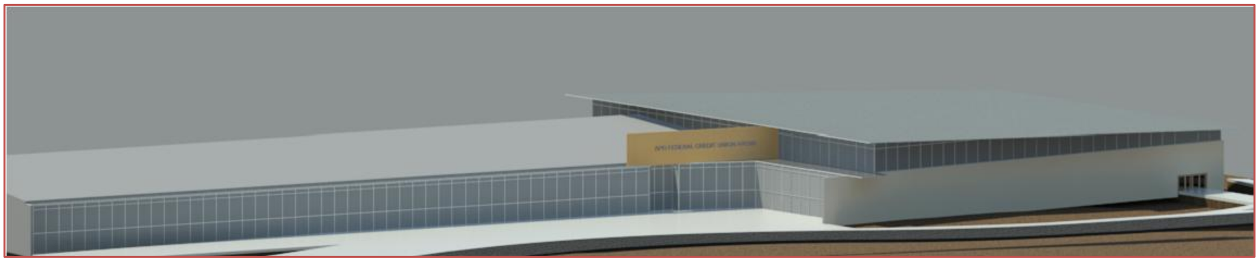

Figure 21: Design #1 Rendering

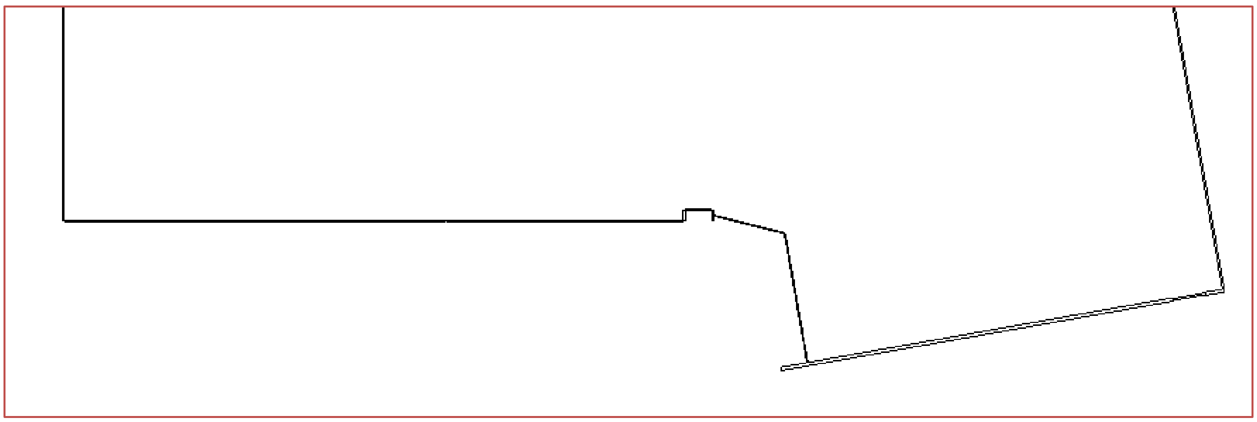

Figure 22: Design #1 Façade Outline

This is a view of the first design step where the canopy is removed and a straight curtain wall has been placed in place where the old brick wall used to be. This will save costs in both canopy construction and demolition for the addition part in front of the Susquehanna Center. This, though, eliminates a big part of the gymnasium area.

Design #2:

Figure 23: Design #2 Rendering

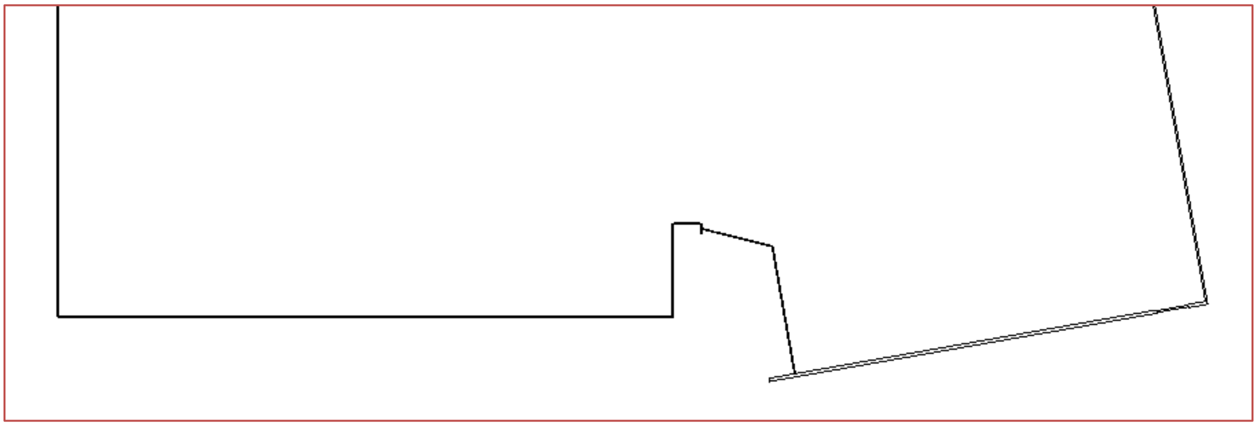

Figure 24: Design #2 Façade Outline

Design #2 fixes the problem that the first design had by adding into the gymnasium area. However, this makes like the gymnasium is kind of isolated and has a blocky look. It is not very aesthetically pleasing.

Design #3:

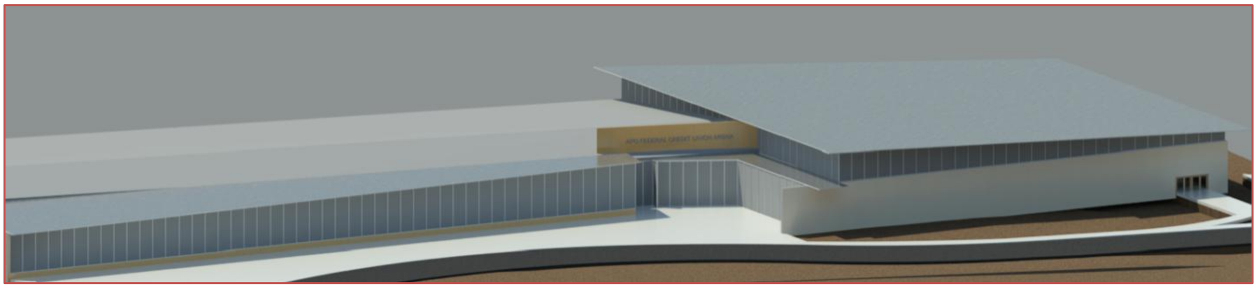

Figure 25: Design #3 Rendering

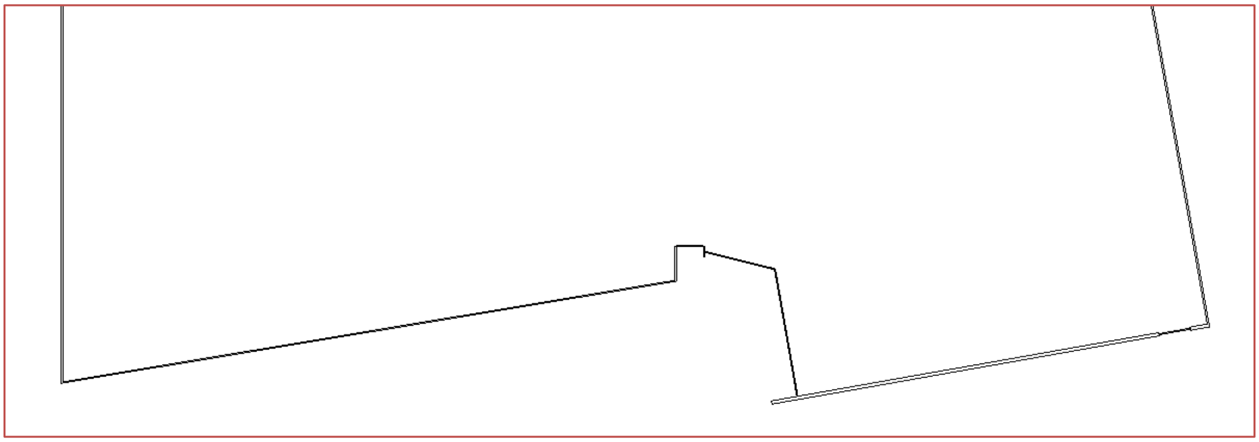

Figure 26: Design #3 Façade Outline

The curtain wall here is tilted to allow for occupants to easily turn left when they are exiting from the main entrance. Also, the roof of the extended part of the façade is sloped to have same gesture as the basketball arena has. This creates a sense of symmetry and homogeneousness with the basketball arena and makes the overall look of the façade more pleasing. It is more homogenous with the rest of the building and has the same materials used. The curtain wall has triple-glazed low-e glass and aluminum frames. The walls are cased with ground face 4’x8’ ground face concrete. This appears to be the best design that can reduce the cost while meeting the owner requirements.

340. Cost Analysis

In order to decide whether the new design is an acceptable alternative or not, the cost factor has to be taken into consideration. The costs of both current and new façades have been analyzed to determine the potential new design cost savings.

	Current Façade				
	Item	**Quantity**	**Unit**	**Unit cost**	**Cost**
Canopy	**Canopy HSS columns, roof, sheathing**	1	EA	92,459	$92,459.00
Facade construction labor	**Curved curtain wall**	280	Man hour	18	$5,040.00
Windows	**Curved custom windows**	2890	SF	86	$248,829.00
TOTAL					**$346,328.00**

Table 8: Current Facade cost analysis

	New Façade				
	Item	**Quantity**	**Unit**	**Unit cost**	**Cost**
Canopy	**N/A**	N/A	N/A	N/A	N/A
Facade construction labor	**Straight curtain wall**	200	Man hour	18	$3,600.00
Windows	**Triple-glazed windows**	2,550	SF	101	$257,550.00
TOTAL					**$261,150.00**

Table 9: New Facade cost analysis

Tables 7 and 8 show the cost analyses for both the current and new façades. The main three areas where savings can occur are the canopy, façade construction labor, and windows. The canopy has been removed in exchange of triple-glazed windows which cost nearly as much as the curved custom windows would cost. Also, the new façade being straight right than concave makes it easier and cheaper to install.

	Savings
Canopy	$92,459
Facade construction labor	$1,440
Windows	-$8,721
TOTAL	**$85,178**

Table 10: New facade cost savings

The cost savings incurred from the new façade design totals $85,178. This is a rough estimate and can have an accuracy of up to %30, but it is enough to show that is cost effective.

341. Effect on schedule and constructability

As far as schedule and constructability, the new design will be easier on both. The new design is easier and faster to construct which means a potential reduction in schedule. One point to make here is to make sure to order the triple-glazed windows in advance to allow for any lead time. The curtain wall itself though should take less time in installing. The current façade canopy has irregular shaped columns which took more than usual time in both procurement and installation. The total time to install the façade and the canopy was 4 weeks. The new façade, which does not have a canopy, should take 2 weeks at most to install. The time difference here will not affect the overall schedule time as this activity was not in the critical path.

350. Mechanical Breadth: Cooling load analysis

The Susquehanna Center is cooled using a McQuay AGS226DP High Efficiency Chiller. Its capacity is 205 tons, which is sufficient for the whole building. The way the cooling system was designed is to calculate the cooling peaks for all spaces. That came out to be 204 tons. This will never occur though, so the 205 ton chiller used should be more than enough. A depth of 3” was added to the pool, which was not accounted for when the mechanical system was designed.

In order to conduct the pool cooling load analysis, the Trane Trace™700 software was utilized. First, the cooling load will be calculated for the original design for the fitness center’s facade. Second, it will be calculated assuming the new façade design was implemented. The new façade design suggests the use of triple-glaze low-e windows which would decrease the heat gain inside the fitness center. The next chiller in the line is the McQuay AGS210DP Chiller which has a capacity of 190 tons. That means that the difference between the two cooling loads has to be 14 tons or greater to impact the mechanical equipment choice. The next two pages show the parameters entered in the Trance Trace™700 software followed by the results.

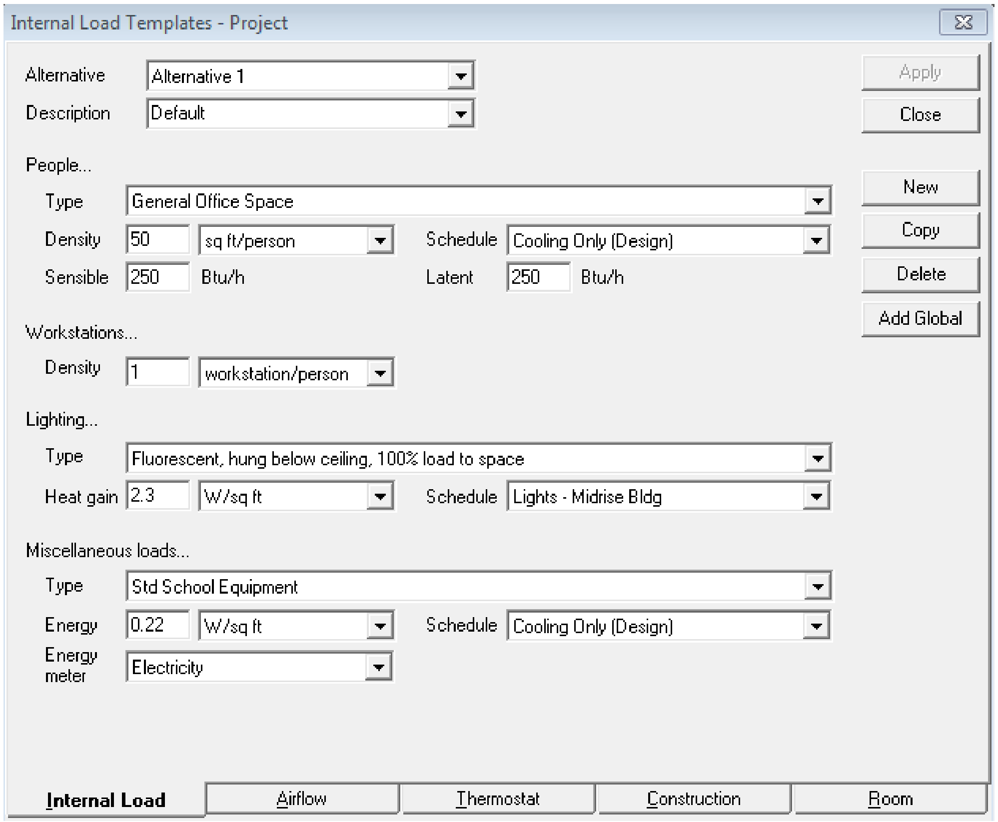

Figure 28: Trace Internal Load parameters

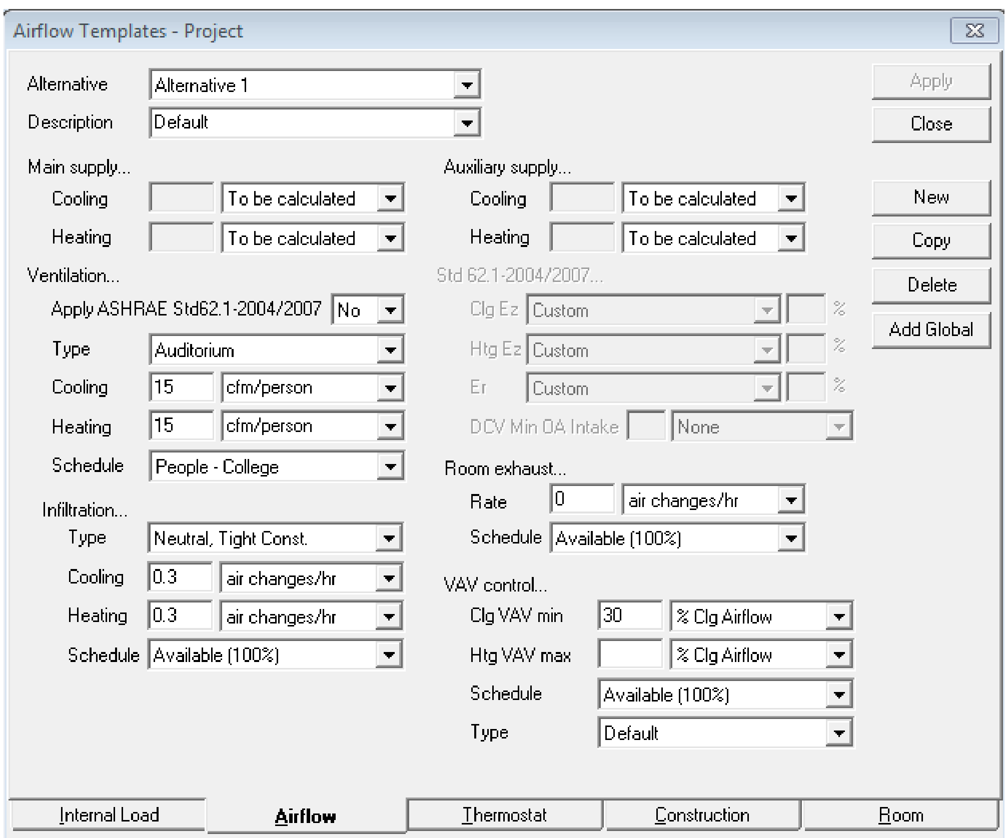

Figure 27: Trace Airflow parameters

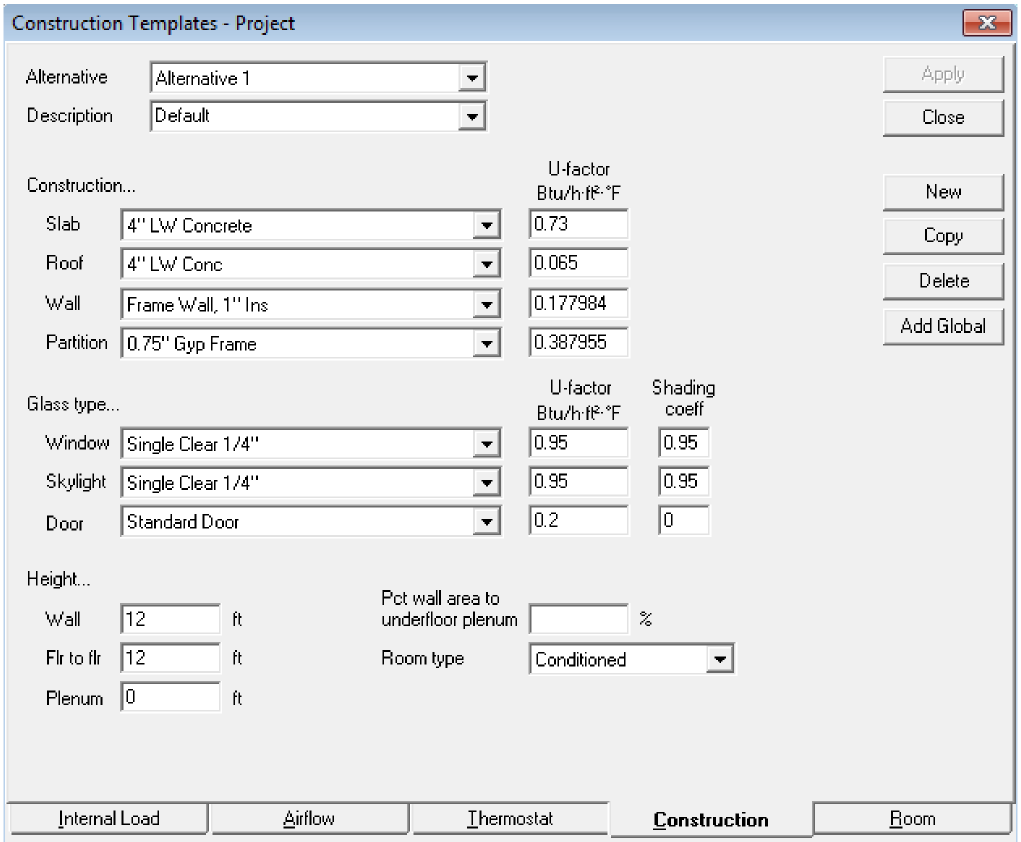

Figure 30: Trace Construction parameters

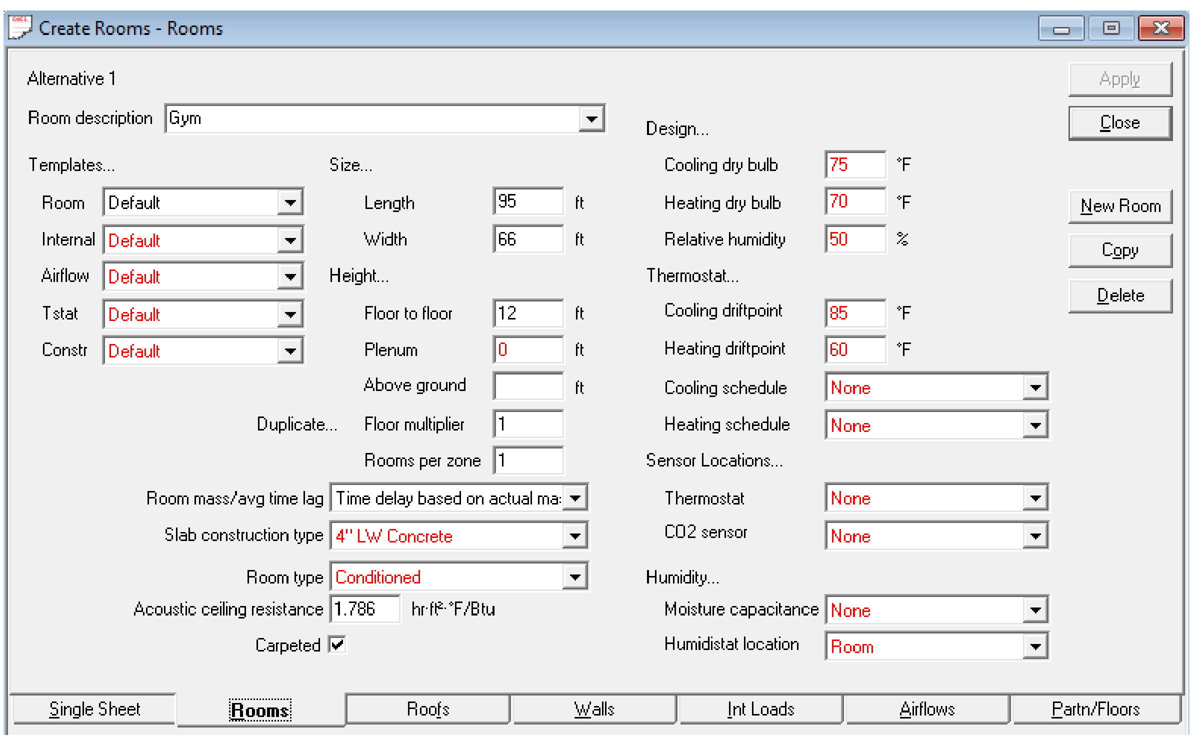

Figure 29: Trace Room features parameters

COOLING COIL SELECTION	Total Capacity		Sens Cap.	Coil Airflow	Enter DB/WB/HR			Leave DB/WB/HR		
	ton	MBh	MBh	cfm	°F	°F	gr/lb	°F	°F	gr/lb
Main Clg	23.8	285.9	172.4	5,151	80.8	68.4	85.2	50.7	50.3	54.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	23.8	285.9								

Figure 31: Original fitness center's cooling load

COOLING COIL SELECTION	Total Capacity		Sens Cap.	Coil Airflow	Enter DB/WB/HR			Leave DB/WB/HR		
	ton	MBh	MBh	cfm	°F	°F	gr/lb	°F	°F	gr/lb
Main Clg	23.1	277.5	165.0	4,876	81.2	68.8	86.6	50.7	50.3	54.0
Aux Clg	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Opt Vent	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0
Total	23.1	277.5								

Figure 32: New fitness center's cooling load

Figures 30 and 31 show the Trane Trace™700 model results. The original fitness center has a peak of 23.8 tons cooling load, while the new design would require 23.1 tons, which mean savings of 0.7 tons. That is much less than what is required (14 tons) to change the mechanical equipment.

360. Conclusion

All in all, a new alternative façade design option has been proposed that costs less while still meets the owner's requirements. Even though it would not affect the overall schedule time, it would carry $85,178 of savings. This is a great value engineering example from a pure architectural point of view where cost and schedule savings have been harvested from manipulating the architectural design. This analysis has proved the limitless potential that both value engineering and architecture carry. The mechanical breadth section analyzed the cooling load saved from using triple-glazed low-e windows and it came out to be 0.7 tons. That would not change the mechanical equipment design.

500. Final Recommendations and Conclusions

Thesis research and analysis have concluded on each of the four analyses with a positive note, whether they were results, recommendations, or lessons learned. The Susquehanna Center Renovation and Addition project has been a perfect example to research on the four topics analyzed. If there were two words to take away from this thesis project they would be "Early Involvement". Early involvement would solve most if not all the cases mentioned whether it was a weather schedule delay, negotiating BIM use, or redesigning a part of building. However, each and every one of the analyses has left a unique and special interpretation of that, explained below:

Analysis 1: Reduction of weather impact on the foundation schedule

The main aspects discussed about weather impact on construction generally (and foundation particularly) are the schedule, physical, and contractual aspects. Early involvement and action is a key in each one of them. NOAA climatological reports are critical to rely on in the schedule aspect, but weather has to be watched out for and checked regularly in order to act as soon as possible if anything happens. There are physical techniques that reduce the weather impact rather than prevent it, except if it was possible to cover the excavation site and prevent whether from affecting it. This was not possible in the Susquehanna Center case though. Lastly, weather related issues have to be clearly addressed and understood.

Analysis 2: BIM use in the Susquehanna Center renovation project

Although BIM is spreading around very fast around the nation and the globe, the Susquehanna Center project team did not implement it. The construction team faced great BIM challenges that seem infeasible. The subcontractors that lack BIM knowledge and the construction documents format are two of the biggest obstacles in the path of implementing BIM in this project. However, after conducting cost, constructability and schedule analyses, it came out that BIM will most likely benefit the project and all the aforementioned aspects. It is estimated to carry 44% to 140% Return Of Investment and at least one week of schedule reduction. The most important recommendation here is that BIM should be seriously considered in every project no matter how many challenges may be faced. However, in order to get the most out it (and actually maintain its feasibility), BIM has to be implemented very early in the project as early as the first meeting of the planning phase.

Analysis 3: Alternative façade system (Architectural and Mechanical Breadths)

The challenge in this analysis was to maintain the owner's requirement while redesigning the façade for a lower cost. After a series of designs and alterations, the analysis concluded with a design that carried total costs savings of about $85,178. It was a great value engineering example from a pure architectural point of view where cost and schedule savings have been harvested from manipulating the architectural design. This analysis has proved the limitless potential that both value engineering and architecture have. Since the windows are suggested to be changed in the new design into triple-glazed low-e windows, the mechanical breadth was about effect of that in the fitness center cooling load. The Trane Trace™700 model have indicated that the cooling load would be less by 0.7 tons which was not enough to change the chiller type.

510. References

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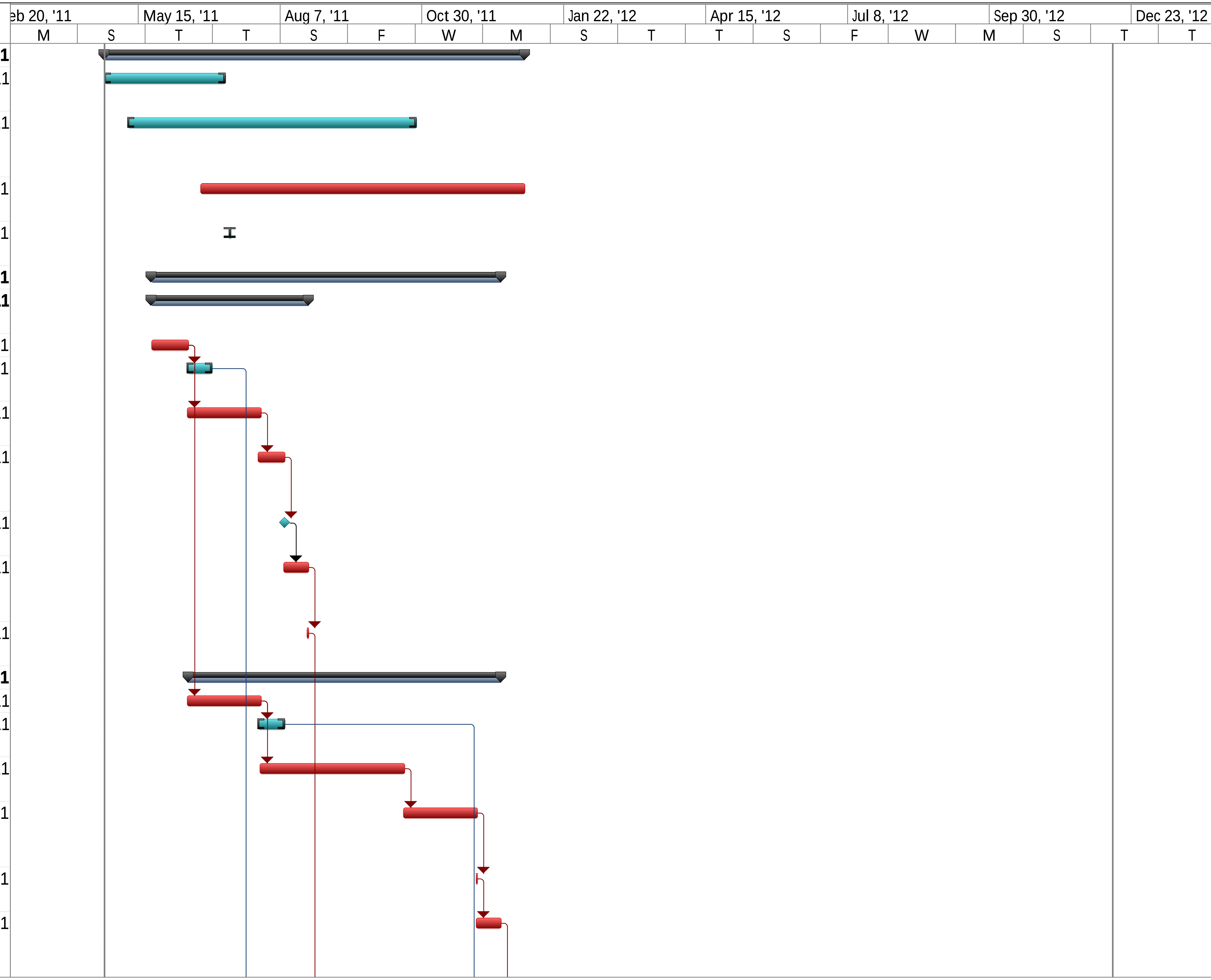
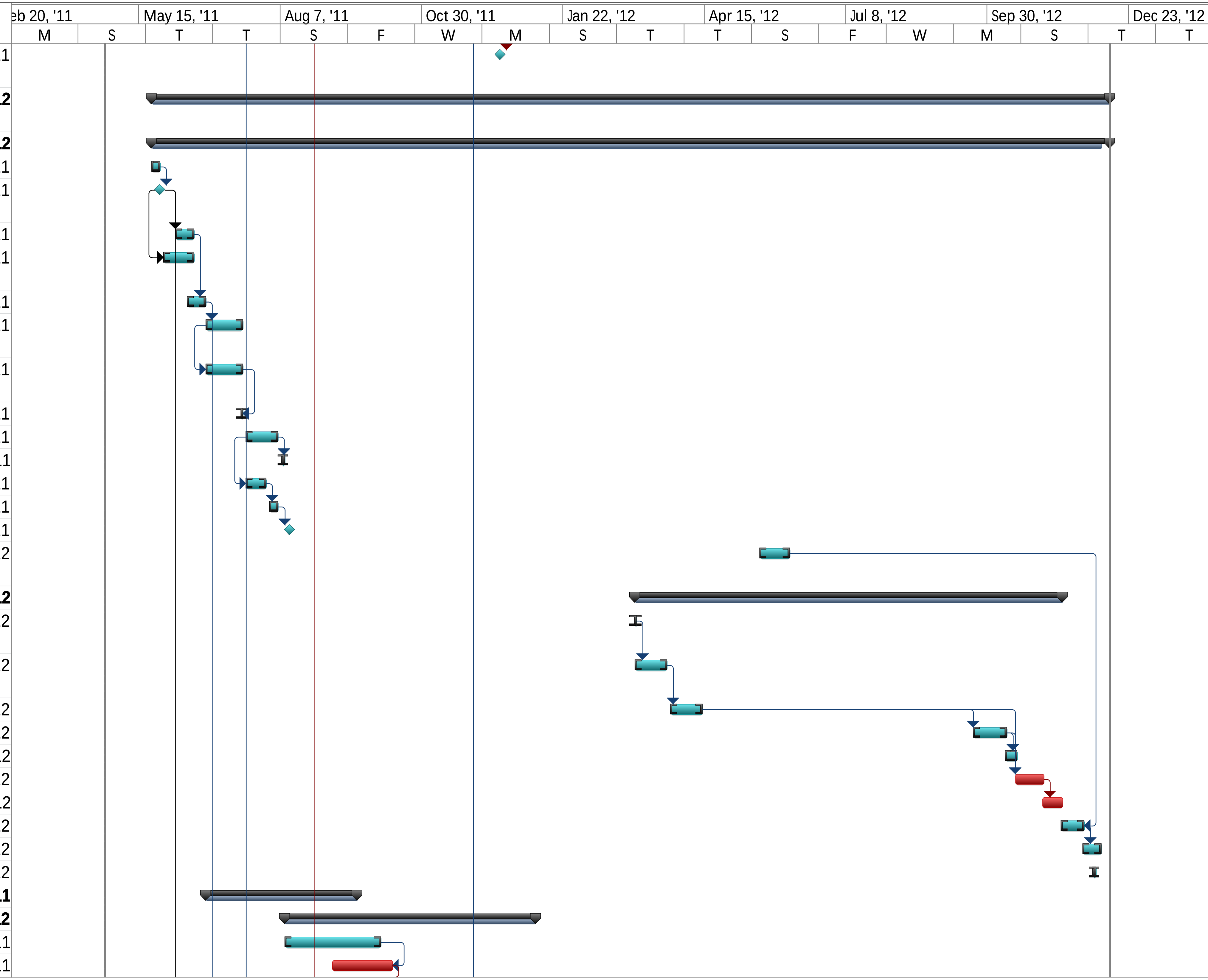
Appendix A
Detailed Project Schedule

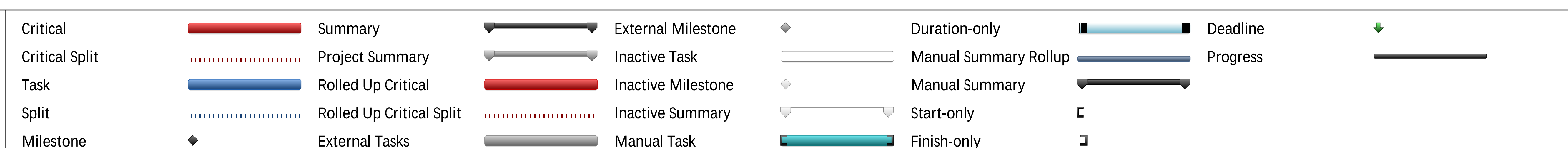
ID	Name	Duration	Start	Finish
1	**Preconstruction**	**179 days**	**Mon 4/25/11**	**Thu 12/29/11**
2	Descope/Award Recommendations	52 days	Mon 4/25/11	Tue 7/5/11
3	Engineering/Shop Drawing Period - Submittal and Approval	123 days	Mon 5/9/11	Wed 10/26/11
4	Material Lead Times After Procurement and Approvals	138 days	Tue 6/21/11	Thu 12/29/11
5	Susquehanna Center Critical Submittals Complete	1 day	Fri 7/8/11	Fri 7/8/11
6	**MEP Coordination**	**149 days**	**Mon 5/23/11**	**Thu 12/15/11**
7	**Susquehanna Center MEP Coordination**	**67 days**	**Mon 5/23/11**	**Tue 8/23/11**
8	Underslab Coordination	3.2 wks	Mon 5/23/11	Mon 6/13/11
9	Underslab Coordination Submittal and Approval	2.2 wks	Mon 6/13/11	Mon 6/27/11
10	Renovation Coordinated Drawing for Approval	6.4 wks	Mon 6/13/11	Tue 7/26/11
11	Design Team Review / Approval Period (1st release)	2.4 wks	Mon 7/25/11	Tue 8/9/11
12	Release Subcontractor (1st area)	0 days	Tue 8/9/11	Tue 8/9/11
13	Sheet Metal Material Lead Time/ Fabrication (1st release)	11 days	Tue 8/9/11	Tue 8/23/11
14	Begin Sheet Metal Work on Site (1st release)	1 day	Tue 8/23/11	Tue 8/23/11
15	**Arena MEP Coordination**	**133 days**	**Tue 6/14/11**	**Thu 12/15/11**
16	Underslab Coordination	6.4 wks	Mon 6/13/11	Tue 7/26/11
17	Underslab Coordination Submittal and Approval	2.4 wks	Mon 7/25/11	Tue 8/9/11
18	Arena Coordinated Drawings for Approval	12.4 wks	Tue 7/26/11	Wed 10/19/11
19	Design Team Review / Approval Period (1st release)	6.4 wks	Wed 10/19/11	Thu 12/1/11
20	Release Subcontractor (1st area)	1 day	Thu 12/1/11	Thu 12/1/11
21	Sheet Metal Material Lead Time/ Fabrication (1st release)	2.2 wks	Thu 12/1/11	Thu 12/15/11



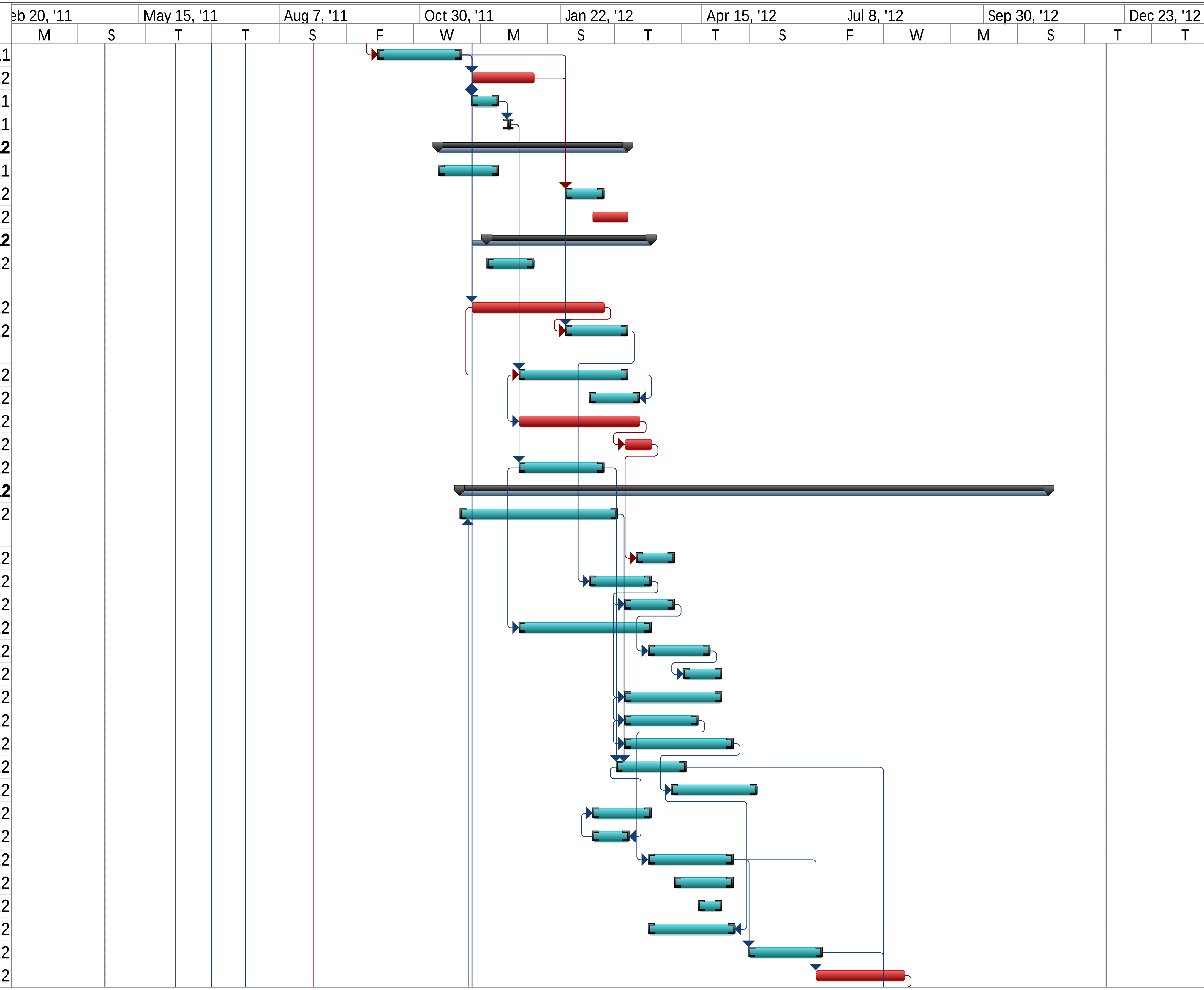
Critical		Summary		External Milestone		Duration-only		Deadline	
Critical Split		Project Summary		Inactive Task		Manual Summary Rollup		Progress	
Task		Rolled Up Critical		Inactive Milestone		Manual Summary			
Split		Rolled Up Critical Split		Inactive Summary		Start-only			
Milestone		External Tasks		Manual Task		Finish-only			

ID	Name	Duration	Start	Finish
22	Begin Sheet Metal Work on Site (1st release)	0 days	Thu 12/15/11	Thu 12/15/11
23	**Susquehanna Center's Arena Addition**	**407 days**	**Mon 5/23/11**	**Tue 12/11/12**
24	**Sitework**	**407 days**	**Mon 5/23/11**	**Tue 12/11/12**
25	Mobilization	1 wk	Mon 5/23/11	Fri 5/27/11
26	Construction Entrance and Site Fencing	0 days	Fri 5/27/11	Fri 5/27/11
27	Excavate Test Pits	9 days	Mon 6/6/11	Thu 6/16/11
28	Install Sedimentation Basin & E & S Controls	14 days	Mon 5/30/11	Thu 6/16/11
29	Site Prep Clearing	9 days	Mon 6/13/11	Thu 6/23/11
30	Bulk Excavation (Strip, Stockpile, Cuts & Fills)	16 days	Fri 6/24/11	Fri 7/15/11
31	Site Utilities Cut, Cap and Divert & Demo	16 days	Fri 6/24/11	Fri 7/15/11
32	Temporary Roadways	1 day	Fri 7/15/11	Fri 7/15/11
33	Underpinning	15 days	Mon 7/18/11	Fri 8/5/11
34	Building Pad Subgrade	2 days	Mon 8/8/11	Tue 8/9/11
35	Parking Lot Subase	10 days	Mon 7/18/11	Fri 7/29/11
36	Curbs	5 days	Mon 8/1/11	Fri 8/5/11
37	Base Course Paving	0 days	Fri 8/12/11	Fri 8/12/11
38	Repairs and Wearing Course Installation	12 days	Fri 5/18/12	Mon 6/4/12
39	**Tennis Courts**	**182 days**	**Mon 3/5/12**	**Tue 11/13/12**
40	WWTP Certified and Connected (By HCC)	1 day	Mon 3/5/12	Mon 3/5/12
41	Remove Existing Sanitary Drain Field	15 days	Mon 3/5/12	Fri 3/23/12
42	Tennis Court Earthwork	15 days	Mon 3/26/12	Fri 4/13/12
43	Retaining Walls & Steps	15 days	Sat 9/22/12	Thu 10/11/12
44	Fencing	5 days	Thu 10/11/12	Wed 10/17/12
45	Court Installation	13 days	Wed 10/17/12	Fri 11/2/12
46	Railings	8 days	Fri 11/2/12	Tue 11/13/12
47	Sand Filter/Pocket Wetland	10 days	Tue 11/13/12	Mon 11/26/12
48	Landscaping	9 days	Mon 11/26/12	Thu 12/6/12
49	Signage	2 days	Sun 12/2/12	Mon 12/3/12
50	**Site utilities**	**64 days**	**Fri 6/24/11**	**Wed 9/21/11**
56	**Structure**	**107 days**	**Wed 8/10/11**	**Thu 1/5/12**
57	Foundations Exc/concrete	41 days	Wed 8/10/11	Wed 10/5/11
58	CMU Foundations	26 days	Wed 9/7/11	Wed 10/12/11





ID	Name	Duration	Start	Finish
59	Steel Framing	36 days	Wed 10/5/11	Wed 11/23/11
60	Exterior CMU Walls	27 days	Wed 11/30/11	Thu 1/5/12
61	Underslab MEP Rough in	12 days	Wed 11/30/11	Thu 12/15/11
62	Slab on Grade	2 days	Wed 12/21/11	Thu 12/22/11
63	**Building Envelope**	**81 days**	**Thu 11/10/11**	**Thu 3/1/12**
64	Roofing	26 days	Thu 11/10/11	Thu 12/15/11
65	Curtainwall	17 days	Wed 1/25/12	Thu 2/16/12
66	Storefront Entrances	15 days	Fri 2/10/12	Thu 3/1/12
67	**Rough - in**	**70 days**	**Fri 12/9/11**	**Thu 3/15/12**
68	Install and Rough in Roof top Equipment	20 days	Fri 12/9/11	Thu 1/5/12
69	MEP Rough In	57 days	Wed 11/30/11	Thu 2/16/12
70	Structural Painting (off hours)	27 days	Wed 1/25/12	Thu 3/1/12
71	Interior CMU Partitions	47 days	Wed 12/28/11	Thu 3/1/12
72	Stud Framing	22 days	Wed 2/8/12	Thu 3/8/12
73	Wall Rough-in	52 days	Wed 12/28/11	Thu 3/8/12
74	Close Walls	12 days	Wed 2/29/12	Thu 3/15/12
75	Metal Pan Stairs & Risers	37 days	Wed 12/28/11	Thu 2/16/12
76	**Finishes**	**251 days**	**Wed 11/23/11**	**Wed 11/7/12**
77	Building Conditioning Available	68 days	Wed 11/23/11	Fri 2/24/12
78	Drywall Finishing	17 days	Wed 3/7/12	Thu 3/29/12
79	Blockfill CMU Walls	27 days	Wed 2/8/12	Thu 3/15/12
80	Ceramic Tile	22 days	Wed 2/29/12	Thu 3/29/12
81	Misc Metals/Railings	57 days	Wed 12/28/11	Thu 3/15/12
82	Plumbing Fixtures	27 days	Wed 3/14/12	Thu 4/19/12
83	Toilet partitions	17 days	Wed 4/4/12	Thu 4/26/12
84	Paint	42 days	Wed 2/29/12	Thu 4/26/12
85	Ceiling Grid	32 days	Wed 2/29/12	Thu 4/12/12
86	Millwork	47 days	Wed 2/29/12	Thu 5/3/12
87	Wood Flooring	30 days	Fri 2/24/12	Thu 4/5/12
88	Carpet/VCT	37 days	Wed 3/28/12	Thu 5/17/12
89	Seat Installation	25 days	Fri 2/10/12	Thu 3/15/12
90	Court Fixture install	16 days	Fri 2/10/12	Fri 3/2/12
91	Grills, Registers, Diffusers	37 days	Wed 3/14/12	Thu 5/3/12
92	Lighting	25 days	Fri 3/30/12	Thu 5/3/12
93	Drop Heads	10 days	Fri 4/13/12	Thu 4/26/12
94	Ceiling Tile	38 days	Wed 3/14/12	Fri 5/4/12
95	Fixtures & Devices	32 days	Sun 5/13/12	Mon 6/25/12
96	Testing and Balancing	37 days	Fri 6/22/12	Mon 8/13/12



Critical | Summary | External Milestone | Duration-only | Deadline

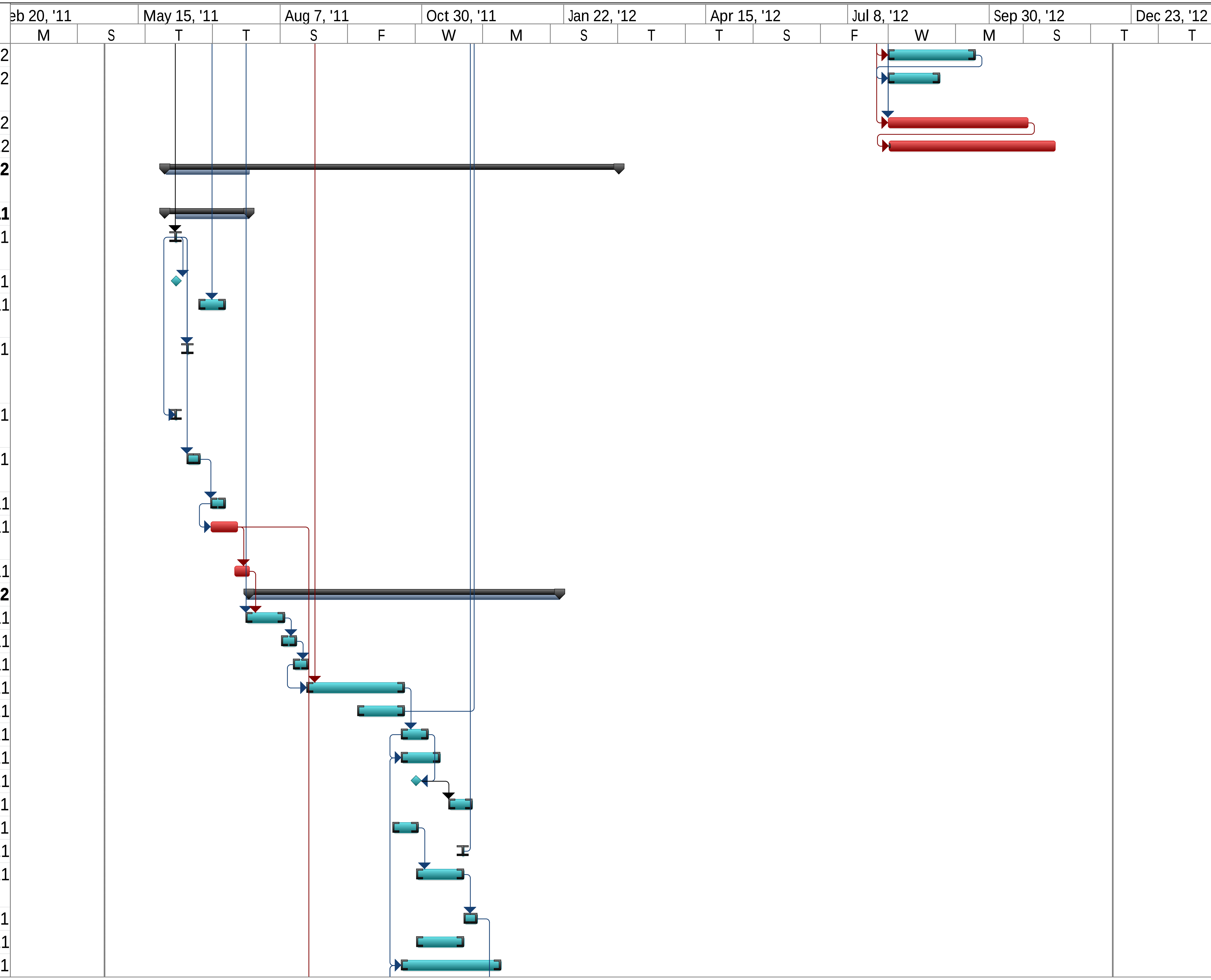
Critical Split | Project Summary | Inactive Task | Manual Summary Rollup | Progress

Task | Rolled Up Critical | Inactive Milestone | Manual Summary

Split | Rolled Up Critical Split | Inactive Summary | Start-only

Milestone | External Tasks | Manual Task | Finish-only

ID	Name	Duration	Start	Finish
97	Commissioning	38 days	Wed 8/1/12	Fri 9/21/12
98	Arena Substantial Completion	23 days	Wed 8/1/12	Fri 8/31/12
99	Punch List	59 days	Wed 8/1/12	Mon 10/22/12
100	Final Completion	70.5 days	Wed 8/1/12	Wed 11/7/12
101	**Renovation of Susquehanna Center**	**193 days**	**Tue 5/31/11**	**Thu 2/23/12**
102	**Demolition**	**36 days**	**Tue 5/31/11**	**Tue 7/19/11**
103	Cut, Cap & Safe-off all Utilities	1 day	Mon 6/6/11	Mon 6/6/11
104	Install Temporary Lighting	0 days	Mon 6/6/11	Mon 6/6/11
105	Install Bypass Utilities (HW & Elec)	12 days	Mon 6/20/11	Tue 7/5/11
106	Remove and Store Scoreboards & Athletic Equipment for Reuse	1 day	Mon 6/13/11	Mon 6/13/11
107	Install Temporary Barricades and Protection	1 day	Mon 6/6/11	Mon 6/6/11
108	Demo Ceilings & Ceiling Hung Equipment	6 days	Mon 6/13/11	Mon 6/20/11
109	Demo Walls	7 days	Mon 6/27/11	Tue 7/5/11
110	Sawcut and Remove SOG for Demo & New Work	12 days	Mon 6/27/11	Tue 7/12/11
111	Demo Underslab Utilities	7 days	Mon 7/11/11	Tue 7/19/11
112	**Fit Out**	**132 days**	**Wed 7/20/11**	**Thu 1/19/12**
113	Underslab MEPS Work	17 days	Mon 7/18/11	Tue 8/9/11
114	Slab Infills	7 days	Mon 8/8/11	Tue 8/16/11
115	Partition layout	7 days	Mon 8/15/11	Tue 8/23/11
116	Above Ceiling MEPS	42 days	Tue 8/23/11	Wed 10/19/11
117	Susquehanna New Veneer	20 days	Thu 9/22/11	Wed 10/19/11
118	Int Framing	12 days	Tue 10/18/11	Wed 11/2/11
119	Wall Rough in	17 days	Tue 10/18/11	Wed 11/9/11
120	New Entrance Steel	0 days	Wed 10/26/11	Wed 10/26/11
121	Entry Doors & Windows	10 days	Tue 11/15/11	Mon 11/28/11
122	Install New Curbs/Roof Repairs	11 days	Thu 10/13/11	Thu 10/27/11
123	Permanent Power Energized	1 day	Wed 11/23/11	Wed 11/23/11
124	Rooftop Equipment Installation	20 days	Thu 10/27/11	Wed 11/23/11
125	Building Conditioning/Start up	1.2 wks	Thu 11/24/11	Thu 12/1/11
126	Generator Installation	20 days	Thu 10/27/11	Wed 11/23/11
127	Drywall/Tape/Spackle	43 days	Tue 10/18/11	Thu 12/15/11



Critical		Summary		External Milestone		Duration-only		Deadline	
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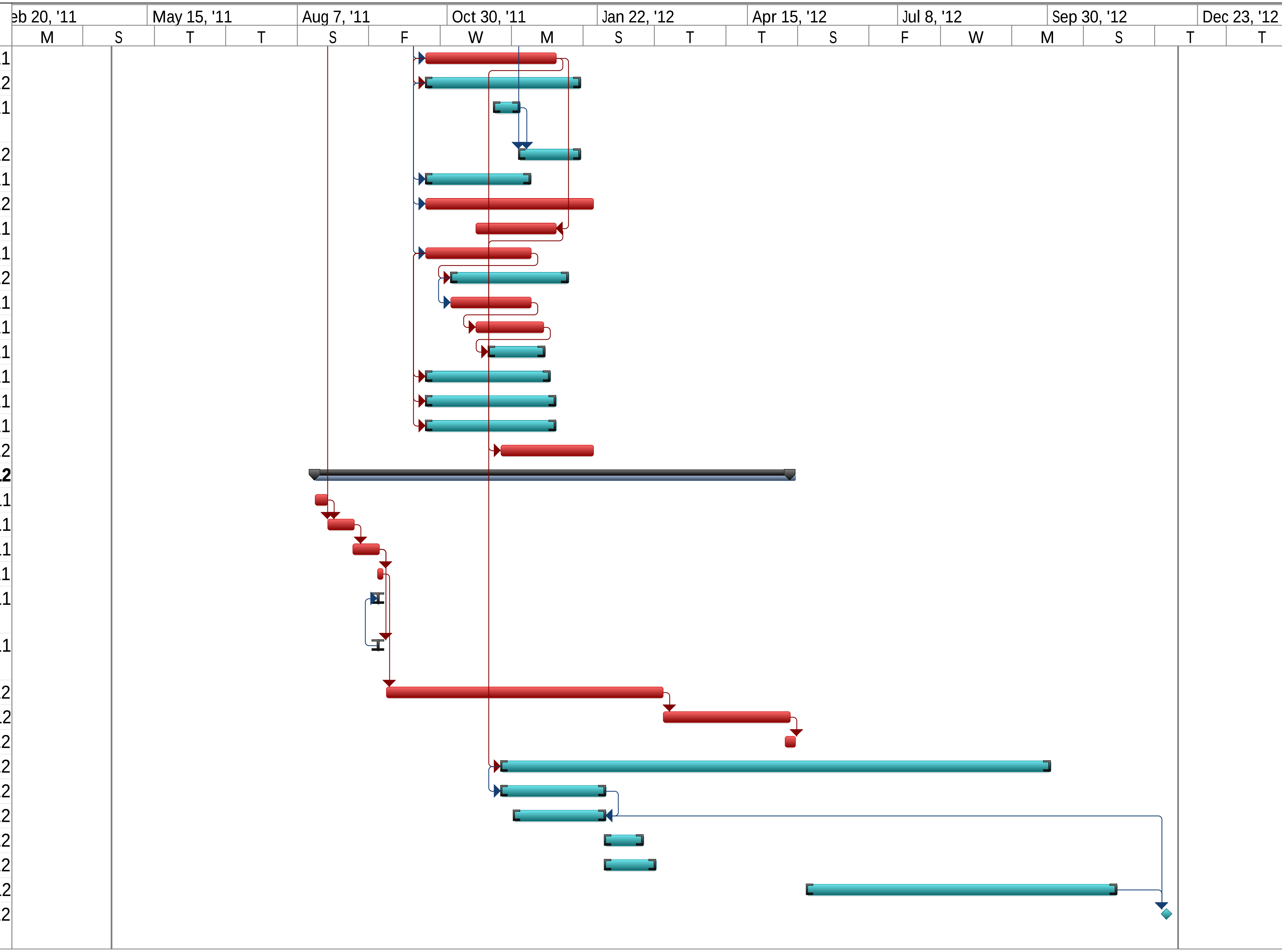
Task		Rolled Up Critical		Inactive Milestone		Manual Summary			
Split		Rolled Up Critical Split		Inactive Summary		Start-only			
Milestone		External Tasks		Manual Task		Finish-only			

ID	Name	Duration	Start	Finish
128	Painting/Finishes	53 days	Tue 10/18/11	Thu 12/29/11
129	Millwork	63 days	Tue 10/18/11	Thu 1/12/12
130	Athletic Equipment Reinstallation	11 days	Fri 11/25/11	Fri 12/9/11
131	Wood Flooring	25 days	Fri 12/9/11	Thu 1/12/12
132	Ceramic Tile	43 days	Tue 10/18/11	Thu 12/15/11
133	Carpet/VCT	68 days	Tue 10/18/11	Thu 1/19/12
134	Doors and Hardware	33 days	Tue 11/15/11	Thu 12/29/11
135	Ceiling Grid	43 days	Tue 10/18/11	Thu 12/15/11
136	Ceiling Tile	48 days	Tue 11/1/11	Thu 1/5/12
137	Plumbing Fixtures	33 days	Tue 11/1/11	Thu 12/15/11
138	Toilet Partitions	28 days	Tue 11/15/11	Thu 12/22/11
139	Toilet Accessories	24 days	Tue 11/22/11	Fri 12/23/11
140	Lighting	50 days	Tue 10/18/11	Mon 12/26/11
141	Grill, Registers, Diffusers	53 days	Tue 10/18/11	Thu 12/29/11
142	Drop Sprinkler Heads	53 days	Tue 10/18/11	Thu 12/29/11
143	Devices	38 days	Tue 11/29/11	Thu 1/19/12
144	**Pool Restoration**	**190 days**	**Wed 8/17/11**	**Tue 5/8/12**
145	Main Drain Work	5 days	Wed 8/17/11	Tue 8/23/11
146	Demo Pool Deck	11 days	Wed 8/24/11	Wed 9/7/11
147	Angles and Decking	11 days	Wed 9/7/11	Wed 9/21/11
148	Concrete	3 days	Wed 9/21/11	Fri 9/23/11
149	Demo MEPS Infrastructure (pumps, gear, surge tank, etc)	1 day	Wed 9/21/11	Wed 9/21/11
150	Pool Filter Loaded into Equipment Room	1 day	Wed 9/21/11	Wed 9/21/11
151	Pool MEP Improvements	111 days	Mon 9/26/11	Mon 2/27/12
152	Pool Tile/Finishes	51 days	Tue 2/28/12	Tue 5/8/12
153	Pool Inspections	6 days	Sun 5/6/12	Fri 5/11/12
154	Testing & Balancing	220 days	Tue 11/29/11	Mon 10/1/12
155	Commissioning	43 days	Tue 11/29/11	Thu 1/26/12
156	Final Cleaning	38 days	Tue 12/6/11	Thu 1/26/12
157	Owner FF & E	16 days	Thu 1/26/12	Thu 2/16/12
158	Punch List	21 days	Thu 1/26/12	Thu 2/23/12
159	Closeout Activities	124 days	Fri 5/18/12	Wed 11/7/12
160	Susquehanna Center Substantial Completion	0 days	Thu 12/6/12	Thu 12/6/12



Critical		Summary		External Milestone		Duration-only		Deadline	
Critical Split		Project Summary		Inactive Task		Manual Summary Rollup		Progress	
Task		Rolled Up Critical		Inactive Milestone		Manual Summary			
Split		Rolled Up Critical Split		Inactive Summary		Start-only			
Milestone		External Tasks		Manual Task		Finish-only			

Appendix B
Square Foot Estimate

CostWorks RSMeans **Square Foot Cost Estimate Report** Back Print Export

Estimate Name: **Untitled**

Building Type:	**Gymnasium with Face Brick with Concrete Block Back-up / Rigid Steel Frame**

Location:	**BALTIMORE, MD**
Stories:	**1**
Story Height (L.F.):	**37.5**
Floor Area (S.F.):	**57500**
Labor Type:	**Union**
Basement Included:	**No**
Data Release:	**Year 2010 Quarter 3**
Cost Per Square Foot:	**$142.60**
Building Cost:	**$8,199,500**

Costs are derived from a building model with basic components. Scope differences and market conditions can cause costs to vary significantly.

		% of Total	Cost Per S.F.	Cost
A Substructure		**6.4%**	**$6.87**	**$395,000**
A1010	**Standard Foundations**		**$0.98**	**$56,500**
	Strip footing, concrete, reinforced, load 11.1 KLF, soil bearing capacity 6 KSF, 12" deep x 24" wide			
	spread footings, 3000 PSI concrete, load 50K, soil bearing capacity 3 KSF, 4' - 6" square x 12" deep			
	spread footings, 3000 PSI concrete, load 50K, soil bearing capacity 6 KSF, 3' - 0" square x 12" deep			
A1030	**Slab on Grade**		**$4.51**	**$259,500**
	Slab on grade, 4" thick, non industrial, reinforced			
A2010	**Basement Excavation**		**$0.16**	**$9,000**
	Excavate and fill, 30,000 SF, 4' deep, sand, gravel, or common earth, on site storage			
A2020	**Basement Walls**		**$1.22**	**$70,000**
	Foundation wall, CIP, 4' wall height, direct chute, .099 CY/LF, 4.8 PLF, 8" thick			
B Shell		**38.4%**	**$40.90**	**$2,352,000**
B1020	**Roof Construction**		**$16.33**	**$939,000**
	Steel frame for 1 story buildings, 60 - 100' span			
	Steel deck, 3" deep, 16 ga, single 20' span, 6.0 PSF, 40 PSF superimposed load			
B2010	**Exterior Walls**		**$16.68**	**$959,000**
	Brick wall, composite double wythe, standard face/CMU back-up, 8" thick, perlite core fill			
B2020	**Exterior Windows**		**$2.95**	**$169,500**
	Windows, aluminum, awning, standard glass, 3'-1" x 3'-2"			
B2030	**Exterior Doors**		**$0.53**	**$30,500**
	Door, aluminum & glass, sliding patio, tempered glass, economy, 6'-0" x 7'-0" opening			
	Door, wood, overhead, panels, heavy duty, manual operation, 10'-0" x 10'-0" opening			

	Door, steel 24 gauge, overhead, sectional, manual operation, 10'-0" x 10'-0" opening			
B3010	**Roof Coverings**		**$4.42**	**$254,000**
	Drip edge, aluminum .016" thick, 5" girth, mill finish			
	Roofing, single ply membrane, EPDM, 60 mils, fully adhered			
	Insulation, rigid, roof deck, polyisocyanurate, 2#/CF, 3.5" thick			
C Interiors		**18.5%**	**$19.72**	**$1,134,000**
C1010	**Partitions**		**$1.48**	**$85,000**
	Concrere block (CMU) partition, light weight, hollow, 6" thick, no finish			
C1020	**Interior Doors**		**$1.87**	**$107,500**
	Door, single leaf, kd steel frame, hollow metal, commercial quality, flush, 3'-0" x 7'-0" x 1-3/8"			
C1030	**Fittings**		**$0.12**	**$7,000**
	Toilet partitions, cubicles, ceiling hung, stainless steel			
C3010	**Wall Finishes**		**$2.83**	**$163,000**
	2 coats paint on masonry with block filler			
	Painting, masonry or concrete, latex, brushwork, primer & 2 coats			
	Ceramic tile, thin set, 4-1/4" x 4-1/4"			
C3020	**Floor Finishes**		**$12.57**	**$722,500**
	Tile, ceramic natural clay			
	Maple strip, sanded and finished, maximum			
	Add for sleepers on concrete, treated, 24" OC, 1"x2"			
C3030	**Ceiling Finishes**		**$0.85**	**$49,000**
	Acoustic ceilings, 3/4"mineral fiber, 12" x 12" tile, concealed 2" bar & channel grid, suspended support			
D Services		**29.3%**	**$31.23**	**$1,796,000**
D2010	**Plumbing Fixtures**		**$6.01**	**$345,500**
	Water closet, vitreous china, bowl only with flush valve, wall hung			
	Urinal, vitreous china, wall hung			
	Lavatory w/trim, wall hung, PE on CI, 19" x 17"			
	Service sink w/trim, PE on CI,wall hung w/rim guard, 24" x 20"			
	Shower, stall, baked enamel, terrazzo receptor, 36" square			
	Water cooler, electric, wall hung, dual height, 14.3 GPH			
D2020	**Domestic Water Distribution**		**$1.74**	**$100,000**
	Electric water heater, commercial, 100< F rise, 500 gal, 240 KW 984 GPH			
D3050	**Terminal & Package Units**		**$9.70**	**$558,000**
	Rooftop, single zone, air conditioner, banks or libraries, 10,000 SF, 41.67 ton			
D4010	**Sprinklers**		**$2.97**	**$171,000**
	Wet pipe sprinkler systems, steel, light hazard, 1 floor, 10,000 SF			
D5010	**Electrical Service/Distribution**		**$0.34**	**$19,500**
	Service installation, includes breakers, metering, 20' conduit & wire, 3 phase, 4 wire, 120/208 V, 400 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 400 A			
	Switchgear installation, incl switchboard, panels & circuit breaker, 400 A			
D5020	**Lighting and Branch Wiring**		**$8.43**	**$485,000**
	Receptacles incl plate, box, conduit, wire, 8 per 1000 SF, .9 watts per SF			
	Wall switches, 1.0 per 1000 SF			
	Miscellaneous power, 1 watt			

	Central air conditioning power, 4 watts			
	Fluorescent fixtures recess mounted in ceiling, 2 watt per SF, 40 FC, 10 fixtures @40 watt per 1000 SF			
D5030	**Communications and Security**		**$1.83**	**$105,500**
	Communication and alarm systems, includes outlets, boxes, conduit and wire, sound systems, 12 outlets			
	Communication and alarm systems, fire detection, non-addressable, 25 detectors, includes outlets, boxes, conduit and wire			
D5090	**Other Electrical Systems**		**$0.20**	**$11,500**
	Generator sets, w/battery, charger, muffler and transfer switch, gas/gasoline operated, 3 phase, 4 wire, 277/480 V, 7.5 kW			
E Equipment & Furnishings		**7.4%**	**$7.89**	**$453,500**
E1090	**Other Equipment**		**$7.89**	**$453,500**
	10 - Emergency lighting units, nickel cadmium battery operated, twin sealed beam light, 25 W, 6 V each			
	8 - Emergency lighting units, lead battery operated, twin sealed beam light, 25 W, 6 V each			
	7 - Sound system, trumpet			
	10 - Sound system, speaker, ceiling or wall			
	7 - Sound system, amplifier, 250 W			
	50 - Lockers, steel, baked enamel, single tier, maximum			
	3 - Basketball backstops, school equipment, wall mounted, swing-up, 6' extended, maximum			
	3 - Basketball backstops, school equipment, wall mounted, fixed, 6' extended, maximum			
	1 - School equipment, scoreboards, basketball, one side, maximum			
	2 - School equipment, scoreboards, basketball, one side, minimum			
	5 - Gym divider curtain, school equipment, mesh top, vinyl bottom, manual			
	30 - Bleachers, telescoping, school equipment, manual, 21 to 30 tier, maximum			
	Architectural equipment, school equipment bleachers-telescoping, manual operation, 15 tier, economy (per seat)			
	Architectural equipment, school equipment, weight lifting gym, universal, deluxe			
	Architectural equipment, sauna, prefabricated, including heater and controls, 7' high, 6' x 4'			
F Special Construction		**0.0%**	**$0.00**	**$0**
G Building Sitework		**0.0%**	**$0.00**	**$0**

SubTotal	**100%**	**$106.62**	**$6,130,500**
Contractor Fees (GC,Overhead,Profit)	**25.0%**	**$26.65**	**$1,532,500**
Architectural Fees	**7.0%**	**$9.33**	**$536,500**
User Fees	**0.0%**	**$0.00**	**$0**
Total Building Cost		**$142.60**	**$8,199,500**

CostWorks® RSMeans

Square Foot Cost Estimate Report

Back Print Export

Estimate Name: **Susquehanna Sports Center - Renovation**

Building Type:	**College, Student Union with Brick Face with Concrete Block Back-up / Steel Frame**
Location:	**BALTIMORE, MD**
Stories:	**2**
Story Height (L.F.):	**16**
Floor Area (S.F.):	**48315**
Labor Type:	**Union**
Basement Included:	**Yes**
Data Release:	**Year 2010 Quarter 3**
Cost Per Square Foot:	**$171.23**
Building Cost:	**$8,273,000**

Costs are derived from a building model with basic components. Scope differences and market conditions can cause costs to vary significantly.

			% of Total	Cost Per S.F.	Cost
A Substructure			**7.0%**	**$8.99**	**$434,500**
A1010	**Standard Foundations**			**$2.34**	**$113,000**
	Strip footing, concrete, reinforced, load 11.1 KLF, soil bearing capacity 6 KSF, 12" deep x 24" wide				
	Spread footings, 3000 PSI concrete, load 200K, soil bearing capacity 6 KSF, 6' - 0" square x 20" deep				
A1030	**Slab on Grade**			**$2.26**	**$109,000**
	Slab on grade, 4" thick, non industrial, reinforced				
A2010	**Basement Excavation**			**$1.51**	**$73,000**
	Excavate and fill, 10,000 SF, 8' deep, sand, gravel, or common earth, on site storage				
A2020	**Basement Walls**			**$2.89**	**$139,500**
	Foundation wall, CIP, 12' wall height, pumped, .444 CY/LF, 21.59 PLF, 12" thick				
B Shell			**36.8%**	**$47.09**	**$2,275,000**
B1010	**Floor Construction**			**$23.46**	**$1,133,500**
	Cast-in-place concrete column, 12" square, tied, 200K load, 12' story height, 142 lbs/LF, 4000PSI				
	Steel column, W12, 400 KIPS, 10' unsupported height, 79 PLF				
	Flat slab, concrete, with drop panels, 6" slab/2.5" panel, 12" column, 15'x15' bay, 75 PSF superimposed load, 153 PSF total load				
	Floor, composite concrete slab on fireproofed W beam, 5.5" slab, 25'x25' bay, 24.5" total depth, 125 PSF superimposed load, 200 PSF total				
B1020	**Roof Construction**			**$9.26**	**$447,500**
	Floor, composite slab on steel beam, 25'x25' bay, 4.5"slab, 20.5" total depth, 40 PSF superimposed load, 99 PSF total load				
B2010	**Exterior Walls**			**$8.10**	**$391,500**
	Brick wall, composite double wythe, standard face/CMU back-up, 8" thick, perlite core fill				

B2020	**Exterior Windows**		**$3.45**	**$166,500**
	Aluminum flush tube frame, for 1/4"glass,1-3/4"x4", 5'x6' opening, no intermediate horizontals			
	Glazing panel, plate glass, 1/4" thick, clear			
B2030	**Exterior Doors**		**$0.35**	**$17,000**
	Door, aluminum & glass, without transom, bronze finish, hardware, 3'-0" x 7'-0" opening			
B3010	**Roof Coverings**		**$2.44**	**$118,000**
	Roofing, asphalt flood coat, gravel, base sheet, 3 plies 15# asphalt felt, mopped			
	Insulation, rigid, roof deck, composite with 2" EPS, 1" perlite			
	Roof edges, aluminum, duranodic, .050" thick, 6" face			
	Flashing, aluminum, no backing sides, .019"			
	Gravel stop, aluminum, extruded, 4", mill finish, .050" thick			
B3020	**Roof Openings**		**$0.02**	**$1,000**
	Skylight, plastic domes, insulated curbs, 30 SF to 65 SF, single glazing			
C Interiors		**18.6%**	**$23.78**	**$1,149,000**
C1010	**Partitions**		**$3.36**	**$162,500**
	Metal partition, 5/8"fire rated gypsum board face, 1/4" sound deadening gypsum board, 2-1/2" @ 24", same opposite face, no insulation			
C1020	**Interior Doors**		**$6.67**	**$322,500**
	Door, single leaf, kd steel frame, hollow metal, commercial quality, flush, 3'-0" x 7'-0" x 1-3/8"			
C2010	**Stair Construction**		**$1.01**	**$49,000**
	Stairs, CIP concrete, w/landing, 20 risers, with nosing			
C3010	**Wall Finishes**		**$2.62**	**$126,500**
	2 coats paint on masonry with block filler			
	Painting, interior on plaster and drywall, walls & ceilings, roller work, primer & 2 coats			
	Vinyl wall covering, fabric back, medium weight			
C3020	**Floor Finishes**		**$6.20**	**$299,500**
	Carpet, tufted, nylon, roll goods, 12' wide, 36 oz			
	Carpet, padding, add to above, maximum			
	Vinyl, composition tile, maximum			
C3030	**Ceiling Finishes**		**$3.91**	**$189,000**
	Acoustic ceilings, 3/4" fiberglass board, 24" x 48" tile, tee grid, suspended support			
D Services		**37.4%**	**$47.85**	**$2,312,000**
D1010	**Elevators and Lifts**		**$7.70**	**$372,000**
	3 - Hydraulic, passenger elevator, 3500 lb, 2 floors, 100 FPM			
	Hydraulic passenger elevator, 2500 lb., 2 floor, 125 FPM			
D2010	**Plumbing Fixtures**		**$2.41**	**$116,500**
	Water closet, vitreous china, tank type, 2 piece close coupled			
	Urinal, vitreous china, wall hung			
	Lavatory w/trim, vanity top, PE on CI, 19" x 16" oval			
	Kitchen sink w/trim, countertop, stainless steel, 19" x 18" single bowl			
	Service sink w/trim, PE on CI, corner floor, 28" x 28", w/rim guard			
	Shower, stall, baked enamel, molded stone receptor, 32" square			
	Water cooler, electric, floor mounted, dual height, 14.3 GPH			
D2020	**Domestic Water Distribution**		**$0.39**	**$19,000**

	Gas fired water heater, commercial, 100< F rise, 200 MBH input, 192 GPH			
D2040	**Rain Water Drainage**		**$0.24**	**$11,500**
	Roof drain, CI, soil,single hub, 5" diam, 10' high			
	Roof drain, CI, soil,single hub, 5" diam, for each additional foot add			
D3050	**Terminal & Package Units**		**$17.49**	**$845,000**
	Rooftop, multizone, air conditioner, schools and colleges, 25,000 SF, 95.83 ton			
D4010	**Sprinklers**		**$2.67**	**$129,000**
	Wet pipe sprinkler systems, steel, light hazard, 1 floor, 10,000 SF			
	Wet pipe sprinkler systems, steel, light hazard, each additional floor, 10,000 SF			
D4020	**Standpipes**		**$0.68**	**$33,000**
	Wet standpipe risers, class III, steel, black, sch 40, 6" diam pipe, 1 floor			
	Wet standpipe risers, class III, steel, black, sch 40, 6" diam pipe, additional floors			
D5010	**Electrical Service/Distribution**		**$1.12**	**$54,000**
	Service installation, includes breakers, metering, 20' conduit & wire, 3 phase, 4 wire, 120/208 V, 600 A			
	Feeder installation 600 V, including RGS conduit and XHHW wire, 600 A			
	Switchgear installation, incl switchboard, panels & circuit breaker, 600 A			
D5020	**Lighting and Branch Wiring**		**$11.68**	**$564,500**
	Receptacles incl plate, box, conduit, wire, 8 per 1000 SF, .9 W per SF, with transformer			
	Wall switches, 2.0 per 1000 SF			
	Miscellaneous power, 1.2 watts			
	Central air conditioning power, 4 watts			
	Motor installation, three phase, 460 V, 15 HP motor size			
	Motor feeder systems, three phase, feed to 200 V 5 HP, 230 V 7.5 HP, 460 V 15 HP, 575 V 20 HP			
	Fluorescent fixtures recess mounted in ceiling, 2.4 watt per SF, 60 FC, 15 fixtures @ 32 watt per 1000 SF			
D5030	**Communications and Security**		**$3.32**	**$160,500**
	Communication and alarm systems, includes outlets, boxes, conduit and wire, sound systems, 12 outlets			
	Fire alarm command center, addressable without voice, excl. wire & conduit			
	Communication and alarm systems, includes outlets, boxes, conduit and wire, intercom systems, 25 stations			
	Communication and alarm systems, includes outlets, boxes, conduit and wire, master TV antenna systems, 12 outlets			
	Internet wiring, 8 data/voice outlets per 1000 S.F.			
D5090	**Other Electrical Systems**		**$0.14**	**$7,000**
	Generator sets, w/battery, charger, muffler and transfer switch, gas/gasoline operated, 3 phase, 4 wire, 277/480 V, 11.5 kW			
E Equipment & Furnishings		**0.2%**	**$0.31**	**$15,000**
E1090	**Other Equipment**		**$0.31**	**$15,000**
	3 - Sound system, trumpet			
	10 - Sound system, speaker, ceiling or wall			
	2 - Sound system, amplifier, 250 W			
	20 - Lockers, steel, baked enamel, single tier, maximum			
F Special Construction		**0.0%**	**$0.00**	**$0**
G Building Sitework		**0.0%**	**$0.00**	**$0**

SubTotal	**100%**	**$128.02**	**$6,185,500**

Contractor Fees (GC,Overhead,Profit)	**25.0%**	**$32.01**	**$1,546,500**
Architectural Fees	**7.0%**	**$11.20**	**$541,000**
User Fees	**0.0%**	**$0.00**	**$0**
Total Building Cost		**$171.23**	**$8,273,000**

Appendix C
Mechanical Assemblies Cost

Harford Community College,

Cost Estimate Report CostWorks RSMeans

Bel Air,

Unit Detail Report

MD , 21015

Year 2010 Quarter 3

Prepared By:
Haitham Alrasbi
aasda

Date: 20-Sep-12

Mechanical Assemblies

Line Number			Description	Quantity	Unit	Total Incl. O&P	Ext. Total Incl. O&P
Division 22 Plumbing							
220716102920			Insulation, domestic water heater wrap kit, with vinyl jacket, 1-1/2" thick, 20-60 gal.	12	Ea.	$95.65	$1,147.80
221423337300			Drain, backwater valve, soil pipe, cast iron body, bronze flapper valve, bolted cover, 4" pipe size	7	Ea.	$1,081.50	$7,570.50
221429131200			Pump, pedestal sump, solid brass, 21 GPM, 1/3 H.P., at 15' head, includes float control	10	Ea.	$415.00	$4,150.00
223530101080			Heat transfer package, complete, hot water, 180Deg. F enter, 200Deg. F leaving, 15 psi steam, one pump system, 255 GPM, includes controls, expansion tank, converter, air separator	2	Ea.	$41,550.00	$83,100.00
223530101120			Heat transfer package, complete, hot water, 180Deg. F enter, 200Deg. F leaving, 15 psi steam, one pump system, 800 GPM, includes controls, expansion tank, converter, air separator	2	Ea.	$62,975.00	$125,950.00
225119501040			Swimming Pool Equip., filter system, 5,000 SF pool, add for chlorination system	2	Ea.	$2,665.00	$5,330.00
Division 22 Plumbing Subtotal							**$227,248.30**
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC)							
230593200700			Balancing, water, fin tube and radiant panels, (Subcontractor's quote including material & labor)	2	Ea.	$124.00	$248.00
230713103430			Insulation, ductwork, blanket type, fiberglass, flexible, FSK facing, 1 lb. density, 2" thick	7781	S.F.	$3.62	$28,167.22
230923101030			Control Components/DDC Systems, subcontractor's quote incl. material & labor, analog outputs, (avg. 50' run in 1/2" EMT), pneumatic, excl. control device	23	Ea.	$613.83	$14,118.09
232120462380			Expansion tanks, steel, liquid expansion, galvanized, 24 gallon capacity, ASME	1	Ea.	$1,205.00	$1,205.00

232120462390			Expansion tanks, steel, liquid expansion, galvanized, 30 gallon capacity, ASME	1	Ea.	$1,293.50	$1,293.50
232123132300			Pump, circulating, cast iron, heated or chilled water application, in line, flanged joints, 1/2 H.P., 3" size	3	Ea.	$1,581.00	$4,743.00
232123132340			Pump, circulating, cast iron, heated or chilled water application, in line, flanged joints, 3/4 H.P., 3" size	5	Ea.	$1,781.00	$8,905.00
233113130150			Metal Ductwork, fabricated rectangular, 2000 to 5000 lb., aluminum alloy 3003-H14, includes fittings, joints, supports and allowance for a flexible connection, excludes insulation	4400	Lb.	$15.17	$66,748.00
233313136020			Duct accessories, multi-blade dampers, opposed blade, 12" x 18"	35	Ea.	$73.50	$2,572.50
233313163040			Duct accessories, fire damper, curtain type, vertical, 12" x 6", U.L. label, 1-1/2 hour rated	35	Ea.	$51.00	$1,785.00
233313328330			Duct accessories, relief damper, electronic bypass with tight seal, 16" x 10"	35	Ea.	$237.50	$8,312.50
233319109013			Duct accessories, duct sound trap, packaged, 9000 CFM, 24" x 30" x 36"	10	Ea.	$891.50	$8,915.00
233416103560			Fans, centrifugal, airfoil, motor and drive complete, 4000 CFM, 3 H.P.	7	Ea.	$3,280.00	$22,960.00
233613105200			Duct accessories, mixing box, constant volume, 150 to 270 CFM, includes electric or pneumatic motor	114	Ea.	$784.00	$89,376.00
235228100240			Swimming pool heater, gas fired, input, 300MBH, excludes wiring, piping, base or pad	6	Ea.	$5,025.00	$30,150.00
235288104825			Burner, burner oil pump, for 10,000 MBH boiler	4	Ea.	$112.00	$448.00
235716100200			Heat Exchanger, shell & tube type, cast iron heads, cast iron tube sheet, steel shell, 2 or 4 pass, hot water 40Deg.F to 180Deg.F, by steam at 10 PSI, 96 GPM, 3/4" copper tubes	2	Ea.	$10,275.00	$20,550.00
236333103720			Condenser, ratings are for evaporative, copper coil, pump, fan motor, 30Deg.F T.D., 150 ton, R-22	10	Ea.	$34,975.00	$349,750.00

236423100515			Packaged water chillers, scroll, liquid chiller, packaged unit with integral air cooled condenser, 30 ton cooling, includes standard controls	3	Ea.	$36,450.00	$109,350.00
237213104030			Heat recovery package, air to air, enthalpy recovery wheel, 4000 max CFM	5	Ea.	$10,375.00	$51,875.00
237313100926			Air handling unit, built-up, horizontal/vertical, constant volume, single zone, 6500 CFM, with cooling/heating coil section, filters, mixing box	16	Ea.	$13,350.00	$213,600.00
238126100130			Split ductless system, cooling only, single zone, wall mount, 1 ton cooling	12	Ea.	$1,420.00	$17,040.00
238219100150			Fan coil A.C., cabinet mounted, chilled water, 2 ton cooling, includes filters and controls	4	Ea.	$1,488.00	$5,952.00
238219100970			Fan coil A.C., direct expansion for use w/air cooled condensing unit, 3 ton cooling, includes filters and controls	4	Ea.	$1,370.00	$5,480.00
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC) Subtotal							**$1,063,543.81**

Printer Friendly Print Cancel

To view the Printer Friendly Version you'll need Adobe Acrobat Reader installed on your computer. To download click on the link below.

Get Acrobat Reader

Harford Community College,

Cost Estimate Report CostWorks RSMeans

Bel Air,

Unit Summary Report

MD , 21015

Year 2010 Quarter 3

Prepared By:

Haitham Alrasbi

aasda

Mechanical Assemblies

Date: 20-Sep-12

Division Description		**Total**
Division 22 Plumbing		$227,248.30
Division 23 Heating, Ventilating, and Air-Conditioning (HVAC)		$1,063,543.81
SubTotal		$1,290,792.11
General Contractor's Markup on Subs	3.00%	$0.00
SubTotal		$1,290,792.11
General Conditions	3.00%	$38,723.76
SubTotal		$1,329,515.87
General Contractor's Overhead and Profit	3.00%	$39,885.48
Grand Total		**$1,369,401.35**

Printer Friendly Print Cancel

To view the Printer Friendly Version you'll need Adobe Acrobat Reader installed on your computer. To download click on the link below.

Appendix D
General Conditions Estimate

General Conditions Estimate	
ITEM	COST
TEMPORARY FACILITIES	
Tools & Supplies	2,100
Job Office/Job Office Cleaning	21,120
Job Office Setup/Removal/Alteration	14,400
Temporary Buildings	18,000
Temporary Roads	49,300
Construction/Maintenance	8,000
Snow Removal/Rainwater Control	3,200
Temporary Stairs/Ladders	3,000
	119,120
TEMPORARY UTILITIES	
Temporary Heat/Install/Remove/Maintenance/Usage	50,000
Temporary Light & Power/Install/Remove/Maintenance/Usage	4,800
Temporary Plumbing & Toilets/Install/Remove/Maintenance/Usage	49,700
	104,500
PROTECTION AND SAFETY	
General Protection & Safety	14,600
Barricades/Railings/Perimeter Cable/Toe Boards	16,000
Safety Program/Watchman/Traffic Control/Drug Testing	27,600
Protect Finished Work In Place	8,000
Sidewalk Bridges/Fences	38,200
First Aid Facilities	5,120
	109,520

Appendix E
Detailed Staffing Plan

STAFFING PLAN					
STAFF	**Quantity**	**Unit**	**% of Time**	**Rate/Mo.**	**Extension**
Preconstruction					
Estimating/Purchasing					
Chief Estimator	5	months	0.1	$18,000.00	$9,000.00
Secretary	5	months	0.2	$5,000.00	$5,000.00
Sr. Estimator	5	months	0.25	$12,500.00	$15,625.00
Superintendent	5	months	0.148846	$10,122.00	$7,533.10
Sr. Mechanical Estimator	3	months	0.2	$10,000.00	$6,000.00
Project Manager	5	months	0.2	$12,000.00	$12,000.00
Superintendent	5	months	0.15	$10,122.00	$7,591.50
				Subtotal: Pr	$62,749.60
Construction					
Management					
Operations Manager	16	months	0.039663	$19,500.00	$12,375.00
Project Executive	16	months	0.04	$18,750.00	$12,000.00
Project Manager	16	months	0.5	$12,000.00	$96,000.00
Estimating/Purchasing					
Purchasing Manager	3	months	0.1	$12,000.00	$3,600.00
Purchasing Agent	2	months	1	$8,444.00	$16,888.00
Purchasing Clerical	2	months	0.25	$5,000.00	$2,500.00
Superintendence					
Project Superintendent	14	months	1	$10,122.00	$141,708.00
PM MEP / Commissioning	1	months	1	$12,000.00	$12,000.00
Asst Super /Engineer	14	months	1	$6,000.00	$84,000.00
Safety Director	14	months	0.08	$10,500.00	$11,760.00
Engineering					
Project Engineer	16	months	0.5	$7,000.00	$56,000.00
Financial					
Accountant	16	months	0.18	$13,259.75	$38,188.07
Cost Engineer	16	months	0.05	$13,259.75	$10,607.80
Other					
Administrative Assistant	14	months	0.25	$5,000.00	$17,500.00
TOTAL					**$515,126.90**

Appendix F
LEED Checklist

Appendix A
LEED Checklist

LEED for New Construction and Major Renovations

v3 / 2009 **Registered Project Scorecard**

Susquehanna Center renovation + Expansion

401 Thomas Run Road, Bel Air, Maryland 21015

hord | coplan | macht

Harford Community College

Yes	No	?		
39	45	25	PROJECT TOTALS (Pre-Certification Estimates)	110
			Certified: 40-49 Silver: 50-59 Gold 60-79 Platinum: 80+	45
				6

Yes	No	?		D/C	Design or Construction Submittal		Responsibility
8	14	4	**SS: SUSTAINABLE SITES**			26	
Y			Prereq 1	C	**Construction Activity Pollution Prevention**	Req'd	TC
1			Credit 1	D	**Site Selection**	1	HCM + SR
	5		Credit 2	D	**Development Density and Community Connectivity**	5	
	1		Credit 3	D	**Brownfield Redevelopment**	1	
	6		Credit 4.1	D	**Alternative Transportation -** Public Transportation Access	6	
1			Credit 4.2	D	**Alternative Transportation -** Bicycle Storage and Changing Rooms	1	HCM + SR
3			Credit 4.3	D	**Alternative Transportation -** Low-Emitting and Fuel-Efficient Vehicles	3	HCM + SR
2			Credit 4.4	D	**Alternative Transportation -** Parking Capacity	2	HCM + SR
		1	* RP Cr 5.1	C	**Site Development -** Protect or Restore Habitat	1	HCM + SR
		1	Credit 5.2	D	**Site Development -** Maximize Open Space	1	HCM + SR
	1		* RP Cr 6.1	D	**Stormwater Design -** Quantity Control	1	SR
	1		Credit 6.2	D	**Stormwater Design -** Quality Control	1	SR
		1	Credit 7.1	C	**Heat Island Effect -** Nonroof	1	HCM + SR
		1	Credit 7.2	D	**Heat Island Effect -** Roof	1	HCM
1			Credit 8	D	**Light Pollution Reduction**	1	BKM
6	0	4	**WE: WATER EFFICIENCY**			10	
Y			Prereq 1	D	**Water Use Reduction:** Reduce by 20%	Req'd	BKM
			Credit 1	D	**Water Efficient Landscaping**	2 to 4	SR
2					Reduce by 50%	2	SR
2					No Potable Water Use or Irrigation	4	SR
		2	* RP Cr 2	D	**Innovative Wastewater Technologies**	2	BKM
			Credit 3	D	**Water Use Reduction**	2 to 4	BKM
2					Reduce by 30%	2	
		1			Reduce by 35%	3	
		1			Reduce by 40%	4	

Appendix A
LEED Checklist

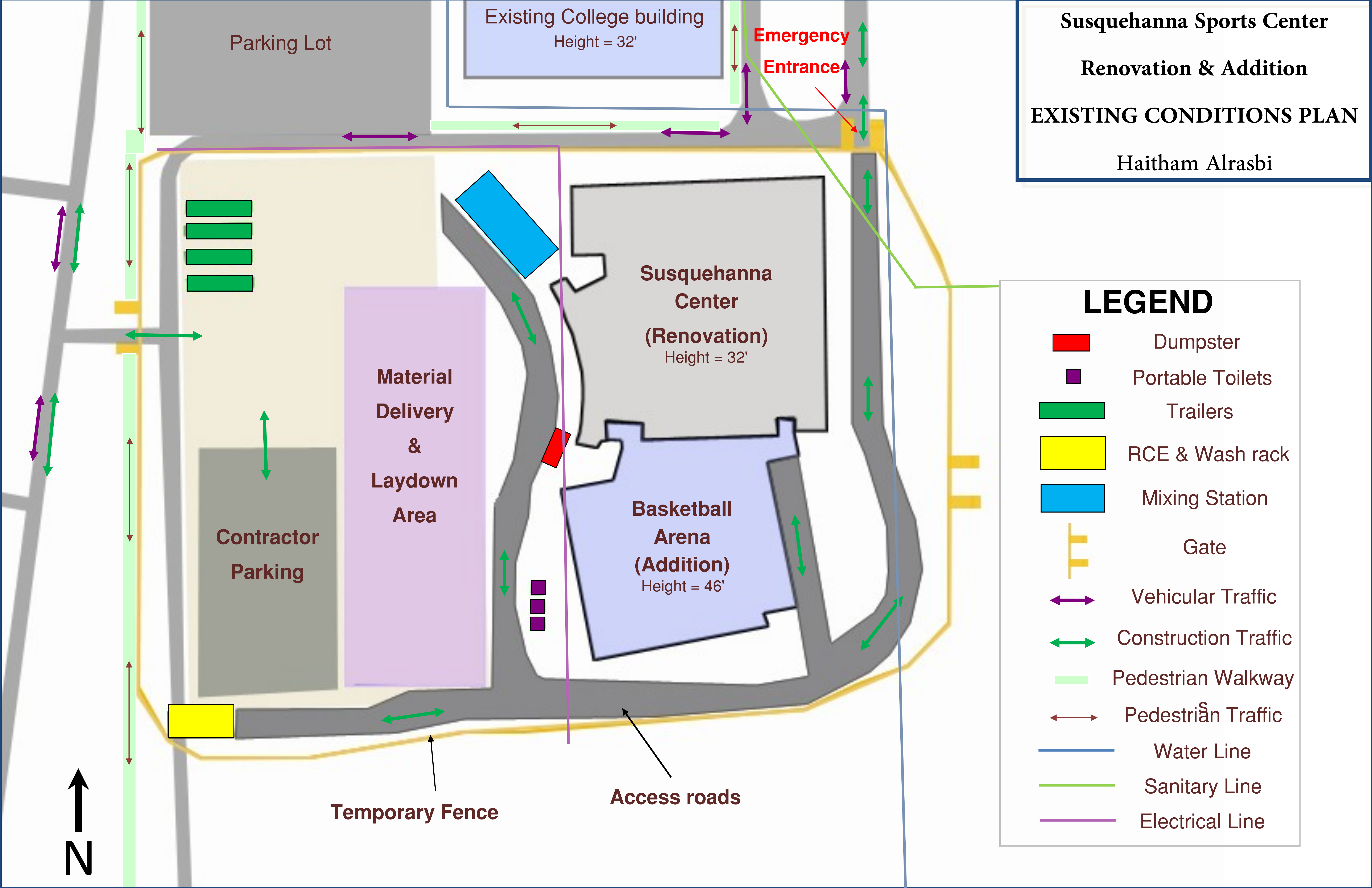
2	23	9			EA: ENERGY & ATMOSPHERE		35	
Y			Prereq 1	C	**Fundamental Commissioning of Building Energy Systems**		**Req'd**	HCC
Y			Prereq 2	D	**Minimum Energy Performance**		**Req'd**	BKM
Y			Prereq 3	D	**Fundamental Refrigerant Management**		**Req'd**	BKM
2	15	2	* RP Credit 1	D	**Optimize Energy Performance**		**1 to 19**	BKM
1						12% for New or 8% for Existing Building Renovations	1	
1						14% for New or 10% for Existing Building Renovations	2	
		1				16% for New or 12% for Existing Building Renovations	3	
		1				18% for New or 14% for Existing Building Renovations	4	
	1					20% for New or 16% for Existing Building Renovations	5	
	1					22% for New or 18% for Existing Building Renovations	6	
	1					24% for New or 20% for Existing Building Renovations	7	
	1					26% for New or 22% for Existing Building Renovations	8	
	1					28% for New or 24% for Existing Building Renovations	9	
	1					30% for New or 26% for Existing Building Renovations	10	
	1					32% for New or 28% for Existing Building Renovations	11	
	1					34% for New or 30% for Existing Building Renovations	12	
	1					36% for New or 32% for Existing Building Renovations	13	
	1					38% for New or 34% for Existing Building Renovations	14	
	1					40% for New or 36% for Existing Building Renovations	15	
	1					42% for New or 38% for Existing Building Renovations	16	
	1					44% for New or 40% for Existing Building Renovations	17	
	1					46% for New or 42% for Existing Building Renovations	18	
	1					48%+ for New or 44%+ for Existing Building Renovations	19	
0	6	0	* RP Credit 2	D	**On-Site Renewable Energy**		**1 to 7**	
	1					1% Renewable Energy	1	
	1					3% Renewable Energy	2	
	1					5% Renewable Energy	3	
	1					7% Renewable Energy	4	
	1					9% Renewable Energy	5	
	1					11% Renewable Energy	6	
	1					13% Renewable Energy	7	
	2		Credit 3	C	**Enhanced Commissioning**		**2**	
		2	Credit 4	D	**Enhanced Refrigerant Management**		**2**	BKM
		3	Credit 5	C	**Measurement and Verification**		**3**	BKM + HCC
		2	Credit 6	C	**Green Power**		**2**	HCC + BKM

Appendix A

LEED Checklist

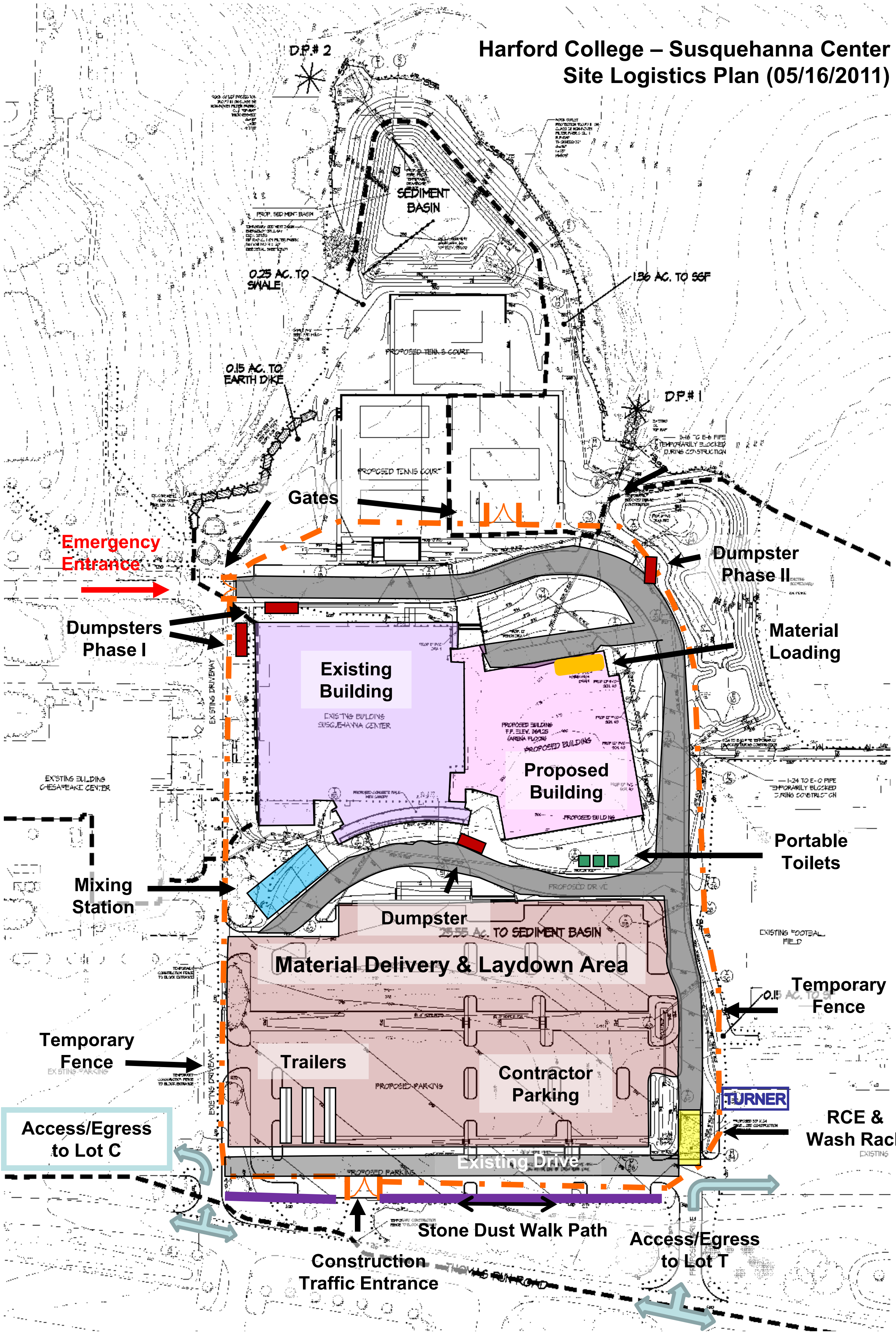
8	4	2	MR: MATERIALS & RESOURCES			14	
Y			Prereq 1	D	**Storage and Collection of Recyclables**	Req'd	HCM + HCC
			*RP Cr1.1	C	**Building Reuse** - Maintain Existing Walls, Floors and Roof	1 to 3	HCM
1					Reuse 55%	1	
		1			Reuse 75%	2	
		1			Reuse 95%	3	
	1		Credit 1.2	C	**Building Reuse -** Maintain Interior Nonstructural Elements	1	
			Credit 2	C	**Construction Waste Management**	1 to 2	TC
1					50% Recycled or Salvaged	1	
1					75% Recycled or Salvaged	2	
			Credit 3	C	**Materials Reuse**	1 to 2	
	1				Reuse 5%	1	
	1				Reuse 10%	2	
			Credit 4	C	**Recycled Content**	1 to 2	HCM + TC
1					10% of Content	1	
1					20% of Content	2	
			Credit 5	C	**Regional Materials**	1 to 2	HCM + TC
1					10% of Materials	1	
1					20% of Materials	2	
	1		Credit 6	C	**Rapidly Renewable Materials**	1	
1			Credit 7	C	**Certified Wood**	1	HCM+TC
11	2	2	EQ: INDOOR ENVIRONMENTAL QUALITY			15	
Y			Prereq 1	D	**Minimum Indoor Air Quality Performance**	Req'd	BKM
Y			Prereq 2	D	**Environmental Tobacco Smoke (ETS) Control**	Req'd	HCC
1			Credit 1	D	**Outdoor Air Delivery Monitoring**	1	BKM
	1		Credit 2	D	**Increased Ventilation**	1	
1			Credit 3.1	C	**Construction Indoor Air Quality Management Plan** - During Construction	1	TC
1			Credit 3.2	C	**Construction Indoor Air Quality Management Plan** - Before Occupancy	1	TC
1			Credit 4.1	C	**Low-Emitting Materials -** Adhesives and Sealants	1	HCM + TC
1			Credit 4.2	C	**Low-Emitting Materials -** Paints and Coatings	1	HCM + TC
1			Credit 4.3	C	**Low-Emitting Materials -** Flooring Systems	1	HCM + TC
1			Credit 4.4	C	**Low-Emitting Materials -** Composite Wood and Agrifiber Products	1	HCM + TC
1			Credit 5	D	**Indoor Chemical and Pollutant Source Control**	1	HCM + BKM
1			Credit 6.1	D	**Controllability of Systems -** Lighting	1	BKM
1			Credit 6.2	D	**Controllability of Systems -** Thermal Comfort	1	BKM
1			Credit 7.1	D	**Thermal Comfort -** Design	1	BKM
		1	Credit 7.2	D	**Thermal Comfort -** Verification	1	BKM+HCC
		1	Credit 8.1	D	**Daylight and Views -** Daylight 75% of Regularly Occupied Spaces	1	HCM
	1		Credit 8.2	D	**Daylight and Views -** Views for 90% of all Regularly Occupied Areas	1	
1	2	3	ID: INNOVATION IN DESIGN			6	
				C/D	**Innovation in Design**	1 to 5	
		1	Credit 1.1		Innovation or Exemplary Performance	1	BKM
		1	Credit 1.2		Innovation or Exemplary Performance	1	HCM
		1	Credit 1.3		Innovation or Exemplary Performance	1	TC
	1		Credit 1.4		Innovation or Exemplary Performance	1	All
	1		Credit 1.5		Innovation or Exemplary Performance	1	All
1			Credit 2	D	**LEED® Accredited Professional**	1	HCM
3	0	1	RP: REGIONAL PRIORITY			4	
				C/D	**Regional Priority** *www.usgbc.org/DisplayPage.aspx?CMSPageID=1984*	1 to 4	
1			Credit 1.1		Regional Priority	1	HCM + SR
1			Credit 1.2		Regional Priority	1	BKM
1			Credit 1.3		Regional Priority	1	BKM
		1	Credit 1.4		Regional Priority	1	BKM

Appendix G
Existing Conditions Plan
and Turner logistics Plan

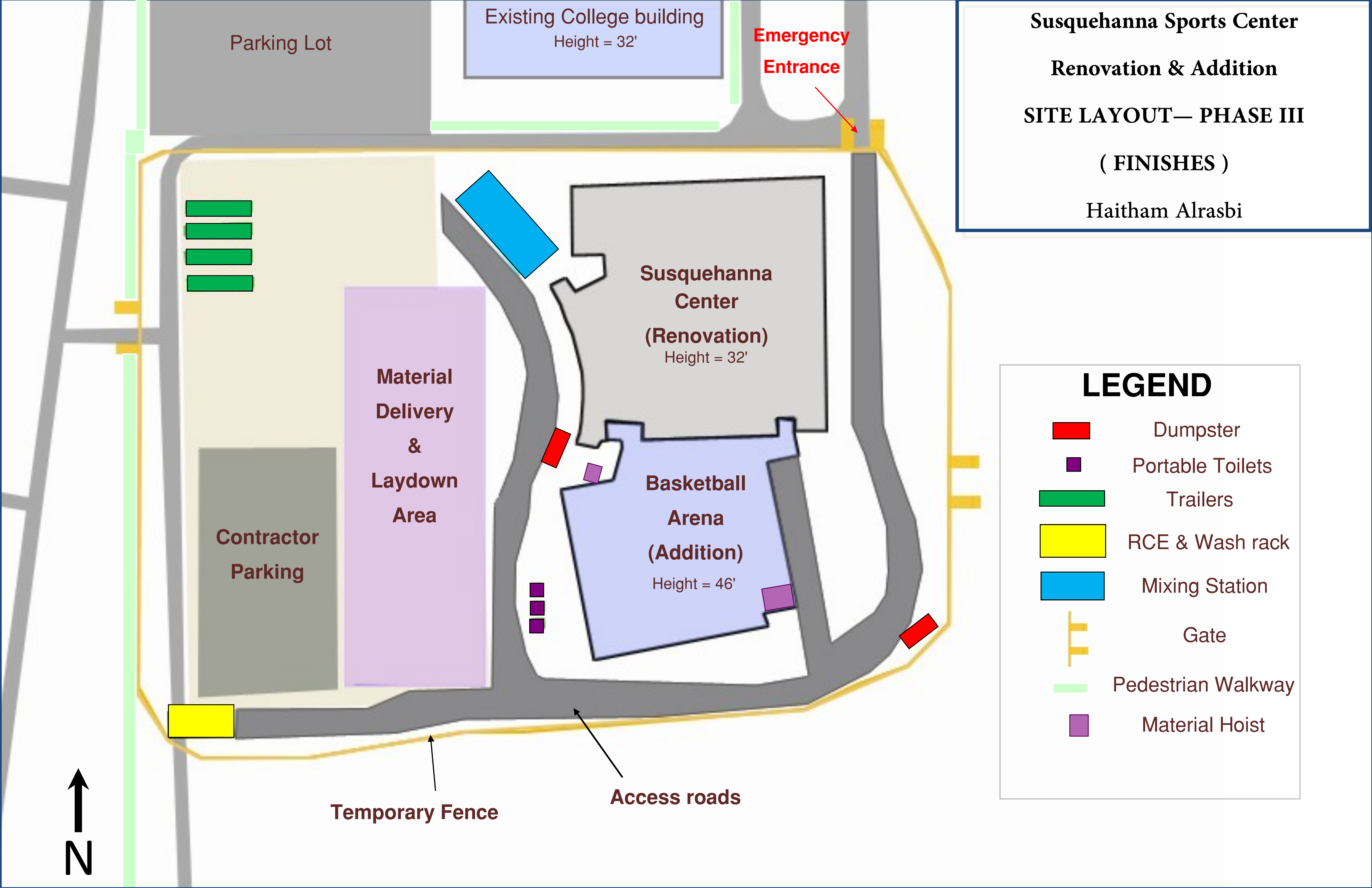


Susquehanna Sports Center
Renovation & Addition
EXISTING CONDITIONS PLAN
Haitham Alrasbi
Parking Lot
Existing College building
Height = 32'
Emergency
Entrance
Susquehanna
Center
(Renovation)
Height = 32'
Material
Delivery
&
Laydown
Area
Contractor
Parking
Basketball
Arena
(Addition)
Height = 46'
Temporary Fence
Access roads
N
LEGEND
Dumpster
Portable Toilets
Trailers
RCE & Wash rack
Mixing Station
Gate
Vehicular Traffic
Construction Traffic
Pedestrian Walkway
Pedestrian Traffic
Water Line
Sanitary Line
Electrical Line

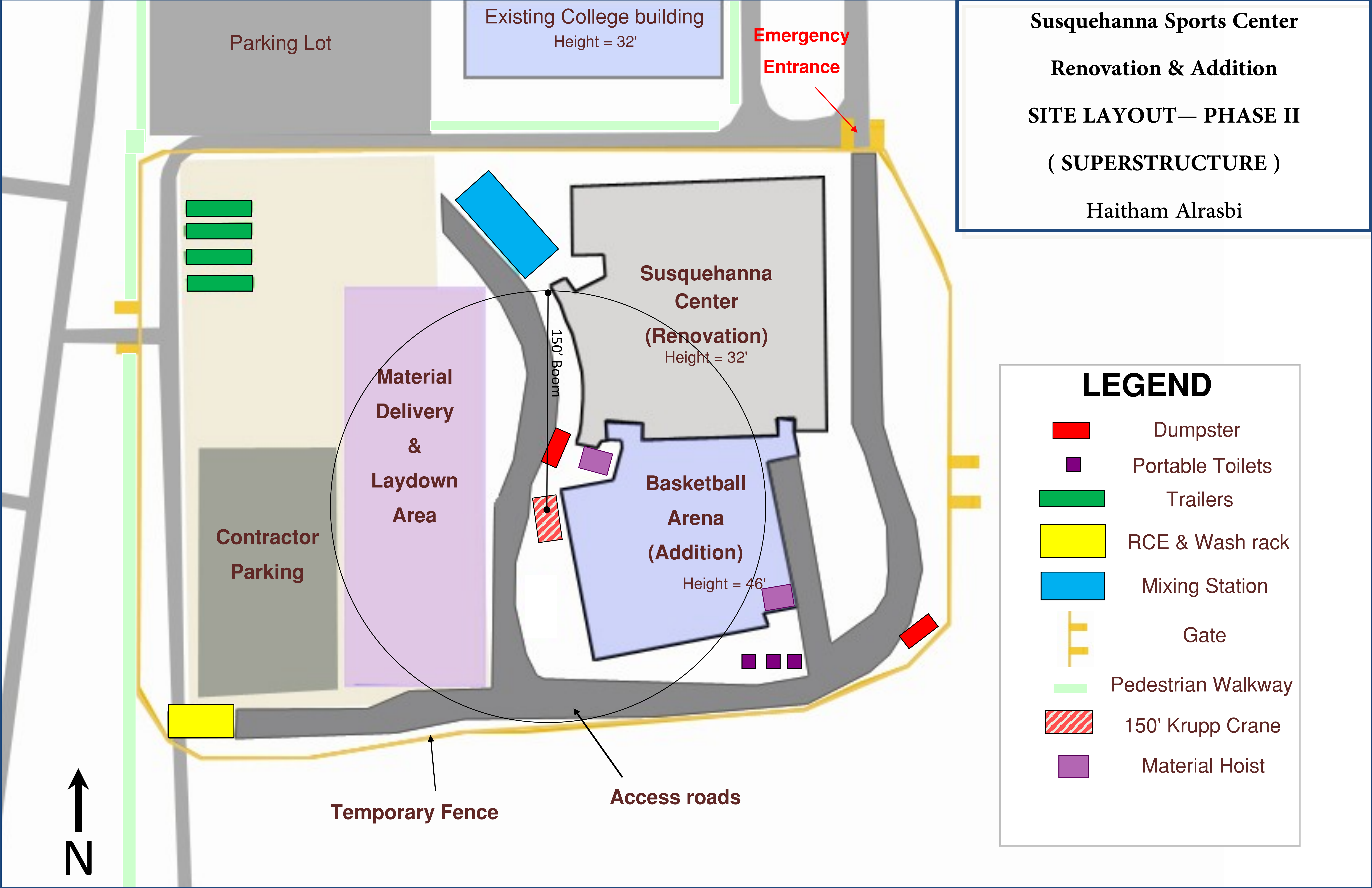
Harford College – Susquehanna Center
Site Logistics Plan (05/16/2011)



Appendix H
Excavation, Superstructure, and Finishes Phases Site Layouts



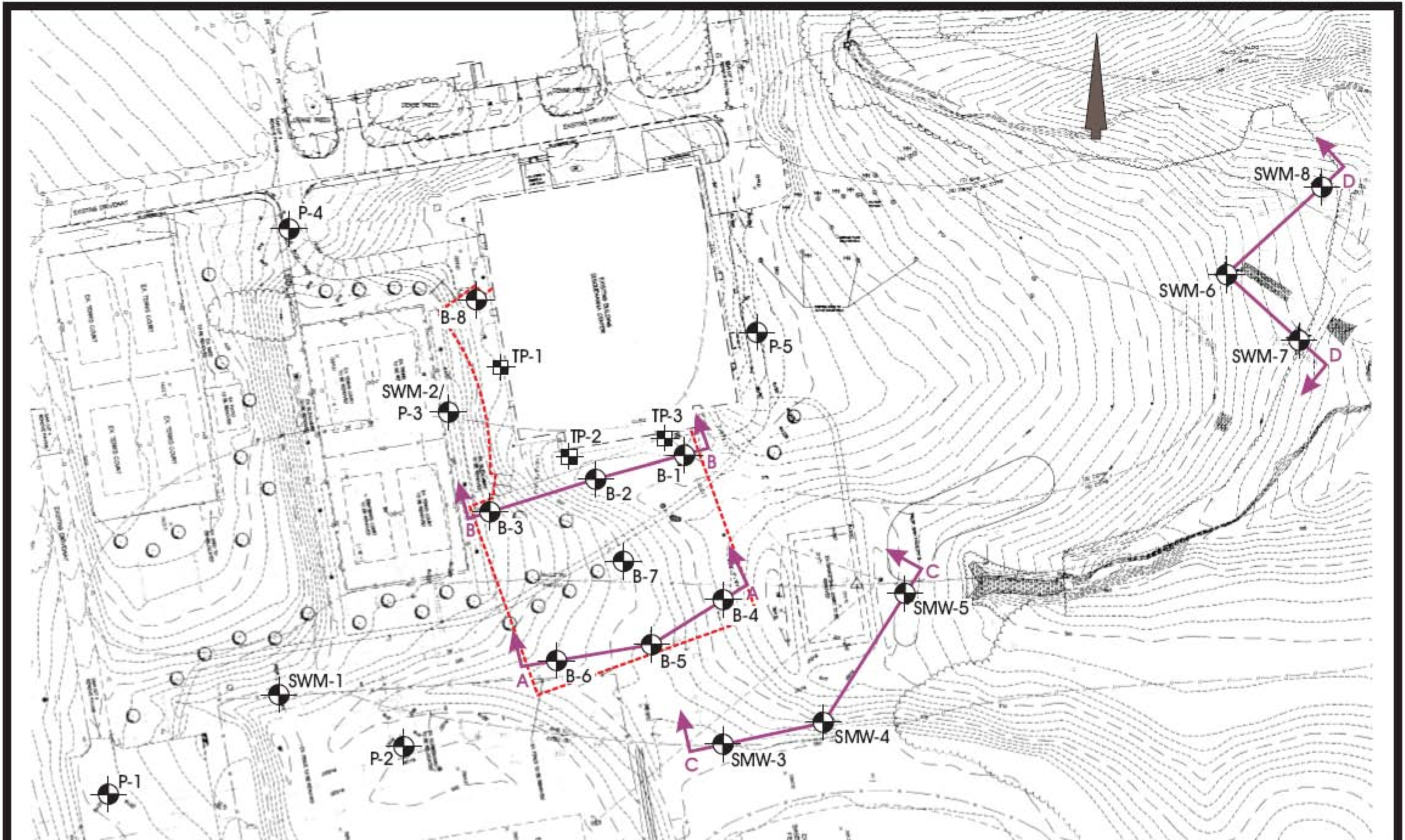
Susquehanna Sports Center
Renovation & Addition
SITE LAYOUT— PHASE III
(FINISHES)
Haitham Alrasbi
Parking Lot
Existing College building
Height = 32'
Emergency
Entrance
Susquehanna
Center
(Renovation)
Height = 32'
Material
Delivery
&
Laydown
Area
Contractor
Parking
Basketball
Arena
(Addition)
Height = 46'
Temporary Fence
Access roads
N
LEGEND
Dumpster
Portable Toilets
Trailers
RCE & Wash rack
Mixing Station
Gate
Pedestrian Walkway
Material Hoist



Susquehanna Sports Center
Renovation & Addition
SITE LAYOUT— PHASE II
(SUPERSTRUCTURE)
Haitham Alrasbi
Parking Lot
Existing College building
Height = 32'
Emergency
Entrance
Susquehanna
Center
(Renovation)
Height = 32'
150' Boom
Material
Delivery
&
Laydown
Area
Contractor
Parking
Basketball
Arena
(Addition)
Height = 46'
Temporary Fence
Access roads
N
LEGEND
Dumpster
Portable Toilets
Trailers
RCE & Wash rack
Mixing Station
Gate
Pedestrian Walkway
150' Krupp Crane
Material Hoist


Susquehanna Sports Center
Renovation & Addition
SITE LAYOUT— PHASE I
(EXCAVATION & DEMOLITION)
Haitham Alrasbi
Parking Lot
Existing College building
Height = 32'
Emergency
Entrance
Susquehanna
Center
(Renovation)
Height = 32'
Material
Delivery
&
Laydown
Area
Contractor
Parking
Excavation for
Sus.C. Renovation
and for the
Basketball Arena
Addition
Temporary Fence
Access roads
N
LEGEND
Dumpster
Portable Toilets
Trailers
RCE & Wash rack
Mixing Station
Gate
Pedestrian Walkway
Equipment
Ramp

Appendix I
Boring and Test Pit Location Plan

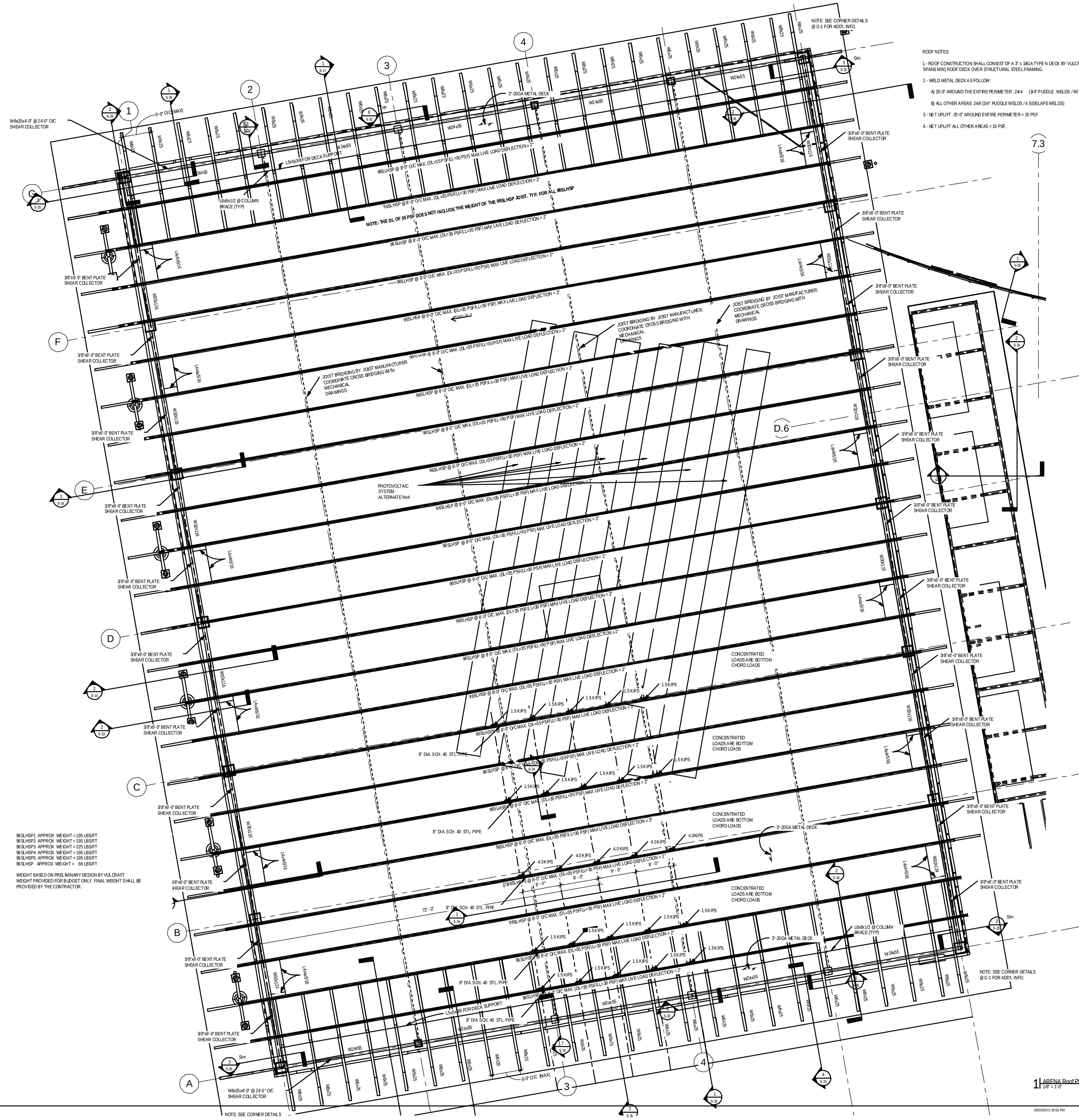


SUSQUEHANNA CENTER ADDITIONS HARFORD COMMUNITY COLLEGE HARFORD COUNTY, MARYLAND	BORING/TEST PIT LOCATION PLAN		PLATE
	HORIZ SCALE (FEET) 0 80	09013MD MAY, 2009	1

Appendix J
Basketball Arena Structural Plan

SUSQUEHANNA CENTER RENOVATION + EXPANSION

401 THOMAS RUN ROAD BEL AIR, MARYLAND 21015



ROOF NOTES:

1.- ROOF CONSTRUCTION SHALL CONSIST OF A 3" x 18GA TYPE N DECK BY VULCRAFT OR EQUIVALENT APPROVED (3 SPANS MIN) ROOF DECK OVER STRUCTURAL STEEL FRAMING.

2.- WELD METAL DECK AS FOLLOW:

A) 25'-0" AROUND THE ENTIRE PERIMETER : 24/4 (3/4" PUDDLE WELDS / W/ 6 SIDELAPS WELDES)

B) ALL OTHER AREAS 24/4 (3/4" PUDDLE WELDS / 4 SIDELAPS WELDS)

3.- NET UPLIFT 25'-0" AROUND ENTIRE PERIMETER = 25 PSF

4.- NET UPLIFT ALL OTHER AREAS = 15 PSF.

96SLHSP1 APPROX WEIGHT = 195 LBS/FT
96SLHSP2 APPROX WEIGHT = 195 LBS/FT
96SLHSP3 APPROX WEIGHT = 225 LBS/FT
96SLHSP4 APPROX WEIGHT = 195 LBS/FT
96SLHSP5 APPROX WEIGHT = 195 LBS/FT
96SLHSP APPROX WEIGHT = 66 LBS/FT

WEIGHT BASED ON PRELIMINARY DESIGN BY VULCRAFT WEIGHT PROVIDED FOR BUDGET ONLY. FINAL WEIGHT SHALL BE PROVIDED BY THE CONTRACTOR.

HORD | COPLAN | MACHT

ARCHITECTURE
LANDSCAPE ARCHITECTURE
PLANNING
INTERIOR DESIGN

750 East Pratt Street Suite 1100
Baltimore MD 21202
410-837-7311
410-837-6530 Fax
www.hcm2.com

CONSULTANTS

Civil
Site Resources, Inc.
14315 Jarrettsville Pike
P.O. Box 249
Phoenix, MD 21131-0249

MEP
Burdette, Koehler, Murphy & Associates, Inc.
1423 Clarkview Road
[Suite 500]
Baltimore, Maryland 21209

Structural
CMJ Structural Engineering, Inc.
20016 Octavia Ct
Montgomery Village, MD

Natatorium
Counsilman Hunsaker
10733 Sunset Office Drive, 4th Floor
St. Louis, MO 63127

SEAL

REVISIONS

SHEET TITLE
Roof Framing Plan - High Arena Roof

SCALE	DATE	PROJ#
1/8" = 1'-0"	10.02.2009	209138.00

PROJECT PHASE
100 Percent Construction Documents

DRAWING #
S-9

Appendix K
NOAA Climatological Report

These data are preliminary and have not undergone final quality control by the National Climatic Data Center (NCDC). Therefore, these data are subject to revision. Final and certified climate data can be accessed at the NCDC - http://www.ncdc.noaa.gov.

Climatological Report (Daily)

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000
CDUS41 KLWX 010524
CLIBWI


CLIMATE REPORT
NATIONAL WEATHER SERVICE BALTIMORE MD/WASHINGTON DC
124 AM EDT THU SEP 1 2011


...................................

...THE BALTIMORE MD CLIMATE SUMMARY FOR AUGUST 31 2011...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 1870 TO 2011


WEATHER ITEM   OBSERVED TIME   RECORD YEAR NORMAL DEPARTURE LAST
                VALUE   (LST)  VALUE       VALUE  FROM      YEAR
                                                  NORMAL
...................................................................
TEMPERATURE (F)
 YESTERDAY
  MAXIMUM         83    249 PM 102    1953  83      0       95
  MINIMUM         56    532 AM  49    1986  63     -7       64
  AVERAGE         70                        73     -3       80

PRECIPITATION (IN)
  YESTERDAY         0.00          2.12 1975   0.10  -0.10     0.00
  MONTH TO DATE    10.38                      3.29   7.09     4.74
  SINCE JUN 1      16.66                     10.82   5.84    10.65
  SINCE JAN 1      32.94                     27.85   5.09    28.26

SNOWFALL (IN)
  YESTERDAY         0.0         MM      MM    0.0    0.0
  MONTH TO DATE     0.0                       0.0    0.0
  SINCE JUL 1       0.0                       0.0    0.0
  SNOW DEPTH        0

DEGREE DAYS
```

HEATING				
YESTERDAY	0	0	0	0
MONTH TO DATE	0	0	0	0
SINCE JUN 1	0	16	-16	0
SINCE JUL 1	0	1	-1	0
COOLING				
YESTERDAY	5	8	-3	15
MONTH TO DATE	346	316	30	393
SINCE JUN 1	1200	926	274	1334
SINCE JAN 1	1385	1010	375	1527

....

WIND (MPH)
HIGHEST WIND SPEED 9 HIGHEST WIND DIRECTION SE (120)
HIGHEST GUST SPEED 13 HIGHEST GUST DIRECTION SE (140)
AVERAGE WIND SPEED 1.6

SKY COVER
POSSIBLE SUNSHINE MM
AVERAGE SKY COVER 0.5

WEATHER CONDITIONS
THE FOLLOWING WEATHER WAS RECORDED YESTERDAY.
NO SIGNIFICANT WEATHER WAS OBSERVED.

RELATIVE HUMIDITY (PERCENT)

HIGHEST	93	100 AM
LOWEST	39	1200 PM
AVERAGE	66	

....

THE BALTIMORE MD CLIMATE NORMALS FOR TODAY

	NORMAL	RECORD	YEAR
MAXIMUM TEMPERATURE (F)	83	99	1962
MINIMUM TEMPERATURE (F)	63	53	1963

SUNRISE AND SUNSET
SEPTEMBER 1 2011.....SUNRISE 635 AM EDT SUNSET 738 PM EDT
SEPTEMBER 2 2011.....SUNRISE 636 AM EDT SUNSET 736 PM EDT

\- INDICATES NEGATIVE NUMBERS.

R INDICATES RECORD WAS SET OR TIED.
MM INDICATES DATA IS MISSING.
T INDICATES TRACE AMOUNT.

&&

....

...THE BALTIMORE INNER HARBOR MD CLIMATE SUMMARY FOR AUGUST 31 2011...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 9999 TO 9999

WEATHER ITEM	OBSERVED VALUE	TIME (LST)	RECORD VALUE	YEAR	NORMAL VALUE	DEPARTURE FROM NORMAL	LAST YEAR
TEMPERATURE (F)							
YESTERDAY							
MAXIMUM	85	335 PM	MM	MM	85	0	96
MINIMUM	67	601 AM	MM	MM	69	-2	75
AVERAGE	76				77	-1	86
PRECIPITATION (IN)							
YESTERDAY	0.00		MM	MM	0.11	-0.11	0.00
MONTH TO DATE	11.97				3.39	8.58	4.41
SINCE JUN 1	17.07				11.28	5.79	11.42
SINCE JAN 1	33.18				27.37	5.81	27.11
SNOWFALL (IN)							
YESTERDAY	MM		MM	MM	MM	MM	
MONTH TO DATE	MM				MM	MM	
SINCE JUL 1	MM				MM	MM	
SNOW DEPTH	MM						
DEGREE DAYS							
HEATING							
YESTERDAY	0				0	0	0
MONTH TO DATE	0				0	0	0
SINCE JUN 1	0				5	-5	0
SINCE JUL 1	0				0	0	0
COOLING							
YESTERDAY	11				12	-1	21
MONTH TO DATE	488				432	56	494
SINCE JUN 1	1624				1257	367	1578
SINCE JAN 1	1931				1396	535	1843

```
WIND (MPH)
  HIGHEST WIND SPEED    MM   HIGHEST WIND DIRECTION    MM
  HIGHEST GUST SPEED    MM   HIGHEST GUST DIRECTION    MM
  AVERAGE WIND SPEED    MM


SKY COVER
  POSSIBLE SUNSHINE  MM
  AVERAGE SKY COVER 0.0


WEATHER CONDITIONS
 THE FOLLOWING WEATHER WAS RECORDED YESTERDAY.
  NO SIGNIFICANT WEATHER WAS OBSERVED.


RELATIVE HUMIDITY (PERCENT)
 HIGHEST    68          500 AM
 LOWEST     37         1100 AM
 AVERAGE    53

..........................................................


THE BALTIMORE INNER HARBOR MD CLIMATE NORMALS FOR TODAY
                         NORMAL    RECORD    YEAR
 MAXIMUM TEMPERATURE (F)   85        MM        MM
 MINIMUM TEMPERATURE (F)   69        MM        MM


SUNRISE AND SUNSET
SEPTEMBER  1 2011.....SUNRISE   635 AM EDT   SUNSET   738 PM EDT
SEPTEMBER  2 2011.....SUNRISE   636 AM EDT   SUNSET   736 PM EDT


-  INDICATES NEGATIVE NUMBERS.
R  INDICATES RECORD WAS SET OR TIED.
MM INDICATES DATA IS MISSING.
T  INDICATES TRACE AMOUNT.
```

These data are preliminary and have not undergone final quality control by the National Climatic Data Center (NCDC). Therefore, these data are subject to revision. Final and certified climate data can be accessed at the NCDC - http://www.ncdc.noaa.gov.

Climatological Report (Daily)

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CLIMATE REPORT
NATIONAL WEATHER SERVICE BALTIMORE MD/WASHINGTON DC
121 AM EDT SAT OCT 1 2011


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...THE BALTIMORE MD CLIMATE SUMMARY FOR SEPTEMBER 30 2011...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 1870 TO 2011


WEATHER ITEM   OBSERVED TIME   RECORD YEAR NORMAL DEPARTURE LAST
                VALUE   (LST)  VALUE       VALUE  FROM      YEAR
                                                  NORMAL
.................................................................
TEMPERATURE (F)
 YESTERDAY
  MAXIMUM         78   1204 PM  92    1986  72       6      78
  MINIMUM         54    257 AM  39    1888  52       2      64
  AVERAGE         66                        62       4      71

PRECIPITATION (IN)
  YESTERDAY        0.00          6.02 2010   0.14  -0.14     6.02
  MONTH TO DATE   13.32                      4.03   9.29     8.26
  SINCE SEP 1     13.32                      4.03   9.29     8.26
  SINCE JAN 1     46.26                     31.88  14.38    36.52

SNOWFALL (IN)
  YESTERDAY        0.0          MM      MM   0.0    0.0
  MONTH TO DATE    0.0                       0.0    0.0
  SINCE JUL 1      0.0                       0.0    0.0
  SNOW DEPTH       0

DEGREE DAYS
 HEATING
  YESTERDAY        0                         5     -5        0
  MONTH TO DATE   27                        50    -23       10
  SINCE SEP 1     27                        52    -25       10
```

....

...THE BALTIMORE INNER HARBOR MD CLIMATE SUMMARY FOR SEPTEMBER 30 2011...

CLIMATE NORMAL PERIOD 1981 TO 2010
CLIMATE RECORD PERIOD 9999 TO 9999

WEATHER ITEM	OBSERVED VALUE	TIME (LST)	RECORD VALUE	YEAR	NORMAL VALUE	DEPARTURE FROM NORMAL	LAST YEAR
TEMPERATURE (F)							
YESTERDAY							
MAXIMUM	81	101 PM	MM	MM	74	7	78
MINIMUM	63	314 AM	MM	MM	58	5	65
AVERAGE	72				66	6	72
PRECIPITATION (IN)							
YESTERDAY	0.00		MM	MM	0.15	-0.15	5.72
MONTH TO DATE	10.73				4.09	6.64	8.18
SINCE SEP 1	10.73				4.09	6.64	8.18
SINCE JAN 1	43.91				31.46	12.45	35.29
SNOWFALL (IN)							
YESTERDAY	MM		MM	MM	MM	MM	
MONTH TO DATE	MM				MM	MM	
SINCE JUL 1	MM				MM	MM	
SNOW DEPTH	MM						
DEGREE DAYS							
HEATING							
YESTERDAY	0				2	-2	0
MONTH TO DATE	6				16	-10	0
SINCE SEP 1	6				18	-12	0
SINCE JUL 1	6				18	-12	0
COOLING							
YESTERDAY	7				3	4	7
MONTH TO DATE	280				229	51	298
SINCE SEP 1	280				229	51	298
SINCE JAN 1	2211				1625	586	2141

WIND (MPH)

HIGHEST WIND SPEED	MM	HIGHEST WIND DIRECTION	MM
HIGHEST GUST SPEED	MM	HIGHEST GUST DIRECTION	MM
AVERAGE WIND SPEED	MM		

Appendix L
BIM Uses Analysis

BIM USE ANALYSIS
Version 2.0

BIM Use*	Value to Project	Responsible Party	Value to Resp Party	Capability Rating			Additional Resources / Competencies Required to Implement	Notes	Proceed with Use
	High / Med / Low		High / Med / Low	Scale 1-3 (1 = Low)					YES / NO / MAYBE
				Resources	Competency	Experience			
Existing Conditions Modeling	HIGH	Subcontractor	HIGH	2	3	3	3D Laser Scanning Tools		**Y**
		Designer	MED	3	2	2			
Cost Estimation	MED	Contractor	HIGH	2	2	3			**Y**
		Designer	MED	2	1	2			
3D Coordination	MED	Contractor	HIGH	3	3	3	Design authoring software		**Y**
		Subcontractors	HIGH	1	3	3			
		Designer	HIGH	2	3	3			
Design Authoring	HIGH	Contractor	HIGH	3	3	3	Knowledge of BIM model applications		**Y**
		Subcontractors	HIGH	1	3	3	for facility updates		
		Designer	HIGH	2	3	3			
Record Model	HIGH	Contractor	MED	2	2	2	3D Model Manipulation Tools		**N**
		Facility Manager	HIGH	3	2	2			
		Designer	MED	2	3	2			
Building Maintenance Scheduling	MED	Owner	MED	2	2	1	Record Model		**N**
		Contractor	MED	2	3	3	Building Automation System (BAS)		
		Subcontractor	MED	2	2	2	Computerized Maintenance Management System (CMMS)		

* Additional BIM Uses as well as information on each Use can be found at http://www.engr.psu.edu/ae/cic/bimex/

Appendix M
BIM Execution Plan

BIM PROJECT EXECUTION PLAN

VERSION 2.0

FOR

Susquehanna Sports Center Renovation and Addition Project

DEVELOPED BY

Haitham Alrasbi

This template is a tool that is provided to assist in the development of a BIM project execution plan as required per contract. The template plan was created from the buildingSMART alliance™ (bSa) Project "BIM Project Execution Planning" as developed by The Computer Integrated Construction (CIC) Research Group of The Pennsylvania State University. The bSa project is sponsored by The Charles Pankow Foundation (http://www.pankowfoundation.org), Construction Industry Institute (CII) (http://www.construction-institute.org), Penn State Office of Physical Plant (OPP) (http://www.opp.psu.edu), and The Partnership for Achieving Construction Excellence (PACE) (http://www.engr.psu.edu/pace). The BIM Project Execution Planning Guide can be downloaded at http://www.engr.psu.edu/BIM/PxP.

This coversheet can be replaced by a company specific coversheet that includes at a minimum document title, project title, project location, author company, and project number.

BIM PROJECT EXECUTION PLAN

VERSION 2.0

FOR

Susquehanna Sports Center Renovation and Addition Project

DEVELOPED BY

Haitham Alrasbi

TABLE OF CONTENTS

SECTION A: BIM PROJECT EXECUTION PLAN OVERVIEW

To successfully implement Building Information Modeling (BIM) on a project, the project team has developed this detailed BIM Project Execution Plan. The BIM Project Execution Plan defines uses for BIM on the project (e.g. design authoring, cost estimating, and design coordination), along with a detailed design of the process for executing BIM throughout the project lifecycle.

SECTION B: PROJECT INFORMATION

This section defines basic project reference information and determined project milestones.

1. **PROJECT OWNER: THE HARFORD COMMUNITY COLLEGE**
2. **PROJECT NAME: THE SUSQUEHANNA SPORTS CENTER RENOVATION AND ADDITION**
3. **PROJECT LOCATION AND ADDRESS: 401 THOMAS RUN RD BEL AIR, MD 21015**
4. **CONTRACT TYPE / DELIVERY METHOD: GUARANTEED MAXIMUM PRICE – CM AT RISK**
5. **BRIEF PROJECT DESCRIPTION:**
6. **ADDITIONAL PROJECT INFORMATION: N/A**
7. **PROJECT SCHEDULE / PHASES / MILESTONES:**

PROJECT PHASE / MILESTONE	ESTIMATED START DATE	ESTIMATED COMPLETION DATE	PROJECT STAKEHOLDERS INVOLVED
PRELIMINARY PLANNING	07/05/2010	11/11/2010	Y
DESIGN DOCUMENTS	11/14/2010	04/22/2011	Y
CONSTRUCTION DOCUMENTS	2/11/2011	04/25/2011	Y
CONSTRUCTION	05/23/2011	09/17/2012	Y

SECTION C: PROJECT GOALS / BIM USES

1. MAJOR BIM GOALS / OBJECTIVES:

PRIORITY (HIGH/ MED/ LOW)	GOAL DESCRIPTION	POTENTIAL BIM USES
HIGH	Provide an efficient and accurate existing conditions documentation	Existing Conditions Modeling
MED	Quickly Assess cost associated with design changes	Cost Estimation
LOW	Review Design progress and increase coordination	Design Reviews
HIGH	Eliminate field conflicts and increase coordination	3D Coordination
HIGH	Ease the transition into 3D modeling, which then allows 3D Coordination	Design Authoring

2. BIM USES:

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

SECTION D: ORGANIZATIONAL ROLES / STAFFING

1. BIM Roles and Responsibilities:

Role	Organization	Organization Role	Contact Name	Contact Info
Owner Representative	Harford Community College (HCC)	Owner	N/A	N/A
Project Architect	Hord Coplan Macht (HCM)	Designer	N/A	N/A
Civil Engineer	Site Resources, Inc	Civil Subcontractor	N/A	N/A
MEP Engineer	Burdette, Koehler, Murphy & Associates, Inc	MEP Subcontractor	N/A	N/A
Structural Engineer	CMJ Structural Engineering, Inc	Structural Subcontractor	N/A	N/A
Project Manager	Turner	Construction Manager	N/A	N/A

2. BIM Use Staffing:

BIM Use	Organization(s)	Staff Required for BIM Use	Worker Duration
Existing Conditions Modeling	Site Resources, Inc / HCM	Site Resources, Inc: (1) Surveyor and (1) Civil Engineer HCM: (2) Architects	(1) week each
Cost Estimation	Turner / HCM	Turner: (2) Estimators HCM: (2) Architects	(3) weeks for estimators (1) week for architects
3D Coordination	Turner / HCM / Subcontractors	Turner: (2) Project Managers HCM: (1) Project Architect and (1) Architect Subcontractors: 1 from each sub = (3) + 1 = 4 total	(1) week each
Design Authoring	Turner / HCM / Subcontractors	Turner: (2) Project Managers HCM: (1) Project Architect and (1) Architect Subcontractors: 1 from each sub = (3) + 1 = 4 total	(3) weeks for project managers (5) weeks for architects (4) weeks for subs

BIM Use	Organization(s)	Number of Total Staff for BIM Use	Estimated Worker Hours	Location(s)	Lead Contact
Existing Conditions Modeling	Site Resources, Inc / HCM	4	160	Jobsite	Site Resources, Inc
Cost Estimation	Turner / HCM	4	320	Office and Jobsite	Turner
3D Coordination	Turner / HCM / Subcontractors	7	280	Accessible from anywhere	Turner
Design Authoring	Turner / HCM / Subcontractors	7	1280	HCM office, Turner offices, and jobsite	HCM

Appendix N
Pedestrian and Car traffic Site Plan

Pedestrian and Car traffic site analysis