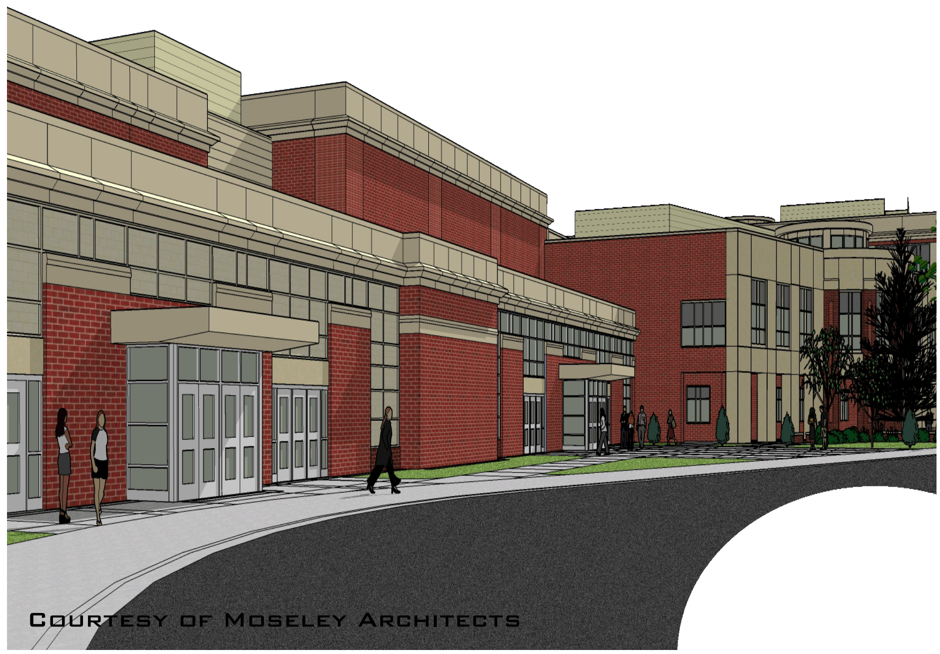
Final Report



Diab Shetayh

Construction Option

Paint Branch High School

Burtonsville, Maryland

Dr. Riley

4/7/11

PAINT BRANCH HIGH SCHOOL MODERNIZATION

BURTONSVILLE, MD

DIAB SHETAYH—CONSTRUCTION OPTION http://www.engr.psu.edu/ae/thesis/portfolios/2011/des295/index.html

PROJECT INFORMATION:

Function: Education

Building Cost: $80,973,293

Size: 349,000 Square Feet

Dates of Construction: 12/15/2010—Summer 2012

Delivery Method: Modified CM @ Risk

PROJECT TEAM

Owner: Montgomery County Public School (MCPS)

Architect: Moseley Architects

Construction Manager: Hess Construction + Engineering Services

Structural Engineer: Wolfman and Associates, P.C.

MEP Engineer: B2E Consulting Engineers, P.C.

STRUCTURAL

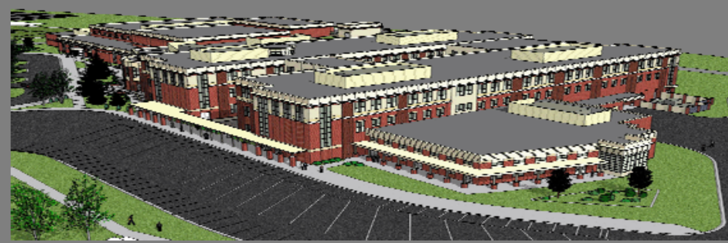
The building is broken up into thirds starting with a three story classroom wing, a two story wing including an auditorium, gymnasium, and a one story lower section which houses lockers and team rooms. It is estimated that about one half of the building is steel bearing and the remaining half is load bearing masonry. All sit on a standard mat foundation systems.

ARCHITECTUR:E

The façade of the building is primarily composed of brick with portions of architectural precast concrete, metal panels, curtain walls, and standard glazed operating windows. The entrance of the building includes large architectural precast panels flanked by stacked brick piers in a circular shape.

MECHANINCAL SYSTEM

The HVAC system being used for the school is a geothermal heat pump system. There are approximately 600 wells that range from 300 to 450 feet below ground. These wells will be installed below completion fields to act as the heat source sink for the system.



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Industry Acknowledgements:

HESS CONSTRUCTION + ENGINEERING SERVICES

MOSELEYARCHITECTS A PROFESSIONAL CORPORATION

MONTGOMERY COUNTY PUBLIC SCHOOLS

b2E consulting engineers

ADTEK

Special Thanks To:

Matt Evans, Saurabh Gangwar, George Houk of HESS Construction + Engineering Services

Matt Ludwig, B2E Consulting Engineers

Matthew Dabrowski, AE Alumni

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EXECUTIVE SUMMARY

This Final Report is intended to discuss the three analyses that were conducted for the final on the Paint Branch High School project. The three topics will include studies in Critical Issues Research, Constructability, Value Engineering, and Schedule Reduction. Along with the three analyses, two breadth analyses will be conducted in areas of structural and mechanical research.

Technical Analysis #1: LEED Certification

The new Paint Branch High School is said to be the latest state of the art facility for Montgomery County Public Schools (MCPS). The facility is currently pursuing a LEED Gold Certification. However, after reviewing the current LEED scorecard, the facility has the potential to attain a LEED Platinum Certification. After assessing the credits necessary to attain a LEED Platinum Certification, a cost analysis was conducted resulting in a **$968,859** increase to the overall total project cost.

Technical Analysis #2: Brick Façade

The new facility will consume a mass amount of face brick for its façade. With a 350,000 square foot facility, there will be a lot of manpower and time required to manually lay the face brick. This analysis evaluated an alternative prefabricated brick panel system in order to eliminate site congestion and reduce manpower and schedule. With the use of a prefabricated masonry panel system, the total project cost would increase by **$4,591,404**. This dollar value includes the cost of the alternative gypsum board finish calculated in the Mechanical Breadth. However, this system will save the project six months in schedule and eliminate site congestion. This analysis also contributed to the Mechanical Breadth showing a total savings of **$16,016** a year in energy costs with the use of the prefabricated masonry panel system. The prefabricated system is also a lighter system compared to the originally designed façade, showing a possibility in reducing the member sizes of the structural system.

Technical Analysis #3: BIM Coordination

Early in the design phase of the project, there was a lack of communication between the Architect and MEP designers. This caused a creation of the BIM model currently used on the project. This analysis found that through the use of a BIM model, there is a potential savings of **$10,799,234** and **2 years** in project time.

Project Summary

Figure 1 – New Facility Render

Paint Branch High School was originally constructed in 1969 and added a classroom addition in 1986. Currently, the existing facility is approximately 260,680 square feet and has a capacity of 1,800 students. The existing outdated facility is to be demolished upon completion of the new 344,000 square foot facility. The new state of the art facility will house nearly 2,400 students on a 45 acre campus. The new $81,000,000 facility will be LEED Gold certified and will be the latest state of the art facility for Montgomery County Public Schools (MCPS).

The new Paint Branch Facility will be located southwest of the existing facility. The new facility will have a façade that will primarily consist of face brick and architectural pre-cast concrete panels. Included in the new facility will be a state of the art auditorium seating 900 occupants, 12 science labs, and a greenhouse. The classrooms will serve a learning environment for culinary arts, finance, pharmacy, and media. The facility will also include classroom spaces for high-tech simulation, technology, engineering research and design, food sciences and JROTC. Paint Branch will also include outdoor soccer fields, tennis courts, basketball courts, softball and baseball fields, and a new football stadium.

One of the largest challenges associated with this project is that the proposed site is shared between the new facility and the existing facility. Although, the new facility is located southwest of the existing facility, having active construction near an occupied facility raises safety concerns. The existing parking lot stands between the new facility and occupied existing facility as shown in *Figure 2*. A portion of the parking lot is being used by the construction team for parking and lay down areas. The remainder of the parking lot is being used by students and faculty for vehicular parking. Safety is a huge concern for both the owner and project team on site. To increase safety around the active

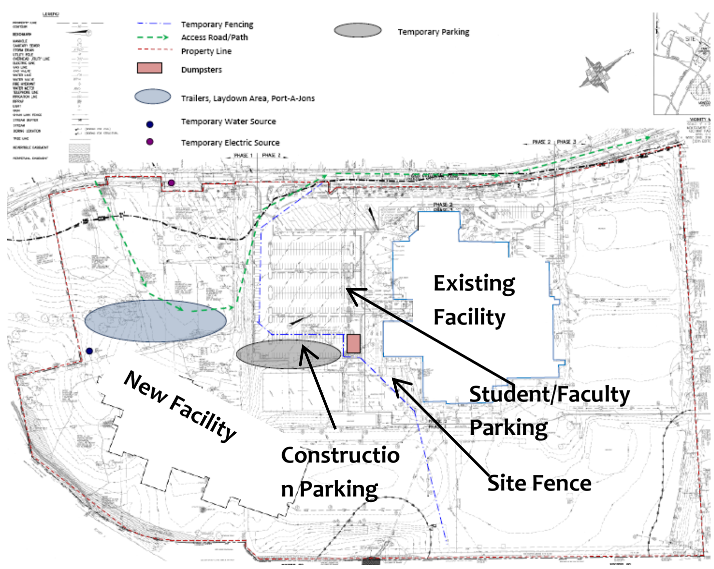

Figure 2 – Paint Branch Site Plan

construction sites, site fences and signs have been placed between the active site and parking lot to restrain students and faculty from crossing into the active construction site.

Construction of the new facility began on December 15, 2009 with initial site work and layouts for sediment and erosion control as part of phase one. The overall project has a total of three phases. Figure 3 shows the areas for their respected phases. The following dates have been set as turnover milestones by HESS Construction + Engineering Services.

Phase 1 completion Date: March 30, 2012

Phase 2 Completion Date: June 12, 2012

Phase 3 Completion Date: August 15, 2013

Figure 3 – Phase Diagram

Phase one will include preparing the existing site and construction of the new facility. Phase two will consist of reconfiguring the parking lot for the student/staff parking, and bus route. Finally, phase three will deal with the abatement and hazmat of the outdated facility and completion of the overall site.

Client Information

Montgomery County Public schools (MCPS) has approximately 200 schools and facilities. MCPS strives to achieve high performance in academics. They are the 16th largest school district in the United States and have approximately 140,000 students enrolled in the school district. They are building the new Paint Branch High school simply due to the fact the existing facility was constructed back in 1969 and has now become outdated. Also, the existing school housed a total of 1,800 students and Paint Branch High School is growing in student population, therefore, a bigger facility will be a necessity. The new facility is said to house a total of 2,400 students.

MCPS expects great quality work. The MCPS Department of Construction stresses a great deal on quality control on all of their projects. MCPS is an experienced owner and have an understanding of what they want on each of their school projects.

The schedule for this project is not a concern for MCPS. This is due to the fact that there already is an existing facility to house the staff and students until the project is complete on July 30, 2013. Also, the demolition of the existing outdated facility will not begin until July 18, 2013 which is another reason there is not a lot of stress being placed on schedule.

While there may not be a strong emphasis on schedule, there is a strong emphasis on the cost of the project. MCPS is a public organization and needed to gather enough funding to support the construction of the new facility. MCPS is thankful for all the donations they have received in order to start construction of the new Paint Branch High School.

Since there will be construction conducted during the school year and around students and faculty, safety is a huge concern for MCPS. MCPS and HESS have teamed up to create a strong safety plan to isolate the construction site from students, faculty, pedestrians, and traffic. Safety is the number one priority for MCPS as well as HESS and HESS will do their best job to keep a safe work environment at all times.

Project Delivery System

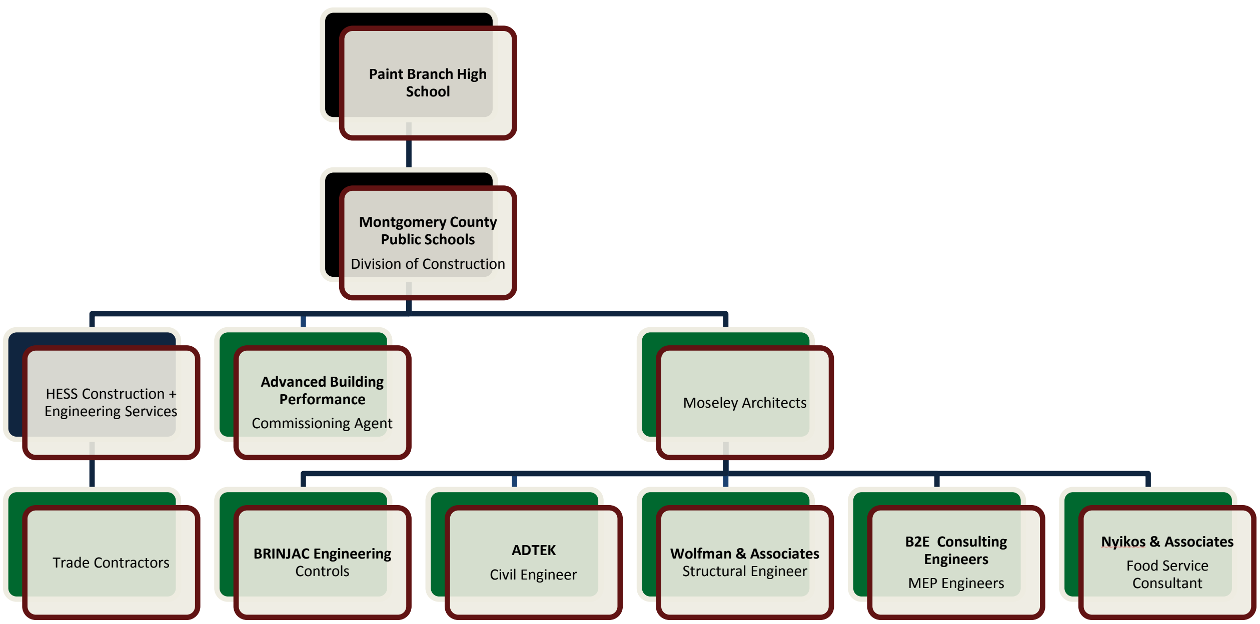

Figure 4 – Project Delivery System

The project deliver is a modified CM at risk. Initially, Montgomery County Public Schools (MCPS) and HESS executed a purchase order agreement for preconstruction services. The preconstruction services included design review, construction document bidding, budgeting, value engineering ideas, scope and schedule development, and the bid process. After the bid process, HESS put together a GMP for the Paint Branch project and was issued a change order to the original purchase order of the preconstruction services for construction services.

The reason a modified CM at risk delivery system was used on this project is because Montgomery County Public School projects are bid publically to award the contract to lowest bidder. The contracts are then reassigned for HESS to manage. HESS and MCPS have a great relationship with each other and HESS has about two to three MCPS projects every year.

Project Team

Project Team	
Owner:	Montgomery County Public Schools (MCPS)
Architect:	Moseley Architects
Construction Manager:	Hess Construction+ Engineering Services
Civil Engineer:	Adtek Engineers, Inc.
Structural Engineer:	Wolfman and Associates, P.C.
MEP Engineer:	B2E Consulting Engineers, P.C.
Food Service Consultant:	Nyikos Associates, Inc.

Table 1 – Paint Branch High School Project Team

Project Schedule Summary

The original design process for the Paint Branch project started back in 2005 and took approximately two and a half years to go from 20% schematic design to 90% construction documents. The bid set was complete in 2007 but was put on hold for two years due to a lack of funding. By 2009, Montgomery County Public Schools (MCPS) gained enough funding to start the project back up. Around June of 2009, HESS Construction + Engineering Services joined back with MCPS to complete the preconstruction services. The project was then set to bid in December of 2009 and contracts were awarded in January 2010.

The project will need to be constructed in three phases. The project needed to be constructed in phases to allow the existing facility to remain open during construction of the new facility. Since the new Paint Branch High School would not be fully complete until the 2013 school year, the existing educational facility will be demolished at the completion of the new facility. Phase 1 consist of preparing the existing site and construction of the new facility. Phase 2 consist of reconfiguring the parking lots for the staff, bussing, and student parking. Finally, phase 3 will deal with the abatement, demolition of the outdated facility, and completion of the overall site.

Phase one is to meet a contract substantial completion date of June 1, 2012. At this point of the project, the facility is said to be ready to move in staff and students. Phase two is set to meet contract substantial completion by August 19, 20111. Finally, Phase three is set to meet contract substantial completion by July 30, 2013.

Steel erection began on May 24, 2010 and will be broken down into a total of ten sets. They will begin erecting steel in areas 1A, 1B and 1C as their first of ten sets. (See *Figure 5.1*). The first floor of steel will be complete with set two which is composed of steel erection in area 1D. Sets 3 and 4 will include erecting steel for areas 2A and 2B. (See *Figure 5.2*). Finally, sets 5 through 10 will conclude steel erection for areas 3A to 3H. (See Figure 5.3). Steel erection is scheduled to complete on April 11, 2011. **See Appendix A for a detailed schedule.**

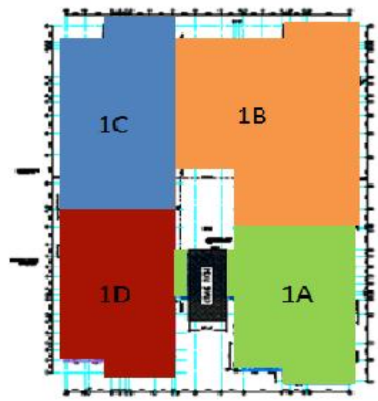

Figure 5.1 – Main Floor Plan

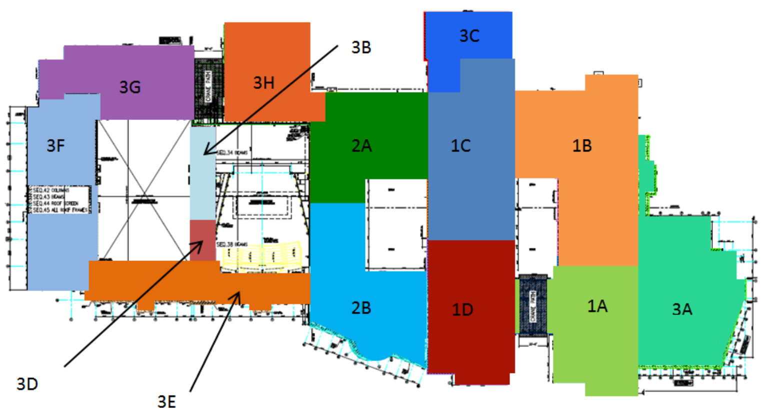

Figure 5.2 – Second Floor Plan

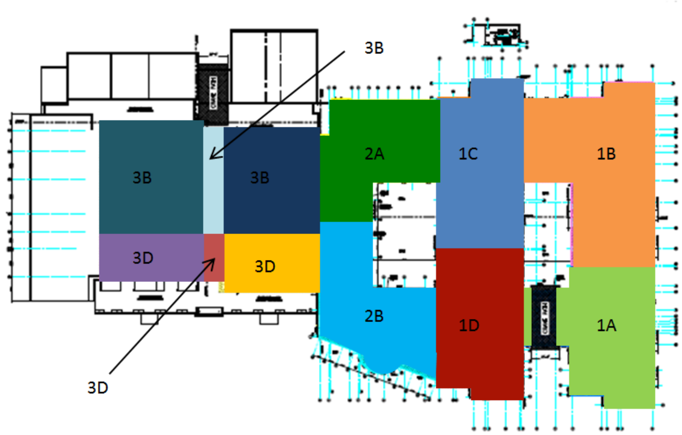

Figure 5.3 – Third Floor Plan

Site Plan for Existing Conditions

The new Paint Branch Facility will be constructed to the south east of the existing out-dated facility. This location of the new facility was chosen to allow for the existing facility to remain open during construction. The site is approximately 45 acres; however, since there is already an existing facility on the site, it will make each construction phase very tight with limited laydown areas. Due to the tight construction space, coordination between field activities with all trades will be necessary. *Figure 6* is a site plan showing trailers, temporary fencing, laydown areas, temporary utilities, dumpsters, and the access path. A copy of the site condition and existing conditions plan can be found in **Appendix B.**

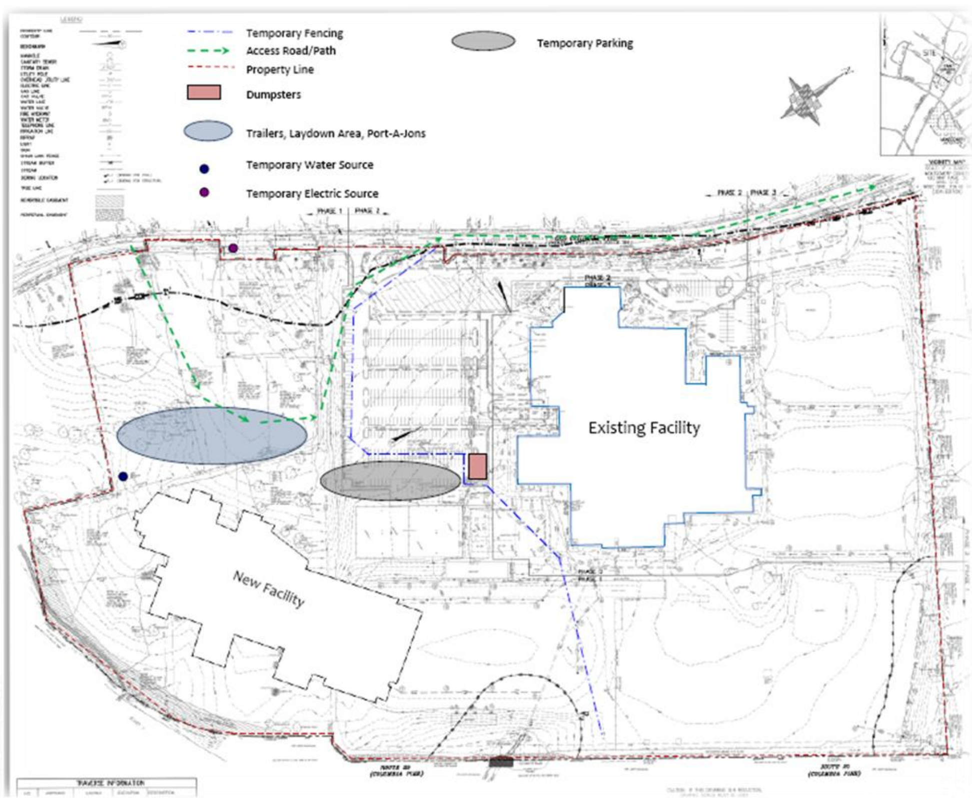

Figure 6 – Site Conditions & Existing Conditions Plan

Local Conditions

Figure 7 – Arial View of Project Site (Photo courtesy of Google Images)

Paint Branch High School is located at 14121 Old Columbia Pike Burtonsville, Maryland. The school property is surrounded by residential houses, and roadways. There are residential houses to the north of the site. Columbia Pike (Rt. 29) is on the eastern side of the site followed by Old Columbia Pike which is on the west side of the site. Finally, there is an existing parcel to the south of the existing site which is owned by The Maryland-National Capital Park and Planning Commission (M-NCPPC). M-NCPPC has given the parcel to MCPS. The existing site is said to slope to the east toward Columbia Pike.

The soil conditions on site are primarily sand. Prior to construction there were about 40 boring samples taken 30-40 feet out of the ground. When analyzed, there was no indication of sand. It was not until the excavation began when they had found sandy conditions. Along with the unexpected sandy soil conditions, there was an immense amount of bamboo that needed to be hauled off site during excavation.

HESS will use approximately 100 parking spots from the existing parking lot for parking and lay down areas. As for temporary utilities, HESS is using Baltimore Gas and Electric to power their trailer along with the building. Temporary power arrived on site in June of 2010. Temporary water was obtained by a fire hydrant meter until permanent water was installed on October 1, 2010.

Building Systems Summary

Work Scope	Yes	No
Demolition	X	
Structural Steel Frame	X	
Casst In Place Concrete	X	
Precast Concrete	X	
Mechanical System	X	
Electrical System	X	
Masonry	X	
Curtain Wall		X
Support of Excavation		X

Table 2 – Building Systems Summary Table

Demolition

Demolition of the out-dated Paint Branch High School will be part of Phase 3 of the project and will begin July 18, 2013. Since the out-dated facility was originally built in 1969 abatement will be necessary.

Structural Steel Frame

Paint Branch High School will have a moment frame structural system. It will consist of diagonal and cross bracing for wind load resistance. The diagonal cross bracing occurs on levels 2 and 3 and consists of W8X24 steel members on level 3 and W8X28 on level 2. Level one is braced with W8X31 steel members. Diagonal bracing occurs on the eastern part of the building on level 3 and uses an HSS66x6X1/4 steel member.

The floors are composed of 4 – ½" thick nominal weight concrete poured over a 2" composite 20 gage metal deck with wire mesh. The roof deck utilizes an 11 – ½" 22 gage type B galvanized metal deck with 4" thick nominal weight concrete.

Cast in Place Concrete

There will be smooth-formed finished concrete and rough-formed finished concrete on the Paint Branch project. The smooth finished concrete will be formed with form-facing panels that will provide continuous, true, and smooth concrete surfaces. They will also be furnished in the largest possible size to minimize the number of joints. The materials used to form the smooth finished concrete will be plywood and metal. The rough-formed finished concrete will formed with plywood, lumber and metal and the lumber will be dressed on at least two edges and one side for a tight fit.

The forms for the cylindrical columns, pedestals and supports will be metal, glass-fiber-reinforced plastic, paper or fiber tubes that will produce surfaces with gradual or abrupt irregularities. The form liners for the exposed textured portions will be GrayLastic Formliners manufactured by Fitzgerald Formliners in Santa Ana, California.

Pre-Cast Concrete

The pre-cast concrete will be provided by David Kucera Inc., located out in Cardiner, New York. The pre-cast panels will be attached by H&B 444 Z clips at the top and bottom of the pre-cast panels. Theses Z clips will be embedded 3" into a 12" concrete masonry unit with non-shrink grout in a ½" diameter hole. *Figure 3* is a section detail showing the connections made to the pre-cast concrete panels.

Mechanical Systems

The mechanical system used for Paint Branch High School will be a geothermal heat pump system. There are approximately 600 wells that vary between 300 and 450 feet deep that will be installed below completion fields to act as the heat source for the system. The teaching spaces and conditioned zones will be served with multiple vertical floor-mounted water-source heat pump units accompanied with roof top energy recovery units. The geothermal heat pumps along with the roof top energy recovery units are being incorporated in the design to attain LEED Gold Certification.

Electrical System

The electrical distribution system used on Paint Branch High School will be 277/480 volt, 3-phase, and 4-wire. This distributions system will serve all lighting, motor, and other heavy power type loads throughout the facility. There will be step down transformers located throughout the building to serve the 120/208 volt, 3-phase, 4-wire requirements. The step down transformers are to carry minor miscellaneous loads and receptacle loads. An emergency generator will handle the critical loads such as fire alarm, emergency lighting, communications, kitchen freezers and refrigerators, and the roof top energy recovery units.

Masonry

There is concrete masonry units and face brick masonry used on the project. The concrete masonry units are used for the load bearing walls whereas the face brick is used for aesthetics and serve no structural purpose. The concrete masonry units will be bonded with vertical and horizontal reinforcing. The vertical reinforcing will be placed every 24” on center and the horizontal reinforcing will be placed every 8” on center. The 4” face brick masonry will be connected to the concrete masonry units with horizontal join reinforcement at 16” on center. Provided in Figure 8 is a wall section showing the connections of the concrete masonry units and the face brick.

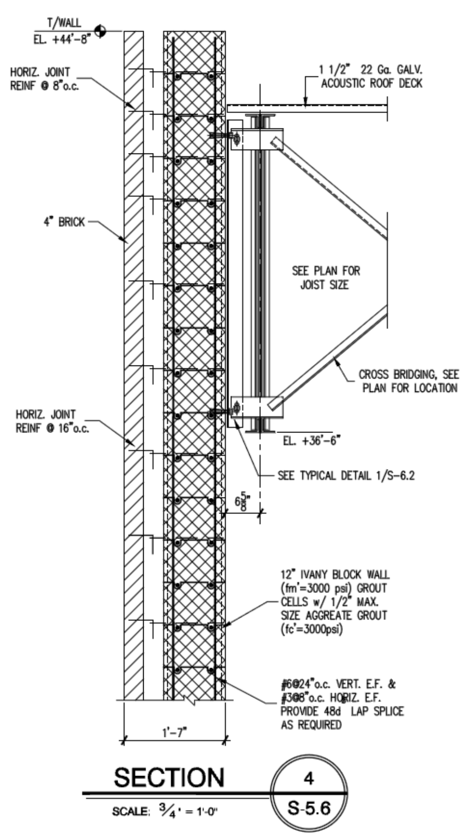

Figure 8 – Wall Section

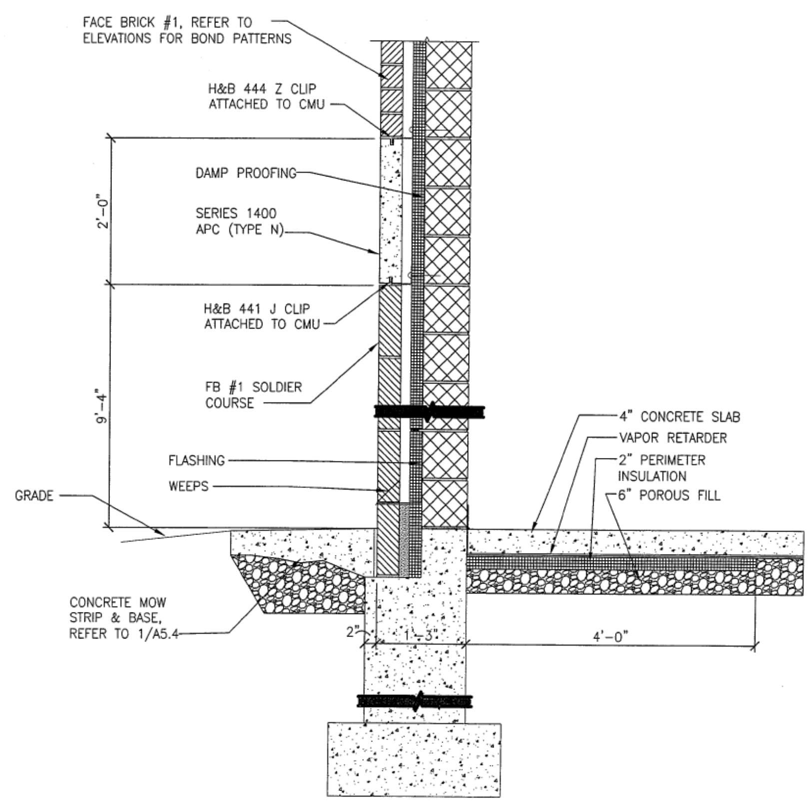

Figure 9 – Wall Section

Technical Analysis #1: LEED Certification

Problem Identification

Building sustainable buildings has been of great importance to MCPS. They have been constructing LEED certified educational facilities since 2004. Currently, Paint Branch High School is striving to achieve a LEED Gold Certification upon completion. However, it is believed that the building has not been designed to its full potential for LEED Certification.

Research Goal

The goal of this analysis is to investigate alternative systems within the building that may improve the overall efficiency of the building. It is also to analyze the impact of cost to the overall project. Finally, I will analyze the relationship between green buildings and a healthy learning environment.

Methodology

- Analyze the current systems being used on the project and reasons for being implemented.
- Compare similar educational facilities and their systems.
- Research alternative systems which may improve buildings efficiency.
- Determine how alternative systems impact overall cost of the building.
- Research relationship between green buildings and healthy learning environments.
- Draw conclusions on impact of schedule, cost, and learning environment.

Resources

- Industry Professionals
- AE Faculty
- HESS Project Team
- Applicable Literature

Expectations

After conducting extensive research on alternative systems throughout the building, it will be believed that the project will be able to attain a LEED Platinum Certification. Although, the upfront cost will increase, the projected savings throughout the life cycle of the building will be greater. It will also be believed to benefit the students learning environment through a more sustainable building.

Analysis

An extreme amount of research has been conducted on green schools and their positive learning effects on students as well as the potential savings to the owner. Paint Branch is currently pursuing a LEED Gold Certification. Since the project was originally design in 2005, the design team used version 2.2 of the LEED Manual. According to the LEED 2005 manual, a project requires 39-51 points on the LEED scorecard to pursue a LEED Gold Certification. Currently, Paint Branch has acquired a total of 43 points. In order for the project to reach a LEED Platinum certification, the project must have a minimum of 52 points. Therefore, I have analyzed the LEED scorecard and found opportunities to capitalize on in order to attain a LEED Platinum Certification.

With a LEED certified school, a children's performance is increased with improving the acoustics, day lighting, and air quality in a building. With a brighter classroom, visibility is increased for both students and teachers. Studies have shown that with a visibly brighter learning environment for students, their test scores will increase by 25%. Studies have also shown that a student will have the ability to learn 20-25% faster on standardized reading with a naturally day lit room.

The air quality within a school is also very important to the occupants. The most vulnerable occupants in an educational facility are children. It is estimated that children miss ten million school days a year due to asthma. Also, having poor air quality within in a building can cause mold growth and diseases that can spread, causing teachers and students to become ill. Furthermore, parents are complaining more about their children acquiring asthma, which may be related to poor air quality.

Acoustics are also very essential in an educational facility. Poor acoustics in an educational facility can easily cause distraction, which in return will affect a student's ability to learn. In order for a school to have good acoustics, there must be low background noise and low reverberation. Students in quieter learning environments scored up to 20% higher on word recognition test.

This analysis takes a look at areas of opportunities to attain a LEED Platinum Certification on the Paint Branch project. Opportunities were discovered by analyzing the LEED score card provided by HESS Construction + Engineering Services, and further researching ways to implement a LEED credit to the project in order to attain a LEED Platinum Certification. *Table 3* shows the credits on the LEED scorecard that have been chosen in order to bring the project to a LEED Platinum Certification. Also, the LEED scorecard for Paint Branch High School can be found in **Appendix C.**

LEED Credit Opportunities		
Sustainable Sites		Points
Credit 7.1	Heat Island Effect, Non Roof	1
Energy & Atmosphere		Points
Credit 2.1	On-Site Renewable Energy	1-3
Credit 4	Enhanced Refrigerant Management	1
Credit 5	Measurement & Verification	1
Indoor Environmental Quality		Points
Credit 1	Outdoor Air Delivery Monitoring	1
Credit 5	Indoor Chemical & Pollutant Source Control	1
Credit 7.1	Thermal Comfort, Design	1
	Total Possible Points	**9**

Table 3 – LEED Credit Opportunities

The current LEED scorecard has a total of 42 points which qualifies the building for a LEED Gold certification. However, Credit 4.2 under the Material & Resources section of the LEED scorecard is currently being pursued and expected to attain by the project team. This will give the project a total of 43 points, requiring only a total of 9 points to achieve a LEED Platinum Certification. This analysis will take a further look into each credit listed in *Table 3* and analyze its impact to the overall cost of the project.

CREDIT 7.1 – HEAT ISLAND EFFECT, NON ROOF

This credit focuses on reducing heat islands, which are thermal gradient differences between developed and undeveloped areas to minimize the impact on microclimate and human and wild life habitat. There are two options to choose from when trying to obtain this credit. Option 1 asks to provide any combination of strategies for 50% of the sites roads, sidewalks, courtyards and parking lots. These strategies include providing shade within 5 years of occupancy, paving materials with a Solar Reflectance Index (SRI)[2] of at least 29, or an open grid pavement system. Option two calls for placing a minimum of 50% of parking spaces underground, under a deck, under a roof or under a building. However, any material used to shade or cover parking must have an SRI of at least 29.

For this analysis, option two will be pursued in order to obtain this credit. In order to achieve this credit, the total amount of parking must first be found. There are a total of 355 parking spaces for the new facility. Therefore, approximately 178 parking spots must be under a roof type system. *Figure 12* and *Figure 13* show the parking spaces that will be placed under a canopy. The canopy systems will have to be a combination of a single and double cantilever system. *Figure 10* and *Figure 11* show the two different cantilever systems.

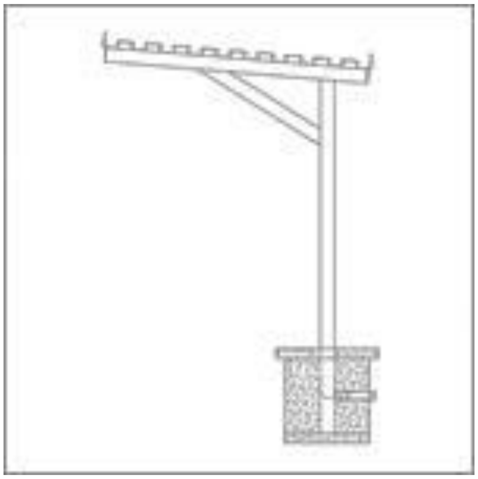

Figure 10 – Single Cantilever System

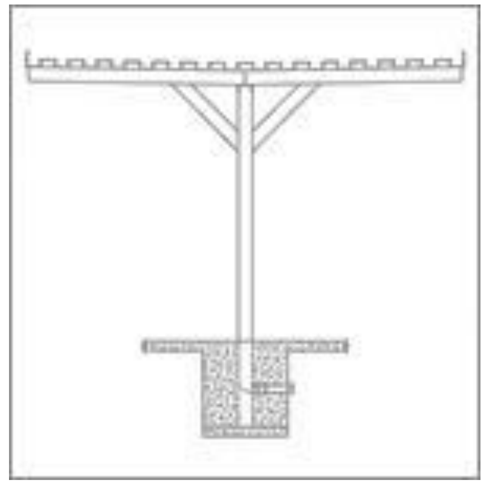

Figure 11 – Double Cantilever System

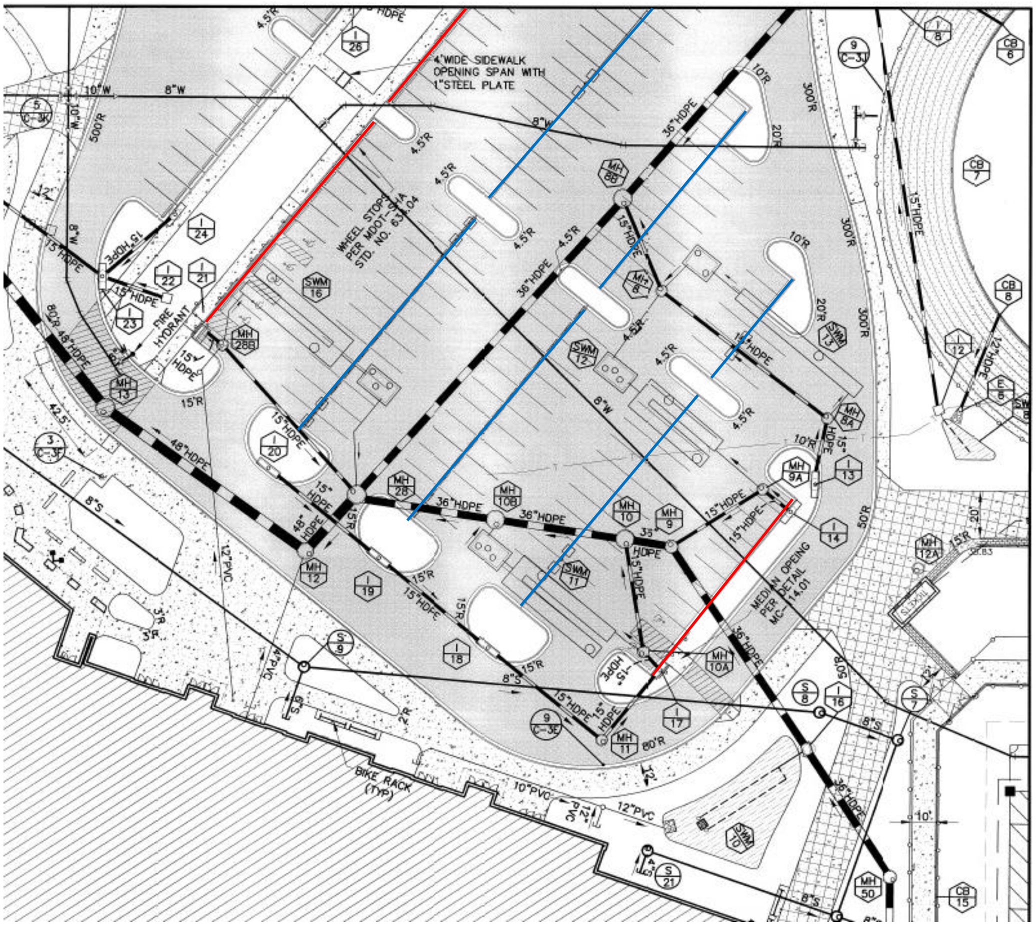

Figure 12 – Proposed Parking Modification

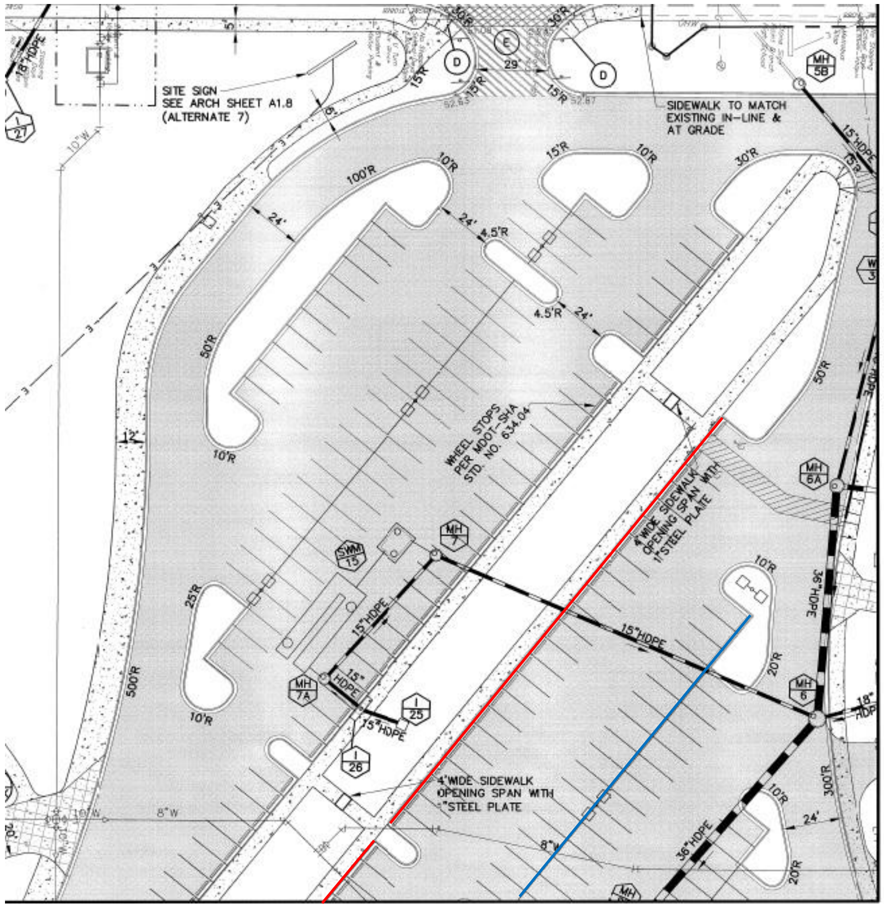

Figure 13 – Proposed Modification (Continued)

The red lines shown in Figure 10 and Figure 11 show where the single cantilever system will be installed. The blue lines show where the double cantilever systems will be installed. The two canopy systems will cover a total of 188 parking spaces, which will accommodate for more than the required 50% of parking spaces. Below, *Table 4* shows the total cost of the canopy systems. The canopy systems will cost a total of **$609,000**. This cost does not include installation or delivery. See **Appendix D** for full site plan with relation to parking. See **Appendix E** and **Appendix F** for specifications for each cantilever system.

Cost Analysis				
Canopy System	Total Parking Spots	Total Linear Ft	Cost/LF	Total Cost
single Cantilever	47	470	300	$ 141,000
Double Cantilever	141	780	600	$ 468,000
Total	188	1,250	900	**$ 609,000**

Table 4 – Canopy Cost Analysis

Credit 2.1 – On-site Renewable Energy

This credit focuses on reducing environmental and economic impacts associated with fossil fuel energy use. This credit's worth ranges from one to three points. This credit requires the use of on-site renewable energy systems to offset building energy cost. The building's performance must be calculated by expressing the energy produced by the renewable systems as a percentage of the building's annual energy cost. In order to gain all 3 points of this credit, the building must show a performance of 12.5% of renewable energy.

To achieve all three points from this credit, a 12.5% savings in energy use must be shown. Based on the Commercial Building Energy Consumption Survey (CCBECS), an educational facility utilizes 83.1 thousand BTU per square feet a year. When factoring in the buildings square footage and converting BTU to kWh, the total energy used in one year will be 8,523.58 kWh. Therefore, a 12.5% savings in energy would amount to 1,065.45 kWh a year.

Incorporating a wind mill as a renewable energy system would be one viable option to fulfill the requirements for this credit. After reviewing the 2010 Wind Generator Buyer's Guide, a Proven 7 windmill will produce an annual energy output of 1,704 kWh at a wind speed of 8 miles per hour. The wind turbine costs a total of **$25,000** and includes a five year warranty. This exceeds the 1,065.45 kWh of energy that is required to be saved each year in order to attain the three points for this credit.

However, there are a few factors that must be taken into account when considering implementing a wind turbine on an educational facility. One must take into account the impact the wind turbine will have architecturally to the building. Also, one must consider the placement of the turbine in order to optimize its maximum performance. Finally, there must be a six month wind study conducted in order to determine the feasibility of the wind turbines performance. See **Appendix G** for wind turbine Specifications.

Credit 4 – Enhanced Refrigerant Management

This credit focuses on reducing ozone depletion as well as minimizing the direct contributions to global warming. This credit can be attained by simply choosing a different type of refrigerant to be used in the buildings HVAC system. The refrigerant must be an ozone friendly refrigerant. Refrigerants such as an R-410 or R-134A refrigerant would be acceptable refrigerants to use for this credit.

However, in order to fulfill the requirements for this credit, all the refrigerants being used throughout the building must be accounted for. In order to do so, the HVAC manufacturer would need to provide the Mechanical Engineer with the total quantity of refrigerant being used in each HVAC system. Once this information is acquired, the Mechanical Engineer can calculate the threshold for the combined contributions to ozone depletion and global warming potential. The resultant of this calculation must be less than or equal to 100. If all requirements are met, the project team will achieve this credit.

Credit 5 – Measurement & Verification

This credit focuses on the ongoing accountability of the building's energy consumption over time. A Measurement & Verification (M&V) Plan must be developed and implemented in order to achieve this point. The M&V plan must be consistent with a calibrated simulation or an Energy Conservation Measure Isolation Plan. The M&V should cover a period of no less than one year after construction has been completed and the building is occupied.

To fulfill the requirements needed to obtain the one point for this credit, a computer simulation of the entire building must be constructed. This simulation must show the entire building's energy use after construction has been completed. The energy use after construction is determined by utility metering or by using and energy simulation model. The energy simulation model must be of the as-built building, and it must be calibrated to metered energy use data.

The responsibility of this credit falls under the owner. It is the owner's responsibility to contact a third party to construct an energy model and manage the model for a year. After a discussion with one of the Mechanical Engineers, Matt Ludwig, on the Paint Branch Project, EMO Energy Solutions was a third party representative recommended for construction and maintaining the energy model for the credit.

After contacting EMO Energy Solutions, I had spoken with Tom Serah who was familiar with Paint Branch High School. He had informed me that EMO would manage the building model and the measurement and verification plan of the building. He also added that the building would possibly require an additional amount of permanent and temporary metering installed in the building in order to obtain the proper information through the measurement and verification process. He had also given me a rough idea of how much it would cost to manage the measurement and verification plan along with the additional permanent and temporary metering. The total cost of this credit would amount to approximately **$55,000**. This value includes the $30,000 fee for the measurement and verification plan and a $25,000 fee for the additional permanent and additional metering systems.

Credit 1 – Outdoor Air Delivery Monitoring

This credit focuses on the occupant's well-being and comfort by monitoring a systems ventilation through the building. Permanent monitoring systems must be installed that provide feedback on a ventilation systems performance. These monitoring systems will ensure that a ventilation system will maintain design minimum ventilation requirements. The monitoring system must be equipped with an alarm the sound when the conditions vary by 10% or more from set point. For mechanically ventilated spaces, carbon dioxide concentrations must be monitored within all densely occupied spaces that are greater than or equal to 25 people per 1000 square feet. All carbon dioxide monitoring systems should be located between three feet and six feet about the door. Any mechanically ventilated system serving a non-densely occupied space, a direct outdoor airflow measurement devise must be included. The devise must be capable of measuring the minimum outdoor airflow rate with an occupancy of plus or minus 15% of the design minimum. Finally, for naturally ventilated spaces, carbon dioxide concentrations must be monitored within all naturally ventilated spaces. The monitoring devise should be located in the room between three and six feet above the floor.

Currently, the Paint Branch project utilizes CO_2 monitoring systems throughout the building. However, these monitoring systems are only being used in the large spaces in the building such as the libraries, gymnasium, and auditorium. In order for this credit to be met, the use of CO_2 monitoring systems would have to be implemented in each of the classrooms. There are a total of 154 classrooms throughout the building. Each CO_2 monitoring system costs approximately $800. Therefore, it would cost an additional **$123,200** to the total project cost.

Credit 5 – Indoor Chemical & Pollutant Source Control

This credit focuses on protecting the building occupants from exposure to potentially hazardous particulates and chemical pollutants. The building must be designed to minimize and control pollutant entry into buildings and later cross contamination of regularly occupied areas. These areas include permanent entryway systems that are at least six feet long, garages, housekeeping/laundry areas, and copying/printing rooms. Also, there must be air filtration media must be applied before the building is to be occupied. The filtration media must provide a Minimum Efficiency Reporting Value (MERV) of 13 or better. The filtration media will help process the return and outside are that is to be delivered as supply air. In order to meet one of the requirements for this credit, an entry grate must be permanently placed at all entry ways. The purpose of the grate is to capture dirt and particles from entering into the building.

There are a total of 35 entry ways throughout the building that will require an entry grate in order to obtain this LEED credit. After researching several types of entry grate systems, an RG-720 Stainless Steel Grating system will be used to achieve this credit. This product is manufactured by Engineering Products, Inc. After selecting the entry system, I had contacted a representative of Engineering Products, Inc. to help with the pricing of this particular system. Susan Whalen helped me price this system at approximately $4,477 for each system. Since there are a total of 35 entrances that will require an entry grate, the total cost for this credit will be **$156, 695**. This cost does not include shipping or installation. See **Appendix H** for the entry grate specifications.

Credit 7.1 – Thermal Comfort, Design

This credit focuses on the productivity and well-being of occupants within a building by providing a comfortable thermal environment. The HVAC system and building envelope must be designed to meet the requirements spelled out in ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy. The Mechanical Engineer must demonstrate design compliances in accordance with the section 6.1.1 Documentation.

In order for this credit to be achieved, the Mechanical Engineer must calculate the heating and cooling loads throughout the entire building. However, this may cause a problem for the Mechanical Engineer since the gymnasium is not cooled by an HVAC system. However, the credit can still be attained.

Cost Impact

Table 5 shows the impact of each credit will have to the overall cost to the project.

LEED Cost Analysis			
Sustainable Sites		Points	Cost
Credit 7.1	Heat Island Effect, Non Roof	1	$609,000
Energy & Atmosphere		Points	Cost
Credit 2.1	On-Site Renewable Energy	1-3	$25,000
Credit 4	Enhanced Refrigerant Management	1	N/A
Credit 5	Measurement & Verification	1	$55,000
Indoor Environmental Quality		Points	Cost
Credit 1	Outdoor Air Delivery Monitoring	1	$123,200
Credit 5	Indoor Chemical & Pollutant Source Control	1	$156,695
Credit 7.1	Thermal Comfort, Design	1	N/A
	Total Possible Points/Cost	**9**	**$968,859**

Table 5 – LEED Cost Analysis

Conclusion

After analyzing all the credits required to bring the Paint Branch project to a LEED Platinum Certification, it is evident there is a significant increase in the overall cost to the project. Bringing the project to a LEED Platinum Certification will add an additional **$968,859** to the overall project.

There are not many owners who would be willing to spend almost $1 million dollars in order to receive a LEED Platinum Certification. However, the money spent to increase the buildings certification to a LEED Platinum level has its benefits. The owner of an educational facility must pay close attention to the occupancies health and well-being. In this case, the occupants are the students and faculty members. The students and faculty would have a much cleaner work environment reducing the number of absences in a school year. Also, another positive aspect of attaining such a high rating would improve the students test score reflecting the schools great academic achievements.

The school would also benefit our environment and reduce the harsh affects outdated facilities place on the environment with CO_2 emissions. A LEED Certified Platinum school would reduce the amount of energy consumption as well as water consumption throughout the building. This would benefit our environment and add a savings to the owner through energy costs.

Another incentive for why an owner may wish to achieve a LEED Platinum school is due to the overall savings in operating costs. It is estimated that a green school saves up to 40% on energy costs. For example, if a regular 350,000 square foot high school costs $1.00 per square foot in energy, it would cost $350,000 a year. However, if a LEED Platinum school had a cost of $0.60 per square foot in energy cost, the owner would be paying $210,000 a year in operating costs. Therefore, the owner would be saving a total of $140,000 a year in operating costs.

All the reasons discussed are all valid reasons why an owner should consider building the most efficient facility. Although, it may not be logical to pursue a LEED Platinum building due to the location of the facility, the owner should still consider attaining at least a LEED Silver Certification. The owner must be open and have an understanding that there will be a substantially high up front cost, however, the potential savings the owner may have are tremendous. Also, the building would be contributing to the well-being of or environment and the occupants within that facility.

Technical Analysis # 2: Brick Façade

Problem Identification

The Paint Branch project utilizes a great deal of face brick for its façade. As noted in the previous section, this can cause a significant affect in the project schedule. The face bricks are to be laid by masons and will take a great deal of time to complete with a 350,000 square foot building. This also will require a great deal of man power as well as man hours to complete, and can potentially affect the overall quality. However, with the use of prefabricated masonry panels, a great deal of time, money, and productivity can be saved.

Research Goal

The goal of this analysis is to perform a design of a prefabricated brick panel system and investigate the impacts on schedule, cost, and site congestion.

Methodology

- Research prefabricated masonry panels and select an applicable manufacturer.
- Contact manufacturer for design consultation.
- Analyze the impact of the prefabricated brick panels to the existing structure.
- Assess impact on LEED Certification requirements.
- Determine means of transportation, erection, and installation requirements for prefabricated panels.
- Analyze impact on cost, schedule, and constructability due to prefabricated panels.

Resources

- Industry Professionals
- Prefabricated Brick Panel Manufacturer
- AE Faculty
- Moseley Architects
- HESS Construction Team
- Applicable Literature
- Structural System Software

Expectations

After completing this research it will be believed that the prefabricated brick panels will cause a reduction in project schedule while causing an increase in project coast. It is also believed the prefabricated panels will eliminate site congestion, and increase safety.

Analysis

A building's façade is a very important part of a projects schedule. It is on the critical path and can sometimes take a very long time to construct. Paint Branch High School is a 350,000 square foot educational facility with a façade that is primarily face brick and architectural prefabricated concrete panels. Although, prefabricated masonry panels are not common in many educational facilities, I proposed the use of prefabricated masonry. I also chose to use a prefabricated masonry panels system because architectural precast concrete panels were already incorporated in the building's façade. This analysis will consider the impact a prefabricated masonry panel system will have on a projects schedule as well as its overall cost to the project.

After taking a look at the projects schedule for the façade, I have concluded that there is a total of 28 weeks of façade construction. Within these 28 weeks, façade construction will include installation of the architectural precast concrete panels and the laying of the face brick. With both activities occurring simultaneously, if a prefabricated masonry panel was being used, the crane being used to erect the precast concrete panels could also be used to erect the precast masonry panels. Originally, I was under the impression that a prefabricated masonry system would reduce a projects schedule as well as cost.

With this hypothesis, I needed to gain a much better understanding on how prefabricated masonry panels are constructed and the process behind their delivery to the site and erection and installation before I could come to any conclusions. I had researched a few prefabricated masonry panel manufacturers around my project site. I came across a company located in Midland, VA by the name of Easi-Set Industries. I had spoken to a man by the name of Rick Groves who was more than willing to assist me with the questions I had.

I had asked Rick a few basic questions regarding a panel's typical size, duration of construction and erection and so on. After I had acquired all the information I had needed about the panels, I was able to organize a table comparing a prefabricated masonry panel system to a traditional stick built masonry system. *Figure 14* and *Figure 15* show the two different facades. *Table 6* shows the cost and time comparison between the two masonry systems.

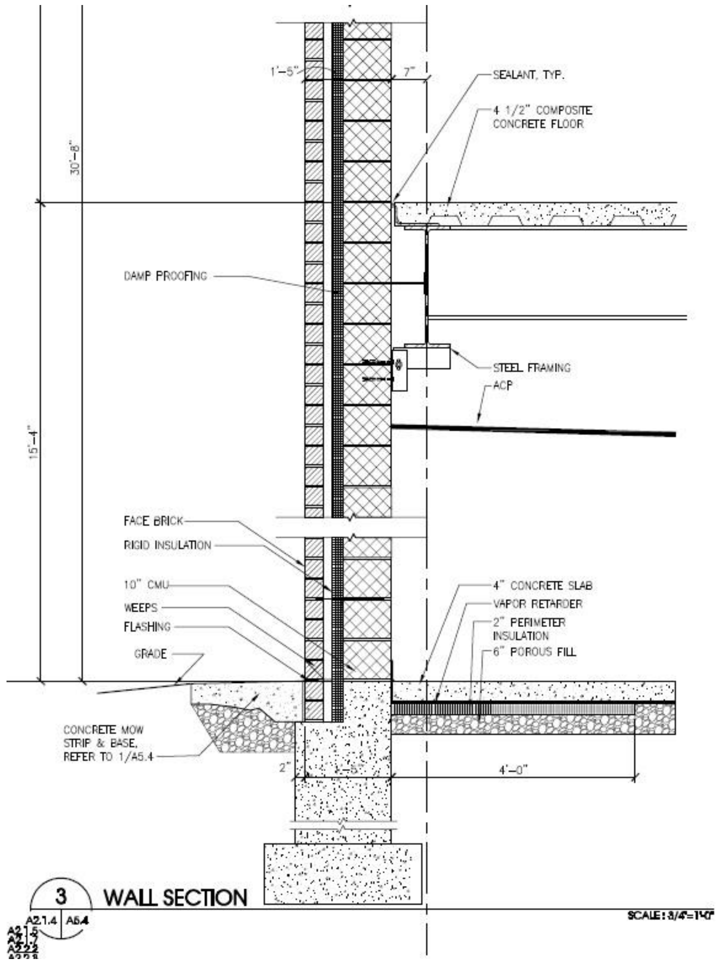

Figure 14 – Wall Section: Original Masonry System

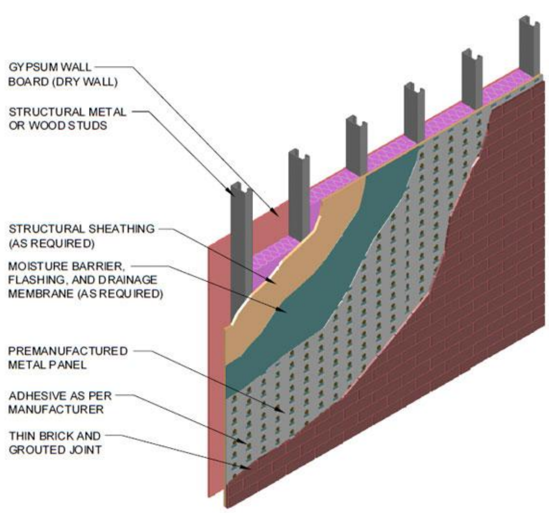

Figure 15 – Thin brick system (http://www.interstatebrick.com/BIM/thin_brick_walls/over_metal_panels.html)

Masonry Systems Comparison			
Original Masonry System			
Duration	Cost/SF	SF of Brick	Total Cost
139 Days	$20.62	108,000	$2,226,960.00
Prefabricated Masonry Panels			
Duration	Cost/SF	SF of Brick	Total Cost
19 days	$40.00	108,000	$4,320,000.00

Table 6 – Masonry Systems Cost Comparison

When reviewing this table, there are a few things one must note. The total cost shown in the table does not reflect the total cost of the masonry bid package. Also, the cost per square foot obtained for the prefabricated masonry panels includes the cost for shipping and installation.

Looking at the schedule provided by HESS Construction and Engineering Services, I was able to find that it will take 139 days for the face brick to be installed. I learned from the statement of probable cost provided by HESS Construction that cost per square foot for the masonry would be $20.62. Utilizing the Revit model also provided by HESS Construction, along with confirmation form Matt Evans, the Project Manager on Paint Branch, the total square foot of face brick being installed would be 108,000 square feet. With the cost per square foot and total square foot of face brick, I was able to come up with a total cost of $2,226,960 for installing the face brick system.

Through my phone conversation with Rick from Easi-Set Industries, I was able to learn that the biggest panel that could be shipped to the site is 12'X40'. I chose to use this size panel to minimize the number of panels required for the total project. With a 12'X40' panel and 108,000 square feet of façade, I was able to find that the project would need a total of 225 panels. I also learned with my conversation with Rick that it takes about a day to make a 12'X40' panel, and a crew of five men would install anywhere from 8 to 15 panels in a 8 hour work day. A five man crew includes one welder, two men grounded, and two men in the building to hold the crane in place to be welded. I chose to use 12 panels a day for installation to figure out it would take 19 days to install all 225 prefabricated panels. Rick also informed me that the cost of a prefabricated panel that is 12'X40' would cost approximately $40.00 per square foot with installation and delivery. With this piece of information I was able to conclude that the cost for the proposed prefabricated masonry system would be **$4,320,000**.

Constructability

Clearly, using a prefabricated masonry panel system shows a substantial savings in the project schedule. Like the originally designed brick façade, the prefabricated system would be able to have a concurrent construction activity with the steel erection. However, the prefabricated system would require the use of a crane unlike the originally designed brick system.

The erection of the prefabricated masonry systems would follow the same erection sequencing as the steel sequencing plan. Shown below in *Figure 16* is the sequencing plan for the erection of the prefabricated masonry panels.

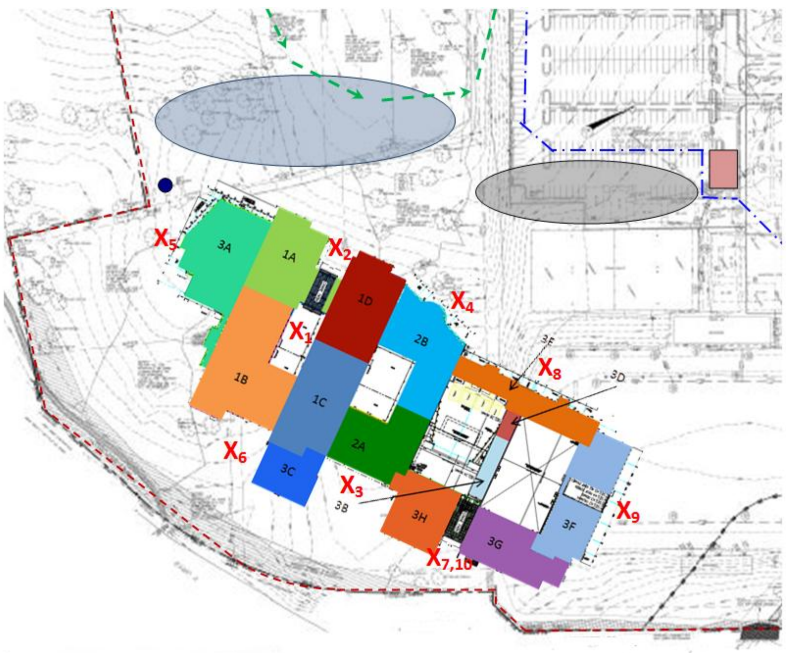

Figure 16 – Prefabricated Masonry Panel Sequencing Plan

Figure 14 shows the crane location for each sequencing phase of the prefabricated masonry panel erection. The "X" denotes the crane location at each sequencing phase. Therefore, an X_1 would show where the crane would be located during sequencing phase 1.

The sequencing would begin at X_1 and follow in a clockwise direction ending at X_{10}. However, there is an important point to take into consideration for the constructability of the prefabricated systems. The prefabricated panels only require a total of 19 days to be erected and installed. Therefore, the panels will have to come in on site after each phase of steel sequencing is complete.

Contribution to LEED

Due to the fact that prefabricated panels are constructed in a factory, the system will have a very small tolerance allowing for a much more water tight barrier. This will affect the on the building envelope and the buildings overall performance. With a water tight barrier, the prefabricated system should prove to be a more efficient system than the traditional stick built system. This assumption will be discussed in more depth in my mechanical breadth analysis. However, with the assumption that the prefabricated masonry system will be a more efficient system, it is believed there is a potential to add points to the Optimizing Energy Performance credit in the LEED scorecard.

Site Congestion

Also, with the use of a prefabricated masonry system, the project site will be susceptible to a less congested work area. The prefabricated panels will eliminate the use of scaffolding, which is one of the main causes of site congestion to the current project site. Also, the prefabricated panels will only require a crew of five men to hang each panel. With a stick built system, there will be approximately a crew of 20 men laying masonry. The difference in crew size between each system will allow for decrease site congestion. Finally, the prefabricated systems will not need an area for storage as opposed to the storage required for the face brick and concrete masonry units along with the mixing stations. The panels will be directly taken off of the truck and hung immediately.

Conclusion

Although, the prefabricated masonry system has a substantially higher cost that the original masonry system, the prefabricated panels would save a substantial amount of time on the job site. The prefabricated panels would save the overall project six months in schedule time. Also, prefabricated systems are constructed with much better quality. This is because the systems are constructed inside a factory as opposed to the stick built systems being constructed on site. The traditional stick built systems utilizes weeps and there is an opportunity for water to enter into the cavity. The prefabricated systems are constructed in a factory where they are closely monitored and inspections can be conducted to ensure the quality of the panels.

However, the prefabricated panels may cause some problems to the overall project. Since the prefabricated systems will require a crane for installation after steel is erected, erecting the panels into the courtyard areas may be a bit tricky. As a result of the implications the courtyards may cause for the erection of the prefabricated systems, it would not make sense to use a prefabricated system. Although, there are plenty of benefits to using a prefabricated system, for a project such as Paint Branch, one should consider an alternative option for a façade. Using a traditional brick system with a CMU backing would be the better option for this particular type of project.

The project team on Paint Branch was aware of the prefabricated systems and had suggested the idea. However, these systems are not common in MCPS schools and they are not really common in any educational facilities for that matter. In this case, MCPS was more concerned with the overall cost of the project as to the substantial savings in schedule. Also, another reason the project team stayed away from the prefabricated systems was due to the amount of electrical work that is integrated into the exterior walls. Educational facilities use a minimal amount of drywall and the rest is exposed masonry. One thing to keep in mind when suggesting a prefabricated system is the owners overall goal; whether they are trying to save money or time.

Technical Analysis #3: BIM Coordination

Problem identification

Originally, there was no use of a BIM model on the Paint Branch project. It was not until there was a lack of communication and coordination between the Architect and Engineers when designing the new educational facility. The lack of communication and coordination led to the use of a BIM model a few months prior to breaking ground. After the BIM model was in use, several issues arose and resulted in having to creatively reroute the MEP work to avoid changes in the structural design and ceiling heights.

Research Goals

The goal of this analysis is to compare a project that used BIM and another that did not and assess the time and money BIM could potentially save on a project.

Methodology

- Investigate the reason for not using BIM at the beginning of the design phase.
- Investigate how much time and cost is required to construct a BIM model.
- Analyze a project that has used BIM and review their clash detection log.
- Analyze a project that has not used BIM and review the time and money spent resolving major issues.
- Compare both projects and conclude analysis.

Resources

- BIM Coordination Meeting Minutes
- Clash Detection logs
- AE 473: Building Construction Management
- Autodesk Revit & Autodesk Navisworks

Expectations

Through the conduction of this research, it will be believed that a substantial amount of time and money would have been saved if a BIM model would have been utilized at an earlier phase of the project. This information will be beneficial to Owners and Project Teams in the future.

Analysis

Originally, there was no use of a BIM model on the Paint Branch project. Not until there became a lack of communication between the Architects and Engineers, a BIM model was created. After the model had been created, the project team began to see the issues with some of the designs and began to make adjustments accordingly. The BIM model allowed the project team to see potential problems during future construction activities.

After creating a BIM model, the project team began to see potential problems during certain construction activities, which allowed them to better coordinate these activities. The use of a BIM model can be very beneficial to both the owner and project team. The BIM model can be used to show the owner a 4D model of the progress of the project and what it should look like during certain periods of the schedule. The model can also be utilized by the project team for clash detection to better coordinate construction activities that may become potential problems.

This analysis will focus on how the use of a BIM model can potentially benefit the owner and project team by saving cost and schedule duration. Two projects were used for this analysis in order to gain a full understanding of time and money spent on a project. One project has utilized BIM throughout the project and the other has not. The two projects being analyzed were Paint Branch High school and Morgan State University. Paint Branch had used BIM and Morgan State University had not used BIM at all.

The first step in this analysis was to obtain and analyze the clash detection log on the Paint Branch project. After the log was obtained, guidelines provided by the HESS BIM team were given in order to classify either clash detection into a category. These categories determined the clash detections impact on schedule and cost. The guidelines were as follows:

A. Schedule and Dollar Impact
    a. Underground Code Compliance Issues (Pipes 12" or Larger)
    b. Duct w/ Steel/Ceiling/Sprinkler Main/Any MEP System
    c. Anything related to Equipment
    d. Any Issues w/ Steel Framing
    e. Congested Areas w/ MEP
B. Schedule but No Dollar Impact
    a. Ceiling Drops
    b. Request For Information (RFI)
    c. Duct Branches
    d. Sprinkler Branches w/ MEP and Steel
    e. Main Conduit in Congested Areas

f. Duct Risers w/ Duct Supports Clashes

C. Processing Time
   a. Sprinkler Heads in Congested MEP Areas
   b. Misc. Steel

D. No Issue
   a. Modeling Errors
   b. Flex Duct
   c. Goosenecks in Sprinkler Lines

After reviewing the guidelines provided by the HESS BIM team, the categories were applied to the Paint Branch clash detection. Once the categories were applied to Paint Branch's clash detection log, analyzing the cost and schedule impact was next. To obtain this information, I obtained a case study from HESS Construction + Engineering services. The case study was Morgan State University Library, which was a project that had not used BIM. Morgan State University Library was approximately 222,000 square feet with a total project cost of $40 million. The project took its potential change orders and placed them into categories with the same requirements explained above. After analyzing the case study, an average of total cost and time for each category was taken and applied to Paint Branch's clash detection log. After the information was applied to the Paint Branch clash detection log a table was created summing the results. *Table 7* shows the summary of the results obtained from analyzing the Paint Branch clash detection log.

PB Clash Detection Log Cost Analysis					
Category	# of Categories	Avg. Cost/Cat.	Avg. Time/Cat.	Total Cost	Total Time
A	104	$77,611	4 Days	$8,071,544	75
B	962	$5,203	2 Days	$5,005,286	635
C	554	$1,382	1 Day	$765,628	150
			Total	**$13,076,830**	**860**

Table 7 – PB Clash Detection Log Cost Analysis

After a total cost was obtained from the Paint Branch clash detection log, the difference of sums between the total cost of the Morgan State University Library and Paint Branch High School was taken to arrive at a total savings cost. The total savings in cost through the use of BIM came out to be **$10,799,234**. In order to obtain the numerical value for the total time required in *Table 7*, a ratio was obtained from the MSU case study and applied to the PB clash detection log. On the MSU case study, there were a percentage of potential change orders that were used to identify the extra time spent on the project. This percentage was determined for each category and then applied to *Table 7*. For categories A, B, and C, the percentages applied to each category were 18%, 33%, and 27% respectively. This percentage value was multiplied by the number of categories and then multiplied by the average time per category to obtain the total time value. Then to obtain the total time saved through the use of BIM, the total time of 860 days was subtracted by 125 days obtained from the MSU case study. The final value of time saved on a project with the use of BIM would amount to **2 years**. Due to the sensitivity of the information obtained by HESS Construction to perform this analysis, the PB Clash detection log along with the MSU case study cannot be added in the appendices for reference.

Implications of BIM

The BIM model can be utilized to obtain information about the building. This information can be either graphical or non-graphical. The information that is obtained from the model can either be directly contained in the building model or can be accessed from the building model that is linked data stored somewhere else.

There are vast amounts of information that can be applied to a building model. The model can show ideas in a more effective way to the owner or project team. The model allows for one to utilize 3D sections for a more conceptual view. The model also allows one to link a two dimensional section to the building model. Interestingly enough, with the 2D and 3D model being linked, when a change is made in one model, the other model is automatically updated. This saves time in going back and forth between each model and updated each piece of information that has been altered. Also, the three dimensional model allows one to perform a clash detection between systems throughout the building to foresee any construction activities that may cause a delay in the project. Catching these problems and resolving them early in the project will minimize any potential change orders, thus saving cost to the project.

The model also allows one to apply information about a system directly to the model. The system can contain information such as wall type, fire rating, insulation type, estimating information and so on. This makes it easier for a project team when estimating a project or searching for a specific piece of information about a system. This may even make it faster to search for information about a system as opposed to scrambling through construction drawings.

As discussed above, the information contained in the building model can be linked to data located elsewhere. There can be information contained within the model that may not show up directly on the model, but will direct one to a manufacturer's cut sheet, or schedule. Again, this information can be beneficial to a project team during the construction phase of a project.

Benefits of BIM

BIM benefits not only the project team, but the owner as well. The building information model allows the architect to experiment with multiple design systems within a single model. The model also allows the architect more time on the overall building design because the construction documents can be easily generated from the building model. The model also allows the architects to visually analyze the space, lighting and structural system through the three dimensional model.

The owner also has their benefits to using BIM on their project. BIM allows the owner to save approximately 5%-10% in project costs just by implementing the use of BIM. The model also facilitates the owner in visualizing each step of the project, resulting in less change orders. Also, since the BIM model incorporates both the schedule and cost of the project, the owner can now make more sound decisions about the project based on the projects current status. The model also allows for an efficient data exchange between the project team and owner for operations and maintenance.

The BIM model allows the contractor to create more accurate schedules and prepare the necessary material for upcoming construction activities. The model also allows a more efficient way for obtaining quantity takeoffs for estimating purposes, which would create a much more accurate estimate. Also, contractors that use BIM would also be able to better coordinate construction activities and sequences, saving any potential delays to the project schedule. BIM allows the construction team to run clash detections in order to see where future construction activities may become issues, and resolve them ahead of time minimizing a delay in the project schedule. Using BIM is also a great tool for helping the owner visualize the end product through the three dimensional model.

Conclusion

As found through this analysis, using BIM on a project has a potential to save a significant amount of time and money on a project. Although, the numerical values obtained in *Table 7* may not be completely accurate, however, it is evident that BIM does contribute to savings in time and cost on a project. The reasons for why these values may not be accurate can be related to the differences in project size. Pain Branch is about 130,000 square feet bigger than the Morgan State University Library case study. This significant difference in size can have an effect on the results obtained through this study. However, the important concept to absorb from this analysis is that BIM does have a positive effect on a project.

The concept of BIM is still in its adolescent stages in the construction industry. There is still a struggle to get owners and architects on board with applying BIM to their projects. Some owners may have the attitude that BIM is a waste of money on a project. The owner may not be educated on the positive effects BIM has on a project such as cost and schedule savings. The sooner everyone on the project team can adopt the concept of BIM and its benefits, the sooner the owner can see a savings in cost and time in schedule.

STRUCTURAL BREADTH: (BRICK FAÇADE)

As discussed in the previous section, the façade for the Paint Branch project is primarily face brick with architectural pre-cast concrete. Since the facility is approximately 350,000 square feet, it would take an immense amount of time and manpower to manually lay face brick. The proposed idea is to substitute face brick with prefabricated brick panels as discussed in Technical Analysis #2. This analysis will include an in depth look at the effect on the existing structure and how the prefabricated panels may cause in increase in member sizes for the structural steel system.

ANALYSIS

Proposing the change in a façade system would require a look into the affects it would have on the structural system. Below, Figure 17 and Figure 18 show the section and plan view of the structural system that will be analyzed. This section of frame will be analyzed in STAAD Pro to show the different effects each wall system will have on the structure.

Figure 17 – Section "F" Elevation View

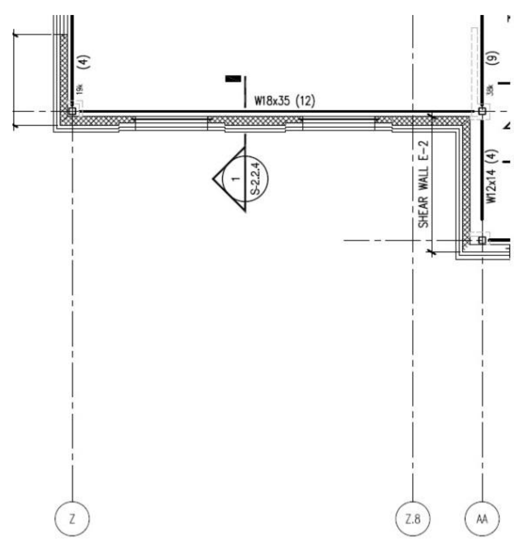

Figure 18 – Section "F" Plan View

BRICK SYSTEM

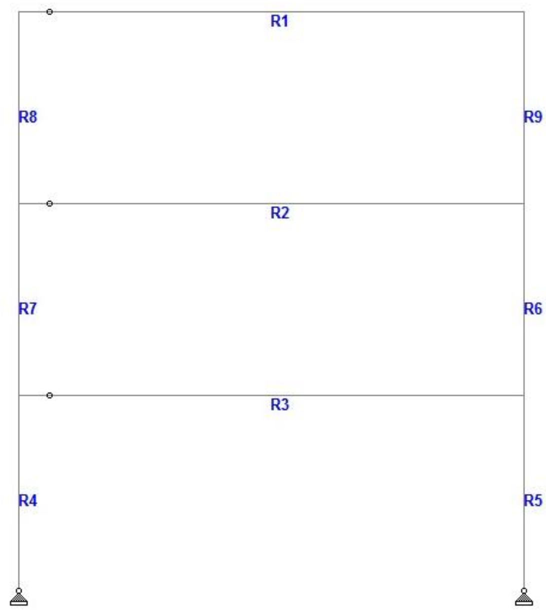

Figure 19 – Frame Modeled in STAAD

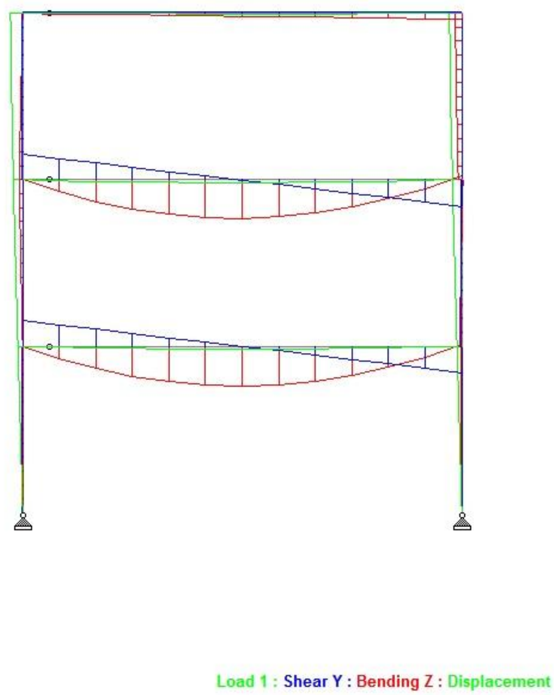

Figure 20 – Floors 2 & 3 Shear, Bending & Displacement (Brick)

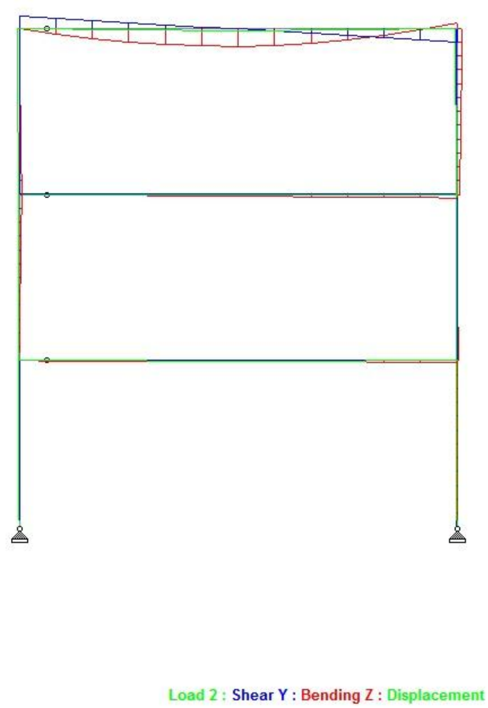

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Figure 21 – Roof Shear, Bending & Displacement (Brick)

Figure 19 shows the frame that is being analyzed for this analysis. R2 and R2 are W21X44 beams and R1 is a W18X35 beam. There are six columns and all of them are W8X48 members. Figure 20 and Figure 21 show the shear, bending moments and displacement for floors two and three along with the roof. The structural systems modeled in these cases are for the originally designed brick façade.

Prefabricated System

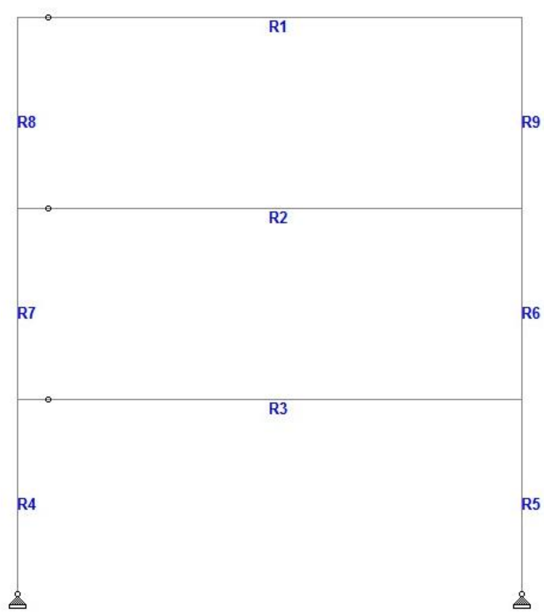


Figure 22 – Frame Modeled in STAAD

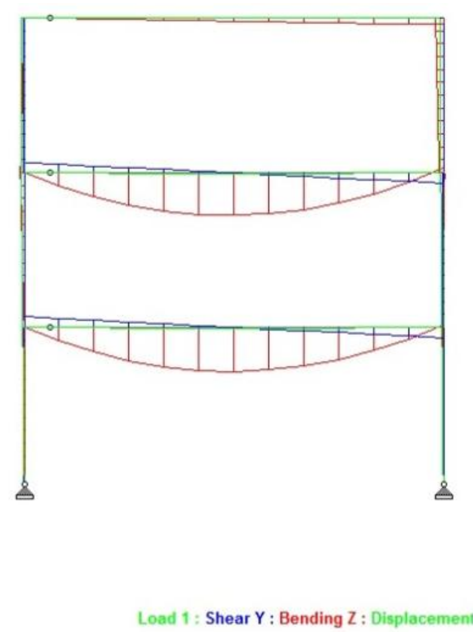


Figure 23 – Floors 2 & 3 Shear, Bending, & Displacement (Prefab.)

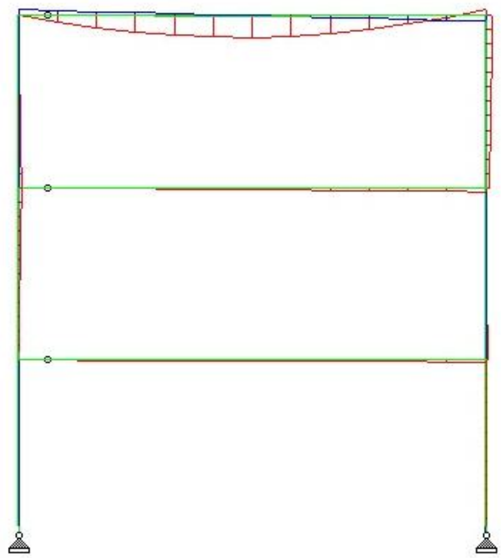


Figure 24 – Roof Shear, Bending, & Displacement (Prefab.)

Figure 122 shows the frame that is being analyzed for this analysis. R2 and R2 are W21X44 beams and R1 is a W18X35 beam. There are six columns and all of them are W8X48 members. *Figure 23* and *Figure 24* show the shear, bending moments and displacement for floors two and three along with the roof. The structural systems designed in these cases are for the proposed prefabricated masonry panel systems.

Brick Façade			
Member	Max Deflection Z (in.)	Max Deflection Y (in.)	Resultant (in.)
R1	0.000	-0.331	0.331
R2	0.000	-0.115	0.115
R3	0.000	-0.050	0.050
Prefabricated System			
Member	Max Deflection Z (in.)	Max Deflection Y (in.)	Resultant (in.)
R1	0.000	-0.106	0.106
R2	0.000	-0.037	0.037
R3	0.000	-0.016	0.016

Table 8 – Deflection Comparisons

Conclusion

Table 8 shows the comparisons in the deflections between the two systems. It is obvious after reviewing the table that the prefabricated system is a lighter system and has an overall lower deflection resultant than the originally designed brick façade. This could potentially allow for a redesign in the steel structure causing a decrease in member sizes. With a decrease in member size for the overall system, there would be an increase in cost savings to the overall project. See **Appendix I** for load calculations for each system.

Mechanical Breadth (Brick Façade)

As discussed in the previous section, changing the masonry system form manually laid face brick to a prefabricated brick panel system will affect the heat transfer through the building. Prefabricated panels tend to be much more water tight systems, therefore this will cause a change in the R-value of the wall type. This analysis will compare the difference in R-values between the prefabricated brick panels and the manually laid brick system. After comparing the R-values and converting those values to U-values, a cost analysis will be conducted to investigate which system is more cost efficient.

Analysis

When considering changing the originally design brick façade to a prefabricated masonry panel system, it was obvious some changes would occur in the wall properties. These changes in wall properties will have an effect on the overall performance of the buildings mechanical systems. The effects can be either beneficial or detrimental to the buildings operating cost and both systems have been compared to conclude which system will be more efficient.

In order to conclude which system will be more efficient, I first had to obtain each materials R-value and U-value. These values will be used to compare both façade systems with each other and conclude which system would be more efficient and the difference in savings the more efficient system will have. I have constructed two tables below for each façade system with their total R-value and U-value.

R & U Values (Brick Façade)			
Material	Material Thickness	R-value/inch	R-value
Air Film	1"	1.00	1.00
Brick	4"	0.011	0.44
CMU	10"	1.20	12.00
Insulation	2"	4.00	8.00
		Total R-value	21.44
		U-Value (1/R)	**0.046641791**

Table 9 - R & U Values for the originally designed brick facade

R & U Values (Prefabricated System)			
Material	Material Thickness	R-value/inch	R-value
Brick	1"	0.11	0.011
Polyurethane	3.5"	6.25	21.875
Steel Stud	4"	1.38	5.52
Gypsum Board	0.625"	0.56	0.35
Membrane (2)	0.08"	1.00	0.16
Fiberboard	0.5"	1.32	0.66
		Total R-values	28.576
		U-Value (1/R)	**0.034994401**

Table 10 – R & U Values for the proposed prefabricated system

Table 9 and Table 10 show the systems material with their respected R-values and the systems overall U-value. After the R-values were summed, the U-value was found by simply dividing 1 by the total R-value. Once the U-values for both systems were found, I was able to conduct a cost analysis based on each systems heat loss. Table 11 shows the overall heat loss through each system and the potential savings in cost.

Cost Analysis			
Summer: ΔT = 100-75 = 25F			
Brick Façade	q=0.0467*108,000*25F=126,090 BTU/h	126,090*4,380=552,274,200 BTU/yr.	
Prefabricated Façade	q=0.0350*108,000*25F=94,150 BTU/h	94,500*4,380=413,910,000 BTU/yr.	
		Difference	138,364,200 BTU/yr.
			40,584.66 kWh/yr.
Cost/kWhr in MD = $0.125kWh	**Cost Difference**= 40,548.66*$0.125= **$5,068.58/yr.**		
Winter: ΔT = 70-16 = 54F			
Brick Façade	q=0.0467*108,000*54F=272,354.4 BTU/h	272,354.4*4,380=1,192,912,272 BTU/yr.	
Prefabricated Façade	q=0.0350*108,000*54F =204,120 BTU/h	204,120*4,380=894,045,600 BTU/yr.	
		Difference	298,866,672 BTU/yr.
			87,585.11 kWh/yr.
Cost/kWh in MD = $0.125 kWh	**Cost Difference**= 87,585.11*$0.125= **$10,948.14/yr.**		
		Total Savings per year: **$16,016.72**	

Table 11 – Cost Analysis

After I had obtained the U-Values from *Tables 9 and Table 10,* I was able to utilize those values in finding the total heat loss through each system. After theses values were obtained, a cost analysis shown in *Table 11* was able to be constructed. I used the equation $q=UA\Delta T$, where U was the U-value I had obtained, A was the total area of the façade, and ΔT would be the change in temperature. I had calculated the performance for each system in both winter and summer conditions. For summer conditions I had used a ΔT of 25°F and a ΔT of 54°F for the winter conditions. After I had found the total heat loss through each system, I was able to find the total heat loss over the course of a year. I found the total heat loss over a year by simply multiplying the total heat loss per hour by 4,380, which are the total hours in half a year. Once these values were calculated, I was able find the difference in heat loss between the two systems and convert that quantity into the amount of energy per year. The amount of energy saved was converted by using the conversion factor of 3412.3 BTU = 1 kWh. Finally, after the total energy saved was found, I was able to find out how much money would be saved over the course of one year. I found the cost of 1 kWh to be $0.125 in the state of Maryland. I used this value to find the total savings in cost in a year by multiplying the total energy saved by the cost per kWh. Finally, I was able to conclude a total savings of **$16,016.72** per year with the use of a prefabricated masonry panel system.

Conclusion

After conducting this analysis, it is clear to see the prefabricated masonry system is a much more efficient system than the stick built masonry system. The reason for the prefabricated system being more efficient is contributed to the polyurethane insulation being used to insulate the system. Originally, when I had compared the two systems, the stick built system proved to be a more efficient system. The theory behind this result is due to the 2" rigid insulation and the 10" concrete masonry unit. However, when exploring alternative techniques to improve the prefabricated masonry system's efficiency, the most obvious way to improve the system was finding an alternative material to insulate the system. Originally, the prefabricated panel would have used a rigid insulation similar to the insulation used in the stick built masonry system. However, this would not allow for the prefabricated system to be a more efficient system. With the use of a polyurethane foam insulation in place of the rigid insulation, the prefabricated panel would prove to be a much more efficient system. *Table 12* shows the additional cost contributed to having an alternative interior gypsum wall board finish with a polyurethane finish.

Gypsum Board Estimate					
Material	Mat'l Cost/SF	Labor Cost/SF	Area/Panel (ft^2)	Total Panels	Total Cost
Gypsum Wall Board	$0.48	$0.54	480	225	$109,404.00
Polyurethane	$1.50		480	225	$162,000.00
				Total=	**$271,404.00**

Table 12 – Gypsum Board Estimate

Traditionally, educational facilities have a concrete masonry block wall as an interior finish. The prefabricated system utilizes a gypsum wallboard finish, which is not common in educational facilities and is only seen in the administrative offices of the school. Owners prefer to use an exposed masonry finish because it is cheaper and it limits the amount of damage students can do to the wall. However, the prefabricated masonry system not only saves the owner in energy cost, but allows for a more efficient construction method. After running the electrical conduit, the concrete masonry units must be raised above the pipe conduit and slid down. This can cause a delay in construction, especially as the layer of block gets higher. With the prefabricate system already having metal studs embedded in the system, it would make it easier for the electrical wiring to be installed. Aside from construction efficiency, there is also energy efficiency. The prefabricated system can potentially save the owner **$16,016.72** a year through energy cost. Therefore, an owner may want to consider using a prefabricated system with a gypsum wallboard finish, even though the upfront cost of the prefabricated system may cost more than the traditional stick built system.

RESOURCES

Carter, A. (2011 March 16). Mitchel Metals. (D. Shetayh, Interviewer).

Colorado Energy, R-Value Table. <www.coloradoenergy.org>.

Dillon, M. "BIM – Breaking Down The Walls". 2005, January 11. <www.blogspot.com>.

Evans, M. (2011, January 24). HESS Construction + Engineering Services. (D. Shetayh, Interviewer).

Gangwar, S. (2011, March 22). HESS Construction + Engineering Services. (D. Shetayh, Interviewer).

Grove, R. (2011, January 31). Easi-Set Industries. (D. Shetayh, Interviewer).

Houk, G. (2011, February 23). HESS Construction + Engineering Services. (D. Shetayh, Interviewer).

LEED for New Construction & Major Renovations, Version 2.2. U.S. Green Building Council.

Ludwig, M. (2011, March 14). B2E Engineering Consultants. (D. Shetayh, Interviewer).

Riley, D. (2011, February 2). AE Thesis Advisor, Penn State. (D. Shetayh, Interviewer).

Serah, T. (2011 March 30). EMO Energy Solutions. (D. Shetayh, Interviewer).

STAAD. Pro V8i. (2008). Exton, PA, USA: Bently Systems, Inc.

Whalen, S. (2011, March 28). Engineering Products, Inc. (D. Shetayh, Interviewer).

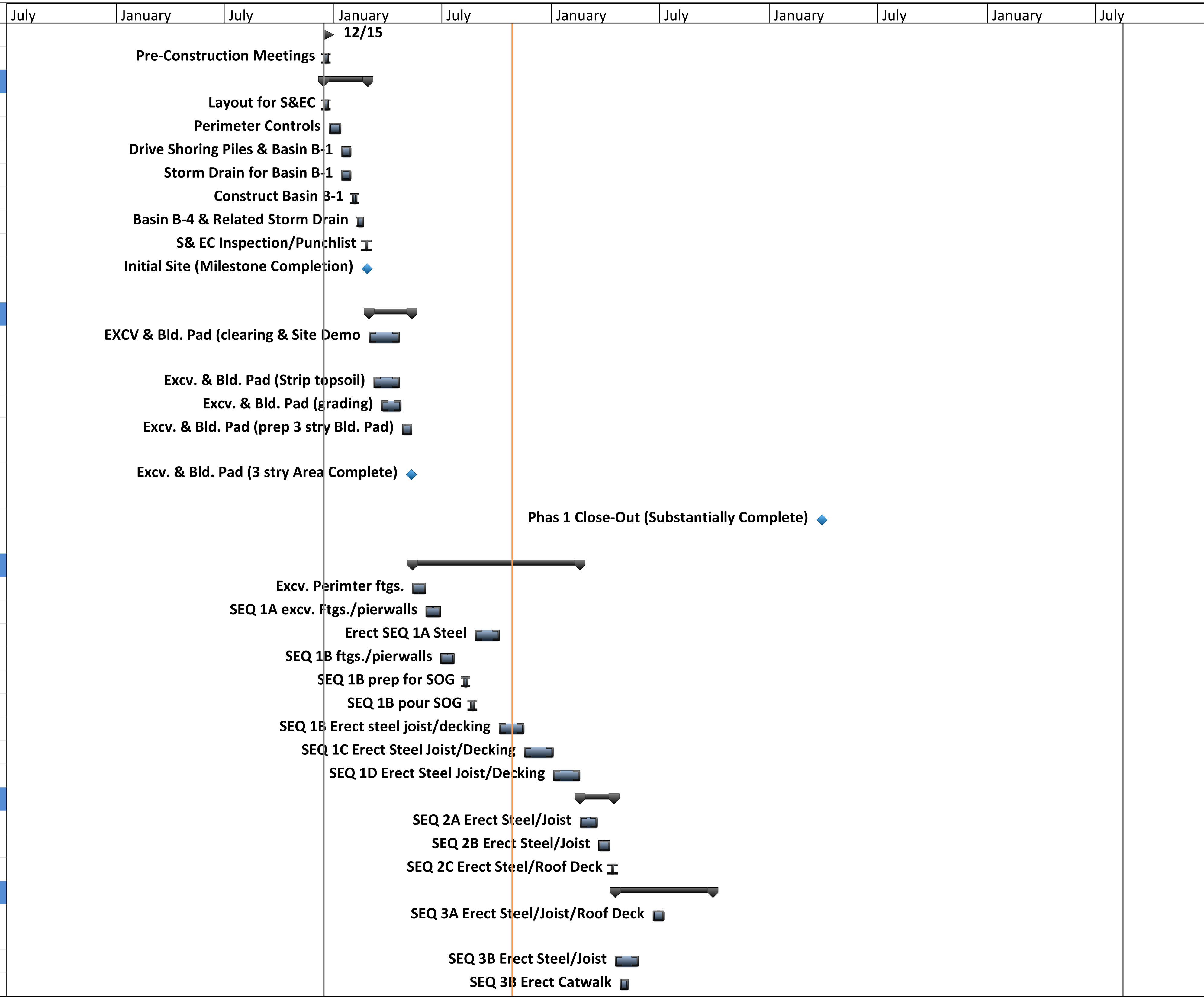
Woofenden, Ian & Sagrillo, Mick. "2010 Wind Generator Buyer's Guide". June & July 2010.

YouTube: "Better Places to Learn". Department of Environmental Protection.

Appendix A

Detailed Schedule

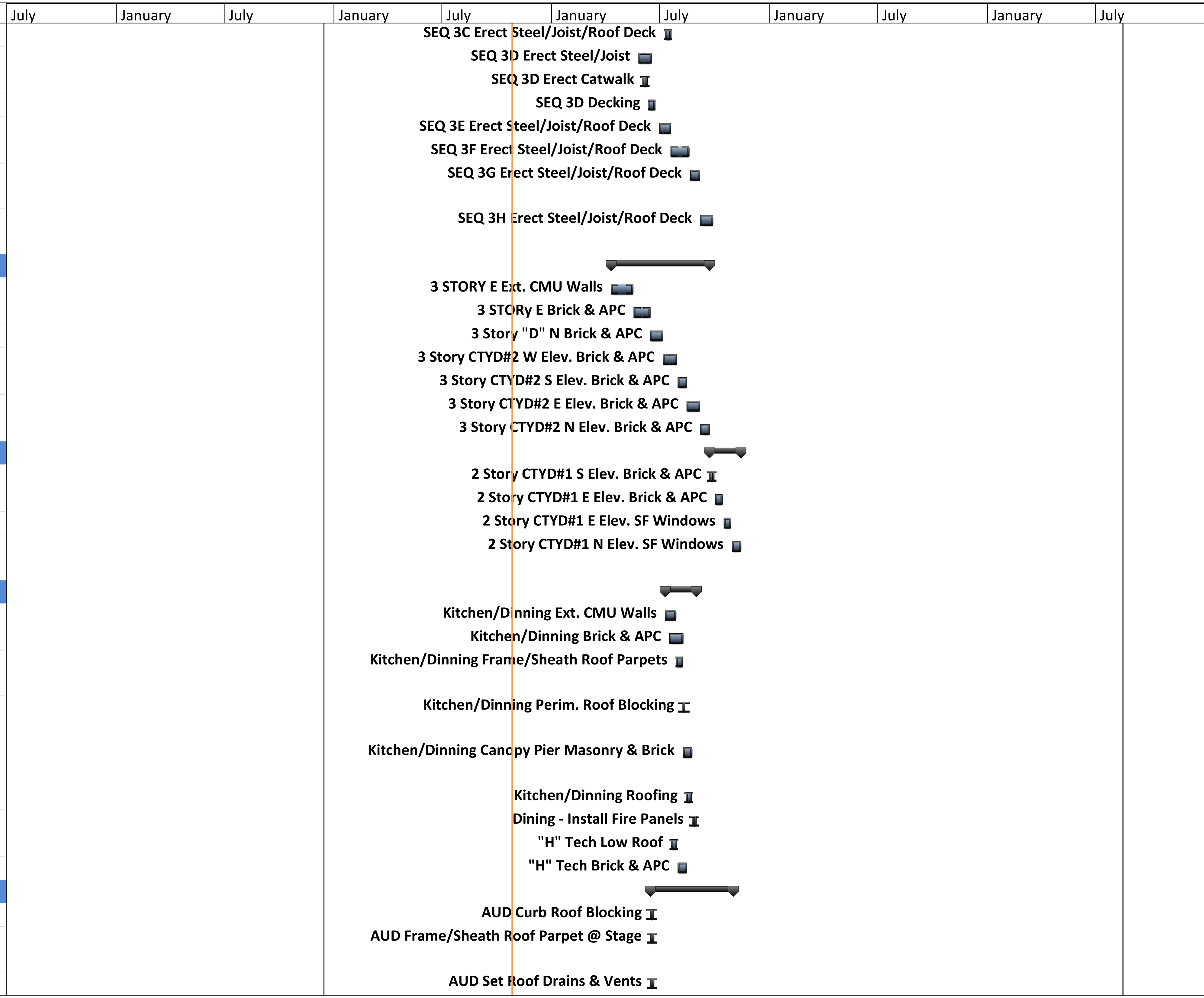
ID	Task Name	Duration	Start	Finish
1	Notice To Procede	0 days	Tue 12/15/09	Tue 12/15/09
2	Pre-Construction Meetings	6 days	Tue 12/15/09	Tue 12/22/09
3	**INITIAL SITEWROK**	**54 days**	**Tue 12/15/09**	**Fri 2/26/10**
4	Layout for S&EC	6 days	Tue 12/15/09	Tue 12/22/09
5	Perimeter Controls	14 days	Thu 12/24/09	Tue 1/12/10
6	Drive Shoring Piles & Basin B-1	12 days	Thu 1/14/10	Fri 1/29/10
7	Storm Drain for Basin B-1	12 days	Thu 1/14/10	Fri 1/29/10
8	Construct Basin B-1	6 days	Mon 2/1/10	Mon 2/8/10
9	Basin B-4 & Related Storm Drain	9 days	Tue 2/9/10	Fri 2/19/10
10	S& EC Inspection/Punchlist	5 days	Mon 2/22/10	Fri 2/26/10
11	Initial Site (Milestone Completion)	0 days	Fri 2/26/10	Fri 2/26/10
12	**EXCAVATION & BUILDING PAD**	**52 days**	**Mon 3/1/10**	**Tue 5/11/10**
13	EXCV & Bld. Pad (clearing & Site Demo	37 days	Mon 3/1/10	Tue 4/20/10
14	Excv. & Bld. Pad (Strip topsoil)	31 days	Tue 3/9/10	Tue 4/20/10
15	Excv. & Bld. Pad (grading)	25 days	Mon 3/22/10	Fri 4/23/10
16	Excv. & Bld. Pad (prep 3 stry Bld. Pad)	12 days	Mon 4/26/10	Tue 5/11/10
17	Excv. & Bld. Pad (3 stry Area Complete)	0 days	Tue 5/11/10	Tue 5/11/10
18	Phas 1 Close-Out (Substantially Complete)	0 days	Fri 3/30/12	Fri 3/30/12
19	**SEQ1 STRUCTURE 3 STRY**	**201 days**	**Thu 5/13/10**	**Thu 2/17/11**
20	Excv. Perimter ftgs.	16 days	Thu 5/13/10	Thu 6/3/10
21	SEQ 1A excv. Ftgs./pierwalls	17 days	Fri 6/4/10	Mon 6/28/10
22	Erect SEQ 1A Steel	29 days	Thu 8/26/10	Tue 10/5/10
23	SEQ 1B ftgs./pierwalls	17 days	Tue 6/29/10	Wed 7/21/10
24	SEQ 1B prep for SOG	6 days	Fri 8/6/10	Fri 8/13/10
25	SEQ 1B pour SOG	5 days	Wed 8/18/10	Tue 8/24/10
26	SEQ 1B Erect steel joist/decking	30 days	Tue 10/5/10	Mon 11/15/10
27	SEQ 1C Erect Steel Joist/Decking	35 days	Tue 11/16/10	Mon 1/3/11
28	SEQ 1D Erect Steel Joist/Decking	33 days	Tue 1/4/11	Thu 2/17/11
29	**SEQ2 STRUCTURE 2 STORY**	**41 days**	**Fri 2/18/11**	**Fri 4/15/11**
30	SEQ 2A Erect Steel/Joist	21 days	Fri 2/18/11	Fri 3/18/11
31	SEQ 2B Erect Steel/Joist	15 days	Mon 3/21/11	Fri 4/8/11
32	SEQ 2C Erect Steel/Roof Deck	5 days	Mon 4/11/11	Fri 4/15/11
33	**SEQ 3 STRUCTURE 1 STORY**	**118 days**	**Mon 4/18/11**	**Wed 9/28/11**
34	SEQ 3A Erect Steel/Joist/Roof Deck	15 days	Mon 6/20/11	Fri 7/8/11
35	SEQ 3B Erect Steel/Joist	29 days	Mon 4/18/11	Thu 5/26/11
36	SEQ 3B Erect Catwalk	10 days	Tue 4/26/11	Mon 5/9/11



Project: Tech 2 Schedule.mpp
Date: Wed 10/27/10

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

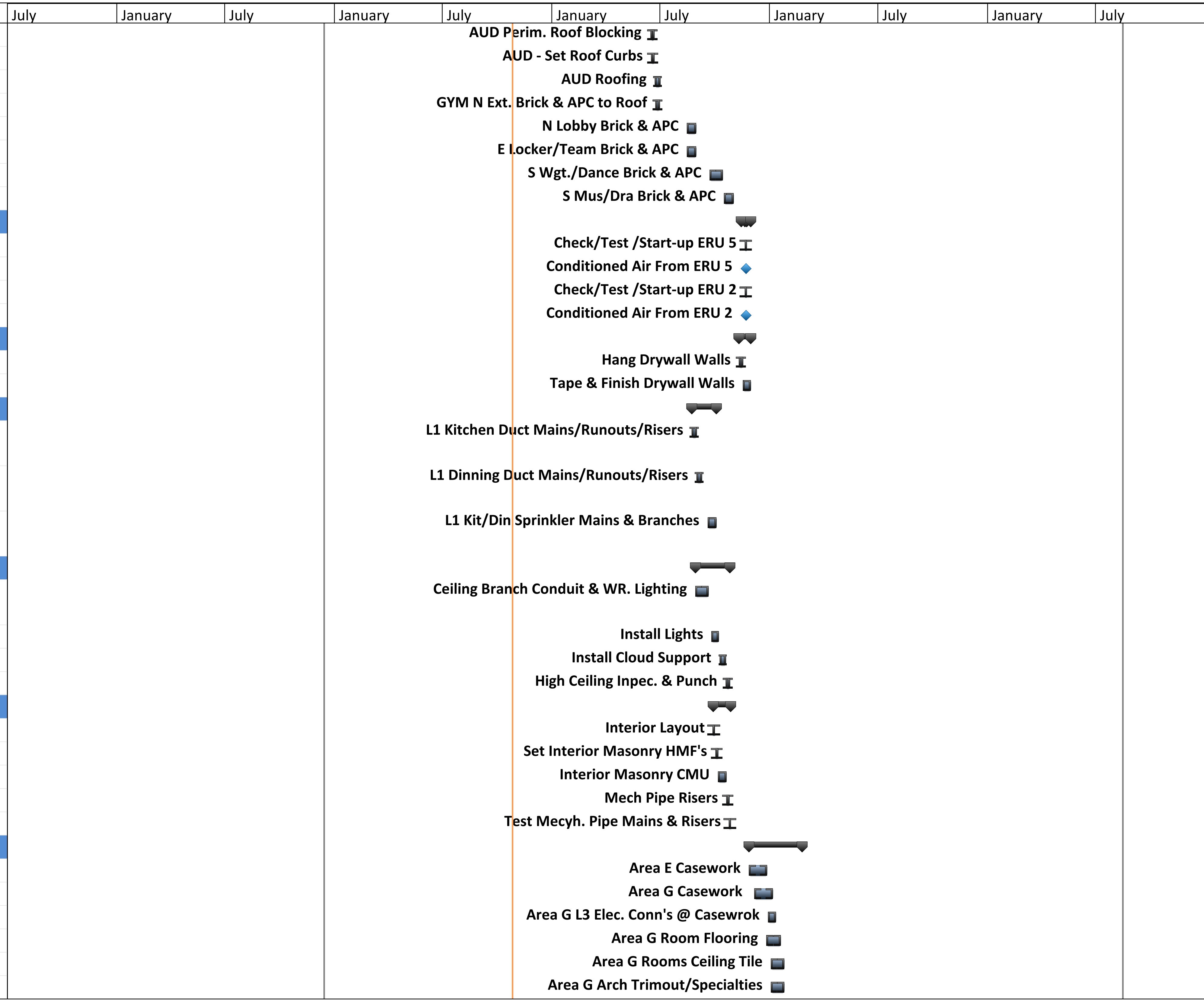
ID	Task Name	Duration	Start	Finish
37	SEQ 3C Erect Steel/Joist/Roof Deck	8 days	Mon 7/11/11	Wed 7/20/11
38	SEQ 3D Erect Steel/Joist	16 days	Fri 5/27/11	Fri 6/17/11
39	SEQ 3D Erect Catwalk	6 days	Fri 6/3/11	Fri 6/10/11
40	SEQ 3D Decking	9 days	Mon 6/13/11	Thu 6/23/11
41	SEQ 3E Erect Steel/Joist/Roof Deck	13 days	Fri 7/1/11	Tue 7/19/11
42	SEQ 3F Erect Steel/Joist/Roof Deck	23 days	Wed 7/20/11	Fri 8/19/11
43	SEQ 3G Erect Steel/Joist/Roof Deck	12 days	Mon 8/22/11	Tue 9/6/11
44	SEQ 3H Erect Steel/Joist/Roof Deck	15 days	Thu 9/8/11	Wed 9/28/11
45	**3 STORY ENCLOSURE**	**119 days**	**Mon 4/11/11**	**Thu 9/22/11**
46	3 STORY E Ext. CMU Walls	27 days	Mon 4/11/11	Tue 5/17/11
47	3 STORy E Brick & APC	20 days	Thu 5/19/11	Wed 6/15/11
48	3 Story "D" N Brick & APC	15 days	Thu 6/16/11	Wed 7/6/11
49	3 Story CTYD#2 W Elev. Brick & APC	17 days	Thu 7/7/11	Fri 7/29/11
50	3 Story CTYD#2 S Elev. Brick & APC	11 days	Mon 8/1/11	Mon 8/15/11
51	3 Story CTYD#2 E Elev. Brick & APC	16 days	Tue 8/16/11	Tue 9/6/11
52	3 Story CTYD#2 N Elev. Brick & APC	11 days	Thu 9/8/11	Thu 9/22/11
53	**2 STORY ENCLOSURE**	**37 days**	**Fri 9/23/11**	**Mon 11/14/11**
54	2 Story CTYD#1 S Elev. Brick & APC	6 days	Fri 9/23/11	Fri 9/30/11
55	2 Story CTYD#1 E Elev. Brick & APC	10 days	Mon 10/3/11	Fri 10/14/11
56	2 Story CTYD#1 E Elev. SF Windows	10 days	Mon 10/17/11	Fri 10/28/11
57	2 Story CTYD#1 N Elev. SF Windows	11 days	Mon 10/31/11	Mon 11/14/11
58	**1 STORY ENCLOSURE**	**38 days**	**Mon 7/11/11**	**Wed 8/31/11**
59	Kitchen/Dinning Ext. CMU Walls	14 days	Mon 7/11/11	Thu 7/28/11
60	Kitchen/Dinning Brick & APC	17 days	Mon 7/18/11	Tue 8/9/11
61	Kitchen/Dinning Frame/Sheath Roof Parpets	7 days	Fri 7/29/11	Mon 8/8/11
62	Kitchen/Dinning Perim. Roof Blocking	4 days	Tue 8/9/11	Fri 8/12/11
63	Kitchen/Dinning Canopy Pier Masonry & Brick	11 days	Wed 8/10/11	Wed 8/24/11
64	Kitchen/Dinning Roofing	7 days	Mon 8/15/11	Tue 8/23/11
65	Dining - Install Fire Panels	5 days	Thu 8/25/11	Wed 8/31/11
66	"H" Tech Low Roof	7 days	Thu 7/21/11	Fri 7/29/11
67	"H" Tech Brick & APC	11 days	Mon 8/1/11	Mon 8/15/11
68	**AUD/GYM ENCLOSURE**	**99 days**	**Thu 6/16/11**	**Tue 11/1/11**
69	AUD Curb Roof Blocking	3 days	Thu 6/16/11	Mon 6/20/11
70	AUD Frame/Sheath Roof Parpet @ Stage	4 days	Thu 6/16/11	Tue 6/21/11
71	AUD Set Roof Drains & Vents	4 days	Thu 6/16/11	Tue 6/21/11



Project: Tech 2 Schedule.mpp
Date: Wed 10/27/10

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

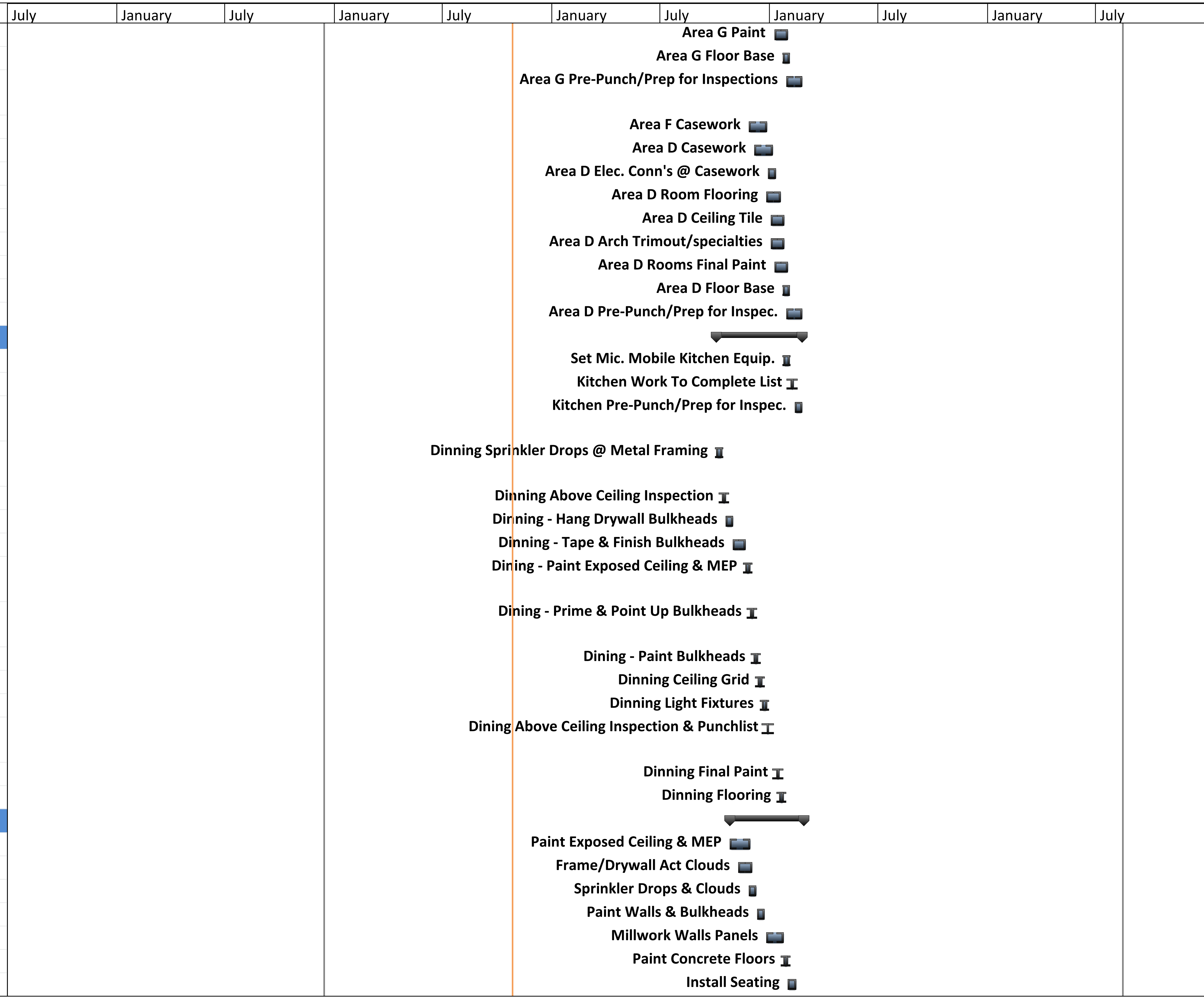
ID	Task Name	Duration	Start	Finish
72	AUD Perim. Roof Blocking	4 days	Thu 6/16/11	Tue 6/21/11
73	AUD - Set Roof Curbs	3 days	Fri 6/17/11	Tue 6/21/11
74	AUD Roofing	7 days	Thu 6/23/11	Fri 7/1/11
75	GYM N Ext. Brick & APC to Roof	5 days	Fri 6/24/11	Thu 6/30/11
76	N Lobby Brick & APC	11 days	Tue 8/16/11	Tue 8/30/11
77	E Locker/Team Brick & APC	11 days	Tue 8/16/11	Tue 8/30/11
78	S Wgt./Dance Brick & APC	16 days	Fri 9/23/11	Fri 10/14/11
79	S Mus/Dra Brick & APC	12 days	Mon 10/17/11	Tue 11/1/11
80	**3 STORY ROUGH-INS**	**12 days**	**Tue 11/15/11**	**Wed 11/30/11**
81	Check/Test /Start-up ERU 5	3 days	Mon 11/21/11	Wed 11/23/11
82	Conditioned Air From ERU 5	0 days	Wed 11/23/11	Wed 11/23/11
83	Check/Test /Start-up ERU 2	3 days	Mon 11/21/11	Wed 11/23/11
84	Conditioned Air From ERU 2	0 days	Wed 11/23/11	Wed 11/23/11
85	**2 STORY ROUGH - INS**	**14 days**	**Fri 11/11/11**	**Wed 11/30/11**
86	Hang Drywall Walls	5 days	Fri 11/11/11	Thu 11/17/11
87	Tape & Finish Drywall Walls	9 days	Fri 11/18/11	Wed 11/30/11
88	**KITCHEN/DINNING ROUGH - INS**	**29 days**	**Wed 8/24/11**	**Mon 10/3/11**
89	L1 Kitchen Duct Mains/Runouts/Risers	6 days	Wed 8/24/11	Wed 8/31/11
90	L1 Dinning Duct Mains/Runouts/Risers	7 days	Thu 9/1/11	Fri 9/9/11
91	L1 Kit/Din Sprinkler Mains & Branches	10 days	Tue 9/20/11	Mon 10/3/11
92	**AUDITORIUM ROUGH - INS**	**42 days**	**Tue 8/30/11**	**Wed 10/26/11**
93	Ceiling Branch Conduit & WR. Lighting	16 days	Tue 8/30/11	Tue 9/20/11
94	Install Lights	10 days	Mon 9/26/11	Fri 10/7/11
95	Install Cloud Support	8 days	Mon 10/10/11	Wed 10/19/11
96	High Ceiling Inpec. & Punch	5 days	Thu 10/20/11	Wed 10/26/11
97	**WGT/DNC/WRST/MSC ROUGH - INS**	**21 days**	**Thu 9/29/11**	**Thu 10/27/11**
98	Interior Layout	2 days	Thu 9/29/11	Fri 9/30/11
99	Set Interior Masonry HMF's	4 days	Mon 10/3/11	Thu 10/6/11
100	Interior Masonry CMU	10 days	Fri 10/7/11	Thu 10/20/11
101	Mech Pipe Risers	3 days	Fri 10/21/11	Tue 10/25/11
102	Test Mecyh. Pipe Mains & Risers	2 days	Wed 10/26/11	Thu 10/27/11
103	**3 STORY FINISHES AREA D-G**	**65 days**	**Mon 11/28/11**	**Fri 2/24/12**
104	Area E Casework	22 days	Mon 11/28/11	Tue 12/27/11
105	Area G Casework	23 days	Wed 12/7/11	Fri 1/6/12
106	Area G L3 Elec. Conn's @ Casewrok	9 days	Fri 12/30/11	Wed 1/11/12
107	Area G Room Flooring	18 days	Tue 12/27/11	Thu 1/19/12
108	Area G Rooms Ceiling Tile	16 days	Wed 1/4/12	Wed 1/25/12
109	Area G Arch Trimout/Specialties	16 days	Wed 1/4/12	Wed 1/25/12



Project: Tech 2 Schedule.mpp
Date: Wed 10/27/10

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

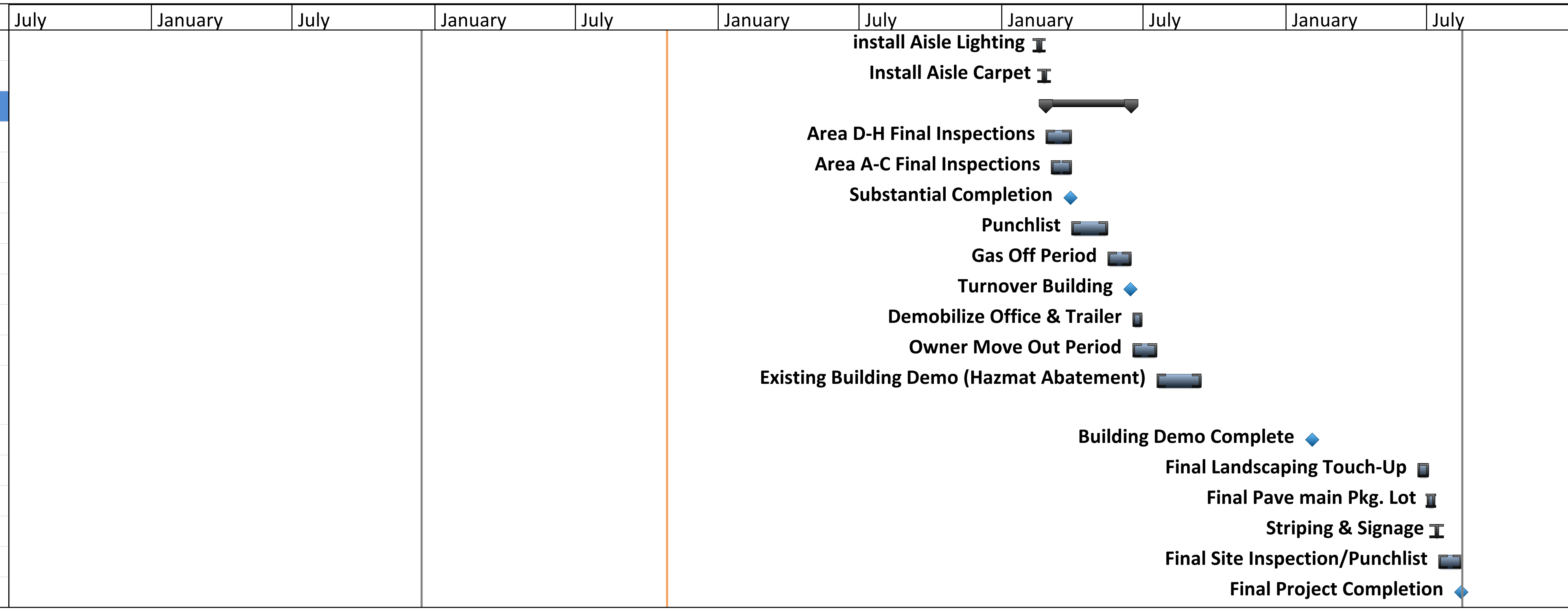
ID	Task Name	Duration	Start	Finish
110	Area G Paint	16 days	Tue 1/10/12	Tue 1/31/12
111	Area G Floor Base	9 days	Tue 1/24/12	Fri 2/3/12
112	Area G Pre-Punch/Prep for Inspections	20 days	Mon 1/30/12	Fri 2/24/12
113	Area F Casework	22 days	Mon 11/28/11	Tue 12/27/11
114	Area D Casework	23 days	Wed 12/7/11	Fri 1/6/12
115	Area D Elec. Conn's @ Casework	9 days	Fri 12/30/11	Wed 1/11/12
116	Area D Room Flooring	18 days	Tue 12/27/11	Thu 1/19/12
117	Area D Ceiling Tile	16 days	Wed 1/4/12	Wed 1/25/12
118	Area D Arch Trimout/specialties	16 days	Wed 1/4/12	Wed 1/25/12
119	Area D Rooms Final Paint	16 days	Tue 1/10/12	Tue 1/31/12
120	Area D Floor Base	9 days	Tue 1/24/12	Fri 2/3/12
121	Area D Pre-Punch/Prep for Inspec.	20 days	Mon 1/30/12	Fri 2/24/12
122	**KITCHEN/DINNING FINISHES**	**104 days**	**Tue 10/4/11**	**Fri 2/24/12**
123	Set Mic. Mobile Kitchen Equip.	8 days	Wed 1/25/12	Fri 2/3/12
124	Kitchen Work To Complete List	5 days	Mon 2/6/12	Fri 2/10/12
125	Kitchen Pre-Punch/Prep for Inspec.	10 days	Mon 2/13/12	Fri 2/24/12
126	Dinning Sprinkler Drops @ Metal Framing	8 days	Tue 10/4/11	Thu 10/13/11
127	Dinning Above Ceiling Inspection	4 days	Fri 10/14/11	Wed 10/19/11
128	Dinning - Hang Drywall Bulkheads	8 days	Thu 10/20/11	Mon 10/31/11
129	Dinning - Tape & Finish Bulkheads	15 days	Tue 11/1/11	Mon 11/21/11
130	Dining - Paint Exposed Ceiling & MEP	6 days	Tue 11/22/11	Tue 11/29/11
131	Dining - Prime & Point Up Bulkheads	4 days	Wed 11/30/11	Mon 12/5/11
132	Dining - Paint Bulkheads	5 days	Tue 12/6/11	Mon 12/12/11
133	Dinning Ceiling Grid	5 days	Tue 12/13/11	Mon 12/19/11
134	Dinning Light Fixtures	6 days	Tue 12/20/11	Tue 12/27/11
135	Dining Above Ceiling Inspection & Punchlist	3 days	Wed 12/28/11	Fri 12/30/11
136	Dinning Final Paint	3 days	Fri 1/13/12	Tue 1/17/12
137	Dinning Flooring	5 days	Wed 1/18/12	Tue 1/24/12
138	**AUDITORIUM FINISHES**	**88 days**	**Thu 10/27/11**	**Mon 2/27/12**
139	Paint Exposed Ceiling & MEP	24 days	Thu 10/27/11	Tue 11/29/11
140	Frame/Drywall Act Clouds	17 days	Thu 11/10/11	Fri 12/2/11
141	Sprinkler Drops & Clouds	10 days	Mon 11/28/11	Fri 12/9/11
142	Paint Walls & Bulkheads	10 days	Mon 12/12/11	Fri 12/23/11
143	Millwork Walls Panels	21 days	Tue 12/27/11	Tue 1/24/12
144	Paint Concrete Floors	5 days	Wed 1/25/12	Tue 1/31/12
145	Install Seating	10 days	Wed 2/1/12	Tue 2/14/12



Project: Tech 2 Schedule.mpp
Date: Wed 10/27/10

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

ID	Task Name	Duration	Start	Finish
146	install Aisle Lighting	5 days	Wed 2/15/12	Tue 2/21/12
147	Install Aisle Carpet	4 days	Wed 2/22/12	Mon 2/27/12
148	**FINAL CLOSOUT**	**80 days**	**Mon 2/27/12**	**Fri 6/15/12**
149	Area D-H Final Inspections	25 days	Mon 2/27/12	Fri 3/30/12
150	Area A-C Final Inspections	20 days	Mon 3/5/12	Fri 3/30/12
151	Substantial Completion	0 days	Fri 3/30/12	Fri 3/30/12
152	Punchlist	34 days	Sat 3/31/12	Wed 5/16/12
153	Gas Off Period	22 days	Thu 5/17/12	Fri 6/15/12
154	Turnover Building	0 days	Fri 6/15/12	Fri 6/15/12
155	Demobilize Office & Trailer	10 days	Mon 6/18/12	Fri 6/29/12
156	Owner Move Out Period	23 days	Mon 6/18/12	Wed 7/18/12
157	Existing Building Demo (Hazmat Abatement)	41 days	Thu 7/19/12	Thu 9/13/12
158	Building Demo Complete	0 days	Mon 2/4/13	Mon 2/4/13
159	Final Landscaping Touch-Up	10 days	Thu 6/20/13	Wed 7/3/13
160	Final Pave main Pkg. Lot	8 days	Tue 7/2/13	Thu 7/11/13
161	Striping & Signage	3 days	Fri 7/12/13	Tue 7/16/13
162	Final Site Inspection/Punchlist	22 days	Wed 7/17/13	Thu 8/15/13
163	Final Project Completion	0 days	Thu 8/15/13	Thu 8/15/13

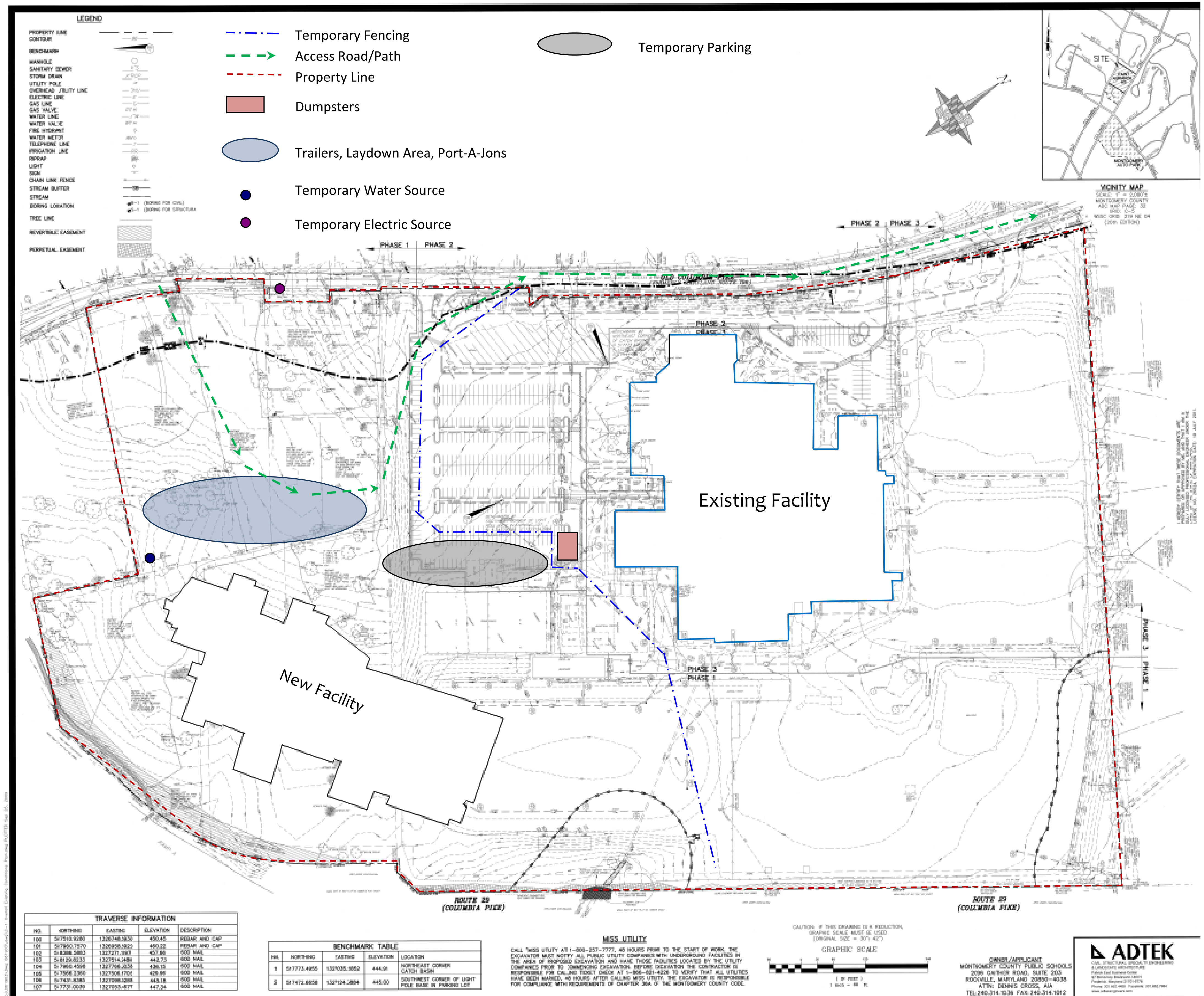


Project: Tech 2 Schedule.mpp
Date: Wed 10/27/10

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

Appendix B

Site Condition & Existing Conditions



Paint Branch High School

Burtonsville, Maryland

General Existing Conditions And Site Utilities Plan

Drawn By: Diab Shetayh

Date: October 4, 2010

Assignment: Technical Report 1

Advisor: Dr. Riley

Appendix C

LEED Scorecard

LEED-NC Version 2.2 Registered Project Checklist

Paint Branch High School
Montgomery County, MD

Updated: 6/15/2010

Yes	?	No				
12		2		**Sustainable Sites**		**14** Points
Y			C	Prereq 1	**Construction Activity Pollution Prevention**	Required
1			D	Credit 1	**Site Selection**	1
1			D	Credit 2	**Development Density & Community Connectivity**	1
1			D	Credit 3	**Brownfield Redevelopment**	1
1			D	Credit 4.1	**Alternative Transportation**, Public Transportation Access	1
1			D	Credit 4.2	**Alternative Transportation**, Bicycle Storage & Changing Rooms	1
1			D	Credit 4.3	**Alternative Transportation**, Low-Emitting and Fuel-Efficient Vehicles	1
1			D	Credit 4.4	**Alternative Transportation**, Parking Capacity	1
		1	C	Credit 5.1	**Site Development,** Protect or Restore Habitat	1
1			D	Credit 5.2	**Site Development,** Maximize Open Space	1
1			D	Credit 6.1	**Stormwater Design,** Quantity Control	1
1			D	Credit 6.2	**Stormwater Design,** Quality Control	1
		1	C	Credit 7.1	**Heat Island Effect,** Non-Roof	1
1			D	Credit 7.2	**Heat Island Effect,** Roof	1
1			D	Credit 8	**Light Pollution Reduction**	1
Yes	?	No				
4		1		**Water Efficiency**		**5** Points
1			D	Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1			D	Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		1	D	Credit 2	**Innovative Wastewater Technologies**	1
1			D	Credit 3.1	**Water Use Reduction**, 20% Reduction	1
1			D	Credit 3.2	**Water Use Reduction**, 30% Reduction	1
Yes	?	No				
7		10		**Energy & Atmosphere**		**17** Points
Y			C	Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Y			D	Prereq 2	**Minimum Energy Performance**	Required
Y			D	Prereq 3	**Fundamental Refrigerant Management**	Required
5		5	D	Credit 1	**Optimize Energy Performance**	1 to 10
		3	D	Credit 2.1	**On-Site Renewable Energy**	1 to 3
1			C	Credit 3	**Enhanced Commissioning**	1
		1	D	Credit 4	**Enhanced Refrigerant Management**	1
		1	C	Credit 5	**Measurement & Verification**	1
1			C	Credit 6	**Green Power**	1
						continued…

Yes	?	No				
5	2	6			**Materials & Resources**	**13** Points
Y			D	Prereq 1	**Storage & Collection of Recyclables**	Required
		1	C	Credit 1.1	**Building Reuse**, Maintain 75% of Existing Walls, Floors & Roof	1
		1	C	Credit 1.2	**Building Reuse**, Maintain 100% of Existing Walls, Floors & Roof	1
		1	C	Credit 1.3	**Building Reuse**, Maintain 50% of Interior Non-Structural Elements	1
1			C	Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
1			C	Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
		1	C	Credit 3.1	**Materials Reuse**, 5%	1
		1	C	Credit 3.2	**Materials Reuse**,10%	1
1			C	Credit 4.1	**Recycled Content**, 10% (post-consumer + ½ pre-consumer)	1
	1		C	Credit 4.2	**Recycled Content**, 20% (post-consumer + ½ pre-consumer)	1
1			C	Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured Regionally	1
	1		C	Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured Regionally	1
		1	C	Credit 6	**Rapidly Renewable Materials**	1
1			C	Credit 7	**Certified Wood**	1
Yes	?	No				
9	1	5			**Indoor Environmental Quality**	**15** Points
Y			D	Prereq 1	**Minimum IAQ Performance**	Required
Y			D	Prereq 2	**Environmental Tobacco Smoke** (ETS) **Control**	Required
		1	D	Credit 1	**Outdoor Air Delivery Monitoring**	1
		1	D	Credit 2	**Increased Ventilation**	1
1			C	Credit 3.1	**Construction IAQ Management Plan**, During Construction	1
1			C	Credit 3.2	**Construction IAQ Management Plan**, Before Occupancy	1
1			C	Credit 4.1	**Low-Emitting Materials**, Adhesives & Sealants	1
1			C	Credit 4.2	**Low-Emitting Materials**, Paints & Coatings	1
1			C	Credit 4.3	**Low-Emitting Materials**, Carpet Systems	1
1			C	Credit 4.4	**Low-Emitting Materials**, Composite Wood & Agrifiber Products	1
		1	D	Credit 5	**Indoor Chemical & Pollutant Source Control**	1
1			D	Credit 6.1	**Controllability of Systems**, Lighting	1
1			D	Credit 6.2	**Controllability of Systems**, Thermal Comfort	1
	1		D	Credit 7.1	**Thermal Comfort**, Design	1
1			D	Credit 7.2	**Thermal Comfort**, Verification	1
		1	D	Credit 8.1	**Daylight & Views**, Daylight 75% of Spaces	1
		1	D	Credit 8.2	**Daylight & Views**, Views for 90% of Spaces	1
Yes	?	No				
5					**Innovation & Design Process**	**5** Points
1			D	Credit 1.1	**Innovation in Design**: Exemplary SSc5.2 Open Space	1
1			D	Credit 1.2	**Innovation in Design**: Green Housekeeping Plan	1
1			D	Credit 1.3	**Innovation in Design**: Integrated Pest Management	1
1			D	Credit 1.4	**Innovation in Design**: Exemplary Performance WEc3 (40%+)	1
1			C	Credit 2	**LEED® Accredited Professional**	1
Yes	?	No				
42	3	24			**Project Totals** (pre-certification estimates)	**69** Points

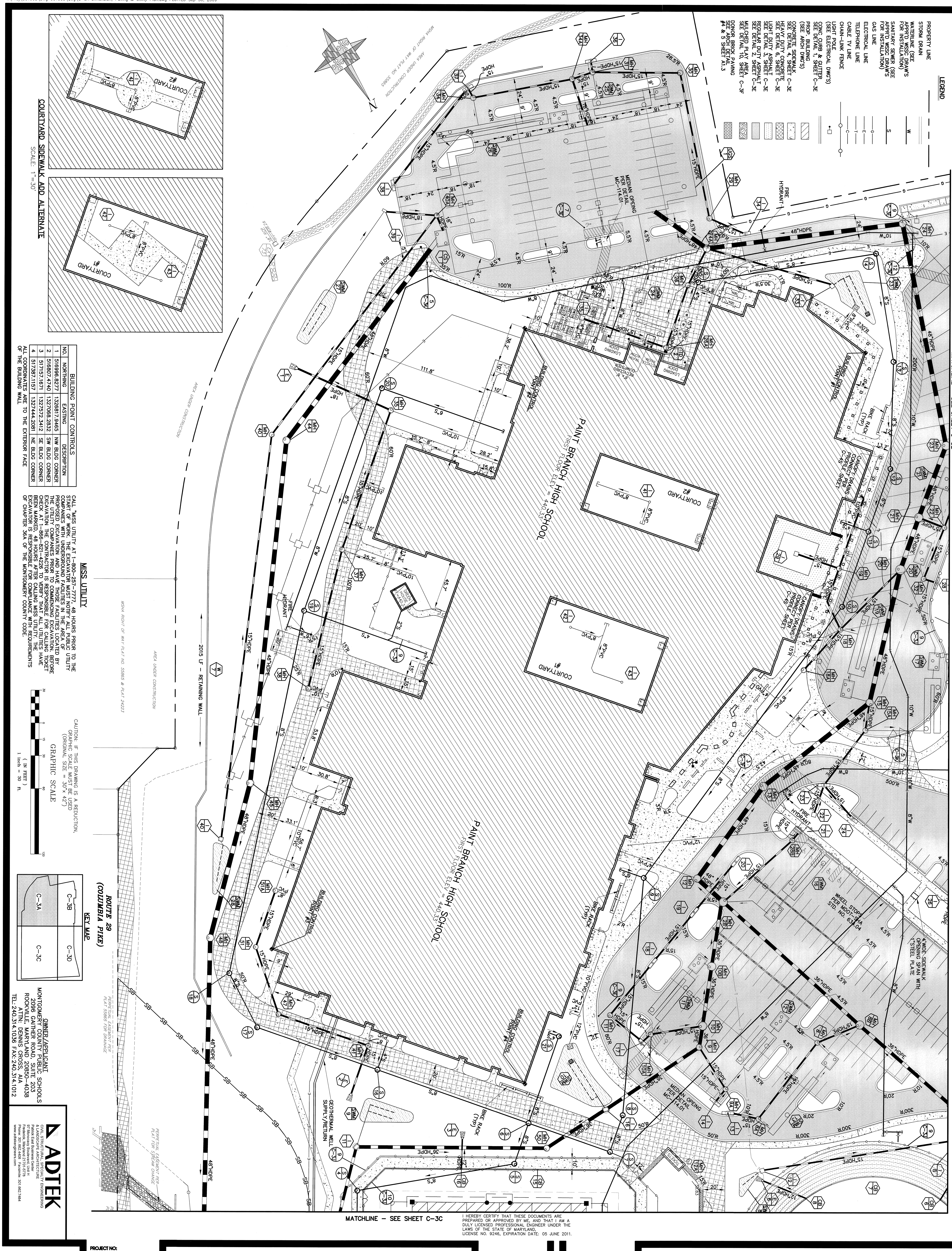
Certified 26-32 points **Silver** 33-38 points **Gold** 39-51 points **Platinum** 52-69 points

O = Owner; A = Architect; C = Civil; M = Mechanical; E = Electrical; P = Plumbing; CM = Contractor/Construction Manager; CxA = Commissioning Authority; K = Kitchen; L = LEED Coordinator

(blue)	Design Phase Credit - Review Complete
(yellow)	Deferred Design Phase or Construction Phase Credit - In Progress

Appendix D

Site Plans – Parking



LEGEND

- PROPERTY LINE
- STORM DRAIN
- WATERLINE (SEE APPR'D WSSC DRAW'S FOR INSTALLATION)
- SANITARY SEWER (SEE APPR'D WSSC DRAW'S FOR INSTALLATION)
- GAS LINE
- ELECTRICAL LINE
- TELEPHONE LINE
- CABLE TV LINE
- CHAIN-LINK FENCE
- LIGHT POLE (SEE ELECTRICAL DWG'S)
- CONC CURB & GUTTER SEE DETAIL 1, SHEET C-3E
- PROP. BUILDING (SEE ARCH DWG'S)
- CONCRETE SIDEWALK SEE DETAIL 4, SHEET C-3E
- HEAVY DUTY CONCRETE SEE DETAIL 6, SHEET C-3E
- LIGHT DUTY ASPHALT SEE DETAIL 3, SHEET C-3E
- REGULAR DUTY ASPHALT SEE DETAIL 2, SHEET C-3E
- MULCHED PLAY AREA SEE DETAIL 10, SHEET C-3F
- DONOR BRICK PAVING SEE ARCH DETAIL #4 & 5 SHEET A1.3

COURTYARD SIDEWALK ADD ALTERNATE
SCALE: 1"=30'

BUILDING POINT CONTROLS			
NO.	NORTHING	EASTING	DESCRIPTION
1	516996.8277	1326817.9465	NW BLDG CORNER
2	516807.4740	1327068.2832	SW BLDG CORNER
3	517157.1671	1327572.3412	SE BLDG CORNER
4	517357.1157	1327444.2081	NE BLDG CORNER

ALL COORDINATES ARE TO THE EXTERIOR FACE OF THE BUILDING WALL

MISS UTILITY

CALL "MISS UTILITY AT 1-800-257-7777, 48 HOURS PRIOR TO THE START OF WORK. THE EXCAVATOR MUST NOTIFY ALL PUBLIC UTILITY COMPANIES WITH UNDERGROUND FACILITIES IN THE AREA OF PROPOSED EXCAVATION AND HAVE THOSE FACILITIES LOCATED BY THE UTILITY COMPANIES PRIOR TO COMMENCING EXCAVATION. BEFORE EXCAVATION THE CONTRACTOR IS RESPONSIBLE FOR CALLING TICKET CHECK AT 1-866-621-4256 TO VERIFY THAT ALL UTILITIES HAVE BEEN MARKED. 48 HOURS AFTER CALLING MISS UTILITY. THE EXCAVATOR IS RESPONSIBLE FOR COMPLIANCE WITH REQUIREMENTS OF CHAPTER 36A OF THE MONTGOMERY COUNTY CODE.

CAUTION: IF THIS DRAWING IS A REDUCTION, GRAPHIC SCALE MUST BE USED (ORIGINAL SIZE = 30"x 42")

GRAPHIC SCALE
(IN FEET)
1 inch = 30 ft.

ROUTE 29 (COLUMBIA PIKE)

KEY MAP

C-3B | C-3D
C-3A | C-3C

OWNER/APPLICANT
MONTGOMERY COUNTY PUBLIC SCHOOLS
2096 GAITHER ROAD, SUITE 203
ROCKVILLE, MARYLAND 20850-4038
ATTN: DENNIS CROSS, AIA
TEL: 240.314.1036 FAX: 240.314.1012

ADTEK
CIVIL, STRUCTURAL, SPECIALTY ENGINEERING & LANDSCAPE ARCHITECTURE
www.adtekengineers.com

MATCHLINE – SEE SHEET C-3C

I HEREBY CERTIFY THAT THESE DOCUMENTS ARE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 9246, EXPIRATION DATE: 05 JUNE 2011.

PROJECT NO: 452101
DATE: September 25, 2009
REVISIONS:
DRAWN BY: AMM/LYV/JEB
REVIEWED BY: SPB

PAINT BRANCH HIGH SCHOOL MODERNIZATION

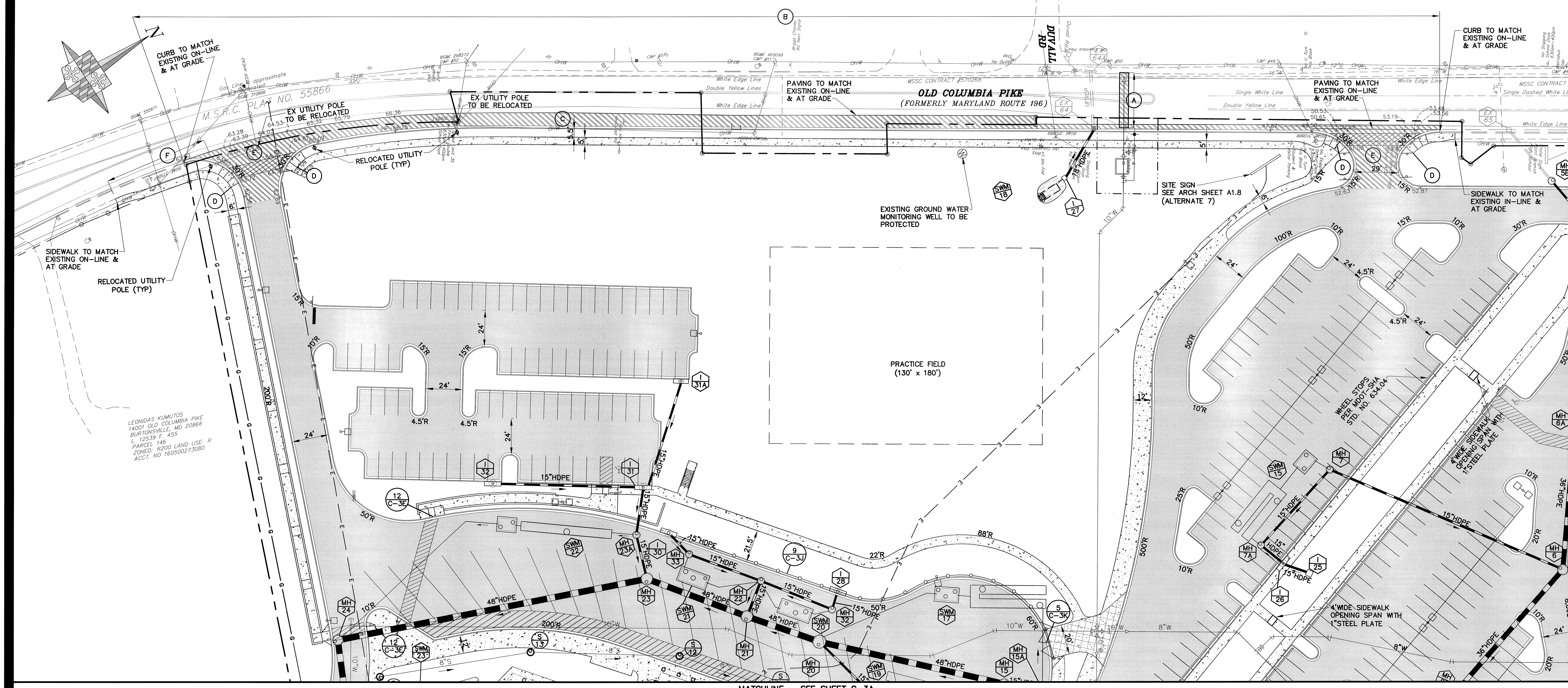
MONTGOMERY COUNTY PUBLIC SCHOOLS
BURTONSVILLE, MD

LIBER: 2844
FOLIO: 182
PARCEL: P895
ZONED: R200
LAND USE: EC
ACCT#: 160500251915

MOSELEY ARCHITECTS
A PROFESSIONAL CORPORATION
50 WEST MARKET STREET HARRISONBURG, VIRGINIA 22801
PHONE (540) 434-1346 FAX (540) 434-7982
MOSELEY ARCHITECTS.COM

DIMENSION, PAVING & UTILITY PLAN

C-3A



LEGEND

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- LIGHT POLE (SEE ELECTRICAL DWG'S)
- CONC CURB & GUTTER SEE DETAIL 1, SHEET C-3E
- STREAM BUFFER
- PROP. BUILDING (SEE ARCH DWG'S)
- CONCRETE SIDEWALK SEE DETAIL 4, SHEET C-3E
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- LIGHT DUTY ASPHALT SEE DETAIL 3, SHEET C-3E
- REGULAR DUTY ASPHALT SEE DETAIL 2, SHEET C-3E
- RIGHT OF WAY ASPHALT SEE DETAIL 1, SHEET C-3B
- MULCHED PLAY AREA SEE DETAIL 10, SHEET C-3F
- SKINNED INFIELD SEE DETAIL 12, SHEET C-3G
- SWM FACILITY

KEY NOTES FOR PUBLIC RIGHT-OF-WAY:

Ⓐ SAWCUT IN OLD COLUMBIA PIKE PUBLIC RIGHT-OF-WAY FOR WATERLINE INSTALLATION/CONNECTION. (PER MCDOT MC-801.02 FOR UTILITY PATCH).

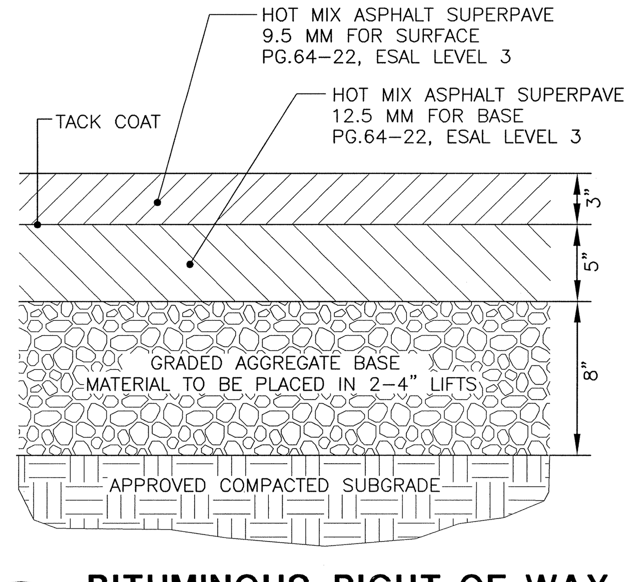
Ⓑ REMOVE EXISTING CURB AND GUTTER IN OLD COLUMBIA PIKE PUBLIC RIGHT-OF-WAY & REPLACE WITH NEW CONC. CURB & GUTTER (SEE DETAIL 1, SHEET C-3E)

Ⓒ SEE DETAIL 1 THIS SHEET.

Ⓓ SEE DETAIL 12 SHEET C-3E FOR ADA/SHA ACCESSIBLE RAMP DETAIL

Ⓔ REFER TO SHEET C-7A FOR RIGHT-OF-WAY PAVEMENT MARKINGS.

Ⓕ INSTALL NEW MONT CO. RESIDENTIAL SIDEWALK CLOSED SECTION PER STD MC-110.01.



1 C-3B **BITUMINOUS RIGHT-OF-WAY CONCRETE SECTION**

NOT TO SCALE

PER MC DOT MC-213.02

MISS UTILITY

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CAUTION: IF THIS DRAWING IS A REDUCTION, GRAPHIC SCALE MUST BE USED (ORIGINAL SIZE = 30"x 42")

GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

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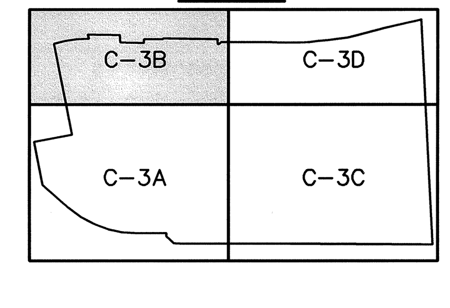
KEY MAP



MANDATORY REFERRAL (07606-MCPS-1)
APPROVED 02-20-09

DPS# 259520
MONTGOMERY COUNTY MARYLAND
DEPARTMENT OF PERMITTING SERVICES
RIGHT-OF-WAY PERMITTING & PLAN REVIEW
FINAL APPROVAL
DATE:
BY:

* SUBJECT TO DEDICATION OF RIGHT OF WAY AND EASEMENTS PER COUNTY CODE SECTION 50.

ADTEK
CIVIL, STRUCTURAL, SPECIALTY ENGINEERING & LANDSCAPE ARCHITECTURE
Patrick East Business Center
97 Monocacy Boulevard, Unit H
Frederick, Maryland 21701-5776
Phone: 301.662.4408 Facsimile: 301.662.7484
www.adtekengineers.com

I HEREBY CERTIFY THAT THESE DOCUMENTS ARE PREPARED OR APPROVED BY ME, AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MARYLAND, LICENSE NO. 26524, EXPIRATION DATE: 19 JULY 2011.

LIBER: 2844
FOLIO: 182
PARCEL: P895
ZONED: R200
LAND USE: EC
ACCT#: 160500251915

MOSELEY ARCHITECTS
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PAINT BRANCH HIGH SCHOOL MODERNIZATION

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BURTONSVILLE, MD

PROJECT NO: 452101
DATE: September 25, 2009
REVISIONS:
DRAWN BY: AMM/LVV/JEB
REVIEWED BY: SPB

DIMENSION, PAVING & UTILITY PLAN

C-3B

I:\Proj\061903\Dwg 061903\dwg\C-3B Dimension, Paving & Utility Plan.dwg PLOTTED Sep 25, 2009

Appendix E

Single Cantilever Canopy Specifications

SPECIFICATIONS
Section 10530 – Aluminum Walkway Covers

CANTILEVERED WALKWAY CANOPY

Part 1: General

1.01 Related Documents

A. The requirements of Division 1 specifications shall apply to work specified in the section.

1.02 References

A. International Building Code 2006
B. ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
C. Aluminum Design Manual 2005
D. Local governing codes and standards for site location

1.03 General Description of Work

A. Work in this section shall include design, fabrication, and installation of aluminum protective covers. All work shall be in accordance with the shop drawings and this specification section.

1.04 Submittals

A. Shop Drawings – Submit complete shop drawings including:
   1) Overall canopy layout dimensions
   2) Cut section details including elevation, bent layout dimensions, and connection details
   3) Flashing details pertaining to aluminum canopy
   4) Concrete footing and/or canopy anchorage details
B. Product Data – Submit manufacturer's product information, specifications, and installation instructions for the aluminum canopy.
C. Samples – Submit color selection samples of actual coated aluminum material or actual anodized aluminum material.
D. Certification – Provide letter of compliance certifying that the proposed canopy design and layout meets or exceeds all applicable loadings (ex: wind load, rain live load, dead load, snow load) for the job location (city & state) in accordance with IBC 2006 and ASCE 7-05.

1.05 Quality Assurance

A. Manufacturer Qualifications: Minimum five years experience in design, fabrication, and production of aluminum protective covers.
B. Components shall be assembled in shop to greatest extent possible to minimize field assembly.
C. Aluminum protective cover, including material and workmanship, shall be warranted from defects for a period of one year from date of completion of aluminum protective cover installation.

Part 2: Products and Materials

2.01 Acceptable Manufacturers

A. **Mitchell Metals, LLC**
1761 McCoba Drive, Suite A
Smyrna, GA 30080
Phone 770.431.7300
Fax 770.431.7305
www.mitchellmetals.net

B. Equivalent systems by other manufacturers will be approved for substitution by addendum if the following conditions are met:
   1) Other manufacturers must have submitted requested information and have been qualified to bid no less than 10 days prior to bid closing date.
   2) Manufacturer must submit complete company literature and information to the architect for review
   3) Manufacturer must submit complete proposed canopy system details, including sizes and strength values of all members to be used.

2.02 Design & Assembly

A. Aluminum protective cover shall consist of cantilevered bents welded into single structures. Mechanically fastened frame connections can be used if shipping does not allow for welded frames.

B. Canopy shall use perimeter false fascia and extruded decking running parallel to length of sidewalk. Beams are to be full welded at both ends to eliminate leaking of water. Extruded Decking shall be a roll-locked design where the extruded cap and pan shall interlock to make a rigid structure. Crimped decking is not allowed. Pans are to be welded at ends to prevent water leakage. Standard T-flashing shall be used where decking is separated at a drain beam. The false fascia is to be secured using a rivet every 4’-0” on center connecting the fascia to the edge pans. Tie back straps are to be installed connecting the top of the fascia to the decking at 4’-0” on center.
C. Canopies shall drain from the decking into the drain beam and discharge at the bottom of the column.
D. Deflector plates are to be installed at the bottom of the column to discharge the water away from the column, unless under ground drainage is desired. The deflector plates are to be caulked inside the column and fastened to the column using a single rivet.
E. Columns are to be locked into the post footer using a single piece of rebar, approximately 9” long, running through the bottom of the column below finished floor.

2.03 Materials

A. Columns
  1) Columns are to be radius cornered aluminum tubular extrusion of size indicated on architect’s drawings. Minimum column size shall be 6”x 6” at 0.188” thick.
  2) Provide clear acrylic protection or bituminous paint protection between the aluminum column and the concrete footer.
  3) Tombstone shaped water outlet holes are to be cut at the bottom of all draining columns with deflector plates installed inside, unless under ground drainage is desired. Circular drain holes are not allowed.
B. Beams
  1) Beams are to be open topped aluminum tubular extrusion of size indicated on architect’s drawings.
  2) Size of beam used shall accommodate applied loadings without over-stress or over-deflection. Minimum beam size shall be 6”x 6” at 0.188” thick.
C. Decking
  1) Decking shall be a rigid roll-locked design that is self flashing and utilizes interlocking sections.
  2) Extruded decking is to be of size indicated on architect’s drawings.
  3) Where decking is run parallel to walkway, the ends of the pans shall be welded closed where decking does not terminate into a drain beam.

D. False Fascia
   1) False Fascia shall be aluminum extrusion of size indicated on architect's drawings. Minimum fascia size shall be 1"x 6" at 0.070" thick.
E. Flashing
   1) Flashing shall be made of aluminum sheet painted to match the color of the canopy. Minimum flashing thickness shall be 0.040" thick.

2.04 Fasteners

A. All fasteners shall be stainless steel with neoprene washers and rivets are 3/16" aluminum.

2.05 Finishes

A. Factory applied baked enamel
   1) Enamel is to comply with AAMA 2603.
   2) Color is to be as selected by architect from manufacturer's standard color chart.
   3) Custom colors can be used upon the architect's request.

Part 3: Installation and Execution

3.01 Erection

A. Canopies are to be installed according to approved shop drawings and plans.
B. The entire structure shall be installed straight, true, and plumb according to standard construction procedures.
C. Canopies shall be installed with positive and negative slope of 1/8" per foot to allow water drainage from top of canopy to draining columns and eliminate ponding.
D. Non-draining columns shall have weep holes installed at top of concrete to remove condensation from post. Minimum weep hole size shall be ¼" in diameter.
E. All joints, corners, and connections shall be tight and clean.
F. All exposed fasteners are to be painted to match the canopy color.
G. Decking is to be aligned and secured to aluminum frame structure.

3.02 Column Footings

A. Styrofoam blockouts shall be provided by the canopy manufacturer and installed by the General Contractor.
B. General Contractor shall pour the required footer size around the Styrofoam blockouts provided by the manufacturer.

C. Canopy installer is to remove the Styrofoam after footer has cured, set column in cavity, and fill with minimum 2000 psi grout to level of finished concrete slab.
D. Slab mounting of aluminum columns for cantilevered canopies is not allowed.
E. Footer design is not covered in this specification and scope of work.

3.03 Cleaning

A. All canopy surfaces exposed are to be cleaned after installation is complete.
B. Surplus materials and debris shall be removed from the jobsite after installation is complete.

3.04 Protection

A. General Contractor shall ensure protection of installed aluminum canopies from other construction so that canopies are without damage at time of substantial completion of project.

Appendix F

Double Cantilever Canopy specifications

SPECIFICATIONS

Section 10530 – Aluminum Walkway Covers

CANTILEVERED WALKWAY CANOPY

Part 1: General

1.01 Related Documents

A. The requirements of Division 1 specifications shall apply to work specified in the section.

1.02 References

A. International Building Code 2006
B. ASCE 7-05, Minimum Design Loads for Buildings and Other Structures
C. Aluminum Design Manual 2005
D. Local governing codes and standards for site location

1.03 General Description of Work

A. Work in this section shall include design, fabrication, and installation of aluminum protective covers. All work shall be in accordance with the shop drawings and this specification section.

1.04 Submittals

A. Shop Drawings – Submit complete shop drawings including:
   1) Overall canopy layout dimensions
   2) Cut section details including elevation, bent layout dimensions, and connection details
   3) Flashing details pertaining to aluminum canopy
   4) Concrete footing and/or canopy anchorage details

B. Product Data – Submit manufacturer's product information, specifications, and installation instructions for the aluminum canopy.

C. Samples – Submit color selection samples of actual coated aluminum material or actual anodized aluminum material.

D. Certification – Provide letter of compliance certifying that the proposed canopy design and layout meets or exceeds all applicable loadings (ex: wind load, rain live load, dead load, snow load) for the job location (city & state) in accordance with IBC 2006 and ASCE 7-05.

1.05 Quality Assurance

A. Manufacturer Qualifications: Minimum five years experience in design, fabrication, and production of aluminum protective covers.
B. Components shall be assembled in shop to greatest extent possible to minimize field assembly.
C. Aluminum protective cover, including material and workmanship, shall be warranted from defects for a period of one year from date of completion of aluminum protective cover installation.

Part 2: Products and Materials

2.01 Acceptable Manufacturers

A. **Mitchell Metals, LLC**
1761 McCoba Drive, Suite A
Smyrna, GA 30080
Phone 770.431.7300
Fax 770.431.7305
www.mitchellmetals.net

B. Equivalent systems by other manufacturers will be approved for substitution by addendum if the following conditions are met:
   1) Other manufacturers must have submitted requested information and have been qualified to bid no less than 10 days prior to bid closing date.
   2) Manufacturer must submit complete company literature and information to the architect for review
   3) Manufacturer must submit complete proposed canopy system details, including sizes and strength values of all members to be used.

2.02 Design & Assembly

A. Aluminum protective cover shall consist of cantilevered bents welded into single structures. Mechanically fastened frame connections can be used if shipping does not allow for welded frames.

B. Canopy shall use perimeter false fascia and extruded decking running parallel to length of sidewalk. Beams are to be full welded at both ends to eliminate leaking of water. Extruded Decking shall be a roll-locked design where the extruded cap and pan shall interlock to make a rigid structure. Crimped decking is not allowed. Pans are to be welded at ends to prevent water leakage. Standard T-flashing shall be used where decking is separated at a drain beam. The false fascia is to be secured using a rivet every 4’-0” on center connecting the fascia to the edge pans. Tie back straps are to be installed connecting the top of the fascia to the decking at 4’-0” on center.
C. Canopies shall drain from the decking into the drain beam and discharge at the bottom of the column.
D. Deflector plates are to be installed at the bottom of the column to discharge the water away from the column, unless under ground drainage is desired. The deflector plates are to be caulked inside the column and fastened to the column using a single rivet.
E. Columns are to be locked into the post footer using a single piece of rebar, approximately 9” long, running through the bottom of the column below finished floor.

2.03 Materials

A. Columns
   1) Columns are to be radius cornered aluminum tubular extrusion of size indicated on architect’s drawings. Minimum column size shall be 6”x 6” at 0.188” thick.
   2) Provide clear acrylic protection or bituminous paint protection between the aluminum column and the concrete footer.
   3) Tombstone shaped water outlet holes are to be cut at the bottom of all draining columns with deflector plates installed inside, unless under ground drainage is desired. Circular drain holes are not allowed.
B. Beams
   1) Beams are to be open topped aluminum tubular extrusion of size indicated on architect’s drawings.
   2) Size of beam used shall accommodate applied loadings without over-stress or over-deflection. Minimum beam size shall be 6”x 6” at 0.188” thick.
C. Decking
   1) Decking shall be a rigid roll-locked design that is self flashing and utilizes interlocking sections.
   2) Extruded decking is to be of size indicated on architect’s drawings.
   3) Where decking is run parallel to walkway, the ends of the pans shall be welded closed where decking does not terminate into a drain beam.

D. False Fascia
   1) False Fascia shall be aluminum extrusion of size indicated on architect's drawings. Minimum fascia size shall be 1"x 6" at 0.070" thick.

E. Flashing
   1) Flashing shall be made of aluminum sheet painted to match the color of the canopy. Minimum flashing thickness shall be 0.040" thick.

2.04 Fasteners

A. All fasteners shall be stainless steel with neoprene washers and rivets are 3/16" aluminum.

2.05 Finishes

A. Factory applied baked enamel
   1) Enamel is to comply with AAMA 2603.
   2) Color is to be as selected by architect from manufacturer's standard color chart.
   3) Custom colors can be used upon the architect's request.

Part 3: Installation and Execution

3.01 Erection

A. Canopies are to be installed according to approved shop drawings and plans.
B. The entire structure shall be installed straight, true, and plumb according to standard construction procedures.
C. Canopies shall be installed with positive and negative slope of 1/8" per foot to allow water drainage from top of canopy to draining columns and eliminate ponding.
D. Non-draining columns shall have weep holes installed at top of concrete to remove condensation from post. Minimum weep hole size shall be ¼" in diameter.
E. All joints, corners, and connections shall be tight and clean.
F. All exposed fasteners are to be painted to match the canopy color.
G. Decking is to be aligned and secured to aluminum frame structure.

3.02 Column Footings

A. Styrofoam blockouts shall be provided by the canopy manufacturer and installed by the General Contractor.
B. General Contractor shall pour the required footer size around the Styrofoam blockouts provided by the manufacturer.

C. Canopy installer is to remove the Styrofoam after footer has cured, set column in cavity, and fill with minimum 2000 psi grout to level of finished concrete slab.
D. Slab mounting of aluminum columns for cantilevered canopies is not allowed.
E. Footer design is not covered in this specification and scope of work.

3.03 Cleaning

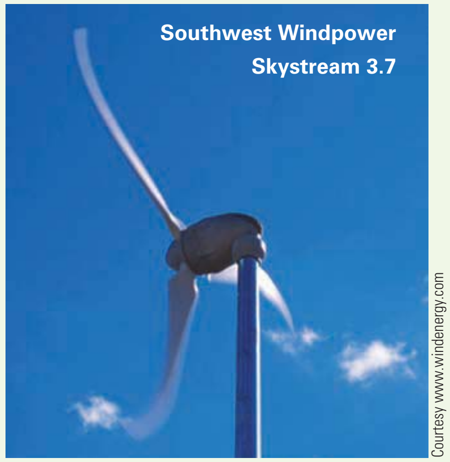
A. All canopy surfaces exposed are to be cleaned after installation is complete.
B. Surplus materials and debris shall be removed from the jobsite after installation is complete.

3.04 Protection

A. General Contractor shall ensure protection of installed aluminum canopies from other construction so that canopies are without damage at time of substantial completion of project.

Appendix G

Wind Turbine Specifications



Wind Turbine Specifications

Manufacturer	Bergey Windpower	SW Wind Power	Raum	Kestrel	Proven Energy	Cascade Wind
Web site	www.bergey.com	www.windenergy.com	www.raumenergy.com	www.kestrelwind.co.za	www.provenenergy.co.uk	www.cascadewindcorp.com
Model	XL.1	Whisper 200	Raum 1.3	e300i	Proven 7	ARE110
Swept area (sq. ft.)	53.0	63.5	73.0	76.0	103.6	110.0
Rotor diameter (ft.)	8.2	9.0	9.5	10.0	11.5	11.8
Tower-top weight (lbs.)	75	65	86	165	420	315
Predicted annual energy output (kWh)						
8 mph	420	794	908	973	1,704	1,629
9 mph	610	1,121	1,110	1,315	2,438	2,274
10 mph	840	1,483	1,539	1,726	3,494	3,039
11 mph	1,110	1,865	2,004	2,131	4,417	3,894
12 mph	1,400	2,254	2,479	2,551	5,627	4,801
13 mph	1,710	2,637	2,940	2,966	6,614	5,728
14 mph	2,040	3,005	3,365	3,356	7,842	6,643
Rpm	490	900	800	600	300	310
Generator type	PM	PM	PM	PM	PM	PM
Governing system	Side furling	Angle furling	Tilt-up furling	Blade pitch	Blade pitch	Side furling
Governing wind speed (mph)	29	26	23	24	27	25
Shutdown mechanism	Dynamic brake	Dynamic brake	Dynamic brake	Dynamic brake	Disc brake	Dynamic brake
Batteryless grid-tied version	Pending	No	Yes	Yes	Yes	Yes
Battery voltages	24	24, 36, 48	24, 48	12, 24, 48	24, 48	48
Controls included	Yes	Yes	Yes	No	Yes	Yes
Tower or installation included in cost	No	No	No	No	Tower (30 ft.)	No
Cost: batteryless version	—	—	$3,650	$6,440	$25,000	$12,650
Cost: battery charging version	$2,790	$3,405	$3,650	$4,138	—	$11,800
Warranty (years)	5	5	5	5	5	5


Raum Energy
Raum 3.5

Courtesy www.raumenergy.com


Southwest Windpower
Whisper 500

Courtesy www.windenergy.com

Fortis
Montana

Courtesy www.fortiswind.com

SW Wind Power	Kestrel	Raum	SW Wind Power	Fortis	Evance	Proven Energy
www.windenergy.com	www.kestrelwind.co.za	www.raumenergy.com	www.windenergy.com	www.fortiswind.com	www.evancewind.com	www.provenenergy.co.uk
Skystream 3.7	e400i	Raum 3.5	Whisper 500	Montana	Iskra R9000	Proven 11
113.0	135.0	135.0	176.0	211.0	246.0	255.6
12.0	13.0	13.2	15.0	16.4	17.7	18.0
170	331	170	155	440	660	1,323
914	2,010	2,021	1,474	3,459	3,500	2,773
1,373	2,781	3,213	2,139	4,438	5,030	3,973
1,925	3,807	4,380	2,907	5,443	6,670	5,752
2,594	5,050	5,811	3,749	6,444	9,012	7,358
3,216	5,996	7,447	4,637	7,410	10,590	9,526
3,898	7,230	8,631	5,544	8,315	12,530	11,331
4,575	8,285	10,272	6,445	9,132	14,500	13,606
330	500	350	325	400	230	200
PM	PM	PM	PM	PM	PM	PM
Dynamic brake	Blade pitch	Active brake	Angle furling	Side furling	Blade pitch	Blade pitch
28	24	35	27	25–30	134	27
Dynamic brake	Dynamic brake	Dynamic brake	Dynamic brake	Electric Braking	Electrodynamic Brake	Disc brake
Yes	Yes	Yes	No	Yes	Yes	Yes
—	48	24, 48	24, 36, 48	48	24 – 300	48
Yes	No	Yes	Yes	Yes	MPPT	Yes
Tower (33 ft.)	No	No	No	No	Tower (50 ft.)	Tower (30 ft.)
$9,695	$13,328	$7,000	—	$15,800	—	$38,000
—	$11,178	$7,000	$8,795	$15,800	$18,800	—
5	5	5	5	5	5	5

Appendix H

Entry Grate Specifications

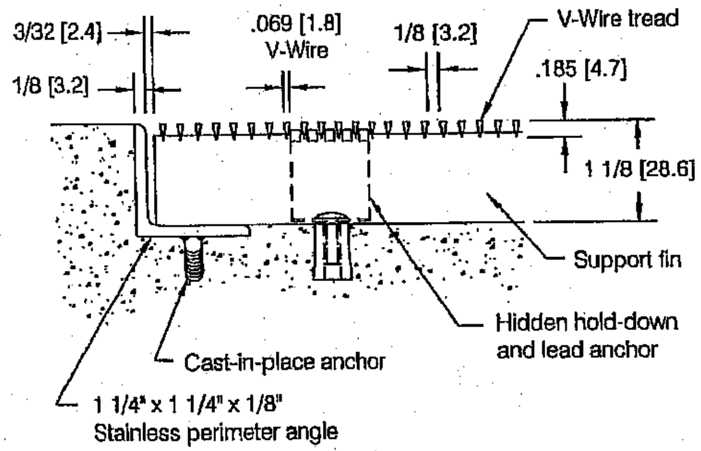
www.pawling.com
PAWLING
CORPORATION

Pro•Tek® Entrance Mats & Gratings

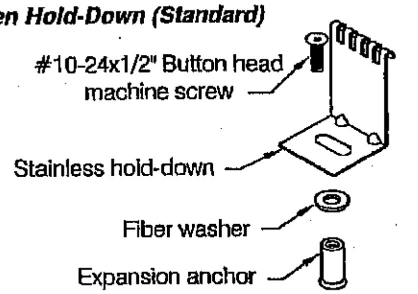
Architectural Building Products Since 1945

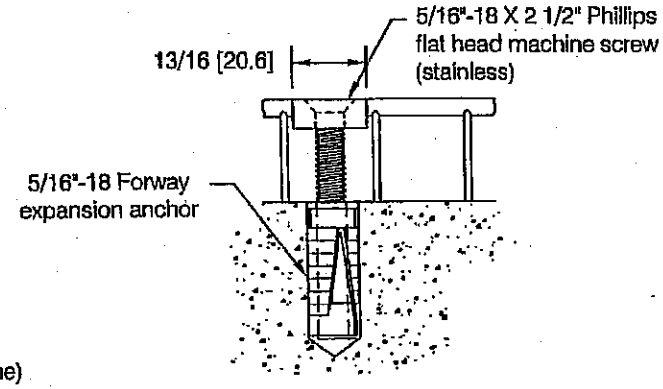
epi
Engineered Products,
200 Jones Street
Verona, Pennsylvania 1
412-423-4000

RG-720 Stainless Steel Grating



Hidden Hold-Down (Standard)

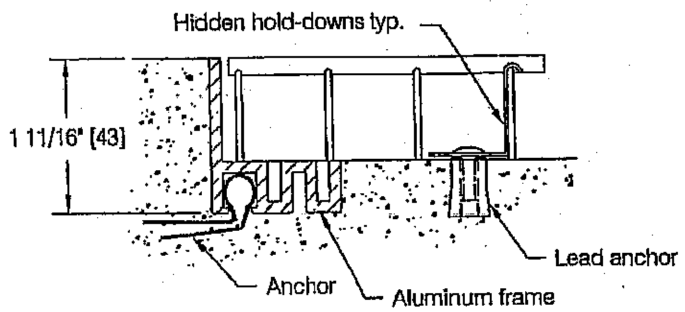




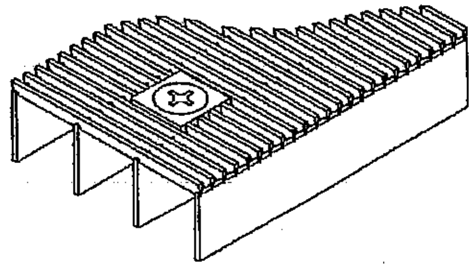
Note On Dimensions:

* ***Pawling requires that exact mat opening dimensions be provided. Factory will fabricate mats 3/16" (4.8) smaller than exact opening dimensions to allow for proper fit.***

Optional Framing: (Grating with RGFA-720 Aluminum Frame)



Exposed Hold-Down (Optional)



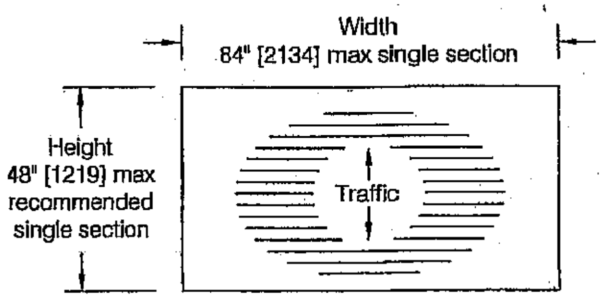
Features:

- 64% open area provides excellent air flow
- Custom designs available
- Material:
  - Standard: 304 Stainless steel
  - Optional: 316L Stainless steel
- Available with stainless angle frame or extruded 6063-T5 aluminum frame
- Hold-downs
  - Standard: Hidden, supplied loose
  - Optional: Exposed, factory welded
- Available in 3/8" depth, RG-700, ED.60.0 and 5/8" depth,RG-710, ED.61.0

Construction:

- Stainless steel wire resistance welded to support fins
- Manufacturing process prevents alignment of wires and support fins between adjacent sections

Sectioning information:



* ***Mats over 28 square feet may require sectioning as determined by the factory***

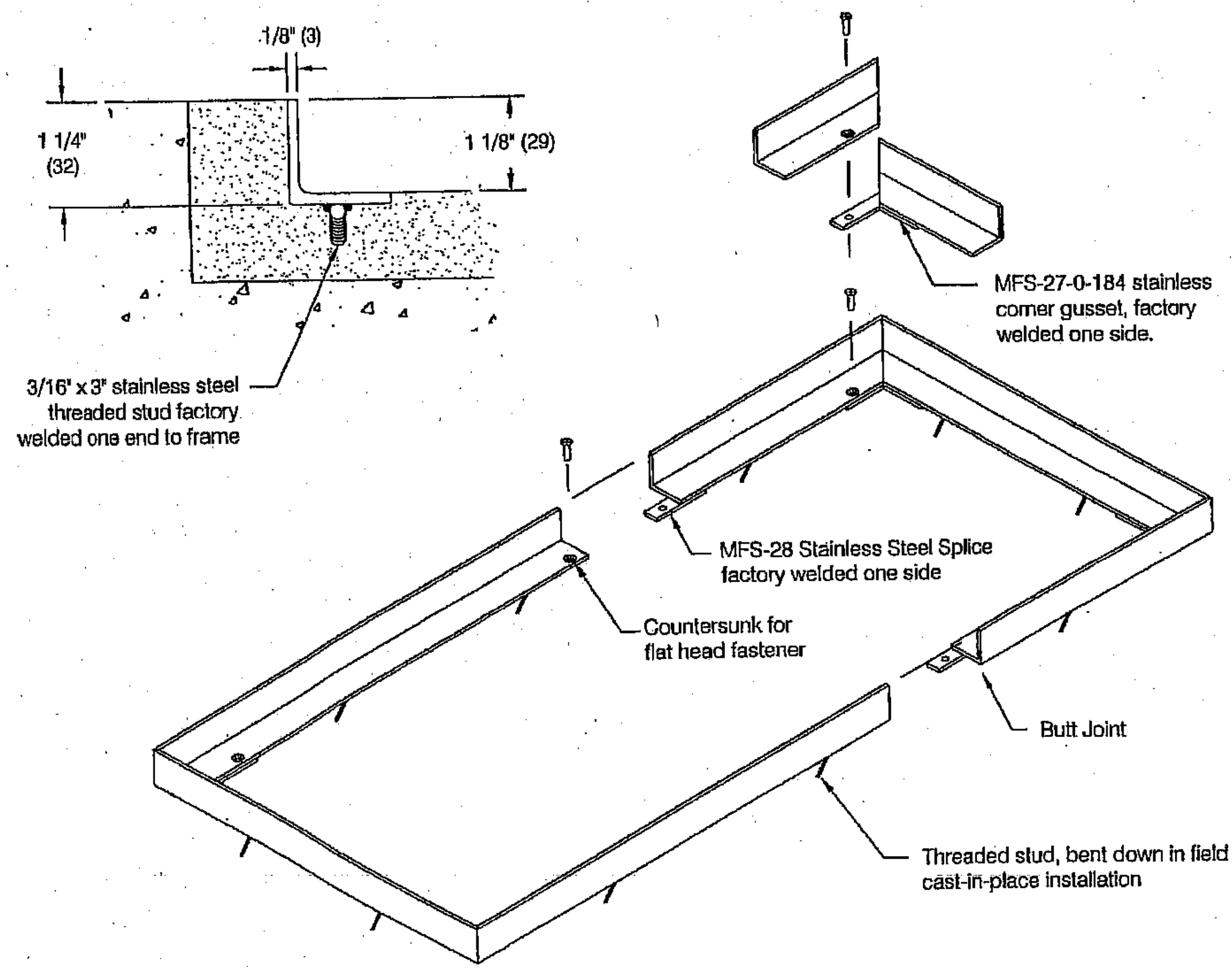
Customer :	Project :	FD 62.0b

PAWLING CORPORATION www.pawling.com

Pro • Tek® Entrance Mats & Gratings

Architectural Building Products Since 1945

RGFS-720 Stainless Steel Recessed Frame



Features:

- Used for RG-720 Stainless Steel Grating
- Type 304 stainless steel
- Stock length: 10'-0" (3048)
- Weight: 1.01 lbs / lf

Installation Options:

- Recessed, cast in place

Standard Finishes:

- Mill Finish #405

Engineered Products, Inc.
200 Jones Street
Verona, Pennsylvania 15147
412-423-4000

Customer :

Project :

FD 62 2a

Entrance Matting Systems: RG-720

Satin Stainless Steel entrance gratings combine the beauty of metal with the exceptional strength of grid systems that are designed to stand up to the toughest traffic. Use in conjunction with our Maxi-Tuft Long Wear Carpet Matting to brush and remove moisture while providing a dramatic look for your entryway. With their smooth rollover capability, metal gratings are also excellent for applications involving wheelchairs or gurneys. And our metal gratings are well suited for both interior and exterior applications. All styles feature:

· Clean architectural lines for an elegant, high-tech appearance
· Safe, heel-proof design
· All-weather durability and easy cleaning

Weight/square foot Aluminum: 2.6 lbs.
Bronze: 7.25 lbs.

Height 3/8" (RG-700)
5/8" (RG-710)
1 1/8" (RG-720)
Rail Material Stainless Steel
Rail Color/Finish Satin
Construction Electronically resistance welded assembly
Rolling Load/wheel 500 lbs.
Traffic Heavy Interior or Exterior
Weight/square foot 3.0 lbs. (RG-700)
4.0 lbs. (RG-710)
6.0 lbs. (RG-720)

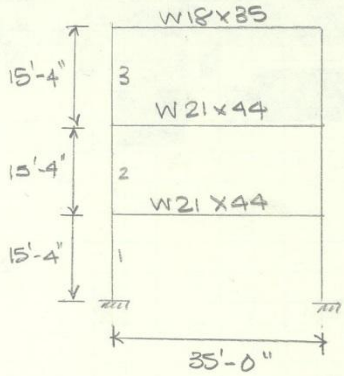
Product Shown: RG-700

PAWLING CORPORATION
32 Nelson Hill Rd., P.O. Box 200
Wassaic, New York 12592
800.431.3456 or 845.373.9300

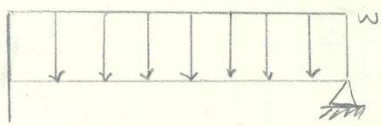
Appendix I

Structural Load Calculations

SENIOR THESIS STRUCTURAL BREADTH DIAB SHETAYH



6 colums = W8x48



BRICK FACADE:

- Brick = 25 psf
- 10" CMU = 70 psf
- insulation = 1.5 psf

Total = 106.5 psf

FLOORS 2 and 3:

$$w = (106.5\,psf)(15.33') = 1632.65\,PLF \Rightarrow \boxed{1.632\,KLF}$$

ROOF:

$$w = (106.5\,psf)(7.67') = 816.855\,PLF \Rightarrow \boxed{0.817\,KLF}$$

PREFABRICATED MASONRY SYSTEM:

- 1" BRICK = 8.75 psf
- polyurethane = 0.1625 psf
- gypsum board = 2.6 psf
- Steel Stud = 18 psf

Total = 29.54 psf = 30 psf

FLOORS 2 & 3:

$$w = (30\,psf)(15.33') = 459.9\,PLF \Rightarrow \boxed{0.460\,KLF}$$

ROOF:

$$w = (30\,psf)(7.67') = 230.1\,PLF \Rightarrow \boxed{0.230\,KLF}$$