April 7, 2010

SENIOR THESIS FINAL REPORT

PENN STATE AE SENIOR CAPSTONE PROJECT

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ADDITIONS & ALTERATIONS
ALEXANDRIA, VA

PENNSTATE
1855

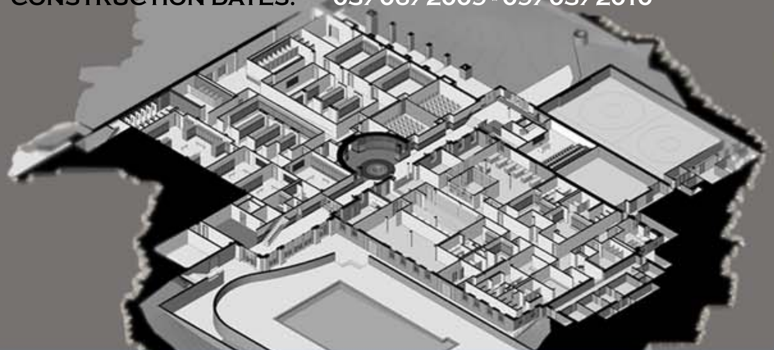
ERIC FEDDER
CONSTRUCTION MANAGEMENT
DR. CHRIS MAGENT

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM
ALEXANDRIA, VA

ERIC FEDDER | CONSTRUCTION MANAGEMENT | WWW.ENGR.PSU.EDU/AE/THESIS/PORTFOLIOS/2010/EWF5002

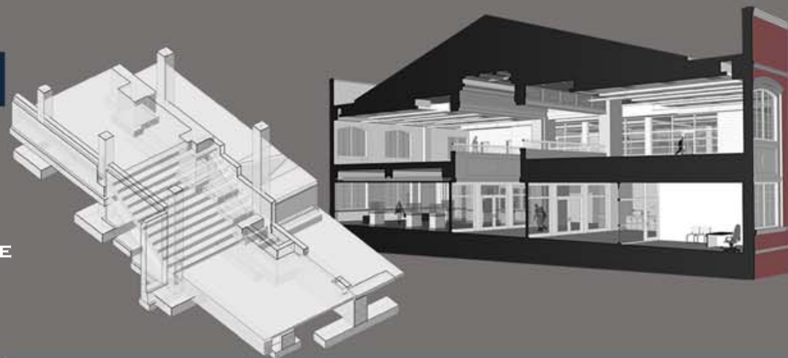
PROJECT OVERVIEW

OWNER:	Episcopal High School
CM AGENCY:	Advanced Project Management
ARCHITECT/ENGINEER:	Cannon Design
GENERAL CONTRACTOR:	James G. Davis Construction
TOTAL HEIGHT:	3 Stories
GROSS BUILDING AREA:	99,044 SF (including renovation work)
CONTRACTED GMP:	$22,457,189.00
CONSTRUCTION DATES:	03/06/2009 - 09/03/2010



ARCHITECTURAL FEATURES

Red-brick façades and large white columns at the entrances are a consistent theme among the buildings on the EHS campus. Cannon Design carried these key architectural features into the new Centennial Gymnasium addition, mirroring the entrance of the existing facility. The new Centennial Gymnasium addition will fill a void between the existing gymnasium and the Flippin' Field House (indoor track facility). One of the main architectural features is the joining of the new addition to the existing Centennial Gymnasium with a two-story glass atrium.



STRUCTURAL SYSTEM

FOUNDATION:	- Aggregate pier soil reinforcement system with #57 stone at an average pier depth of 14 feet - Concrete pier caps, grade beams, foundation walls and partial slab-on-grade
STRUCTURE:	- One way slab system (9 1/4" thick) with concrete columns and spandrel beams - Steel columns/beams
FACADE:	- "Delmarva" style brick exterior wall with glazed aluminum curtain wall system at atrium
ROOF:	- 108' trusses with 18" wide standing-seam metal panels with a fluoropolymer finish system

CONSTRUCTION LOGISTICS

A detailed 3 phase construction process will require demolition, renovation and new building construction to take place simultaneously throughout the project schedule to allow for sections of the existing facility to be functional during the school year.

PHASE ONE:	Utility relocation, complete cage renovation, Flippin' renovation and new gym construction
PHASE TWO:	New gym construction, existing fitness area demoltion and mechanial room construction
PHASE THREE:	Construction of new gym and demoltion/renovation of existing gym

MECHANICAL AND ELECTRICAL SYSTEMS

The mechanical system is a variable air volume fan coil system consisting of (5) hideaway celing fan coil units, (7) AHU's ranging from 5,000 - 21,000 CFM, (1) induced draft cooling tower, (1) chiller, (1) boiler, and (57) VAV terminal units ranging from 150-1800 CFM.

Centennial's power is supplied by Dominion Virginia Power. The main feed is stepped down at the DVP exterior transformer to a 277/480v, 3 phase, 3 wire system.

SENIOR THESIS FINAL REPORT

Eric Fedder – CM
Dr. Chris Magent - Advisor

1.0 EXECUTIVE SUMMARY

Senior Thesis Final Report is intended to discuss the findings and conclusions of the three analyses performed on the Episcopal High School Centennial Gymnasium Addition/Renovation. This project includes a 60,000 SF new gymnasium addition as well as 39,000 SF of renovation work to the existing gymnasium and wrestling facilities. Each topic is centered on the central theme of improving efficiency in the construction industry: project procurement efficiency, prefabrication efficiency and energy efficiency.

ANALYSIS #1: Critical Industry Issue

The current economy has forced many companies to venture into unfamiliar markets with different procurement strategies. A shift from negotiated GMP contracts to hard bid lump sum contracts requires a change in techniques and methods when pursuing projects. This analysis entailed a qualitative perspective on this critical issue by interviewing several industry members and comparing techniques. The analysis showed that the main factor for success when pursing hard bid lump sum projects is establishing relationships with subcontractors and securing the bottom-line pricing to produce the most competitive bid.

ANALYSIS #2: Elimination of Inefficiency through use of Prefabrication

Site congestion and minimal storage/lay down space has lead to trades working inefficiently and unsafely on site. The masonry trade has occupied the most space on site and encountered many delays due to inefficient work. This analysis showed that utilizing prefabricated panels for the façade in lieu of the designed CMU wall with brick veneer reduced the amount of on-site labor and trade coordination and eliminated delays due to inefficiency. This was achieved due to the ability to start the precast erection after the concrete superstructure, instead of overlapping the major trades as originally scheduled. Also, the precast panels produced a significant savings of nearly $460,000 when considering the removal of CMU/brick, the reduction of spandrel beam size and the cost/SF of precast panels.

ANALYSIS #3: Feasibility and Design Study for Photovoltaic Energy System

The Centennial Gymnasium project is slated to achieve LEED Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to Episcopal High School. The focus of this analysis was a design and feasibility study for a rooftop PV system. This analysis showed that the 9000SF South facing roof area of the New Centennial addition could be utilized to construct a PV array capable of producing enough energy to support all of the overhead gymnasium lighting in both the new and existing gymnasiums. A preliminary structural analysis revealed that there would be no impact to the design and the electrical analysis provides recommendations for connecting to the existing system. Taking into consideration the rebate/incentive programs within the state of Virginia, the feasibility study showed that the system would recuperate initial costs within 14 years of start-up.

2.0 ACKNOWLEDGMENTS

Academic Acknowledgments:

Penn State AE Faculty

Dr. Chris Magent – CM Advisor

Industry Acknowledgments:

Special Thanks To:

The DAVIS Project Team

Grant Rogers at Cannon Design

Episcopal High School Project Team

Andy Mackey –AE Grad Student

PACE Industry Members

My Family and Friends

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3.0 PROJECT OVERVIEW

3.1 Introduction

Episcopal High School (EHS) is one of the premier private high schools in the nation, distinguishing itself among the most prestigious academic and athletic facilities. Red-brick façades and large white entrance colunms are a consistent theme among the buildings on the EHS campus. The existing Centennial Gymnasium was constructed over 75 years ago to reflect these classical design features similar to those of Thomas Jefferson. Cannon Design carried these key architectural features into the new Centennial Gymnasium addition, mirroring the entrance of the existing facility.

The new Centennial Gynmnasium addition will fill a void between the existing gymnasium and the Flippin' Field House (indoor track facility). A new auxillary gym with two full length basketball courts will be housed on the entry level of the new addition along with an athletics hall of fame and athletic department offices. The lower level of the addition will include team meeting rooms and locker facilities. On the upper level, centered around the two story atrium will be a 6,000 sq. ft. state-of-the-art fitness and weight center that will overlook the gymnasium floor. One of the main architectural features is the joining of the new addition to the existing Centennial Gymnasium with a two-story glass atrium.

Showing signs of use over the years, the existing Centennial Gymnansium and attached Wrestling Cage is to be completely rennovated with modern equipment and high-end finishes. The lower level of Centennial will house trainer facilities, laundry and equipment issue rooms and visiting team locker rooms. Making room for two full-size mats, the Wrestling Cage mezzanine is to be removed, expanding the facilities size and capability. Overall, the additions and alterations to the Centennial Gymnasium will meet the increased demand for updated training facilities and provide the school with a premier athletic center to hold competitions.

BUILDING NAME	Centennial Gymnasium
LOCATION	1200 N. Quaker Lane, Alexandria, VA
PRIMARY OCCUPANCY TYPE	Assembly group A-4 (gymnasium with spectators)
ACCESSORY OCCUPANCIES	Assembly group A-3 (gymnasium without spectators)
	Business Group B
	Educational Group E (K-grade 12)
	Storage Groups S1 & S2 (low and moderate hazard)
GROSS BUILDING AREA	99,044 SF
NUMBER OF STORIES	3 stories (half of lower level below grade)
CONSTRUCTION DATES	03/06/2009 - 09/03/2010
CONTRACTED GMP AMOUNT	$22,457,189
PROJECT DELIVERY METHOD	Design-Bid-Build with a CM Agency

Table 1: General Building Information

3.2 Project Location

The site for the Centennial Gymnasium addition, shown below in Figure 1, is located between two existing structures. The Flippin' Field House, located north of the proposed site, is the indoor track facility for the EHS athletic department. The existing Centennial Gymnasium, located south of the proposed site, currently houses all of the athletic department offices, as well as the basketball, volleyball and wrestling facilities. The new addition is designed to connect the two existing buildings to increase and improve the athletic department facilities. The main issue with the new addition site is the amount of existing utilities that cross the area. Gas, water, electric, storm and sanitary lines run through the site connecting several other campus buildings. Several of these utility lines will need to be re-routed prior to excavation of the new addition building pad. While public vehicular and pedestrian traffic is not a concern since the site is located on a private campus, the site is currently a main walkway for students/faculty and will need to be addressed during construction. See **APPENDIX A** for the existing conditions site plan.

Figure 1: Google Map of EHS Campus and Surrounding Area

3.3 Client Information

Episcopal High School is a private preparatory academy that pursues high performance in academics and athletics. Several years ago, the Board of Trustees identified the Centennial Gymnasium addition and renovation as the top facility priority for the EHS campus due to the outdated conditions of the existing athletic facilities. This project will allow the School to better meet the needs of the athletic department that supports 43 interscholastic teams (www.episcopalhighschool.org).

EHS has several key expectations for the expansion project. Walking around the campus, ***tradition and quality*** are common themes throughout all of the facilities. Carrying this into the new addition, EHS has selected high-end finishes for the Lobby and Trophy Hall of Fame area and extra attention has been given to detailed architecture/landscape design to uphold the rich traditions of the campus.

Given the nature of construction projects on school facilities, ***schedule*** is a major concern when discussing expectations. The project is slated to be completed over one full school year with multiple phases and occupancies to allow for continued use of the facilities throughout the construction process. All parties involved are committed to meeting the phasing needs of EHS and turning over a completed facility prior to the start of the 2010/2011 school year.

EHS is a private organization that is funded by "The Roll Call" foundation that supports all aspects of the School's operations. While ***cost*** is not the driving factor in the expectations for the Centennial Gymnasium addition, a detailed and concise budget is necessary to ensure that the project meets all of the needs for EHS and those who graciously donated to the foundation.

As with all projects, EHS and all of the firms involved have committed to design, construct and maintain a ***safe*** facility. All necessary regulations and codes have been followed to ensure a sound design of the gymnasium. EHS and DAVIS Construction have worked together to implement a logical and safe site plan that separates construction activities from pedestrian/vehicular traffic. No aspect of quality, tradition, schedule or cost is more important than ensuring the safety of all individuals involved in the construction process.

As described in the Project Summary Schedule section, a detailed 3-phase sequencing process has been developed for the Centennial Gymnasium project to ensure that EHS has access to certain areas throughout the entire schedule. There are four distinct turnover dates that allow the athletic department to relocate equipment, personnel and athletes without losing functionality of the facility. It is key for DAVIS Construction to understand this complex phasing plan and closely manage the process to ensure that EHS is able to continue with day-to-day activities during the construction schedule.

3.4 Project Delivery Method

The project delivery system for the Centennial Gymnasium project, shown below in Figure 2, is a ***DESIGN-BID-BUILD with a CM AGENCY***. DAVIS' contract for general contractor services is a negotiated guaranteed maximum price. Due to the incomplete design at the time of the bid, the GMP allowed for contingencies and allowances to encompass any additional costs related to design changes and additions. The presence of a CM Agency is appropriate since the EHS School Board does not have the time or expertise to manage a large scale project effectively. Contracting with APM allowed for advice during the preconstruction phase and sound management and supervision throughout construction. All of the subcontracts held by DAVIS are lump sum contracts awarded to the lowest, prequalified bidder.

DAVIS is not required to submit a bond to the owner for this project. Instead, EHS has requested that only certain subcontractors (selected by EHS) must submit a bond to DAVIS in lieu of a contractor bond. This system was developed to minimize the amount of bonds paid for by the owner. EHS is carrying the Builders Risk Insurance and DAVIS is carrying the General Liability Insurance for the project.

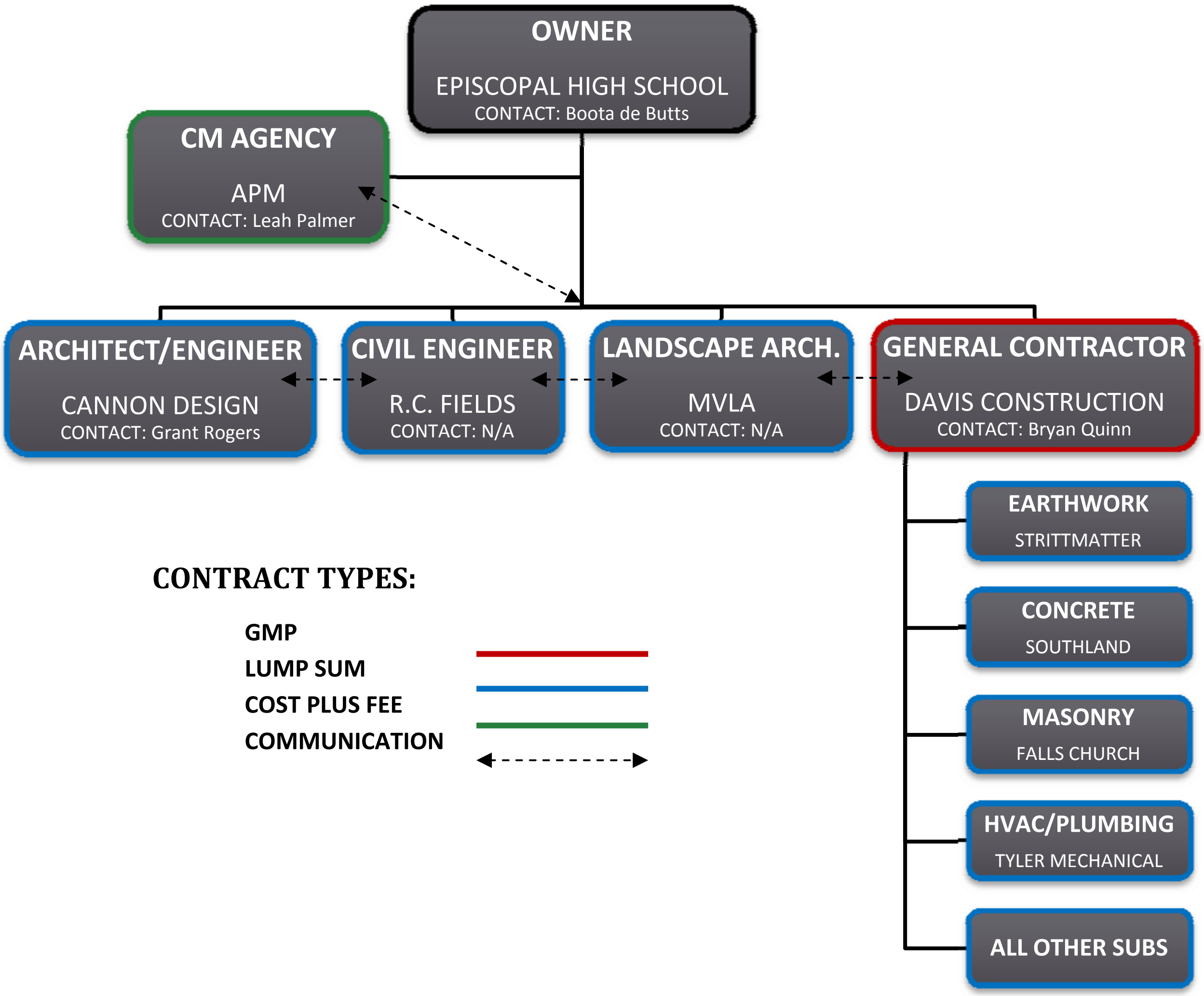

Figure 2: Project Organizational Chart

3.5 Project Team Staffing Plan

DAVIS Construction staffs their projects based on project size. The standard staffing plan for DAVIS, which includes a project manager, superintendent, assistant project manager and a layout engineer, is shown below in Figure 3. This particular project only had one management team given the size and complexity. At DAVIS, a project executive oversees 3-4 project teams, and the vice president will manage an entire group, which may include 8-10 project teams. Each project team may manage an entire project, as is the case for Centennial Gymnasium, or a group of divisions within a larger project.

On this project, the management staff (VP, PX, PM, APM and intern) is located at the office headquarters. The field staff (superintendent, layout engineer and laborers) is stationed at the jobsite in a field trailer. Typically, the management staff visits the site 2-3 times a week for progress meetings, safety inspections and conflict resolution.

Aside from the project specific staff shown above, DAVIS has a safety department that assigns safety managers to monitor a group of projects on a weekly basis. There is not a safety manager assigned solely to the Centennial Gymnasium project, therefore a majority of the daily safety related issues are handled by the superintendent.

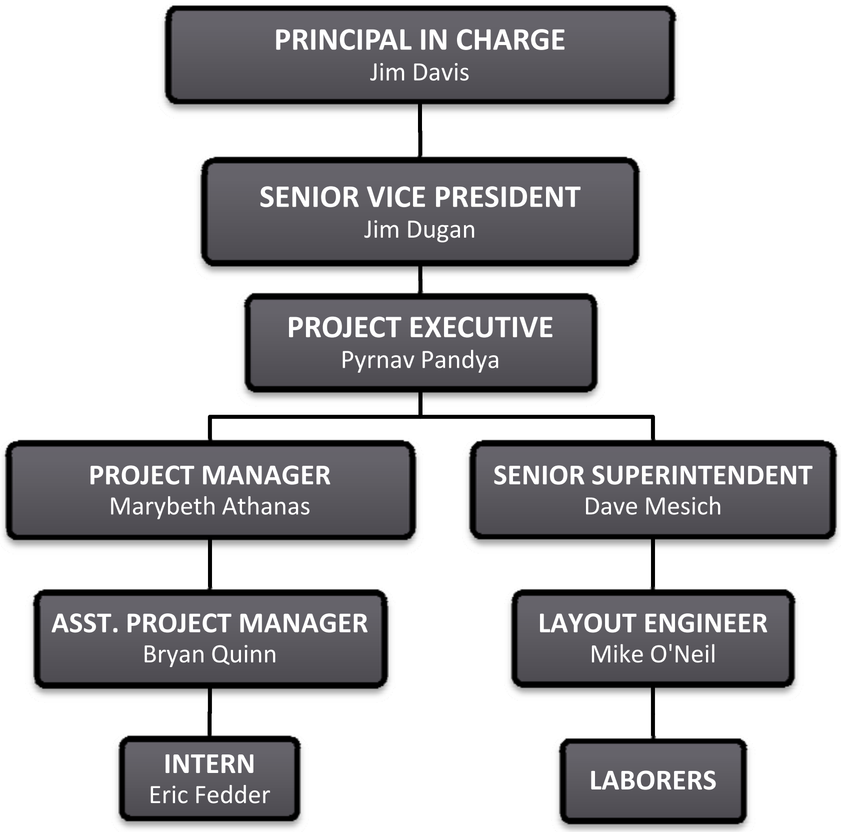

Figure 3: GC Staffing Plan

4.0 DESIGN AND CONSTRUCTION OVERVIEW

4.1 Building Systems

4.1.1 Demolition

Approximately 39,000 SF of demolition is required prior to the renovation of the existing Centennial Gymnasium, Fitness Area and Wrestling Cage. Types of materials found in this area of demolition include plumbing/electrical fixtures, furniture, interior wall assemblies, bleachers, locker facilities, basketball equipment and select structural elements to make way for the expanded mechanical room. The wood floor in the existing gymnasium is to be removed and the under slab prepped for new work. There is no asbestos in any of the demolition areas; however, lead paint covers several door frames and entry walls in the existing Centennial Gymnasium and will need to be removed prior to demolition. The 22 large bay windows on the North, East and West elevations of the existing Centennial Gymnasium are to be removed and prepped for installation of new window assemblies. In all, close to 50 fenestrations (includes doors, windows and louvers) are to be removed from the exterior elevations of the existing buildings and replaced with high performance assemblies.

To make way for the new gymnasium addition, the 1.1 acre site between the existing Centennial Gym and Flippin' Field House had to be cleared of large trees, brick/concrete sidewalks, the North Stair tower of existing Centennial and a metal canopy. Also, this area houses several utility mains including storm, sanitary, electrical and water. All utilities must be relocated and a 100' long, 5' deep steam tunnel demolished prior to excavation of the building pad. A new transformer and electrical duct bank is to be installed by Dominion Virginia Power prior to removal of underground electrical lines to ensure power is maintained at all adjacent existing buildings.

4.1.2 Foundation System

The subsurface foundation for the new gymnasium addition is to be an aggregate pier soil reinforcement system. The piers are 2 ½' in diameter and filled with compacted #57 stone. 297 piers are to be installed to an average depth of 14' in order to support the building loads on the concrete footings that have a 5000 PSF net allowable bearing pressure. Concrete grade beams ranging in size from 12-27" wide by 25-81" deep will support a 5" slab-on-grade with 23 lbs./CY of blended fiber reinforcing. All foundation walls are designed to be retaining walls and have heights ranging from 3'-0" to 15'-0". All pier caps, footings and SOG are to be 3000 psi normal-weight concrete, while the foundation walls and grade beams are to be 4000 psi normal-weight concrete.

4.1.3 Structural Steel

While the majority of the structural system is cast-in-place concrete, there are several structural steel elements in the Centennial Gymnasium project. The six large white columns at the West entrance to the new addition house two-story tall HSS8x8x.25" steel columns with W12x14 beams spanning 13'-0" from the columns to the bearing wall. At the expanded mechanical room area, four HSS6x6x.25" columns support W18x35 beams for the rooftop AHU's and cooling towers. Inside the Wrestling Cage area, a two story mat-lift hoist will be supported by 4'-0" HSS5x5x.25" beams connected to three HSS6x5x3/8" columns.

The largest structural steel element on the project is the 107' roof trusses spanning the two story gymnasium. Between each truss will be W8x18 braces spaced to allow for all MEP lines to pass through the structure above the bottom chord of the truss. The roof of the new Centennial Gymnasium will be ER3.5A 18 gage G90 galvanized metal decking supported by the trusses above the open gymnasium portion, and 1 ½" x 18 gage G90 galvanized metal decking supported by W14x22 beams over the remainder of the addition. On top of the metal decking will be 18" wide standing-seam metal panels with high performance two-coat fluoropolymer finish system to minimize the heat island effect and contribute to the LEED certification. All of the structural elements will be erected by the same tower crane being used for the cast-in-place concrete placement. The crane model is Comansa #21LC290 with a rated capacity of 10,140 pounds. At a height of 100', the crane is located along column line 5 at the West end of the new addition and can reach the entire building structure with the 177.1' boom.

4.1.4 Cast-In-Place Concrete

Reinforced cast-in-place concrete is the main structural system for the new addition. The majority of the columns are 18"x18" with 4000 psi normal-weight concrete. The floor slabs are 9 ¼" thick one-way slabs supported by concrete spandrel beams with an average depth of 1'-6" and average width of 1'-0". Both the slabs and beams are to be 4000 psi normal-weight concrete. A unique feature of the CIP concrete system is sixteen 12" round, exposed columns that run along the South side of the new gym addition. Special type 'A' formwork and placement strategies must be used to achieve the specified finish for these elements. A tower crane and bucket will be utilized to place concrete for all footings, foundation walls, columns and beams. The SOG and elevated slabs will be placed with a concrete truck and pump. All concrete materials will be recycled in a separate container as part of the construction waste management program for LEED certification.

4.1.5 MEP Systems

There are two mechanical rooms located on the lower level of the existing Centennial Gymnasium in the current fitness room area, and a third mechanical room located on the upper level of the new addition adjacent to the gymnasium. The overall system is an air-water AC system with the primary air supplied by air-handling-units and secondary air circulated by terminal/fan coil units. There are two AHU's and one cooling tower located on the roof above the lower level mechanical room, and five AHU's located inside the building. AHU 1 is a glycol run-around heat recovery system with 100% outside air. The rest of the AHU's operate with a VAV mixed air system. One 572 GPM centrifugal chiller is located in the lower level mechanical room and provides the chilled water for the AC system. Two 3000 MBH condensing boilers supply the hot water for the reheat/radiation system. Single line ductwork distributes the treated air to the individual spaces, while hydronic piping transports water to the terminal units. The entire new addition and renovated area will be completely sprinklered with a wet-pipe system. An existing 480Y/277, 3-phase, 5-wire, 60 hertz feed will be supplied by Dominion Virginia Power Company for the electrical system. There is no back-up generator specified for the project, however battery back-ups are to be provided for the emergency fire alarm system. The lighting for the Centennial Gymnasium project includes several types of fixtures to accommodate the many different areas throughout the facility. All fluorescent fixtures have high-powered electronic ballasts unless otherwise noted. The main area lighting fixtures are as follows:

- **Locker Rooms:** 4'-0" 277V fluorescent pendants
- **Team Rooms:** 2'x2' 277V recessed fluorescent fixtures in the center surrounded by 6" 277V recessed, wet location downlight fixtures at the perimeter
- **Lounge:** 277V compact fluorescent flex linear cove system in the center surrounded by 8" 277V recessed downlight fixtures at the perimeter
- **Existing Gymnasium/Wrestling Cage:** 400W pulse-start hi-bay pendants with electronic ballast
- **New Gymnasium:** 4'-0" 277V fluorescent pendants
- **Fitness/Weight Area:** 8" 277V recessed downlights
- **Corridors:** 2'x2' direct/indirect 277V recessed fluorescent fixtures

4.1.6 Facade

The main building enclosure system for the exterior wall of the new Centennial Gymnasium is a modular "Delmarva" face brick backed by structural reinforced masonry bearing walls with 8" CMU's and air cavities. Structural steel lintels are to be utilized at interfaces with the existing structures to support the brick façade. Cast stone masonry sills are to be installed at all exterior windows with cast stone masonry clad units between the entry and upper level windows on the new gym addition. The general sequence for brick façade will be the East/South elevations followed by the North/West elevations. The scaffolding will be erected for the first phase and then repositioned for the second.

Connecting the new Centennial Gymnasium to the existing gymnasium is a two story glass atrium constructed of aluminum curtain wall framing with Solarban 70XL glazing. There is approximately 1500 SF of curtain wall designed by the Architect, Cannon Design. The stick-built system is to be erected by the installer with a 1/8 inch in 10 feet plumb tolerance and a 1/8 inch in 20 feet level tolerance.

4.2 Project Cost

The actual construction costs are based on the GMP tabulation provided by DAVIS Construction. The amounts are slightly altered and rounded for comparison purposes. All costs shown do not represent actual bid costs for the project.

PROJECT PARAMETERS

Square Footage of New Addition:	60,000 SF
Square Footage of Renovation Work:	39,000 SF
Total Square Footage:	99,000 SF

CONSTRUCTION COST (New addition and renovation work)

Actual:	$17,535,400
Per SF:	$177.13

TOTAL PROJECT COST (New addition and renovation work)

Actual:	$22,457,000
Per SF:	$226.85

MAJOR BUILDING SYSTEMS COST ESTIMATE (New addition and renovation work)

MAJOR BUILDING SYSTEMS		
SYSTEM	ACTUAL	PER SF
Cast-In-Place Concrete	$2,192,000	$24.14
Masonry	$2,016,000	$20.36
Structural Steel	$657,200	$6.64
Glass and Glazing	$1,529,400	$15.45
Mechanical/Plumbing	$3,868,500	$39.08
Electrical	$2,011,400	$20.32

Table 2: Major Building Systems Cost Estimate

4.3 Local Conditions

Episcopal High School is located at 1200 N. Quaker Lane in Alexandria, VA. Spread out over a 130-acre campus, EHS is approximately 10-minutes from downtown Washington, DC. The DC Metro area is commonly known for using reinforced concrete for structural systems on low to mid-rise buildings. Due to the private access of the campus, the project site has minimal impact on public vehicular/pedestrian traffic. The main concern is the high volume of student/faculty pedestrian traffic within the campus grounds near the Centennial site. As shown in Figure 4, the new addition (shown in yellow) is being constructed between the existing Centennial Gymnasium (building 20) and the Flippin' Field House (building 22). Minimal construction parking is available north of the Flippin' Field House (shown in blue). An on-site parking program will be implemented to monitor the amount of parking available for each subcontractor.

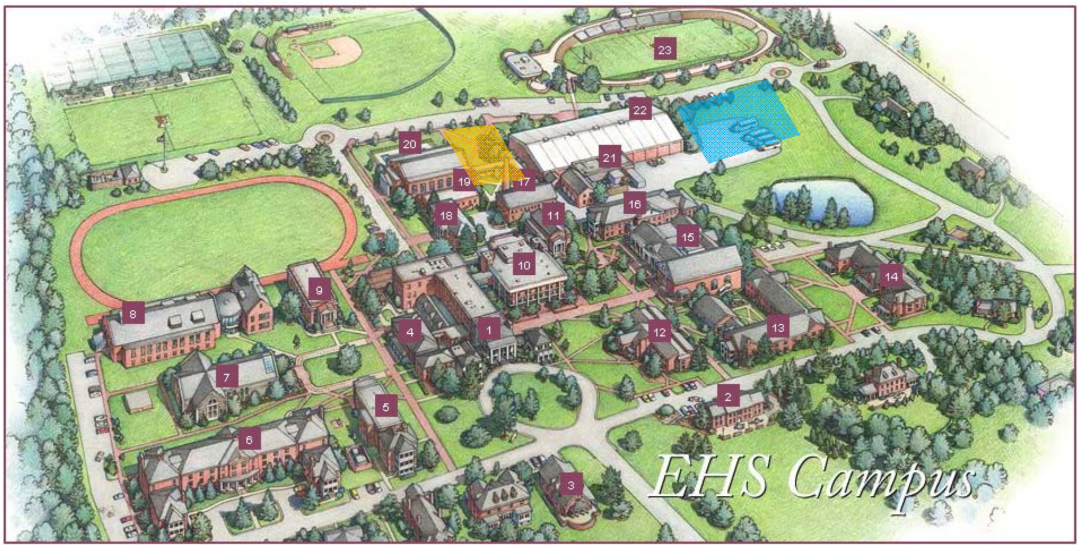

Figure 4: EHS Campus Map (www.episcopalhighschool.org)

The subsurface test borings for the site revealed 4-5 inches of topsoil followed by 3.5-6 feet of existing fill that is primarily moist clay. Below the topsoil and fill, the natural soils of site are comprised of a layer of coarse-grained sand/gravel and a layer of fine-grained silts/clays 10-18.5 feet below existing ground surface. Groundwater was recorded at depths varying between 8.6-14.4 feet below existing surface grades. The presence of the groundwater at these depths will require groundwater-control during installation of the deep foundations.

In the Alexandria, VA area, a standard co-mingled dumpster costs $350 per offload. A separated material dumpster (i.e. concrete, metal, etc.) will cost $280 per offload and tends to be slightly smaller in size. DAVIS estimated that on this project the co-mingled dumpster will need to be emptied once a week, and the separated recycled content dumpsters twice a week.

4.4 Detailed Project Schedule

A design competition for the Episcopal High School Centennial Gymnasium addition was held in the summer of 2006, culminating in the selection of Cannon Design and a schematic design submission in

March of 2007. Design development began in June of 2007 and construction documents started in January of 2008. Bid documents were delivered to the general contractor in October of 2008. This milestone is the beginning of the attached detailed project schedule in Appendix A.

When working on a school campus, the school year becomes a critical factor in the creation of a successful project schedule. The end of the 2008/2009 EHS school year was May 29, 2009 with graduation ceremonies held that weekend. DAVIS Construction was allowed to begin work three months prior to this date; however, full construction activities, including major demolition and excavation, where not to commence until all end-of-year school activities were complete. A great deal of utility relocation and erosion/sediment control phases had to be completed over this initial three month time span in order to be ready for excavation at the beginning of June. The 2009/2010 school year will be impacted by the construction of the new Centennial Gymnasium as well as the renovation to the surrounding buildings. Multiple turnover dates for critical areas, shown in Figure 5, were scheduled throughout the renovation process. The following dates were set as turnover milestones by DAVIS and EHS to allow use of certain facilities by the athletic department throughout the project duration.

Flippin' Field House: (Renovation)
Turnover to DAVIS: July 1, 2009
Turnover to EHS: July 22, 2009

Existing Wrestling Cage: (Renovation)
Turnover to DAVIS: April 20, 2009
Turnover to EHS: October 9, 2009

Fitness Area/Mechanical Room: (Renovation)
Turnover to DAVIS: October 1, 2009
Turnover to EHS: February 9, 2010

New Gymnasium: (New Construction)
Ground Breaking: June 15, 2009
Turnover to EHS: July 21, 2010

Existing Gymnasium: (Renovation)
Turnover to DAVIS: February 23, 2010
Turnover to EHS: September 3, 2010

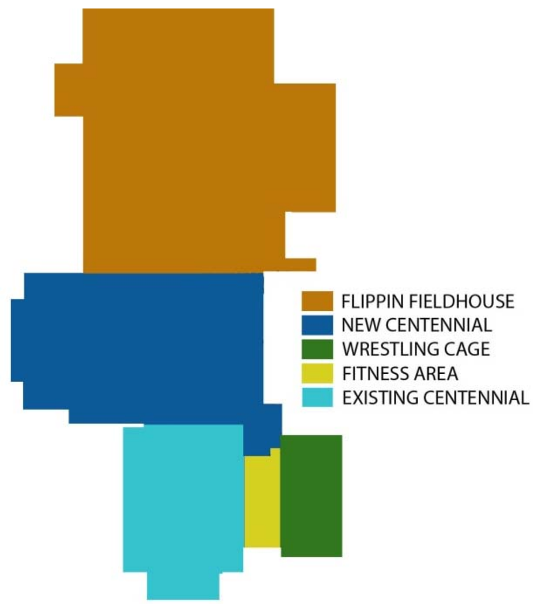

Figure 5: Turnover Phase Diagram

The entire Centennial Gymnasium construction and renovation project is slated to be substantially complete by August 4, 2010, nearly a full month before the start of the 2010/2011 school year. The punch list and commissioning processes will comprise the remainder of the project duration with the final overall project completion scheduled for September 3, 2010. See **APPENDIX B** for the detailed project schedule.

4.5 Site Layout Planning

The site for the New Centennial Gymnasium Addition is located on the campus of Episcopal High School between the existing Flippin' Field House and Centennial Gymnasium. As shown below in Figure 6, construction traffic has been restricted to using only the West campus entrance off of Braddock Road in order to eliminate the congestion and safety concerns at the main campus entrance on N. Quaker Lane.

All construction vehicles are restricted to the road directly West of the site and are permitted to use the round-about for turning around only. There is limited on-site parking for construction personnel. All subcontractors are required to have laborers park of campus and then shuttle them to the site. Site parking is restricted to GC/CM personnel and subcontractor foremen. Based on the detailed schedule, the project consists of two major phases: Superstructure and MEP/Interior Finishes. Most notable and of upmost importance to EHS during all construction phases is the mandatory tree protection area for the 100 year old tree located within the construction fence area.

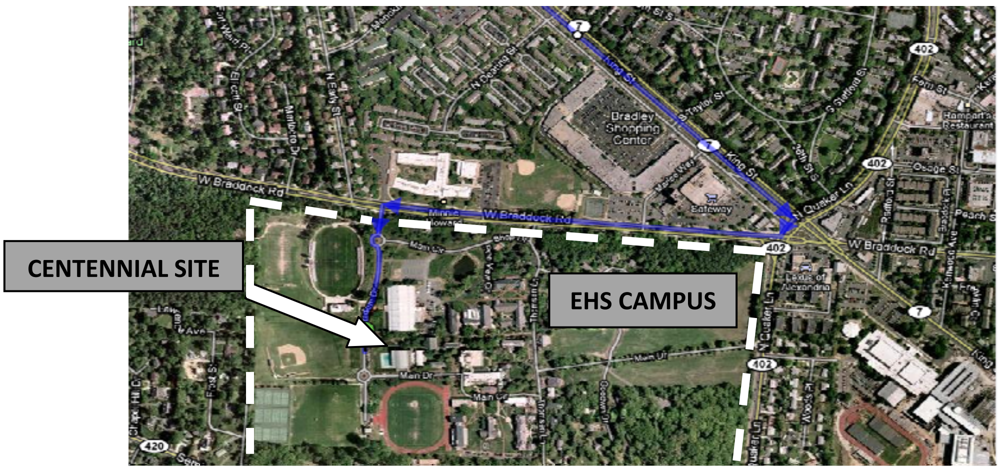

Figure 6: Google Map of Construction Traffic Route to Site

SUPERSTRUCTURE SITE LAYOUT

During the superstructure phase of the project, the site will be more congested than any other point during construction. The concrete, steel, masonry, mechanical and electrical subcontractors will all be present on site with field trailers and storage facilities. A 180' boom tower crane will be stationed within the building footprint to be used for all concrete, steel and masonry work. There will be two main concrete pump locations located on the East and West sides of the new addition and plenty of material storage areas allocated for each of the major trades. Adjacent to the new addition site, the existing Wrestling Cage will undergo renovation at this time. The existing Centennial Gymnasium will be occupied during this phase and require egress protection. See **APPENDIX C** for the superstructure phase site plan.

MEP/INTERIOR FINISHES SITE LAYOUT

The transition from the superstructure phase into the MEP/interior finishes site layout is characterized by the removal of the tower crane and loss of the majority of the site due to hardscaping and landscaping activities. During this phase of construction, the majority of the material storage is inside the building, with only the mechanical and electrical subcontractors having field trailers. The main workflow path will be from West to East utilizing the New Centennial main entrance as the access point for material and labor. At the same time as the interior work on New Centennial, existing Centennial Gymnasium will undergo its renovation. The adjacent Wrestling Cage will be occupied at this time and require egress protection. See **APPENDIX C** for the MEP/interior finishes phase site plan.

4.6 General Conditions Estimate

The estimate summarized in Table 3 below shows a representation of the costs for the general condition line items on the Centennial Gymnasium project. These numbers are an approximation and do not reflect the actual amounts contracted between DAVIS Construction and Advanced Project Management.

LINE ITEM	UNIT RATE	UNIT	QUANTITY	COST
Supervision and Personnel	$14,451.33	WEEK	75	$1,083,850.00
Construction Facilities and Equipment	$1,974.77	WEEK	75	$148,107.50
Temporary Utilities	$1,546.50	WEEK	75	$115,987.50
Miscellaneous Costs	$3,517.00	WEEK	75	$263,775.00
TOTAL:	**$21,489.60**	**WEEK**	**75**	**$1,611,720.00**

Table 3: General Conditions Estimate Summary

The estimate was broken down into four categories: Supervision and Personnel, Construction Facilities and Equipment, Temporary Utilities and Miscellaneous Costs. ***Supervision and Personnel*** includes the entire management and support staff for the project, such as the Vice President, Project Managers, Field Supervisors and labor. The ***Construction Facilities and Equipment*** category incorporates items such as the field office trailer, storage containers, tools, dumpsters, construction fence, etc. Allocation for the temporary utilities on the project is difficult to determine due to the renovation portions of the project. Certain areas of the construction phases are utilizing existing utilities supplied by EHS. The majority of the new construction phase will rely on temporary utilities provided by DAVIS. The ***Temporary Utilities*** includes installation and service costs for field LAN/telephone lines, temporary power installation and consumption, temporary water/sanitary supply, and temporary toilet facilities. Finally, the ***Miscellaneous Costs*** accounts for items such as permits, document reproduction, travel expenses, etc.

As shown below in Figure 7, the supervision and personnel costs account for nearly 70% of the general conditions estimate, which is fairly typical for construction projects. The overall general conditions amount of $1.6 million is just over 7% of the total project cost of $22.5 million. See **APPENDIX D** for the general conditions estimate.

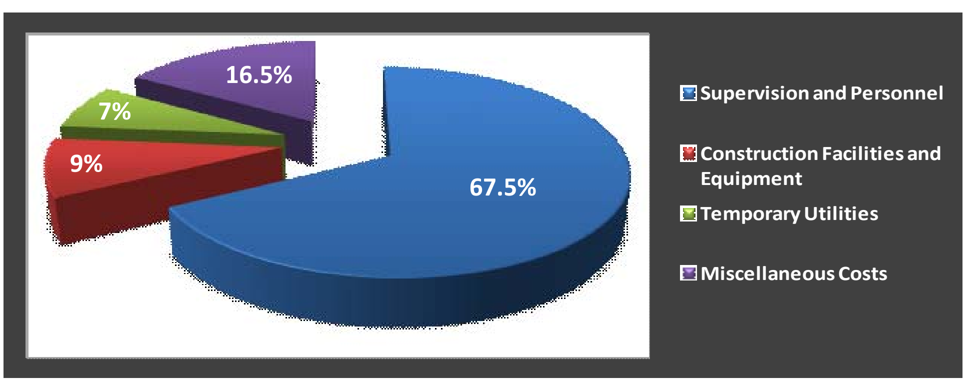

Figure 7: General Conditions Percent Break-Down

5.0 CRITICAL INDUSTRY ISSUE – Shift from Negotiated GMP to Lump Sum Contracts

5.1 Problem Identification

The Centennial Gymnasium project is a negotiated GMP contract, the preferred and standard contracting method for DAVIS Construction, who regularly deals with repeat clients using this contract strategy. However, due to the shifting economy and decrease in private sector work, DAVIS has been forced to pursue different markets to obtain other projects, such as public schools and government. These projects tend to be competitive lump sum bids and require a shift in strategies to procure the work from unknown clients. This shift has been met with many difficulties and failures due to inexperience with hard bid procurement strategies. Companies across the industry have been faced with this ***critical industry issue*** and continue to struggle in the current economic situation.

5.2 Research Goal

The goal of this analysis is to investigate the influences that shift companies from one market sector to another and assess the changes in strategies and factors of success/failure these companies encounter when pursuing work from the unknown clients and different procurement techniques.

5.3 Methodology

- Contact DAVIS Construction to receive data for a similar school project under lump sum contract
- Develop/distribute survey for industry members regarding market shift/procurement strategies
- Interview select industry members on key changes in company strategy due to shift
- Compare data for projects under negotiated GMP and those under hard bid lump sum
- Analyze key factors for success/failure when pursuing hard bid projects
- Draw conclusions with similarities among data collected
- Develop a summary of findings and provide possible guidelines for success when pursuing hard bid projects in the current economy

5.4 Background Information

Across the industry, companies have been forced to re-evaluate market strategies and business plans when analyzing future projects to pursue. Within the past 2-3 years, the normally reliable private sector work has practically vanished, leaving companies that thrive on this market no choice but to alter their focus on hard bid, public sector projects. Ultimately, whether public or private, hard bid lump sum or negotiated GMP, the building must be built and turned over to meet the owner's expectations. The process of constructing the building remains the same; however, the procurement and management of the project differs greatly. The clear differences between public and private sector projects can be found in the contract strategies and bidding process. Negotiated GMP contracts place a large emphasis on the owner-contractor relationship and rely heavily on trust among all parties. The hard bid lump sum environment minimizes the need for owner-contractor relationships and dictates the project in a clear, black-and-white manner. Both strategies have advantages and disadvantages; the key to success in either contract strategy is to be able to identify and align procurement techniques with these factors.

The following analysis is a qualitative description of interviews conducted with several industry members associated with PACE to identify and analyze successful techniques in the project procurement environment. Members were selected to provide a quality representation of company types, individual job titles and market specialties. Much appreciation and acknowledgement is owed to the following individuals for providing the time and insight that contributed to this analysis:

Mike Pittsman……………. DAVIS Construction
Mike Arnold……………….. Foreman Group
Barry Perkins………………DAVIS Construction
Jim Faust……………………..FaustFACT Consulting
Dominic Argenteri……….DAVIS Construction
John Bechtel………………. Penn State OPP
Michael Barnhardt…….. Forrester Construction

5.5 Factors Influencing Shifts in Strategy

Owners and contractors establish preferred contract types to pursue. Whether this is negotiated GMP or hard bid lump sum, a company decides to focus on a particular contract/market and specialize in this area. For the most part, this is a successful technique and allows companies to become well versed in a specific niche. However, companies are often forced to re-evaluate and shift focus to a different market and contract strategy. The factors that influence this shift are described below for both the owner and contractor perspectives.

5.5.1 Contractor

General contractors and construction mangers do not have the ability to dictate what contract strategy will be implemented on a project. This decision is set by the owner and design team early in the project conception. From the contractor's perspective, it is critical to identify factors that influence a company to shift market types, which often leads to encountering different contract strategies.

Economic climate and market forces are major factors that can shift a contractor to pursue different markets. A down economy tends to deter private sector work, which forces companies to expand into public projects. Projects such as schools, military and government facilities dominate the market during a drop in the economy. Pursuing a different market during a down economy can prove to be beneficial in many ways. Initially, the shift will provide work for the company during a time that other markets are not as active. This ensures financial stability for the company and employees during an otherwise unstable period. Aside from the immediate effects, expanding into different markets can have a long term benefit for the company. Staff development and company growth in new sectors will make the company more marketable in the future, allowing for continued expansion with new clients.

Pursuing a different market sector is not always triggered by a negative force on the company. Often, contractors will shift into a new market due to acquisition of new staff with market specific connections and experiences. Bringing on new talent that specializes in a different market type can provide opportunity for expansion and growth for the company, ensuring more stability during future economic down-turns. Occasionally, a contractor will shift to a different market to pursue work with a repeat client. Most often in this scenario, the preferred contract type would be negotiated GMP given the previous relationship between the contractor and owner.

5.5.2 Owner

In general, the owner has the freedom to select the type of contract strategy to implement on a project. Most entities have a preferred method and will utilize it from one project to the next. When a contractor is forced to enter a new market with new clients, it is helpful to understand what factors influence the owner to select a certain contract strategy. Understanding the owner's perspective may give a contractor a competitive edge when pursuing a project.

The main factor identified by all of the members interviewed is the financial status/requirements of the client. Owners are required to secure lending for the project, which can often dictate the contract structure and procurement technique. For example, a government funded school project within the state of Pennsylvania is required to implement a multiple prime, hard bid strategy dictated by the state legislature. Also, the current economy factors into the aggressiveness of the owner in terms of financial status. During a prospering economy, an owner may be more inclined to secure a preferred contractor early in the process to ensure that the best contractor is obtained from the market. In this situation, a negotiated GMP would be the contract strategy of choice. However, in a down economy, owners are pressured to meet strict budgets and forced to adopt a lowest-bid approach to secure the cheapest cost for the project. Obviously, this scenario aligns directly with a competitive hard bid lump sum contract.

Aside from the financial and economic influences, there are other factors that influence an owner's contract strategy. The level of confidence that the owner has with the design team can determine whether preconstruction services are required by the contractor. Typically, if an owner is not comfortable with the design documents, a CM/GC will be contracted early in the process to provide preconstruction services. The presence of the contractor provides the client with confidence that the design is constructible. More often than not, this contractor will then be contracted for the construction services through a negotiated GMP strategy.

5.6 Procurement Techniques

Depending on the market being pursued, i.e. public vs. private sector work, the contractor is faced with a different contract type while bidding and procuring the project. There are significant differences in the techniques used to pursue a hard bid lump sum project as compared to a negotiated GMP. Ultimately, the culture and mindset while executing the bid is completely different from one contract type to the next.

5.6.1 Negotiated GMP

A successfully negotiated GMP bid is centered on the ability to develop a relationship with the client and sell the companies culture and services. Since a negotiated contract is typically not awarded to the absolute lowest bidder, it becomes more critical to focus on effective site logistic plans, construction strategies, knowledge of the subcontractor market and innovative preconstruction techniques. Selling the companies benefit to the owner is key since selection is not solely based on the bottom-line pricing. Time and effort has to be directed towards the owner to showcase the company's strengths and convince the client that the project will be built to the best interests of all parties. To achieve this, often the contractor will provide information on previous projects built, track record of savings, testimonials of relationships with subcontractors and any other pertinent information that can set the company apart from the other competitors. A negotiated GMP contract provides a lot more flexibility for the contractor when selecting subcontractors and negotiating contingencies/allowances. This creates a situation where the contractor is more concerned with bidding the project based on quality and not solely the lowest price. The contractor is able to be more creative in preparing a bid package.

5.6.2 Hard Bid Lump Sum

The competitive, low price environment of hard bid lump sum contracts forces contractors to alter procurement techniques and focus time and energy differently during the bid process. The black-and-white nature of hard bid projects eliminates the contractor-owner relationship, therefore making it useless for the contractor to sell the company culture and additional services provided. The owner is strictly looking for the lowest bid that will complete the project on schedule. A hard bid contract does not allow any negotiation of contract terms and typically dictates the bid process and requirements. The major requirement identified from all interviews was that public sector hard bid projects often require subcontractors to be listed when the bid is submitted. This requirement reduces the ability for the contractor to negotiate after the bid is awarded, and ultimately forces the contractor to select the lowest subcontractor, even it is unsolicited. Quality can be compromised as a result since subcontractors will cut pricing just to win the bid. Since obtaining the absolutely lowest subcontractor pricing is vital to a successful competitive hard bid, establishing relationships and contacts with all available subcontractors is critical. The contractor has to know every available price for each trade, which requires time and energy spent on contacting vendors and suppliers to determine the subcontractors that are in fact bidding on the project. Not having the lowest subcontractor pricing on a specific trade can be the difference between winning and losing the overall bid. Unfortunately, this cut-throat state of mind shifts the focus from overall project success to individual security. In the words of Mike Pittsman from DAVIS Construction, “Hard bid projects set up a look at yourself mentality, everyone is concerned about their own success.”

5.6.3 Cost, Duration and Award Rate

It is important for the contractor to allocate and budget the amount of cost and time necessary to develop a successful bid package. Through discussions with the industry members, the general consensus was that the overall cost of preparing a bid does not vary significantly between negotiated GMP and hard bid contracts. It is difficult to pinpoint an exact percentage of contract amount or lump sum cost for this process, since it varies significantly from one project to the next; however, 1-5% of the contract amount was the target range provided for the cost of estimating and preparing the bid package. The actual price is affected by project type, project size, complexity and bidding requirements. The one point of interest found was how the cost was distributed during the bid process. In hard bid projects, the lump sum amount for preparing the bid was a one time cost for estimating and obtaining pricing. However, a negotiated GMP contract often requires two separate phases for bid preparation. The initial qualification phase includes literature decsribing technical services provided, company information, site logistics, etc. This can range from 15-30% of the overall bid cost and is often required in the first 1-2 weeks of the bid period. Once the qualifications are met, the remainder of the bid cost is spent to estimate, obtain pricing and formulate the final GMP. Ultimately, the overall amount spent is similar to a hard bid project.

As described above, the hard bid lump sum process is a one step process that requires a quick estimate, subcontractor pricing and final bid submimssion. Typically, this is accomplished in a 2-4 week period, which creates a fast paced, stressful atmosphere. This timeframe can be increased depending on the amount of addendums issued during the bid process. In some instances, the bid period can be extended upwards of 8 weeks due to incomplete or inaccurate drawings. In general, the larger the project, the more estimators and bidders involved with the process. It is critical for the company to allocate the proper staff to manage and prepare a detailed bid to provide the best chance of winning the project. Conversely, a negotiated GMP contract requires a two step process that typically takes a longer period of time. The initial qualification phase can be accomplished in 1-2 weeks. Once completed, the negotiation of the GMP can last upwards of 1-1.5 months, depending on complexity and owner urgency.

It is clear to see that the hard bid projects require roughly the same amount of money to bid in a significantly shorter duration. Contractors are finding that an award rate of 1 in every 6 submitted bids is acceptable for hard bid projects. This means that the cost of bidding the five lost projects has to be absorbed by the one awarded contract. It is criticial for the company to manage this process, as too many submitted bids without awarded projects will increase estimating overhead. However, too selective of bidding will require the contractor to take financial risks with lower fees just to ensure winning the project.

5.7 Associated Risk

A critical element in determining the success of a bid is anticipating and identifying the amount of risk associated with pursuing the project. Risk can be distributed in many different ways among the involved parties depending on project and contract type. In general, the larger the amount of risk assumed, the larger the ending profit, but also the greater the chance of failure.

5.7.1 Owner

Project risk is not solely associated with the general contractor. The owner assumes a level of risk in terms of quality of drawings and incorporation of building elements in the final pricing. It is critical that the owner is confident that the construction drawings are complete and accurate. In a lump sum contract, there is no owner/design contingency built into the final pricing. All discrepancies are dealt via change order, which can prove to be extremely costly and detrimental to the overall project success. Typically, owners distribute this risk by wording contracts in a manner that covers all potential omissions and discrepancies. For example, a common agreement will state that the owner is owed “the more stringent, the item of better quality or the item of greater quantity.” If the drawings call for one level of quality in one section, but a greater quality in another, the contractor owes the owner the higher quality item regardless of whether the contractor noticed the discrepancy in the construction documents or not. Items such as this require the owner to cover all bases when dealing with a lump sum contract.

Owners do not allow contract modifications in a typical hard bid lump sum scenario. Again, this assures that the wording of the agreement is in favor of the owner. Ultimately, a hard bid lump sum approach carries almost zero risk for the owner since they are getting the lowest price and expect the contractor to include everything in the submitted pricing. Some industry members feel that overall quality can be an associated risk for the owner under a hard bid lump sum contract. This method pressures contractors and subcontractors to build the building the cheapest way possible, which often means cutting corners and substituting for lower quality products. To combat this, owners typically employ third party inspectors to monitor construction processes to ensure quality expectations are met. Also, all proposed product substitutions typically have to be submitted prior to the bid date. Any substitutions after the bid date are subject to extensive review and rejection by the owner and the architect.

Liquidated damages are another tool that the owner utilizes to distribute risk throughout the project entities. Under lump sum contracts, the liquidated damages are clearly stated in the contract and followed as expected. However, negotiated GMP contracts introduce the relationship aspect and can alter the implementation of the stipulations. Often, the liquidated damages are simply used as a pressuring tool to ensure completion of the project and can be negotiated if issues arise. The relationships formed during the negotiation and construction processes allow for a potentially relaxed approach on liquidated damages.

In general, hard bid lump sum contracts allow owners to push risk to the other project entities, and assume very little for themselves. In contrast, a negotiated GMP contract allows for risk distribution and a more open book approach. Owners are more willing to modify agreements and allocate risk fairly among the project.

5.7.2 Contractor

A hard bid lump sum contract is clearly a much riskier venture for the contractor. Most hard bid lump sum projects require the contractor to submit a bond at bid time equal to the cost of construction, ensuring that the company is financially capable of covering the project. When submitting the bid, the contractor is locking themselves in to providing the building at the estimated cost. There are no contingencies or allowances to cover missed items or estimation errors. To be successful, it is essential that the contractor knows every detail of the project and includes all necessary pricing in the bid. Obviously, this is difficult to do and there are always items missed. This pushes the contractor to be very aggressive with change orders during the construction process and often strains an already shallow relationship with the owner. Also, hard bid lump sum contracts force contractors to push risk onto the subcontractors. This reduces the overall amount of risk assumed by the contractor, but strains relationships with the subcontractors.

As expected, a negotiated GMP contract reduces the associated risk for the contractor. A key reason for this is that the contractor can build in contingencies and allowances to cover any missed items or areas that need more design. Preconstruction involvement allows the contractor to gain comprehensive knowledge of the project and identify any potential changes or discrepancies that need to be allocated for in allowances. This in turn reduces the amount of risk that the contractor has to pass on to the subcontractor, which encourages a more open relationship and higher quality of work. As described above, negotiated GMP contracts are typically allowed to be modified, therefore giving the contractor an opportunity to word the agreement in terms that share the overall project risk. Another, major aspect of a negotiated GMP contract that affects the amount of risk assumed is the timing of the agreement. Owners try to get contractors to lock into a price as early as possible, which can be very risky for the contractor. Ideally, a GMP is agreed upon around 75% construction document completion. This allows the contractor to feel confident on the details and design of the project and gives the owner a set price to pursue financing.

5.8 Influence on Relationships

Negotiated GMP contracts place a large emphasis on the relationship formed between the contractor and the owner. In many cases, an "open book" atmosphere is developed, which encourages open communication and review of all subcontract approvals and agreements. Relationships tend to start out favorably and, barring any major project issues, end favorably on a negotiated GMP project. The value of pursuing a good relationship with the owner is much higher in this contract type. Often times the contractor is looking to continue working for the owner on future projects; therefore establishing a sound working relationship is key to the future success of the company. Relationships formed with owners and developers are major business development tools for contractors, and quite possibly the most beneficial when dealing with repeat clients that prefer negotiated GMP contract structures. Typically, a negotiated GMP project eases the strain between the contractor and the subcontractor. Both parties are able to collaborate and draw from the available allowances/contingencies in order to provide the building as specified.

Hard bid lump sum projects have a completely different value on relationships. The general black/white, straightforward nature of the project is strictly driven by the contract documents, i.e. construction drawings, specifications, contract agreement, etc. Subcontractors are bound to provide the building as specified with no exceptions. This forces contractors to have an aggressive stance when dealing with subcontractor materials and installation methods, which can put a major strain on the relationship between the two parties. Money is the bottom line motivator on a hard bid lump sum project. The owner expects the building to be provided as specified for the lowest cost possible. The contractor may have underbid portions of the project and will fight to recuperate as much as possible through change orders. Subcontractors are pressured to meet all quality expectations for the cheapest price possible. Throughout all of this, the projects tend to be run with a "closed book" mentality, which emphasizes the "look at yourself" approach in which everyone involved in the project is more concerned with their own well being instead of the overall project success. Relationships become very strained and tenuous on hard bid lump sum projects. The value of a good relationship is much less significant in this contract structure as compared to a negotiated GMP contract since the contractor is not concerned with future business development. The owner will simply hard bid the next project and it will be awarded based on the price and not past experiences.

5.9 Success Factors for Hard Bid Lump Sum Contracts

Each of the industry members interviewed provided insight into what has been identified as factors and techniques leading to successful projects under hard bid lump sum contracts. This is by no means an exhaustive list of factors; there are numerous variables and unique factors from one company to the next that contribute to a successful bid process. These are simply the techniques that were identified as being the most influential from the industry members involved in this analysis.

5.9.1 Contractor Knowledge

It is vital that the contractor is familiar with the type of construction involved in the project (i.e. medical, education, government, etc.). Since hard bid lump sum projects do not typically have a preconstruction phase, the contractor must take the time to completely understand the construction documents and become familiar with every detail of the project. This is the only way that the project will be properly estimated and the best chance of an accurate bid price. Unfortunately, the quality and level of detail provided in the documents can affect the success of the contractor in this area. Also, the contractor has to be willing to put in the extra effort to formulate logical site utilization plans and accurate schedules that meet the requirements of the client. Many of these details are common between hard bid lump sum and negotiated GMP contracts, however the difference is that many times a contractor is involved in preconstruction activities prior to the formulation of the GMP and is able to gather extensive knowledge about the project during this phase. In a hard bid lump sum atmosphere, the contractor has to put in the effort during the bid period.

5.9.2 Subcontractor Pricing

Quite possibly the most influential factor that determines the success of a hard bid is the pursuit of the right subcontractor and absolute lowest price for each trade. This sounds straightforward, but in practice it tends to be extremely difficult. A contractor must reach out for pricing to the standard list of subcontractors that they prefer to work with and also identify any other subcontractor that may be providing pricing to other companies. This can be done by contacting vendors and suppliers and obtaining a list of all subcontractors that have submitted quotes for a given project. The contractor can then contact the subcontractor and request a bid for the given trade. This is not a straightforward process, and requires a lot of behind the scenes work by the contractor to track down all possible pricing. The more time and effort put into the pursuit of the lowest subcontractor bids, the higher the chance of formulating the most competitive hard bid price for the project.

5.9.3 Subcontractor Partnerships

It is common for subcontractors to provide discounted pricing to contractors that they prefer to work with, or have had favorable experiences with in the past. Formulating subcontractor partnerships will give a contractor a competitive advantage and the opportunity to submit a lower bid for a given trade. Often, subcontractors will provide a contractor a price for a given trade and then submit a higher price to a competing contractor for the same bid. Establishing relationships with the subcontractor is key in developing these partnerships. The most effective way to establish a partnership with a subcontractor is to be fair and straightforward when working on a project and be loyal when soliciting subcontractors for bid pricing.

5.9.4 Contractor Aggressiveness

Ultimately, the contractor has the ability to determine the final bid amount for the project. It is common for the chief bidder to cut subcontractor bids by 2-5% minutes before the bid is due solely based on gut instinct. While this can increase the chance of winning the bid, it creates a tenuous relationship between the contractor and subcontractor, as there will be constant cost cutting and pressuring throughout the project to try and reduce the subcontractor to the lower cost. Also, contractors determine the associated fee for the project. In a normal economy, fees can range from 3-7% of the contract amount. However, in down economies with increasing competition, contractors have been known to reduce fees to less than 1% just to win the project. The level of aggressiveness from the contractor can be a powerful tool during the bid period and can also greatly influence the success of the project all the way through completion of the building.

5.10 Benefits

5.10.1 Negotiated GMP

A fair negotiated GMP contract provides the smoothest project experience with a higher quality of team collaboration. All parties involved in the project are willing to work together for the better of the project. The relationship between the owner and the contractor allows for contract negotiations and open book accountability. This environment tends to provide less change orders and more flexibility in subcontractor buy-out. The GMP enable allowances and contingencies to be built in, which provides a better understanding of total project cost and less disputes during construction. In general, a negotiated GMP contract requires less associated risk for the contractor and the ability to modify the contract language. A successful negotiated GMP project tends to provide contractors with repeat work with satisfied clients. All of the industry members interviewed have had experiences with both contract types. It was clearly evident among all individuals that a negotiated GMP contract provides for an all around better project experience in terms of project success and team morale.

5.10.2 Hard Bid Lump Sum

A competitive hard bid lump sum project is beneficial for the owner since it guarantees the lowest cost for the project on day one. The owner knows the cost and can budget accordingly. Typically, the increased competition drives down the cost of construction for the owner. For the contractor, hard bid lump sum projects are good opportunities to enter new markets without any previous experience or solid qualifications. There is a chance for a lot of profit to be made on lump sum projects since there is not cost auditing or shared savings between owner and contractor. Of course, this does come with higher associated risk on the contractor and a more stressful work atmosphere.

5.11 Contract Case Study

To further investigate the characteristics of negotiated GMP and hard bid lump sum contracts, one project under each contract type was analyzed to compare bid requirements, contract language, terms of agreement and project success. The EHS Centennial Gymnasium was used for the negotiated GMP study and Woodgrove High School was selected for the hard bid lump sum analysis. Both projects are being built in Virginia by DAVIS Construction and are currently under construction. Although size and scope of the projects do vary slightly, it was decided that the fact that they are both school projects being constructed at the same time in the same general area makes for a solid case study. The following study is the result of comparing the bid process, bid documents and contract terms for the two projects.

5.11.1 Episcopal High School – Negotiated GMP

The bid process for the New Centennial project began in July of 2008 when an RFP was sent out to four contractors in the DC metro area that have established a respected working relationship with EHS and the project management company on the project. The RFP did not contain any contract language or bid terms. The intent was to select the best proposal based on a combination of qualifications, general conditions and fee. There were no construction costs to be included in the original proposal. About a week after submission, DAVIS Construction was selected to partake in an interview/presentation process where they fielded questions about fee, previous work experience and general project strategies. In one of the interviews, the president of DAVIS offered a performance fee technique in which EHS could withhold $100,000 of the contractor fee until the end of the project. At that time, if EHS felt that DAVIS performed above expectations for the project then DAVIS would be awarded the $100,000. If EHS was not satisfied with the performance, they could keep the lump sum amount. This strategy was a technique that relied heavily on the previously established relationship with EHS. In September of 2008, DAVIS was awarded the Centennial Gymnasium project.

After being awarded the project, DAVIS completed in-house estimates for the construction costs. In mid-November, they began the subcontractor bid process, which led to the first GMP proposal submitted in early December. This proposal included the agreed upon fee from the RFP and the solicited subcontractor pricing. Over the next two months, DAVIS and EHS went through contract and GMP agreements, resulting in 8-pages of modifications and alterations. In February of 2009, the GMP contract was negotiated and the terms finalized. The contract did not require DAVIS to submit any bonds for the project, including a performance and payment bond. EHS felt that this was an unnecessary expense do to the established relationship with DAVIS. The subcontractor buy-out process was managed by EHS in the sense that they dictated that the lowest submitted bid was to be awarded the contract; however, DAVIS did have the ability to recommend preferred subcontractors that could closely match the lowest price. The project management team and EHS ultimately made the decision on whether or not DAVIS could award the subcontractor the project.

To date, there has been approximately $725,000 worth of approved change orders on the project. This value is constantly fluctuating since some change orders are an expense to EHS and others are a credit. The overall project savings clause states that 75% is to go to EHS and 25% to DAVIS.

5.11.2 Woodgrove High School – Hard Bid Lump Sum

Woodgrove High School is a $51,000,000 education facility being constructed by DAVIS in Purcellville, VA. The dates of construction match those of EHS: February 2009 – August 2010. The client is Loudoun County Public Schools (LCPS); therefore the project is completely funded by tax payer money. LCPS was strictly concerned with completing the project on time and for the absolute lowest price. For this reason, the competitive hard bid lump sum strategy was appropriate for this project. The delivery method for this project is design-bid-build.

LCPS did not pre-qualify contractors prior to the bid period. The project bid date was publicly announced and any contractor that was interested could purchase the bid documents from the architect. The only requirement was that a contractor had to sign a waiver and submit payment for the documents. The bid instructions and requirements were 245 pages long and included as part of the provided specifications. The bid was set as a competitive lump sum where the absolute low number was awarded the project. In all, there were ten contractors to bid on the project. The bid documents specified that the contractor must provide a bid bond on the day of the bid and provide proof that a payment and performance bond for 100% of the project cost would be provided. The contract language dictated that bid clarifications and contract modifications were not allowed and the bid would be deemed non-compliant and disqualified if submitted with modifications. LCPS stipulated that any proposed substitutions had to be submitted at least ten days prior to the bid date, and that no substitutions would be accepted after the bid date unless specified in the construction documents.

One of the major items specified in the bid documents was the requirement to name subcontractors intended to perform work in the major trades. The specialties were required to be named as follows:

On bid date:

- HVAC
- Plumbing
- Electrical
- Sprinkler System
- Site Work
- Site Utilities
- Structural Steel
- Masonry

Within two days from the receipt of bid:

- Casework
- Flooring
- Roofing
- Temperature Control and Energy Monitoring System

Once the contract was awarded and executed, the winning contractor was required to submit to the architect all remaining subcontractors proposed to complete the work. This requirement binds the contractor to use the absolute lowest subcontractor and vendor for each trade and eliminates the possibility to negotiate pricing after the contract is awarded. After the bid submission, any change in subcontractors used has to be approved by the architect and owner. The entire bid process, from document purchase to bid submission, was approximately three weeks long.

Woodgrove High School is currently under construction with approximately four months remaining in the schedule. To date, there has been approximately $2 million worth of approved change orders on the project, with disputes and claims becoming increasingly prevalent. This value will only continue to increase since there are no owner credits submitted under this contract.

5.11.3 Comparison

The two projects used for the case study, Episcopal High School and Woodgrove High School, provide a solid comparison of negotiated GMP versus hard bid lump sum contracts. The value of relationships is clearly shown in how the bid processes were conducted and the contract terms dictated. In the case of the Centennial project, the previously established relationship between DAVIS and EHS eased the contract language and eliminated the need for bonds on the project. Conversely, the Woodgrove project was very black and white with the project dictated by the contract and bid documents. Clearly, the bid processes described for each project reveal the type of contractor each owner was pursuing; EHS was more concerned about the best value and previous relationships, whereas Woodgrove was solely concerned about the absolute lowest price. Table 4 below summarizes the key differences between the two contract types showcased in the case study.

PROJECT CASE STUDY COMPARISON		
	EPISCOPAL HIGH SCHOOL	WOODGROVE HIGH SCHOOL
CONTRACT TYPE	Negotiated GMP	Hard Bid Lump Sum
BID PERIOD	12 weeks	3 weeks
COST TO ESTIMATE/BID	$50,000 (< 1% of contract)	$110,000 (< 1% of contract)
NUMBER OF BIDDERS	4	10
REQUEST FOR PROPOSAL	Yes	No
PREQUALIFICATION REQUIREMENTS	Pre-selected list, proposal submission, interview and presentation	None
BID INSTRUCTIONS	None	245 pages
AWARD CRITERIA	Best value	Absolute lowest price
FEE	Performance based aggreement	Standard percentage
CONTRACT MODIFICATIONS	8-pages of alterations	None allowed
VALUE OF RELATIONSHIPS	High	Low
BOND REQUIREMENTS	None required	Contractor submit bid bond and 100% performance and payment bond
PRODUCT SUBSTITUTIONS	Permitted throughout project, pending Architect approval	Have to be submitted a least ten days prior to bid date
SUBCONTRACTOR BUY-OUT	Best value decided by EHS	Absolute lowest subcontractor had to be listed on bid date and awarded contract
PROJECT SAVINGS CLAUSE	75% to Owner, 25% to DAVIS	0% to Owner, 100% to DAVIS
CHANGE ORDER VALUE (To Date)	$725,000	$2,000,000

Table 4: Contract Case Study Comparison

5.12 General Guidelines and Recommendations

Companies entering into new markets and encountering hard bid lump sum projects for the first time have to expect a period of adjustment. The strategies and techniques necessary to successfully win lump sum contracts differ greatly from negotiated GMP projects. Unfortunately, there are no set-in-stone guidelines that can guarantee success during competitive hard bids. A company will develop its own

techniques and factors for success over time as it progresses along the learning curve. After completing the interviews with the group of industry members and reviewing the similarities and differences between the two contract types in the case study, the following general guidelines were developed as a tool to identify areas that are key to focus on when pursuing hard bid lump sum projects. This is by no means an exhaustive list of guidelines, and as mentioned above individual companies will develop their own standards by trial and error as it ventures into the hard bid lump sum environment.

1. Contractors have to devote extensive time and effort into studying and reviewing all details of the project at the beginning of the bid period. This is critical to understand project requirements and indentify possible problem areas in the design. Since hard bid lump sum projects typically do not have a preconstruction phase, this study/review has to be done by the contractor on its own time. The more in-depth the review, the more accurate the estimate, which leads to a successful project.

2. The nature of hard bid lump sum projects dictates that the absolute low price wins the project. To be successful, a contractor has to establish a competitive advantage among the bidders. Forming subcontractor partnerships can ensure discounted pricing and schedule savings, which can be the difference between winning and losing a hard bid. It is not uncommon for subcontractors to give one contractor a price, and then turn around and give another one a lower price based on previous relationships and work experiences. The more partnerships that can be formed between contractor and subcontractors, the better the chance of formulating the lowest bid on a project.

3. All contractors have a set list of subcontractors that they reach out to for pricing during bids. There will be common subcontractors from list to list, but there will also be different subs that are not solicited by all contractors. It is vital that a contractor identifies all possible subcontractors that are submitting pricing for each trade. This can be accomplished by contacting suppliers and vendors and asking for all subcontractors that have requested material quotes for the project under bid. This confirms all known and unknown subcontractors, and then allows the contractor to pursue the unknown subcontractors. Going this extra mile can determine the overall lowest subcontractor bid for each trade and increase the chance of submitting the absolute lowest overall project bid.

4. There is a large amount of work that has to be completed in a short amount of time to develop a detailed hard bid. It is critical that a contractor distributes the work among several individuals within the company. In general, the lead estimators, preconstruction directors and project management personnel should be involved in identifying and soliciting subcontractor pricing. To increase chances of success, it is beneficial to get superintendents involved in the review of construction drawings and site logistics to determine complex construction phases. Of course, not all operations personnel can be tied up in bid development since a majority of them should be occupied by current projects; however, there is an advantage to involving individuals with various backgrounds and expertise when developing a hard bid.

5. Since there is more competition when bidding on hard bid lump sum projects, the award rate is not as high as compared to other contract methods. It is critical that a contractor allocates for time and money spent on lost bids and is able to absorb costs encountered. As mentioned in the analysis, an acceptable award rate of 1 in 6 hard bids is common among the industry. A contractor must be able to decipher which projects to pursue and which ones to pass. Too many submitted bids will result in large overhead expenses. Too few submitted bids will decrease the chance of being awarded projects. Being able to effectively manage this process and identify the proper quantity of bids to pursue at a given time is a skill that is learned over time as contractors become familiar with the market and bid process.

6.0 ELIMINATION OF INEFFICIENCY THROUGH USE OF PREFABRICATION

6.1 Problem Identification

Site congestion is a major concern identified on this project. This issue has impacted several trades and caused delays in excavation, geo-pier installation and masonry work to date. The lack of material storage and lay-down space has caused contractors to work inefficiently and unsafely. More than once, a trade had to demobilize until the site cleared up to allow for productive work. The masonry trade occupied the most space on site and encountered many delays due to inefficient work.

6.2 Research Goal

The goal of this analysis is to perform a preliminary design of a precast masonry wall system and assess the impacts on schedule, cost and trade coordination on site.

6.3 Methodology

- Design preliminary precast system for exterior facade of New Centennial Gymnasium
- Analyze how the precast system impacts existing structure
- Determine transportation and erection requirements for precast panels
- Analyze schedule and cost impacts of precast system
- Analyze constructability of the precast system
- Analyze site congestion and trade coordination improvements
- Assess architectural implications/concerns

6.4 Background Information

The Centennial Gymnasium Addition is designed with exterior walls consisting of modular "Delmarva" face brick backed by structural reinforced masonry bearing walls with 8" CMU's and air cavities. The masonry package cost just over $2.0 million and was scheduled to be constructed in four months, from September 3, 2009 to December 24, 2009. The challenge with this schedule is that the concrete superstructure was not to be completed until mid October, creating a situation where there was more than a month overlap of major trades on a very small, congested site. When the masonry contractor mobilized on site, it was quickly determined that the congestion was resulting in efficient work. The masonry contractor de-mobilized and returned once the concrete operation was near completion. This delayed the façade by almost three weeks and required additional man-power and money to recuperate lost time.

Prefabricated panels are widely known to reduce on-site labor and decrease the amount of time required for erection. By utilizing a precast panel façade, a majority of the labor durations will occur at the factory while the concrete operation is finishing. Once the superstructure has topped out, the panels can be delivered and erected in a relatively short period of time. This will minimize the need to coordinate major trades on a small site and ultimately eliminate delays due to inefficient work.

6.5 Preliminary Precast Design

After consulting a representative from Universal Concrete Products and referencing several precast panel catalogs, it was determined that the most logical design for the precast façade would be to span from spandrel beam to spandrel beam. This resulted in a typical panel height of 14'-0" and varying widths to account for window/door openings. The overall design included 429 pieces of precast, with 75 different panel sizes covering roughly 18300SF of building façade. Window layout was slightly altered to align panels vertically and maintain standard panel widths. Figure 8 below shows the preliminary precast panel design for the West elevation of the Centennial Gymnasium Addition. Panels of the same color have the same width and are designed to be aligned vertically. See **APPENDIX E** for the precast panel design take-off charts.

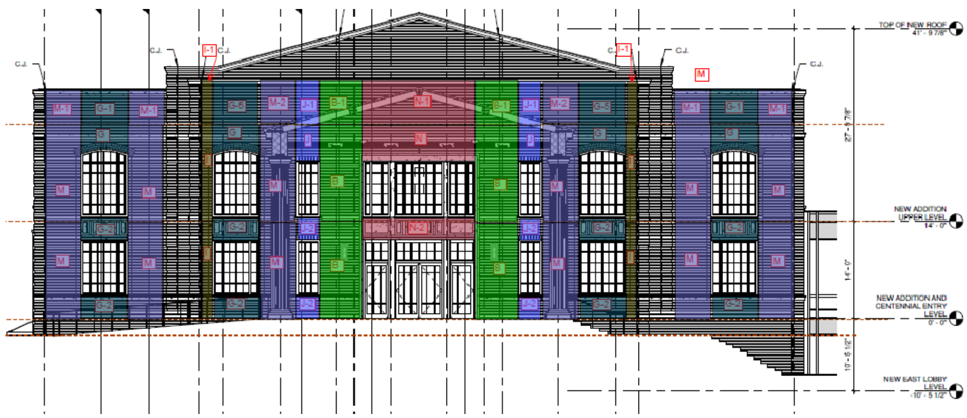

Figure 8: Preliminary Precast Design for West Elevation

6.6 Structural Impact

As previously mentioned, the precast panels were designed to span from spandrel beam to spandrel beam. These beams occur at each floor level as well as at the roof level to provide support for the steel roof trusses and parapet wall. Currently, each spandrel beam supports the exterior CMU/brick wall. Since the precast panels will be replacing this masonry wall system, the structural analysis performed below determines the amount of spandrel beam deflection in the current design compared to expected deflection under the new precast loads for a typical column bay.

As shown below in Table 5, the 5" thick architectural precast panel weighs significantly less per square foot as compared to the masonry wall system. This leads to the assumption that the spandrel beams may be able to be downsized due to the reduced load on the beam.

STRUCTURAL WEIGHTS			
MASONRY WALL		ARCH. PRECAST	
MATERIAL	WEIGHT/SF (lbs.)	MATERIAL	WEIGHT/SF (lbs.)
CMU	55.0	5" Thick Panel	62.5
Brick	42.0		
TOTAL	97.0	TOTAL	62.5

Table 5: Structural Weights for Wall Systems

The column bay analyzed is between CL 7 and CL 8 as shown in Figure 9. There are three panels that bear on the roof level spandrel beam and four panels on the upper level spandrel beam. The roof level panels will only be connected at the roof spandrel beam since this is the parapet wall per the original design. The upper level panels will be connected at the roof spandrel beam for lateral support only and at the upper level spandrel beam for gravity and lateral support. Table 6 below shows the existing line loads on each spandrel beam from the masonry wall system, and the expected line loads from the precast panels per the new design. As expected, based on the significantly smaller structural weights, the line loads are much less for the precast panel system, which further proves that the spandrel beams may be able to be reduced in size.

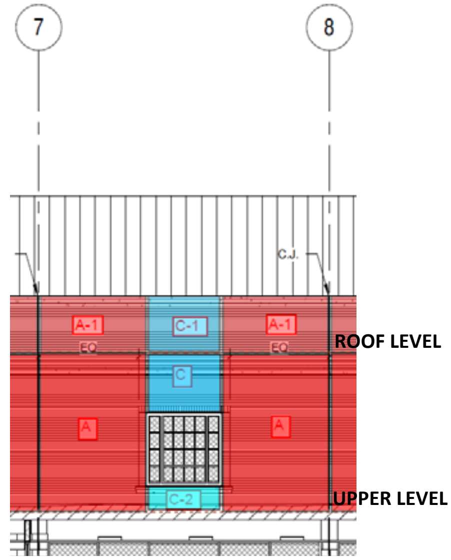

Figure 9: Analyzed Column Bay

STRUCTURAL LOADS ON SPANDREL BEAMS AT BAY 7-8 FROM MASONRY					
ROOF SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A-1	47.5	4607.5	100.00%	4607.5	180.69
C-1	33.75	3273.75	100.00%	3273.75	128.38
A-1	47.5	4607.5	100.00%	4607.5	180.69
			TOTAL	12488.75	489.75
UPPER SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A	133	12901	100.00%	12901	505.92
C	35.43	3436.71	100.00%	3436.71	134.77
C-2	15.18	1472.46	100.00%	1472.46	57.74
A	133	12901	100.00%	12901	505.92
			TOTAL	30711.17	1204.36

STRUCTURAL LOADS ON SPANDREL BEAMS AT BAY 7-8 FROM PRECAST					
ROOF SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A-1	47.5	2968.75	100.00%	2968.75	116.42
C-1	33.75	2109.375	100.00%	2109.375	82.72
A-1	47.5	2968.75	100.00%	2968.75	116.42
			TOTAL	8046.875	315.56
UPPER SPANDREL BEAM					
PANEL	SF	TOTAL WEIGHT (lbs.)	% ON BEAM	LOAD ON BEAM (lbs.)	LINE LOAD ON BEAM (PLF)
A	133	8312.5	100.00%	8312.5	325.98
C	35.43	2214.375	100.00%	2214.375	86.84
C-2	15.18	948.75	100.00%	948.75	37.21
A	133	8312.5	100.00%	8312.5	325.98
			TOTAL	19788.125	776.00

Table 6: Structural Loads on Spandrel Beams from Wall Systems

Before the column bay could be modeled and analyzed in STAAD to determine deflections, the existing point loads from the roof trusses had to be factored for the roof spandrel beam. Table 7 shows the calculated load per truss that is transferred to the spandrel beam. This point load occurs at three locations on the beam: column line 7, the mid-point and column line 8. The upper level spandrel beam does not have any additional loads since this beam is located in the gymnasium space that has a two-story floor-ceiling height; therefore no floor slab is located at this level.

POINT LOAD FROM TRUSS ON ROOF SPANDREL BEAM			
TYPE	LOAD (PSF)	TRIB. AREA (SF)	POINT LOAD (LBS.)
ROOF LIVE	20.0	690.0	13800.0
SNOW	20.0	690.0	13800.0
SELF WEIGHT			
DECKING	2.8	690.0	1932.0
TRUSS	N/A	N/A	5000.0
TOTAL	42.8		34532.0

Table 7: Roof Truss Point Load

After determining all loads transferred to the spandrel beams, the column bay was modeled and analyzed in STAAD Pro to determine maximum deflection for the existing spandrel beam size under the masonry wall load case and the precast panel load case. The model was then changed to reduced spandrel beam sizes and analyzed for the precast panel load case. Table 8 below shows the results for each spandrel beam size and load case. See **APPENDIX F** for the deflection charts and model diagrams.

SPANDREL BEAM DEFLECTION		
BEAM SIZE	LOAD CASE	MAX DEFLECTION
2.16' x 1.5'	Masonry Wall Loads	0.027
	Precast Panel Loads	0.017
2.0' x 1.0'	Precast Panel Loads	0.033
1.75'x1.0'	Precast Panel Loads	0.076

Table 8: Spandrel Beam Deflection

As expected, the maximum deflection for the existing spandrel beam size under the precast panel load was significantly less than the masonry wall loads. Reducing the spandrel beam to 2.0' x 1.0' resulted in a maximum deflection similar to the existing beam size and load case. The slight increase in deflection is under the allowable deflection per conversations with the structural engineer. The 1.75' x 1.0' spandrel beam resulted in a much higher deflection, well above the existing deflection and therefore is not an acceptable design. Since the precast panels are all spandrel beam bearing, the columns showed no change in deflection or load requirements. It was determined that the columns should remain the standard 18" x 18" size to maintain a consistent column size for constructability and formwork purposes.

Reducing the spandrel beams will provide a cost savings due to the reduction in concrete quantity. The spandrel beams for the column bay analyzed were reduced by approximately 38%. Assuming that a similar reduction can occur for the rest of the spandrel beams in the structure, the existing quantity of 399CY of concrete for spandrel beams could be reduced to approximately 246CY and provide an estimated $37,260 savings for the concrete superstructure. Table 9 below shows the estimated savings for the reduction of spandrel beams in the building.

SAVINGS DUE TO REDUCTION OF SPANDREL BEAMS						
EXISTING BEAM SIZE (CY)	REDUCED BEAM SIZE (CY)	% REDUCTION	INITIAL BEAM TOTAL CY	REDUCED BEAM TOTAL CY	$/CY	SAVINGS
3.06	1.89	38.27%	399.00	246.30	$244.00	$37,259.70

Table 9: Savings Due to Spandrel Beam Reduction

6.7 Schedule Reduction

The goal of the façade redesign was to eliminate delays incurred by site congestion and trade coordination. The masonry wall was scheduled to take 86 days to complete all CMU walls and brick façade for all four elevations. Erection duration for 429 precast pieces, assuming 12 pieces per day from a conversation with DAVIS Construction, will be just under 36 days. The resulting schedule savings is shown below in Table 10. For the purpose of take-off clarity, the corners were treated as a separate entity in the precast durations and included in the elevations for the masonry durations. It is to be assumed that the corner pieces would be erected with the elevations in actual practice.

SCHEDULE REDUCTION DUE TO PRECAST FAÇADE						
ELEVATION	FAÇADE SF	MASONRY DURATION (DAYS)	TOTAL # OF PRECAST PANELS	PANELS/DAY	PRECAST DURATION (DAYS)	SCHEDULE SAVINGS (DAYS)
South	4222.25	25.00	86.00	12	7.17	(17.83)
North	4461.38	25.00	81.00	12	6.75	(18.25)
East	4659.59	18.00	90.00	12	7.50	(10.50)
West	3054.06	18.00	72.00	12	6.00	(12.00)
Corners	1911.00	0.00	100.00	12	8.33	8.33
TOTAL	**18308.28**	**86.00**	**429.00**	**12.00**	**35.75**	**(50.25)**

Table 10: Schedule Reduction Due to Precast Façade

While the calculated schedule reduction of 50 days is significant, it is important to note that the precast erection cannot take place until the superstructure is completed. The original masonry wall schedule had the East façade starting prior to the completion of the concrete structure. This overlap was the cause of the delays due to inefficient work from site congestion. The reduced precast duration allows for the erection to occur after concrete and still be completed a month earlier than the masonry wall. Figure 10 below shows the change in schedule with the precast activities in place of the masonry wall activities.

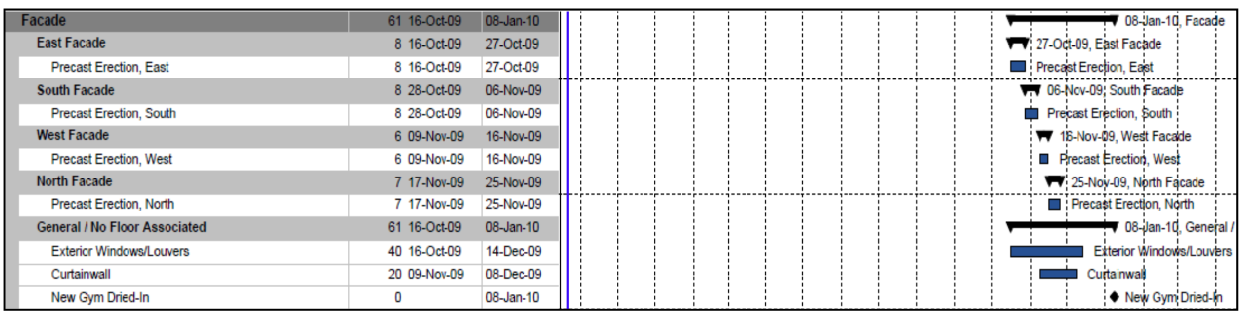

Figure 10: Snapshot of Schedule with Precast Facade Activities

Unfortunately, the façade is not on the critical path for either the masonry wall or precast panel option. The new gym dry-in milestone is dictated by the completion of the roof. Therefore, while a significant schedule reduction can be expected for the new gym façade, using precast panels has no impact on the overall project schedule and does not reduce any general condition costs.

6.8 Cost Reduction

In order to assess the cost implications of the precast panel façade, it was necessary to determine the savings from eliminating the CMU walls and brick façade. Per a discussion with the masonry subcontractor and by dividing the overall masonry contract amount by the total SF of building façade, it was determined that $75.00/SF of masonry wall assembly was a reasonable estimate. After designing the precast façade and acquiring a square footage of building façade that was going to be replaced, the total savings from masonry wall elimination was determined. Next, the cost of precast panels was estimated at $50.00/SF. This was determined by using a previous DAVIS Construction project and dividing the overall precast contract amount by the square footage of building façade. The price includes fabrication, transportation, erection and overhead for the precast panels. It was decided that the price for the corner pieces should be higher due to complexity of detail and shape. Table 11 below shows the calculated savings due to the use of precast panels.

COST REDUCTION DUE TO PRECAST FAÇADE						
ELEVATION	FAÇADE SF	MASONRY COST/SF	MASONRY TOTAL COST	PRECAST COST/SF	PRECAST TOTAL COST	COST SAVINGS
South	4222.25	$75.00	$316,669.02	$50.00	$211,112.68	($105,556.34)
North	4461.38	$75.00	$334,603.21	$50.00	$223,068.81	($111,534.40)
West	3054.06	$75.00	$229,054.43	$50.00	$152,702.96	($76,351.48)
East	4659.59	$75.00	$349,469.54	$50.00	$232,979.69	($116,489.85)
Corners	1911.00	$75.00	$143,325.00	$65.00	$124,215.00	($19,110.00)
TOTAL	**18308.28**	**$75.00**	**$1,373,121.20**	**$65.00**	**$944,079.13**	**($429,042.07)**

Table 11: Cost Reduction Due to Precast Façade

Replacing the masonry wall assembly with precast panels proves to be a significant savings when comparing the two systems. The façade cost is reduced by 32% when using precast panels. Additionally, the overall savings increases even more when the spandrel beam reduction is factored in to the calculation. The overall savings is shown below in Table 12.

OVERALL SAVINGS	
Precast Panel Cost	$944,079.13
Masonry Wall Deduct	($1,373,121.20)
Spandrel Beam Deduct	($37,259.70)
TOTAL SAVINGS	**($466,301.77)**

Table 12: Overall Savings

6.9 Site Congestion and Trade Coordination

The main purpose of pursuing the precast façade was to reduce the amount of on-site trade coordination and eliminate as much site congestion as possible. As previously mentioned in the schedule reduction section, the precast façade has a significantly shorter duration as compared to the masonry wall assembly. This allows for the precast erection to take place after the concrete superstructure is completed, and therefore eliminating the main culprit that contributed to the many inefficiencies and delays on the project. Not having to overlap the concrete and façade activities may be the most important aspect of utilizing the alternative façade system.

Implementing the precast panel system alters the site layout plan for the superstructure phase since the masonry operation will not be present. Site congestion will be greatly reduced since masonry staging areas, mortar mixing stations and scaffolding will not be located on site. Figure 11 shows the superstructure site layout plan with the masonry operation removed. Compared to the existing layout plan in Appendix C, the site is considerably less congested during this phase. This will allow for the concrete activity to continue as scheduled and eliminate any delays incurred due to the inefficient work of the masonry contractor. See **APPENDIX G** for the complete superstructure layout plan without the masonry operation.

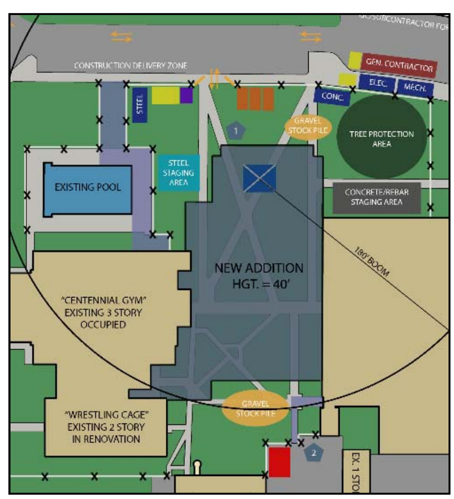

Figure 11: Superstructure Plan without Masonry

While eliminating the masonry wall assembly reduces site congestion during the superstructure phase, it does add an additional phase to construction that must be accounted for in site layout planning. Precast panel façade erection requires extensive planning for sequencing, crane placement and delivery locations. Luckily, the new addition is easily accessible for precast delivery trucks at the West and East elevations, allowing cranes to pick directly from the trucks and erect the panels on the structure. As shown in Figure 12, the precast erection will begin on the East façade (light blue) with crane placement #1 (red rectangle) since the steel roof truss erection will be completing at the West end of the structure. This will eliminate any coordination issues with crane placement and swing. The sequence will move around the building in a clockwise direction, completing with the North façade and crane placement #4. The delivery trucks will utilize two different locations; the East façade location for sequence one and the West façade location for sequences two through four. While precast erection is occurring, the only other superstructure activity will be metal decking at the roof, which will have minimal impact on the precast erection. See **APPENDIX G** for the complete precast erection plan.

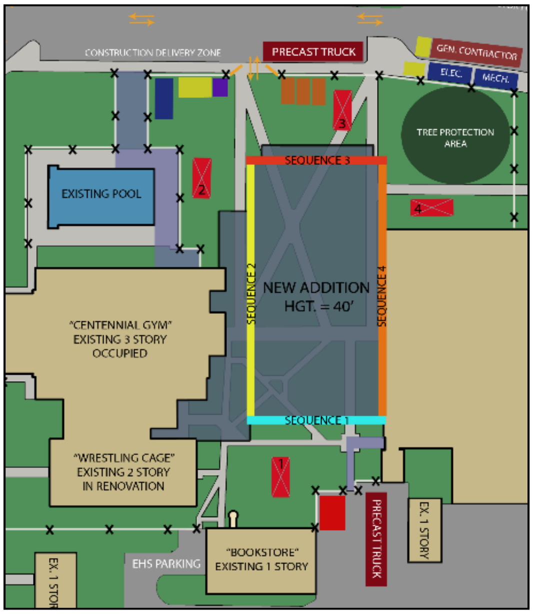

Figure 12: Precast Erection Plan

6.10 Architectural Implications

Often, when the issue of utilizing a precast panel façade is brought to the design table it is immediately disregarded due to concerns with aesthetic quality. Architects and designers tend to prefer hand-laid masonry brick to achieve high levels of detail and complex designs. In the past, this argument was valid. However, prefabricated panels have come a long way in terms of quality and detail. Today, precast panels are designed and fabricated to replicate hand-laid bricks and often achieve the same level of quality standards. While achieving complex corner designs is difficult with precast, it is not impossible. As accounted for in the cost analysis, a slightly higher cost/SF is associated with a high level of detail for precast panels.

One issue that would have to be addressed for the New Centennial addition is the standardization of window and louver dimensions. Figure 13 details the alignment of windows and louvers on the North façade of the building. As originally designed, the lower level louvers are approximately 1' wider than the above window openings. To simplify the precast panel layout, it would be ideal to match the louvers to the window openings, which would allow for a standard panel width from top to bottom of the structure. In general, the New Centennial

Figure 13: Window/Louver Alignment

addition is symmetrical when it comes to window and door openings. There are only a few scenarios like the one described in Figure 13 that would require architectural alterations.

Another aesthetic implication of using a precast façade is the interior wall surface in the gymnasium space. The original design intended for the CMU back-up wall to be exposed and painted inside the gymnasium. Utilizing a precast system will eliminate the CMU wall and require an alternative interior finish design. Possible solutions could be a basic lightweight metal stud wall with drywall on the interior of the precast panels. This would require trade sequencing and coordination, but should not add to the overall schedule since the precast panels are finishing well before the original masonry façade schedule.

Changing the façade from a hand-laid brick veneer to the architectural precast panels poses some complications in designing the interfaces between the system and other surfaces. The critical areas identified on the New Centennial Gymnasium are areas where the precast comes into contact with the glazed aluminum curtain wall at the atrium, the windows and the masonry walls of the existing Centennial Gymnasium and Flippin' Field House. Through discussions with the architect and precast subcontractor it was determined that the precast system would present challenges in terms of interface design, but it is believed that there would be no issues that would prevent the system from functioning properly. Further analysis and design would be required by the architect and precast subcontractor to develop proper interface details at the identified areas of concern.

6.11 Recommendation and Conclusion

As shown in sections 6.7 and 6.8, utilizing the precast panel system in lieu of the originally designed masonry wall system proves to be a very attractive alternative. The precast system will reduce overall costs by over $450,000 and the façade schedule by 50 days. The goal of this analysis was to reduce site congestion and trade coordination during the critical phase of the project. As mentioned in the analysis, the current schedule required the masonry trade to overlap with the concrete superstructure construction, which caused countless site congestion issues and ultimately over three weeks of delays. The information in section 6.9 shows that the proposed precast system eliminates the need for the overlap of trades since precast erection can wait until the concrete superstructure is completed. Unfortunately, the 50 days of schedule reduction does not affect the overall project schedule, since the building façade is not on the critical path.

As described in section 6.10, there are architectural implications and concerns that would need to be addressed to allow for the precast system to be installed properly. Minor fenestration alignment alterations would allow for uniform panel widths across the building elevations. The interior wall finish in the gymnasium space would have to be altered due to the elimination of the CMU wall and critical interfaces between precast and other building surfaces would have to be designed by the Architect and precast subcontractor.

Ultimately, the decision to use the precast panel façade would be in the hands of EHS and the architect. Based on schedule, cost and constructability issues detailed in this analysis, the precast system proves to be a viable alternative for the exterior façade of the New Centennial Gymnasium and it would be strongly recommended to consider the use of precast panels on the new addition.

7.0 FEASIBILITY AND DESIGN STUDY FOR PHOTOVOLTAIC ENERGY SYSTEM

7.1 Problem Identification

The Centennial Gymnasium project is slated to achieve LEED Certification upon completion. However, the project has utilized very few sustainable techniques that could provide a financial benefit to Episcopal High School. Features such as photovoltaic (PV) roof panels were identified as possibilities by EHS in the initial design phases of the project, but eliminated from scope due to perceived financial restrictions.

7.2 Research Goal

The goal of this analysis is to perform a preliminary design of a building integrated PV energy system and determine the financial feasibility to incorporate the system into the existing power plan to reduce energy costs for the owner.

7.3 Methodology

- Research PV panel technologies and sustainable design techniques
- Contact PV panel manufactures for design consultation to determine loading requirements
- Determine quantity of panels to be placed on roof and amount of kWh able to be produced
- Analyze how the existing structure will be affected with added PV panel loads
- Analyze how the PV system will connect to the existing electrical power system
- Perform feasibility analysis on life-cycle cost and payback period

7.4 Background Information

As mentioned in the problem identification, the New Centennial Gymnasium is pursuing LEED Certification with no attempt at energy production techniques. EHS intends to own and operate this facility for a minimum of 50 years. It can be assumed that it may be much longer than that given there are buildings on campus that have been in operation for close to 75 years. This long lifespan is very attractive for a photovoltaic solar array that can typically recoup initial costs in the first 10-15 years and reduce electric bills significantly over the duration of occupancy in the building.

PV systems have come a long way in recent years and are gaining in popularity. The average cost of an installed PV system is dropping each year, which is coupled with increases in federal credit and energy programs that provide rebates and incentives to owners that install energy producing systems. EHS did consider the installation of a PV system when designing the New Centennial Gymnasium. At the time, it was not deemed feasible and disregarded after little consideration. A grid-tie system would be ideal for this application since the campus is already connected to the grid. It is not expected that the PV system can provide all energy necessary for the new addition. However, with the large, available roof space, a significant portion of the buildings energy consumption can be accounted for with this renewable energy source and ultimately reduce the cost of energy for Episcopal High School.

7.5 Preliminary PV Array Design

7.5.1 Orientation and Shading

The orientation of the New Centennial Gymnasium addition is optimal for a rooftop PV array. Table 13 details the key design parameters for the PV system. The large, angled rooftop faces directly South at a 15 degree tilt. The 4.9 sun hours/day value for Washington, DC was obtained from a chart in the *Kyocera Solar Energy Product Catalog Design Guide*. The optimum tilt angles for the PV panels were calculated by subtracting 15 degrees from the latitude for the summer, adding 15 degrees to latitude for the winter and setting it equal to the latitude for the fall/spring. A schematic *Google SketchUp* model was created to analyze the solar shading effects on the roof surface. Figures 14-16 depict the solar shading on the rooftop at 9AM and 4PM for the summer solstice, fall/spring equinox and winter solstice. As shown, there is no shading on the roof area at any given point during the year from the adjacent buildings.

DESIGN PARAMETERS FOR PV SYSTEM	
Location	Alexandria, VA
Latitude	38.8° N
Longitude	77.05° W
Elevation	12m
Roof Orientation	Directly South
Roof Space	9000SF
Slope of Roof	3:12 pitch (14.5°)
Optimum Tilt Angles	
Summer	23.0°
Fall/Spring	38.0°
Winter	53.0°
Sun hours/day	4.9

Table 13: Design Parameters

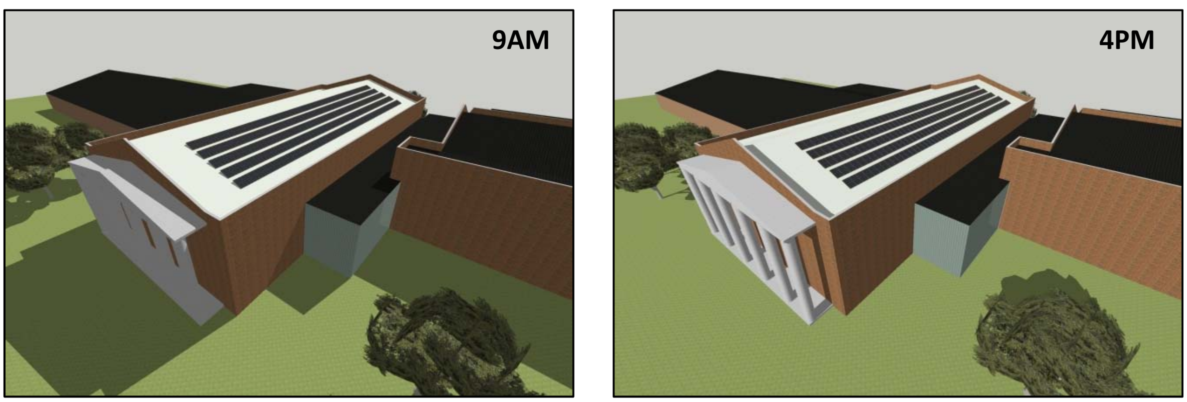

Figure 14: Summer Solstice Shading (June 20)

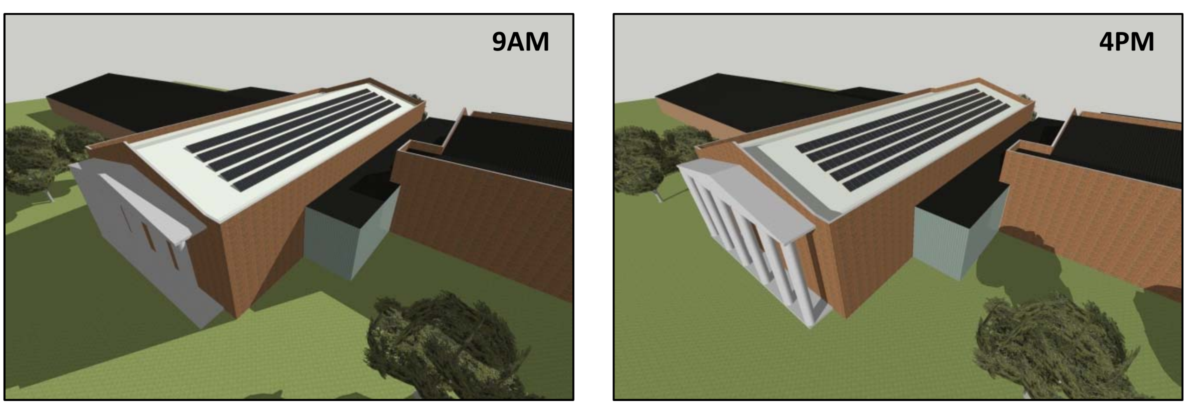

Figure 15: Fall/Spring Equinox Shading (March 20, September 22)

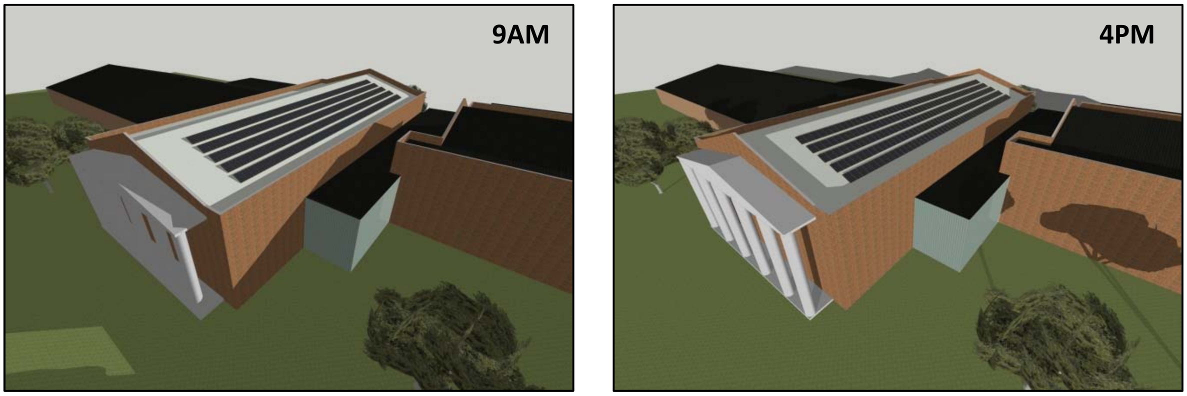

Figure 16: Winter Solstice Shading (December 21)

7.5.2 System Size and Layout

In order to determine the number of panels required for the PV array, an estimated building energy consumption of 500kWh per day was assumed. This was based on energy data from a nearby school building that consumed approximately 1000kWh per day. Given that this is only a gymnasium/athletic facility and not a school building with a cafeteria and classrooms, 500kWh per day was considered reasonable. Table 14 shows the sizing calculation obtained from the Kyocera Solar Energy Design Guide. The actual produced power per panel was determined using the amperage and charging voltage for the KD210GX-LP panel from Kyocera. As shown, the required number of panels to produce the daily building energy consumption would be nearly 1000 panels. This would require over 25,000SF of roof space, almost three times more than what is available.

SOLAR ARRAY SIZING CALCULATION - WHOLE BUILDING		
Sun Hours Per Day	4.90	Reference chart on pg. 6 Kyocera Catalog
Watt-Hours Per Day	500000	Estimated assuming 500kWh per day
Watts per Hour of Sunlight	102041	Daily watt-hours divided by sun hours per day
Actual Produced Power Per Panel	102.70	Amperage x charging voltage for KD210GX-LP panel
# of Panels Required	993.58	Watts/hour divided by actual power of panel

Table 14: PV Array Sizing Calculation - Whole Building Energy

Given that the system will not be able to provide enough energy for the entire building, it was decided to isolate one aspect of the building energy usage and design the system to meet this particular load. The overhead lighting in the new and existing gymnasium will consume a large portion of the buildings energy usage. To design the PV system to account for the energy used by the lights, an estimate was performed to determine the energy load from these fixtures. Table 15 details the energy calculation for the new and existing gymnasium lights. The new gymnasium is designed to function as the auxiliary gymnasium and is assumed to operate longer than the existing gymnasium.

ENERGY LOADS - GYM LIGHTS				
COMPONENT	**QUANTITY**	**WATTS**	**HRS/DAY**	**kWH**
New Gym Overhead Lights - 4’-0” 277V Fluorescent Pendants	45	32.00	6.00	8.64
Existing Gym Overhead Lights - Pulse-Start Hi-Bay Pendants	65	400.00	4.00	104.00
TOTAL	**110**			**112.64**

Table 15: Estimated Energy Load from Gymnasium Lighting

With the estimated energy load for the gymnasium lights determined to be 112kWh, the same sizing calculation from Kyocera was used to determine the required number of panels. The energy load was increased to 125kWh to account for any unexpected usage and inefficiencies within the system. Table 16 details the sizing calculation and shows the required number of panels to be just under 250 to meet the energy load for the overhead lights in the new and existing gymnasiums. This array size is much more feasible as compared to the size requirement for the whole building energy load.

SOLAR ARRAY SIZING CALCULATION - GYM LIGHTS		
Sun Hours Per Day	4.90	Reference chart on pg. 6 Kyocera Catalog
Watt-Hours Per Day	125000	From Energy Load Table
Watts per Hour of Sunlight	25510	Daily watt-hours divided by sun hours per day
Actual Produced Power Per Panel	102.70	Amperage x charging voltage for KD210GX-LP panel
# of Panels Required	248.40	Watts/hour divided by actual power of panel

Table 16: PV Array Sizing Calculation - Gymnasium Lights

The PV array system, consisting of 250 panels since the panels must be connected in pairs, will account for roughly 25% of the total building energy use and 100% of the gymnasium lighting energy use. The selected KD210GX-LP panels are 59” x 39” with a mounting structure that sets the panels at a 15 degree tilt. For ease of maintenance and serviceability, the panels will be fixed on the mounting structures, resulting in a 30 degree tilt (15 degrees from the roof, 15 degrees from the mount) which is roughly the mean angle for optimum performance. This will reduce the amount of time required by the EHS staff to monitor and adjust the system. With roughly 9000SF of roof space to work with, the panels will be aligned in 5 rows of 50 panels with a 3’ space between each row. This panel layout will allow for maintenance access as well as prevent any shading effects from one panel to the next. The first row will be offset by 5’ from the edge of the roof to prevent shading from the parapet wall and the entire layout will be centered East-West on the roof surface. Figure 17 shows the preliminary PV array layout on the South facing roof of the New Centennial Gymnasium addition.

See **APPENDIX H** for the product data cut sheets for the selected solar panel and mounting structure from Kyocera Solar Energy Products.

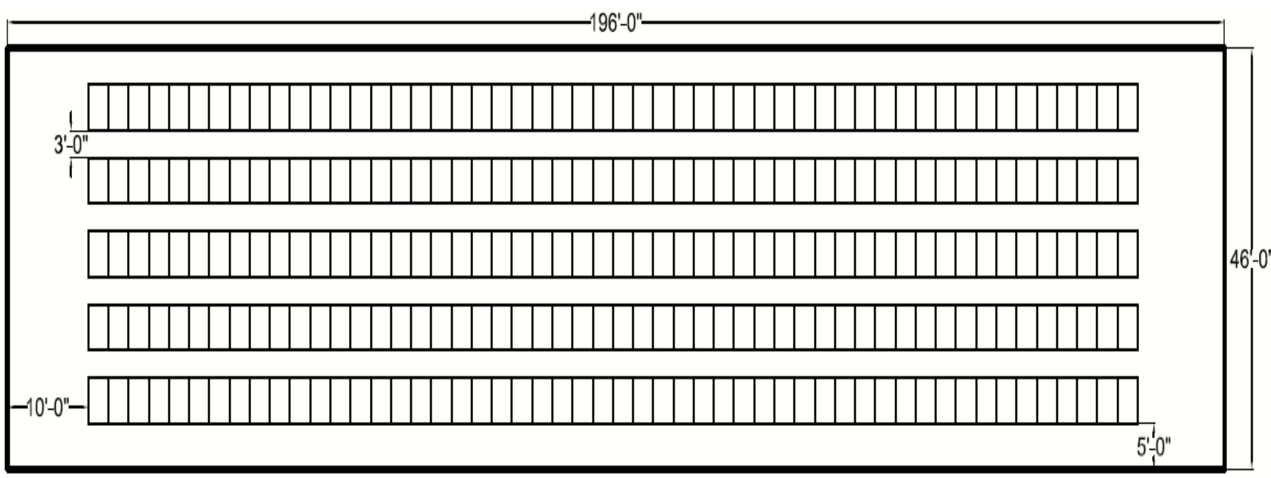

Figure 17: Preliminary PV Array Layout

7.6 Structural Impact

The selected mounting structure, RapidRac, for the rooftop PV panels will connect directly to the metal roof deck with specially designed "RapidFoot" anchors that penetrate the deck and create a moisture tight seal. To determine the structural impact of the system, the tributary area of the roof trusses had to be calculated, which would reveal the quantity of PV panels supported by each truss. Figure 18 shows the tributary areas for three roof trusses on the new addition (each color is a separate truss tributary area). The trusses are spaced 12.5' apart; therefore the resulting tributary area is 6.25' in each direction, for a total of 12.5'. As shown, a maximum of 20 PV panels and mounts fall within each truss tributary area on the structure.

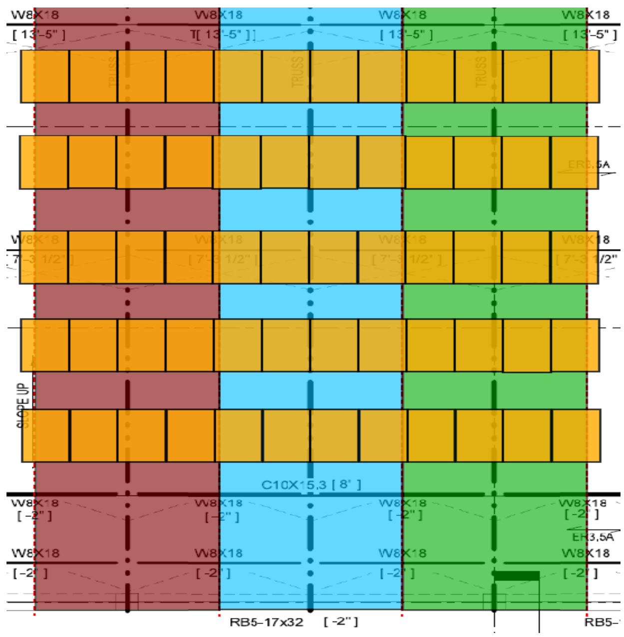

Figure 18: Tributary Area for Roof Trusses

From the Kyocera product data cut sheets in Appendix H, the selected KD210GX-LP panels weigh 40lbs. each and the RapidRac mounts weigh 12lbs. each. Table 17 details the calculated loads for the panels and mounts and the resulting line load for the length of truss the falls within the PV layout. The calculated total line load of 19.26 PLF will be applied to the South half of each roof truss. After discussing this additional load with the Structural Engineer of Record and steel truss fabricator/erector, it was determined that this minor additional load would not require any design change and the current truss design and concrete superstructure would be sufficient to handle the loads from the PV array.

LOADS ON TRUSS FROM PV SYSTEM						
COMPONENT	WEIGHT (LBS.)	TRIB. AREA (FT)	#/TRUSS	LOAD (LBS.)	TRUSS LENGTH (FT)	LINE LOAD (PLF)
PV Panel	40.00	12.50	20.00	800.00	54.00	14.81
Mount	12.00	12.50	20.00	240.00	54.00	4.44
TOTAL	**52.00**	**12.50**	**20.00**	**1040.00**	**54.00**	**19.26**

Table 17: Additional Load on Roof Truss from PV System

7.7 Energy and Electrical Impact

7.7.1 Energy Production

Prior to determining the financial feasibility of the PV system, the yearly value of energy produced had to do be calculated based on the given parameters for the array design and local conditions. By utilizing the PVWatts calculator at pvwatts.org and station identification information for Sterling, VA, shown in Table 18, a yearly energy value of $5182.56 was calculated. Sterling, VA was selected since it is the closest station to Alexandria. More importantly, the results from the PVWatts calculator provide the yearly AC energy produced by the system. Using the value of 64,782 kWh produced per year and dividing it by the overall size of the system, 52.5 kW, a PVWatts factor of 1234 was obtained for the photovoltaic array. This factor is useful for the feasibility analysis described in the following section. Table 19 below highlights the results from the PVWatts calculator.

STATION IDENTIFICATION	
City:	Sterling
State:	Virginia
Latitude:	38.95° N
Longitude:	77.45° W
Elevation:	82 m
PV SYSTEM PARAMETERS:	
DC Rating:	52.5 kW
DC to AC Derate Factor:	0.77
AC Rating:	40.4 kW
Array Type:	Fixed Tilt
Array Tilt:	30.0°
Array Azimuth:	180.0°
ENERGY PARAMETERS:	
Cost of Electricity:	8.0 ¢/kWh

Table 18: Station Identification

PV WATTS ENERGY PRODUCTION RESULTS			
MONTH	**SOLAR RADIATION** (kWh/m^2/day)	**AC ENERGY** (kWh)	**ENERGY VALUE** ($)
1	3.36	4346	347.68
2	4.11	4681	374.48
3	4.76	5849	467.92
4	5.44	6236	498.88
5	5.56	6257	500.56
6	5.98	6531	522.48
7	5.74	6299	503.92
8	5.53	6182	494.56
9	5.08	5605	448.40
10	4.56	5369	429.52
11	3.35	3957	316.56
12	2.81	3469	277.52
Year	4.69	64782	5182.56
PV WATTS FACTOR = Annual AC Energy/System DC Rating = 64782/52.5 = 1234			

Table 19: Annual AC Production and PVWatts Factor

The resulting annual AC energy production of 64,782 kWh is sufficient for the estimated requirement for the overhead gymnasium lighting of 125 kWh per day. In fact, the PVWatts results estimates that 177 kWh will be produced daily, which implies that additional building energy loads may be accounted for by the photovoltaic system.

7.7.2 Electrical Components and System Tie-in

The main factor in determining the required electrical components for the PV system is the system tie-in design. The easiest and most cost effective method is to tie-in the PV power feed via a load-side tap into the main breaker panel. NEC states that a panel can handle loads up to 120% of the rated capacity of the main bus. The designed PV system would require an additional 250A capacity for the panel, which is not feasible. Therefore, the PV system must tie-in to the existing electrical system via a supply-side interconnection. This requires the PV power feed to tie-in with the utility power supply at a service-tap meter box before the main distribution panel. The power supplies are combined in the meter box and one feed is sent to the panel and distributed to meet the buildings loads. Figure 19 below diagrams the supply-side interconnection for the PV array.

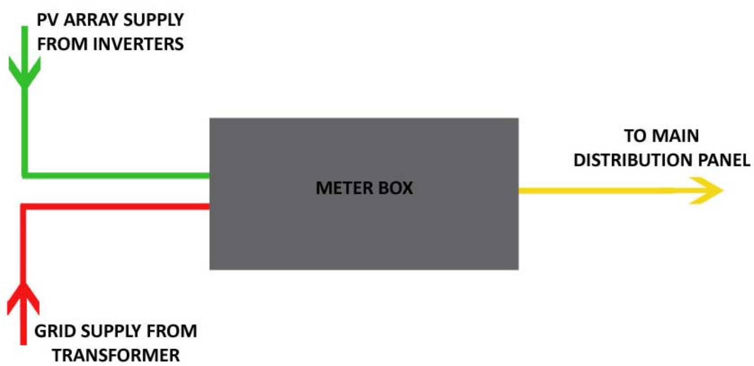

Figure 19: Supply-Side Interconnection for PV Array

A supply-side interconnection system requires the following electrical components to connect the PV array to the existing electrical system in the building:

- DC Wire Run – connects panels to inverter
- DC Disconnects
- Inverter – converts DC power to AC power
- AC Disconnects
- AC Wire Run – connects inverter to meter box
- Service-Tap Meter Box – combines PV power feed with utility power feed

Long DC wire runs present a possibility for large voltage drops and tend to be more costly since DC wire is significantly more expensive than AC wire. To minimize the required amount of DC wire, it was determined that locating the inverters at the roof level was the best design for the system. The selected inverter set-up, The Sunny Tower from SMA Solar Technology, houses six Sunny Boy 7000US inverters with a combined recommended PV power rating of 52.5 kW, which is the exact size of the New Centennial PV array design. The Sunny Tower includes all required DC/AC disconnects and can be mounted outdoors. The overall dimensions for the tower are approximately 43" wide, 70" high, 39" deep and the system weighs 1000lbs. The 5' parapet wall surrounding the new addition rooftop will conceal a majority of the inverter, therefore minimizing the architectural impacts of locating the component on the roof level. It is recommended that the inverters be housed in a ventilated enclosure to minimize the amount of sun exposure, which will maintain cooler operating temperatures. Figure 20 below shows the proposed location of the inverter tower on the roof level and the resulting DC wire run from the panels to the inverters. See **APPENDIX H** for complete product data for the selected inverter tower.

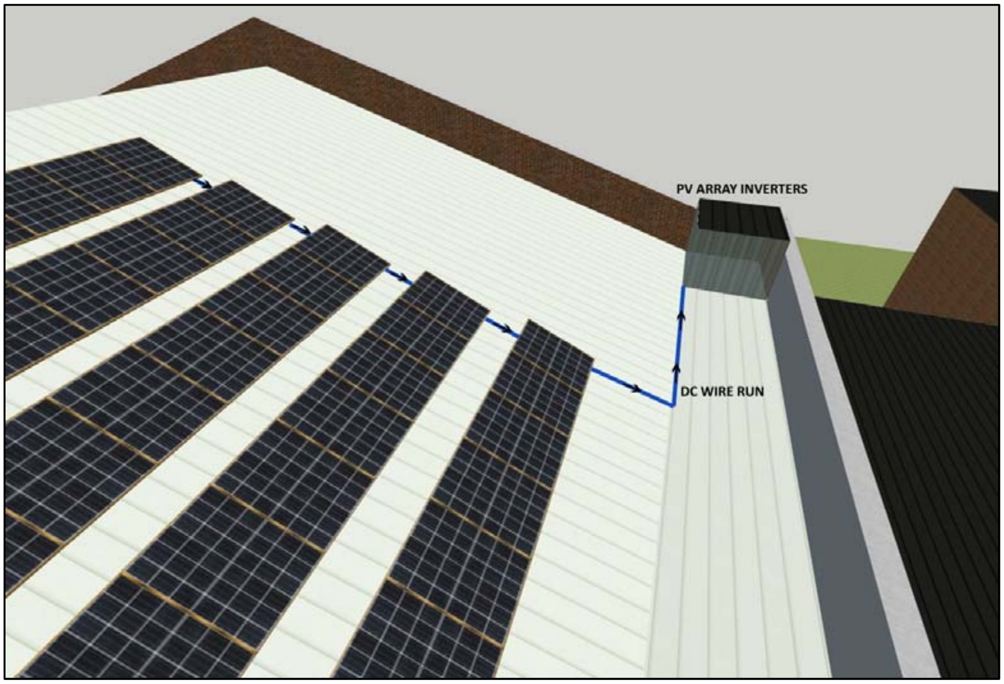

Figure 20: Inverter Tower Location and DC Wire Run for PV Array

It was determined to locate the inverter tower at the Southwest corner of the roof area since the main electrical room is located on the West side of the building at the lower level. The AC wire can run straight down from the inverter tower inside the exterior wall and then turn 90 degrees into the main electrical room, where the utility power supply feed enters the building. Figure 21 below diagrams this design and highlights how the wires will run from the inverters to the electrical room.

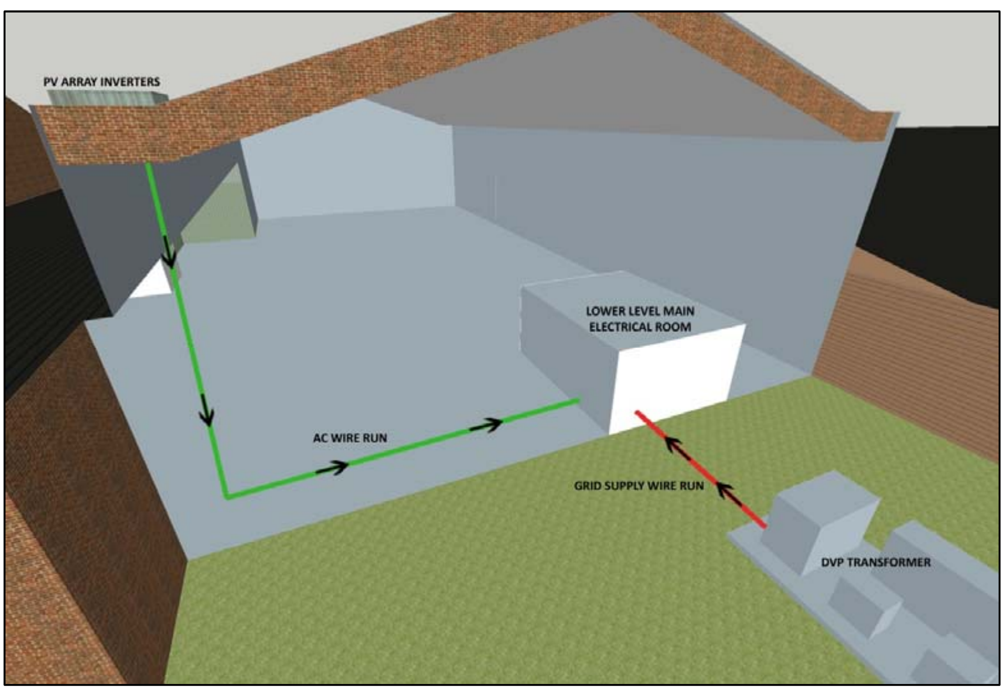

Figure 21: AC Wire Run from Inverters to Main Electrical Room

Locating the inverter tower on the roof results in a DC wire run of 53' and an AC wire run of 115'. Housing the inverter in the lower level electrical room would have resulted in 68% more DC wire, a substantial increase in large, expensive wire. Housing the inverter tower on the roof raises minimal constructability concerns. The PV panels will already require a crane to lift the components onto the roof level. The same crane can be utilized to hoist the inverter tower. With the total tower weight of 1000lbs, there are no structural concerns with locating the system at the roof level.

7.8 Feasibility Analysis

7.8.1 System Cost

In order to effectively determine the feasibility of the photovoltaic array, an approximate cost for the system was determined from an average cost per watt from the U.S. Department of Energy annual energy report. The report showed that the average cost to install a PV array under 250kW in the Mid-Atlantic region was $7.50/watt for the coming year. This value was also confirmed as an accurate estimate by the Kyocera Solar Products design guide. Table 20 below shows the estimated cost for the 52.5kW system designed for the New Centennial Gymnasium project.

ESTIMATED COST OF PV SYSTEM		
SIZE (kW)	$/W	COST
52.5	$7.50	$393,750.00

Table 20: Estimated PV Array Cost

7.8.2 Rebates and Incentives

The state of Virginia offers several rebates and incentives for the installation and production of solar energy. Incentives are based on residential or commercial construction as well as public or private entity. The following are the credits found to be available to Episcopal High School and used to calculate the payback period and feasibility of the New Centennial Gymnasium photovoltaic array:

- Virginia State Energy Program - $2000/kW system size up to 10kW
- Federal Tax Credit – 30% of gross installation cost
- Virginia Alternative Energy Credit – 0.20$/kWh produced

7.8.3 Payback Period

The ultimate goal of installing a photovoltaic array is to recuperate initial costs within an acceptable payback period. To determine the expected payback period of the New Centennial Gymnasium PV array, several factors had to be assumed. Currently, *electricitypricecomparison.org* shows the retail cost of electricity in the state of Virginia to be 0.082$/kWh with an expected market rate increase of 1.00% each year. Estimated loan amounts were calculated assuming a 2.00% APY interest rate over a 25 year loan period. All rebates/incentives discussed in the previous section were calculated assuming EHS qualifies for each program. The PVWatts factor of 1234 was used to determine the annual AC energy production and value for the system. To showcase the feasibility of the system, the payback period was calculated for three options: 0.0% of initial system cost borrowed, 50.0% borrowed and 100.0% borrowed. See **APPENDIX I** for each options complete feasibility analysis.

Case one assumes 0.0% of the up-front system cost borrowed. This option implies that EHS will fully fund the PV array at the time of installation. EHS can achieve this by paying for the system outright, or setting up a sponsorship program where individuals or parents can donate a given amount of money and "sponsor" a panel. This tactic is an effective technique to promote alternative energy and allow individuals to leave a legacy at the school. This option includes an up-front cost of $255,625.00 after rebates/incentives. With no loan amount, the total project expense remains at that cost. A yearly energy savings of approximately $20,000 per year produces a net positive $218,338.33 25-year value for the system. Figure 22 below shows that the system recuperates all up-front costs by year 14, which is beneficial to EHS given that the building is intended to operate for at a minimum of 50 years.

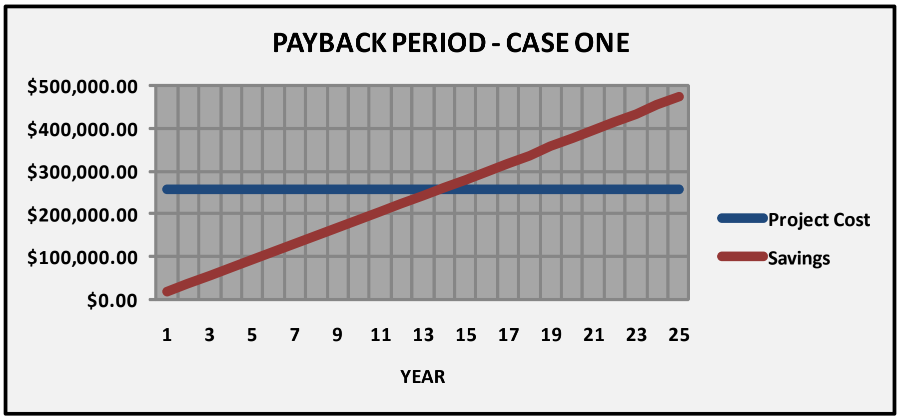

Figure 22: Option One Payback Period

Case two assumes 50.0% of the up-front system cost borrowed. This option implies that EHS will fund half of the PV array cost at the time of installation. EHS can achieve this in a similar fashion as the previous scenario. This option includes an up-front cost of $107,813.00 after rebates/incentives. With 50.0% of the system cost borrowed, the total loan amount with interest is $187,953.00, resulting in a total project cost of $295,765.00. A yearly energy savings of approximately $20,000 per year produces a net positive $178,198.92 25-year value for the system. Figure 23 below shows that the system recuperates all up-front costs by year 16, which is still beneficial to EHS given that the building is intended to operate for at a minimum of 50 years.

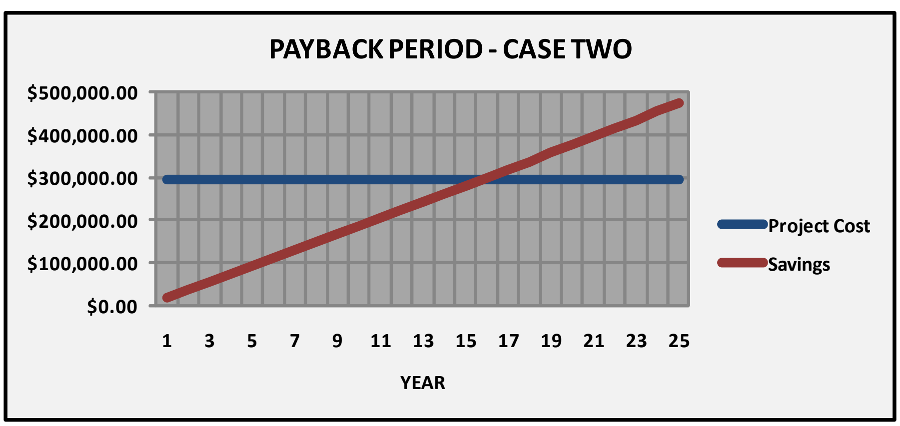

Figure 23: Option Two Payback Period

Case three assumes 100.0% of the up-front system cost borrowed. This option implies that EHS will not fund any of the PV array cost at the time of installation, which results in a $0.00 up-front cost. With 100.0% of the system cost borrowed, the total loan amount with interest is $325,043.00, resulting in a total project cost of $325,043.00. A yearly energy savings of approximately $20,000 per year produces a net positive $148,920.00 25-year value for the system. Figure 24 below shows that the system recuperates all up-front costs by year 18, which is still beneficial to EHS given that the building is intended to operate for at a minimum of 50 years.

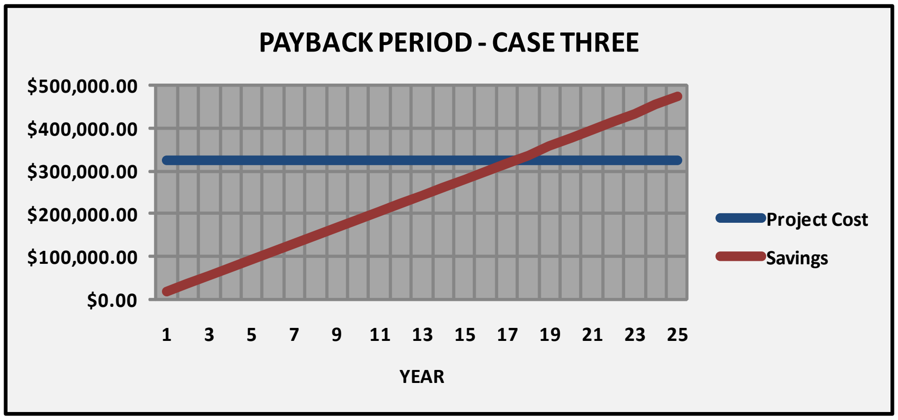

Figure 24: Option Three Payback Period

Each option provides insight into how EHS could install and fund the photovoltaic system. As shown below in Table 21, there are minimal differences in 25-year value and payback period for each option. As expected, fully funding all up-front costs, as shown in option 1, proves to be the most financially beneficial for the school in terms of long-term feasibility.

PV ARRAY FEASIBILTY ANALYSIS OPTION SUMMARY					
OPTION	UP-FRONT COST	LOAN AMOUNT	YEARLY ENERGY SAVINGS	25-YEAR VALUE	PAYBACK PERIOD
1	$255,625.00	$0.00	$20,000.00	$218,338.33	14 years
2	$107,813.00	$187,953.00	$20,000.00	$178,198.92	16 years
3	$0.00	$325,043.00	$20,000.00	$148,920.00	18 years

Table 21: PV Array Feasibility Summary

7.9 Recommendation and Conclusion

Based upon the information presented in section 7.5, the orientation and layout of the new addition is optimal for a rooftop photovoltaic array. There is enough open space that is free from any shading affects to produce enough energy to power all of the overhead gymnasium lighting in both the new and existing gymnasium. A 52.5kW system is recommended for EHS, which results in 250 PV panels mounted on the roof structure. As shown in section 7.6, the system poses no structural impacts and can easily be mounted to the metal roof panels. Per the analysis in section 7.7, it is recommended that the PV array be tied-in to the current electrical system via a supply-side interconnection with the inverters located at the roof level to minimize the DC wire run.

EHS had previously deemed a photovoltaic array not possible due to financial implications. The findings in section 7.8 show that the initial cost for the system of $393,750.00 will be reduced by over $125,000 due to qualifying rebates and incentives. The three proposed payback period options show that the system will recuperate all up-front costs within the first quarter of the buildings overall expected lifespan. Based on the proposed options, it is recommended that EHS fund all of the initial costs, which will eliminate any additional costs due to loan interests. This option provides the earliest payback period of 14 years, which is very beneficial since EHS intends to own and operate this facility for well over 50 years.

7.10 MAE Requirement

The integrated BAE/MAE requirement for the senior thesis project was met by incorporating several course topics into the third analysis: *Feasibility and Design Study for a Photovoltaic Energy System*. Key concepts were utilized from two graduate courses to complete the analysis.

AE 597D: Sustainable Building Methods was a course on current and future sustainable design techniques. Topics such as building orientation, optimal tilt/angle requirements, rebates/incentives available for solar arrays and current solar panel technologies available were all discussed in the course and implemented within this analysis. Each of the topics mentioned contributed to the design and study of the photovoltaic system proposed for the New Centennial Gymnasium at Episcopal High School.

The second graduate course that contributed to this analysis was ***AE 572: Project Development and Delivery Planning***, which was a course on project procurement and delivery methods from the owner's perspective. The main concept utilized from this course was the feasibility and life cycle cost analysis that proved the financial benefit of incorporating the photovoltaic system into the design and construction of the New Centennial Gymnasium. Topics involved include loan period, monthly payments, payback period and 25 year cumulative savings.

8.0 RECOMMENDATIONS AND CONCLUSIONS

Over the course of the fall and spring semesters, the New Centennial Gymnasium Addition and Alterations project on the campus of Episcopal High School has been evaluated to identify and enhance certain areas of design and construction on the project to make them more efficient. This final report served as a culmination of research and analysis of the three main topics: shift from negotiated GMP to hard bid lump sum contracts; elimination of site congestion and inefficiency through the use of precast façade; and a feasibility study for an energy efficient photovoltaic system. The findings in the report do not reflect any perceived mistakes by the actual project team and are purely a theoretical analysis performed for the purposes of the senior thesis capstone project.

The critical industry issue identified for the first analysis was the tendency for contractors to struggle when entering new markets and being forced to shift from negotiated GMP contracts to hard bid lump sum contracts. Strictly a research study, this analysis reflected interviews and discussions held with several industry members from a sampling of contractors. Each individual provided insight into the factors and techniques that can lead to a successful hard bid and also the major differences between the two contract types. By utilizing the Centennial Gymnasium project as a negotiated GMP case study and nearby Virginia public school Woodgrove High School as a hard bid lump sum study, the differences in contract requirements was showcased. Some of the general guidelines developed included contractor knowledge, subcontractor partnerships and contractor aggressiveness. The analysis revealed that there is no clear-cut method to successfully procure hard bid projects. It is recommended that a company entering hard bid projects for the first time allocate resources in order to financially support the company since the expected award rate is less than 20%. Ultimately, a company must develop their own factors for success through trial and error.

Analysis two attempted to rectify the site congestion and trade coordination issue on the New Centennial Gymnasium project. A major source of conflict and delays was the overlap of the concrete superstructure and exterior masonry façade trades. To solve this problem, a precast façade was substituted for the CMU and brick façade. The re-design proved to be a $450,000 savings, but more importantly, allowed for the façade erection to begin once the concrete was completely finished. This eliminated any inefficiencies encountered do to site congestion and eased the trade coordination issue. The precast façade was significantly lighter than the existing masonry wall, therefore the concrete spandrel beams were able to be reduced, contributing to the overall savings. Several architectural implications were identified as potential concerns for the architect, and these would have to be discussed further with the design team. The precast façade is recommended as a viable option for the New Centennial Gymnasium in terms of constructability and trade coordination, but the ultimate decision would be with EHS and the design team.

The third and final analysis was a feasibility and design study for a building integrated photovoltaic system. A comprehensive design analysis revealed that the orientation of the new addition was optimal for a 52.5 kW rooftop array. This would produce enough energy to supply all of the energy required for the overhead lighting in both the new and existing gymnasiums, which results in approximately $20,000 in energy savings a year. It was determined that the 250 panel array required no change to the existing structural design. Given the magnitude of the system, it is recommended that the PV array be connected to the building's electrical system via a supply-side interconnection with the inverters located at the roof level to minimize the length of the DC wire run. The overall system cost was estimated to be just under $400,000 with approximately $125,000 in rebates and incentives available. It is recommended that EHS fully funds the initial cost of the PV array by developing a parent sponsorship program for each panel. This option requires no loan and will result in a 14 year payback period. Since EHS intends to own and operate the facility for at least 50 years, it is recommended that the photovoltaic energy system should be pursued given the expected financial and energy savings.

Overall, each of the three analyses provided insight into the design and construction industry. Identifying the critical factors for success when bidding hard bid lump sum projects revealed beneficial techniques that can increase efficiency when procuring these types of projects. The precast façade re-design proved to be financially beneficial and eliminated construction inefficiencies do to site congestion. Finally, the building integrated photovoltaic system study confirmed that renewable energy can be energy efficient and financially feasible for the building owner. Ultimately, each topic addressed an issue that can improve efficiency within the construction industry.

9.0 RESOURCES

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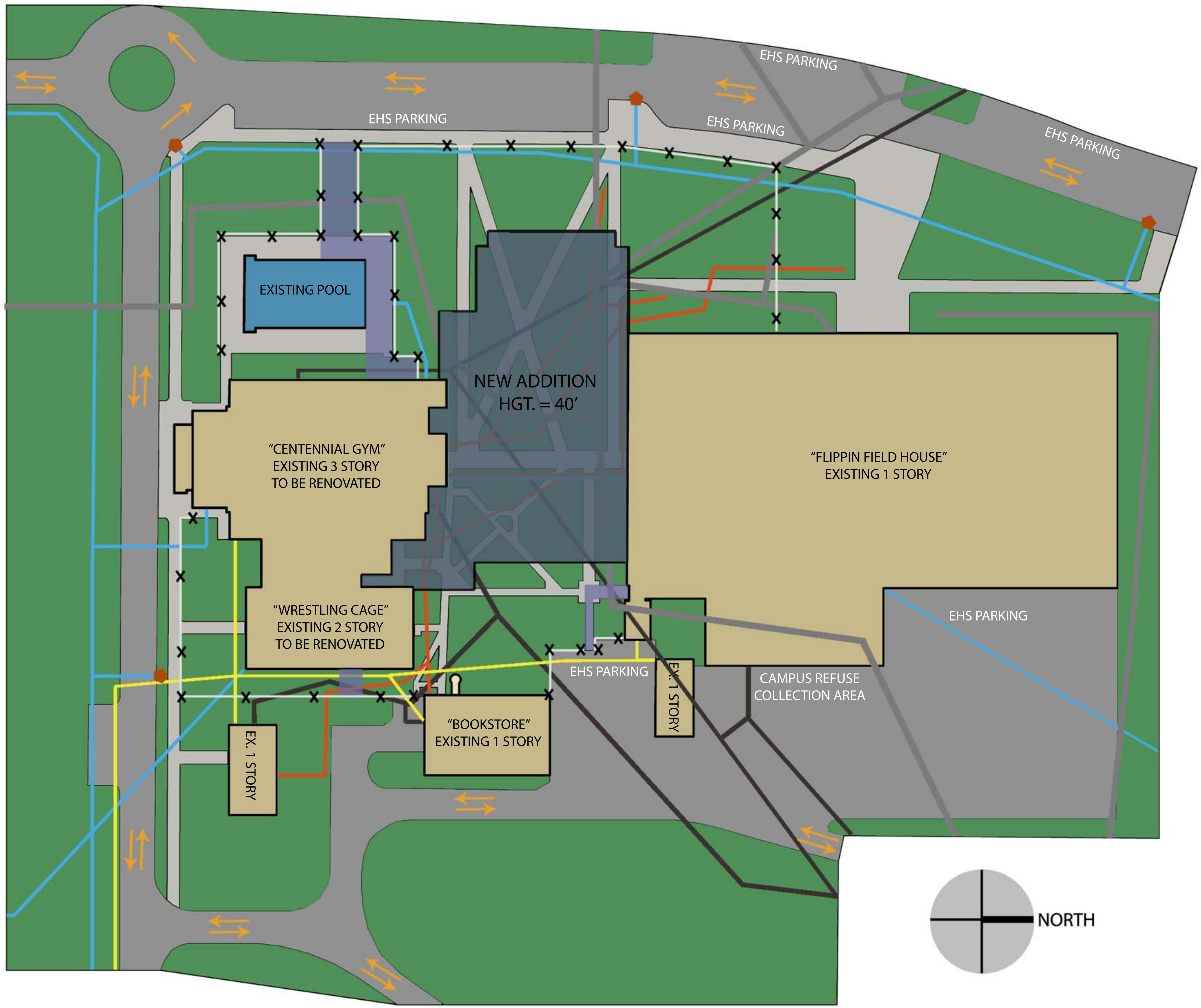
APPENDIX A – Existing Conditions Site Plan



LEGEND:

EXISTING UTILITIES:

- WATER
- GAS
- STORM
- SANITARY
- ELECTRIC

SYMBOLS:

- FIRE HYDRANT
- VEHICULAR TRAFFIC
- CONSTRUCTION FENCE
- COVERED EGRESS

EPISCOPAL HIGH SCHOOL CENTENNIAL GYMNASIUM

EXISTING CONDITIONS SITE PLAN

OCTOBER 5, 2009

ERIC FEDDER - CM

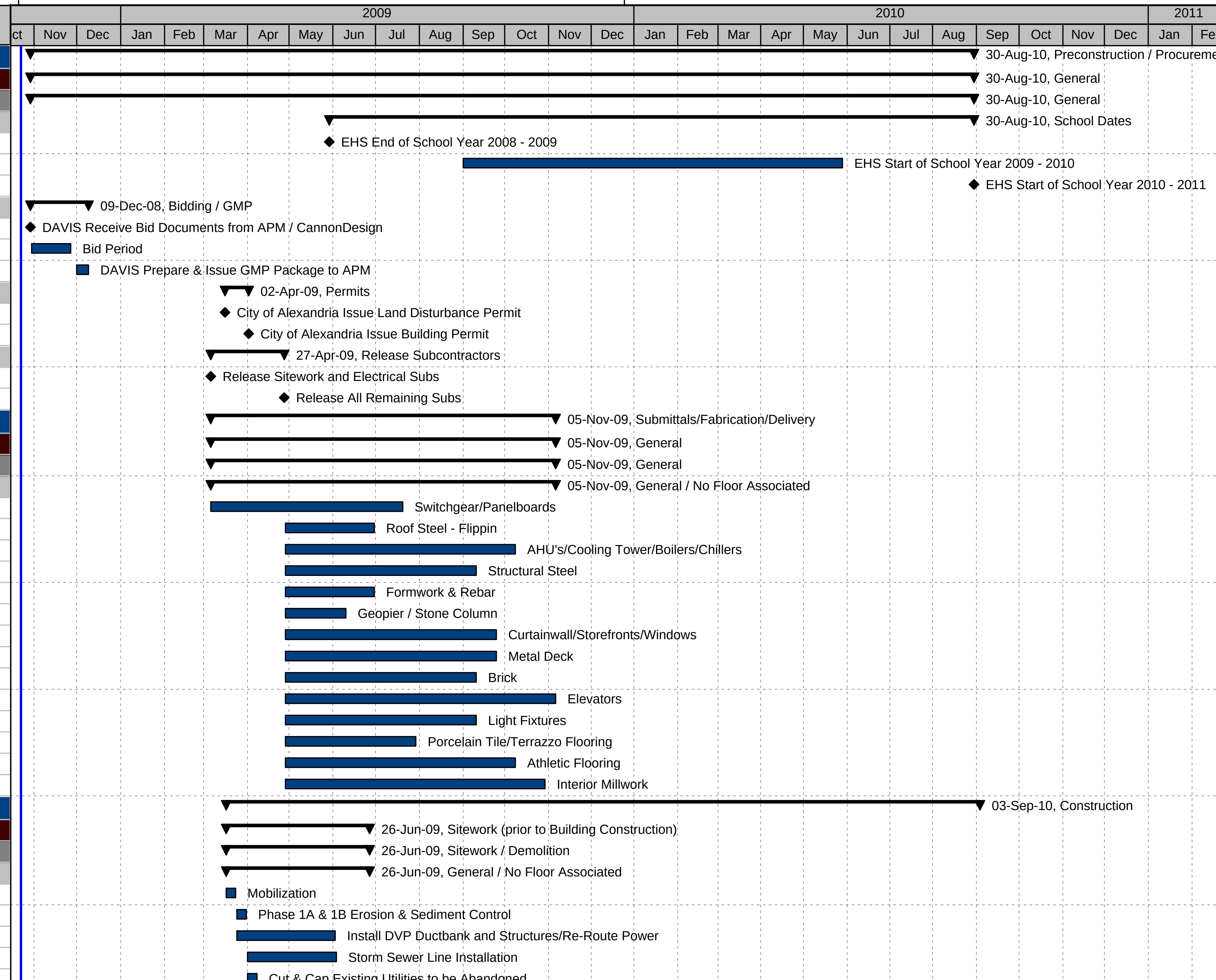
APPENDIX B – Detailed Project Schedule

ERIC FEDDER
CONSTRUCTION MANAGEMENT

DETAILED PROJECT SCHEDULE - TECH TWO
OCTOBER 28, 2009

PENNSTATE

Activity Name	Original Duration	Start	Finish
Preconstruction / Procurement	478	29-Oct-08	30-Aug-10
General	478	29-Oct-08	30-Aug-10
General	478	29-Oct-08	30-Aug-10
School Dates	325	29-May-09	30-Aug-10
EHS End of School Year 2008 - 2009	0		29-May-09*
EHS Start of School Year 2009 - 2010	189	01-Sep-09*	28-May-10
EHS Start of School Year 2010 - 2011	0	30-Aug-10*	
Bidding / GMP	30	29-Oct-08	09-Dec-08
DAVIS Receive Bid Documents from APM / (	0	29-Oct-08*	
Bid Period	20	30-Oct-08*	26-Nov-08
DAVIS Prepare & Issue GMP Package to AP	7	01-Dec-08*	09-Dec-08
Permits	13	16-Mar-09	02-Apr-09
City of Alexandria Issue Land Disturbance Pe	0	16-Mar-09*	
City of Alexandria Issue Building Permit	0	02-Apr-09*	
Release Subcontractors	36	06-Mar-09	27-Apr-09
Release Sitework and Electrical Subs	0	06-Mar-09*	
Release All Remaining Subs	0	27-Apr-09*	
Submittals/Fabrication/Delivery	175	06-Mar-09	05-Nov-09
General	175	06-Mar-09	05-Nov-09
General	175	06-Mar-09	05-Nov-09
General / No Floor Associated	175	06-Mar-09	05-Nov-09
Switchgear/Panelboards	95	06-Mar-09*	20-Jul-09
Roof Steel - Flippin	45	28-Apr-09*	30-Jun-09
AHU's/Cooling Tower/Boilers/Chillers	115	28-Apr-09*	08-Oct-09
Structural Steel	95	28-Apr-09*	10-Sep-09
Formwork & Rebar	45	28-Apr-09*	30-Jun-09
Geopier / Stone Column	30	28-Apr-09*	09-Jun-09
Curtainwall/Storefronts/Windows	105	28-Apr-09*	24-Sep-09
Metal Deck	105	28-Apr-09*	24-Sep-09
Brick	95	28-Apr-09*	10-Sep-09
Elevators	135	28-Apr-09*	05-Nov-09
Light Fixtures	95	28-Apr-09*	10-Sep-09
Porcelain Tile/Terrazzo Flooring	65	28-Apr-09*	29-Jul-09
Athletic Flooring	115	28-Apr-09*	08-Oct-09
Interior Millwork	130	28-Apr-09*	29-Oct-09
Construction	384	17-Mar-09	03-Sep-10
Sitework (prior to Building Construction)	74	17-Mar-09	26-Jun-09
Sitework / Demolition	74	17-Mar-09	26-Jun-09
General / No Floor Associated	74	17-Mar-09	26-Jun-09
Mobilization	5	17-Mar-09*	23-Mar-09
Phase 1A & 1B Erosion & Sediment Control	6	24-Mar-09	31-Mar-09
Install DVP Ductbank and Structures/Re-Rou	50	24-Mar-09	02-Jun-09
Storm Sewer Line Installation	45	01-Apr-09	03-Jun-09
Cut & Cap Existing Utilities to be Abandoned	5	01-Apr-09*	07-Apr-09



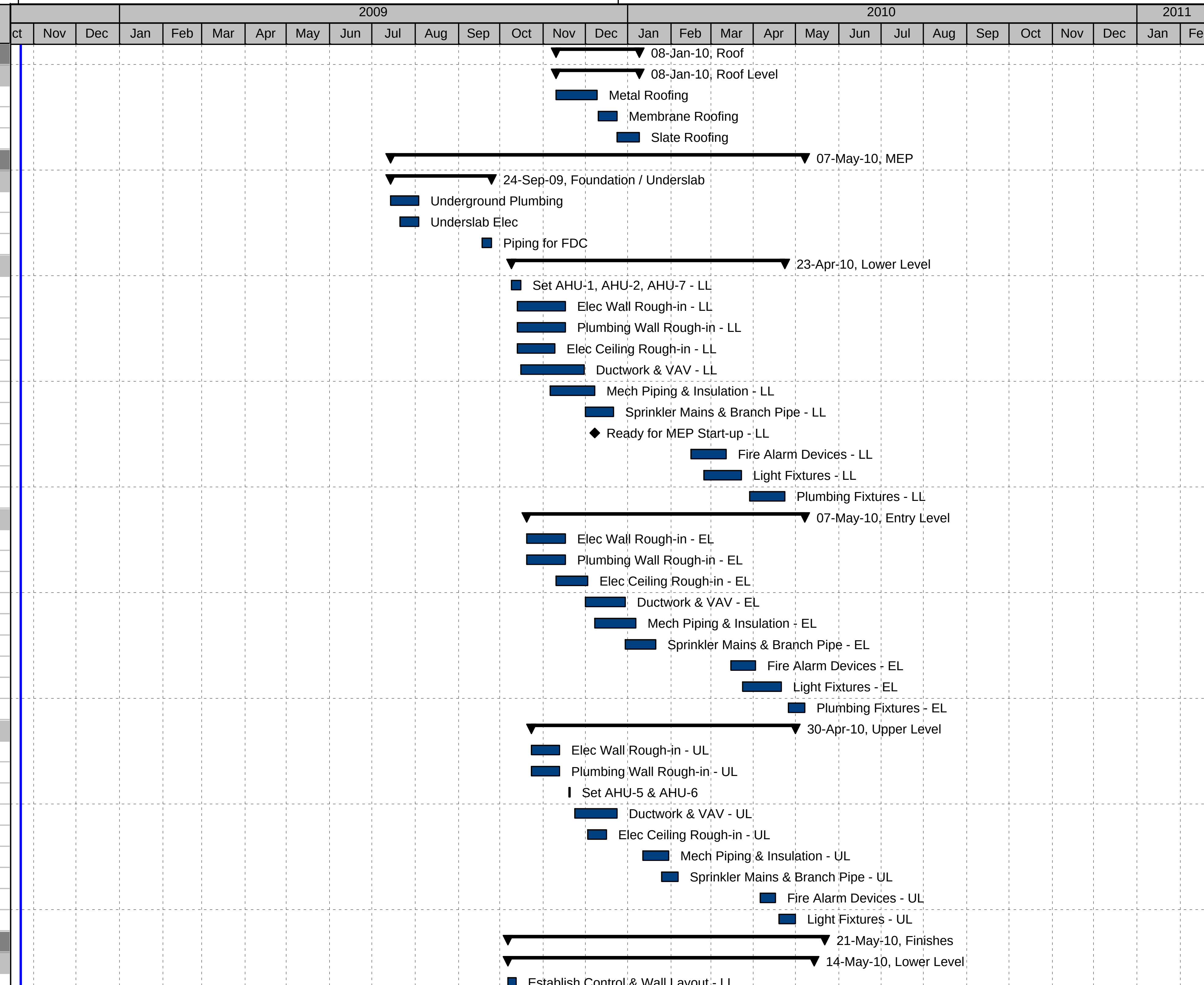
Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

EPISCOPAL HIGH SCHOOL
CENTENNIAL GYMNASIUM PROJECT
ALEXANDRIA, VA

Activity Name	Original Duration	Start	Finish
DVP Set & Energize Transformers	33	21-Apr-09*	05-Jun-09
Site Demolition	34	27-Apr-09	12-Jun-09
Phase 2 Erosion & Sediment Control	3	04-Jun-09	08-Jun-09
Excavate for Building Pad	10	15-Jun-09	26-Jun-09
Flippin Field House	16	01-Jul-09	22-Jul-09
Structure	16	01-Jul-09	22-Jul-09
General / No Floor Associated	16	01-Jul-09	22-Jul-09
Roof Steel at Flippin	15	01-Jul-09*	22-Jul-09
Centennial Gym Addition	256	29-Jun-09	21-Jun-10
Structure	111	29-Jun-09	30-Nov-09
Foundation / Underslab	33	29-Jun-09	12-Aug-09
Geopiers / Stone Columns	15	29-Jun-09	20-Jul-09
Form, Rebar, Pour Foundation Level Concre	15	14-Jul-09	03-Aug-09
Underslab Drainage System	10	23-Jul-09	05-Aug-09
Prep & Pour SOG	5	06-Aug-09	12-Aug-09
Entry Level	38	13-Aug-09	05-Oct-09
Form, Rebar, Pour Concrete	15	13-Aug-09	02-Sep-09
Remove Concrete Reshores - Underside of E	2	02-Oct-09	05-Oct-09
Upper Level	30	27-Aug-09	07-Oct-09
Form, Rebar, Pour Concrete	15	27-Aug-09	17-Sep-09
Remove Concrete Reshores - Underside of U	2	06-Oct-09	07-Oct-09
Roof Level	57	11-Sep-09	30-Nov-09
Form, Rebar, Pour Roof Level Concrete	10	11-Sep-09	24-Sep-09
Concrete Attain 75% Design Strength	5	25-Sep-09	01-Oct-09
Roof Trusses	10	02-Oct-09	15-Oct-09
Roof Level & West Portico Steel	15	16-Oct-09	05-Nov-09
Metal Deck - New Gym	10	30-Oct-09	12-Nov-09
Spray Fireproofing	10	13-Nov-09	30-Nov-09
Facade	117	03-Sep-09	12-Feb-10
East Facade	34	03-Sep-09	20-Oct-09
CMU at Exterior Walls, East	15	03-Sep-09	24-Sep-09
Brick & Cast Stone Facade, East	18	25-Sep-09	20-Oct-09
South Facade	30	25-Sep-09	05-Nov-09
CMU at Exterior Walls, South	15	25-Sep-09	15-Oct-09
Brick & Cast Stone Facade, South	15	16-Oct-09	05-Nov-09
West Facade	33	16-Oct-09	01-Dec-09
CMU at Exterior Walls, West Side	20	16-Oct-09	12-Nov-09
Brick & Cast Stone Facade, West Side	11	13-Nov-09	01-Dec-09
North Facade	30	13-Nov-09	24-Dec-09
CMU at Exterior Walls, North Side	15	13-Nov-09	07-Dec-09
Brick & Cast Stone Facade, North Side	13	08-Dec-09	24-Dec-09
General / No Floor Associated	79	27-Oct-09	12-Feb-10
Curtainwall	20	27-Oct-09	23-Nov-09
Exterior Windows/Louvers	40	17-Dec-09	12-Feb-10
New Gym Dried-In	0		08-Jan-10

Actual Work · Critical Remaining Work · Summary · Remaining Work · Milestone

Activity Name	Original Duration	Start	Finish
Roof	44	10-Nov-09	08-Jan-10
Roof Level	44	10-Nov-09	08-Jan-10
Metal Roofing	20	10-Nov-09	09-Dec-09
Membrane Roofing	10	10-Dec-09	23-Dec-09
Slate Roofing	10	24-Dec-09	08-Jan-10
MEP	214	14-Jul-09	07-May-10
Foundation / Underslab	53	14-Jul-09	24-Sep-09
Underground Plumbing	15	14-Jul-09	03-Aug-09
Underslab Elec	10	21-Jul-09	03-Aug-09
Piping for FDC	5	18-Sep-09	24-Sep-09
Lower Level	141	09-Oct-09	23-Apr-10
Set AHU-1, AHU-2, AHU-7 - LL	5	09-Oct-09	15-Oct-09
Elec Wall Rough-in - LL	25	13-Oct-09	16-Nov-09
Plumbing Wall Rough-in - LL	25	13-Oct-09	16-Nov-09
Elec Ceiling Rough-in - LL	20	13-Oct-09	09-Nov-09
Ductwork & VAV - LL	30	16-Oct-09	30-Nov-09
Mech Piping & Insulation - LL	20	06-Nov-09	07-Dec-09
Sprinkler Mains & Branch Pipe - LL	15	01-Dec-09	21-Dec-09
Ready for MEP Start-up - LL	0		07-Dec-09
Fire Alarm Devices - LL	20	15-Feb-10	12-Mar-10
Light Fixtures - LL	20	24-Feb-10	23-Mar-10
Plumbing Fixtures - LL	20	29-Mar-10	23-Apr-10
Entry Level	144	20-Oct-09	07-May-10
Elec Wall Rough-in - EL	20	20-Oct-09	16-Nov-09
Plumbing Wall Rough-in - EL	20	20-Oct-09	16-Nov-09
Elec Ceiling Rough-in - EL	15	10-Nov-09	02-Dec-09
Ductwork & VAV - EL	20	01-Dec-09	29-Dec-09
Mech Piping & Insulation - EL	20	08-Dec-09	06-Jan-10
Sprinkler Mains & Branch Pipe - EL	15	30-Dec-09	20-Jan-10
Fire Alarm Devices - EL	15	15-Mar-10	02-Apr-10
Light Fixtures - EL	20	24-Mar-10	20-Apr-10
Plumbing Fixtures - EL	10	26-Apr-10	07-May-10
Upper Level	136	23-Oct-09	30-Apr-10
Elec Wall Rough-in - UL	15	23-Oct-09	12-Nov-09
Plumbing Wall Rough-in - UL	15	23-Oct-09	12-Nov-09
Set AHU-5 & AHU-6	2	19-Nov-09	20-Nov-09
Ductwork & VAV - UL	21	23-Nov-09	23-Dec-09
Elec Ceiling Rough-in - UL	10	03-Dec-09	16-Dec-09
Mech Piping & Insulation - UL	15	11-Jan-10	29-Jan-10
Sprinkler Mains & Branch Pipe - UL	10	25-Jan-10	05-Feb-10
Fire Alarm Devices - UL	10	05-Apr-10	16-Apr-10
Light Fixtures - UL	10	19-Apr-10	30-Apr-10
Finishes	164	06-Oct-09	21-May-10
Lower Level	159	06-Oct-09	14-May-10
Establish Control & Wall Layout - LL	5	06-Oct-09	12-Oct-09



Actual Work · Critical Remaining Work · Summary · Remaining Work · Milestone

Activity Name	Original Duration	Start	Finish
Wall Finishes - LL	20	18-Jan-10	12-Feb-10
Ceilings - LL	20	15-Feb-10	12-Mar-10
Floor Finishes - LL	20	15-Mar-10	09-Apr-10
Specialties (Lockers, Toilet Partitions, etc) - LL	15	26-Apr-10	14-May-10
Entry Level	159	13-Oct-09	21-May-10
Establish Control & Wall Layout - EL	5	13-Oct-09	19-Oct-09
Wall Finishes - EL	10	08-Feb-10	19-Feb-10
Ceilings - EL	15	15-Mar-10	02-Apr-10
Floor Finishes - EL	5	12-Apr-10	16-Apr-10
Specialties (Lockers, Toilet Partitions, etc) - EL	5	17-May-10	21-May-10
Upper Level	154	20-Oct-09	21-May-10
Establish Control & Wall Layout - UL	3	20-Oct-09	22-Oct-09
Wall Finishes - UL	5	22-Feb-10	26-Feb-10
Ceilings - UL	10	05-Apr-10	16-Apr-10
Floor Finishes - UL	5	19-Apr-10	23-Apr-10
Specialties (Lockers, Toilet Partitions, etc) - UL	5	17-May-10	21-May-10
Elevator	80	18-Jan-10	07-May-10
General / No Floor Associated	80	18-Jan-10	07-May-10
Install Elevator Eqpt & Cab	80	18-Jan-10	07-May-10
Commissioning & Close-out	91	15-Feb-10	21-Jun-10
General / No Floor Associated	91	15-Feb-10	21-Jun-10
MEP Commissioning	70	15-Feb-10	21-May-10
Final Inspections	20	24-May-10	21-Jun-10
Gym Addition Ready for Occupancy / Move In	0		21-Jun-10
Sitework (after Building Construction)	60	15-Feb-10	07-May-10
General	60	15-Feb-10	07-May-10
General / No Floor Associated	60	15-Feb-10	07-May-10
Complete Sitework, Hardscaping & Landscaping	60	15-Feb-10	07-May-10
Existing Wrestling Cage	125	20-Apr-09	09-Oct-09
General	10	20-Apr-09	01-May-09
General / No Floor Associated	10	20-Apr-09	01-May-09
Owner Vacate Existing Wrestling Cage	5	20-Apr-09*	24-Apr-09
Mobilization at Cage	5	27-Apr-09	01-May-09
Sitework / Demolition	21	04-May-09	01-Jun-09
Lower Level	21	04-May-09	01-Jun-09
Demolition (Interior) - Cage	10	04-May-09	15-May-09
Demolition (Exterior) - Cage	10	18-May-09	01-Jun-09
Structure	63	18-May-09	12-Aug-09
Lower Level	63	18-May-09	12-Aug-09
Footings for Mat Lift Eqpt - Cage	4	18-May-09	21-May-09
Steel for Mat Lift Eqpt - Cage	3	30-Jul-09	03-Aug-09
SOG Repairs - Cage	2	11-Aug-09	12-Aug-09
Facade	83	02-Jun-09	24-Sep-09
Entry Level	83	02-Jun-09	24-Sep-09
Windows/Doors/Canopies - Cage	81	02-Jun-09	24-Sep-09

Actual Work | Critical Remaining Work | Summary | Remaining Work | Milestone

Activity Name	Original Duration	Start	Finish
MEP	101	18-May-09	05-Oct-09
Lower Level	90	18-May-09	18-Sep-09
Underslab Plumbing Rough-in - Cage	3	18-May-09	20-May-09
Underslab Elec Rough-in - Cage	4	18-May-09	21-May-09
Plumbing In-Wall Rough-in LL - Cage	3	17-Aug-09	19-Aug-09
Elec In-Wall Rough-in LL - Cage	3	17-Aug-09	19-Aug-09
Elec Ceiling Rough-in LL - Cage	5	17-Aug-09	21-Aug-09
Ductwork LL - Cage	2	24-Aug-09	25-Aug-09
Mech Piping LL - Cage	4	26-Aug-09	31-Aug-09
Fire Alarm Devices LL - Cage	3	26-Aug-09	28-Aug-09
Sprinkler Mains & Branch Lines LL - Cage	3	01-Sep-09	03-Sep-09
Plumbing Fixtures LL - Cage	5	10-Sep-09	16-Sep-09
Lighting LL - Cage	5	14-Sep-09	18-Sep-09
Entry Level	33	20-Aug-09	05-Oct-09
Plumbing Rough-in EL - Cage	2	20-Aug-09	21-Aug-09
Elec Wall Rough-in EL - Cage	2	20-Aug-09	21-Aug-09
Elec Ceiling Rough-in EL - Cage	3	24-Aug-09	26-Aug-09
Ductwork EL - Cage	10	27-Aug-09	10-Sep-09
Fire Alarm Devices EL - Cage	5	02-Sep-09	09-Sep-09
Mech Piping EL - Cage	3	11-Sep-09	15-Sep-09
Sprinkler Mains & Branch Lines EL - Cage	4	16-Sep-09	21-Sep-09
Plumbing Fixtures EL - Cage	5	17-Sep-09	23-Sep-09
Lighting EL - Cage	5	29-Sep-09	05-Oct-09
Finishes	42	13-Aug-09	09-Oct-09
Lower Level	28	13-Aug-09	21-Sep-09
Establish Control & Wall Layout LL - Cage	2	13-Aug-09	14-Aug-09
Wall Finishes LL - Cage	5	19-Aug-09	25-Aug-09
Floor Finishes LL - Cage	10	26-Aug-09	09-Sep-09
Ceilings LL - Cage	5	04-Sep-09	11-Sep-09
Specialties LL - Cage	3	17-Sep-09	21-Sep-09
Entry Level	40	17-Aug-09	09-Oct-09
Establish Control & Wall Layout EL - Cage	1	17-Aug-09	17-Aug-09
Wall Finishes EL - Cage	5	26-Aug-09	01-Sep-09
Floor Finishes EL - Cage	5	10-Sep-09	16-Sep-09
Ceilings EL - Cage	5	22-Sep-09	28-Sep-09
Specialties EL - Cage	12	24-Sep-09	09-Oct-09
Ceiling Finishes - Cage	4	29-Sep-09	02-Oct-09
Commissioning & Close-out	5	24-Sep-09	30-Sep-09
General / No Floor Associated	5	24-Sep-09	30-Sep-09
Owner Move Fitness Equip to Cage	5	24-Sep-09	30-Sep-09
Existing Fitness Area / New Mechanical Roon	94	01-Oct-09	09-Feb-10
Sitework / Demolition	5	01-Oct-09	07-Oct-09
General / No Floor Associated	5	01-Oct-09	07-Oct-09
Demolition - Fitness Area	5	01-Oct-09	07-Oct-09
Structure	14	08-Oct-09	27-Oct-09

Actual Work | Critical Remaining Work | Summary
Remaining Work | Milestone

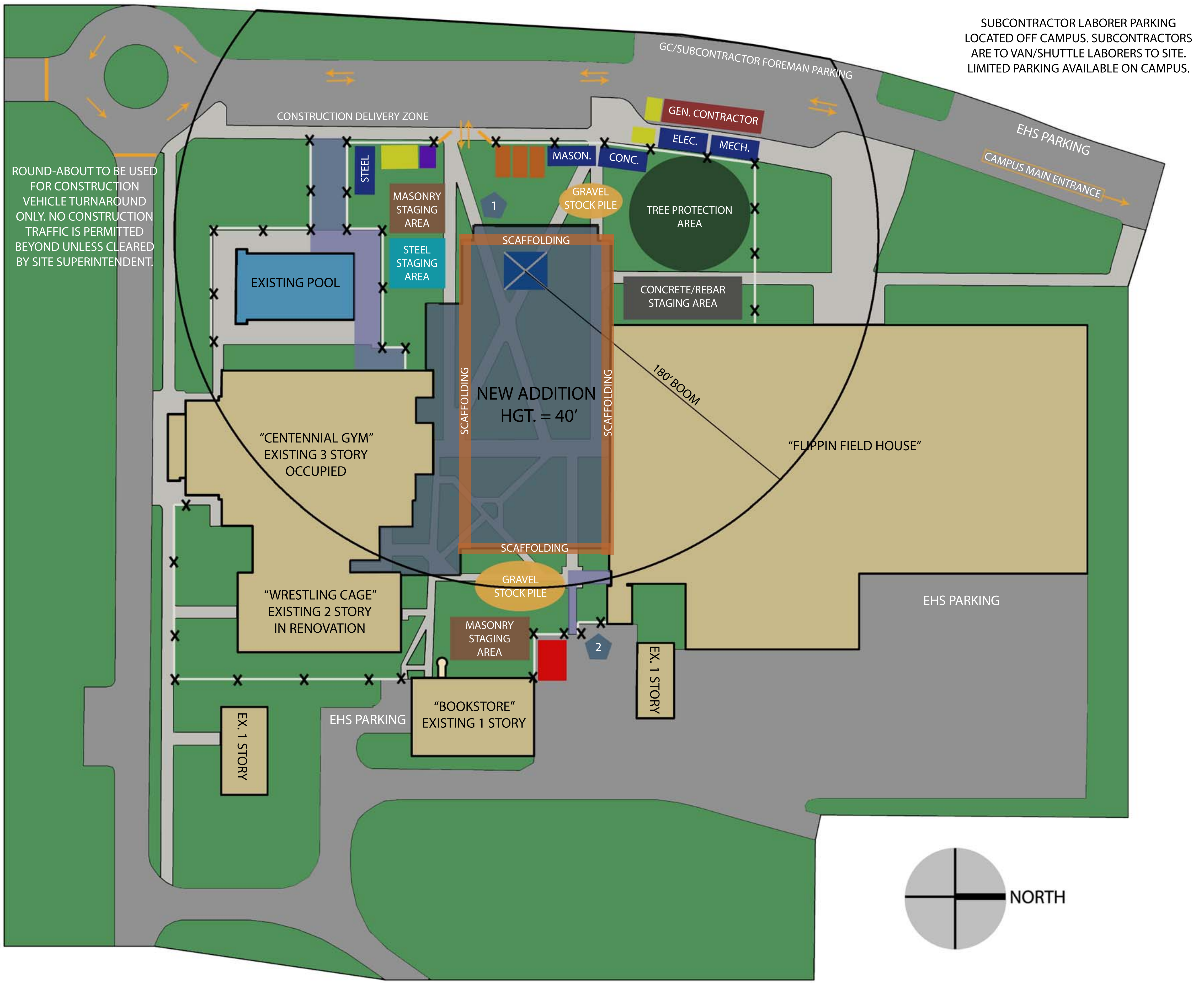
Activity Name	Original Duration	Start	Finish
General / No Floor Associated	14	08-Oct-09	27-Oct-09
Footings for New Steel Columns - Fitness Ar	3	08-Oct-09	12-Oct-09
Steel Columns - Fitness Area	2	13-Oct-09	14-Oct-09
Steel Roof Beams, Dunnage & Metal Deckin	6	15-Oct-09	22-Oct-09
Pour Slab on Grade - Fitness Area	2	26-Oct-09	27-Oct-09
Roof	15	23-Oct-09	12-Nov-09
Roof Level	15	23-Oct-09	12-Nov-09
Roof - Fitness Area	15	23-Oct-09	12-Nov-09
MEP	78	23-Oct-09	09-Feb-10
General / No Floor Associated	78	23-Oct-09	09-Feb-10
Set Mechanical Equipment - Fitness Area	17	23-Oct-09	16-Nov-09
Elec In-Wall Rough-in - Fitness Area	3	29-Oct-09	02-Nov-09
Elec Ceiling Rough-in - Fitness Area	5	29-Oct-09	04-Nov-09
Sprinkler Mains & Branch Lines - Fitness Area	1	05-Nov-09	05-Nov-09
Lighting - Fitness Area	5	05-Nov-09	11-Nov-09
Mech Piping - Fitness Area	40	17-Nov-09	15-Jan-10
Fire Alarm Devices/Power - Fitness Area	7	01-Feb-10	09-Feb-10
Finishes	68	28-Oct-09	29-Jan-10
General / No Floor Associated	68	28-Oct-09	29-Jan-10
Establish Control & Layout Walls - Fitness Ar	1	28-Oct-09	28-Oct-09
Interior Finishes - Fitness Area	10	18-Jan-10	29-Jan-10
Commissioning & Close-out	0	09-Feb-10	09-Feb-10
General / No Floor Associated	0	09-Feb-10	09-Feb-10
Fitness Area Complete	0		09-Feb-10
Existing Centennial Gym	139	23-Feb-10	03-Sep-10
General	10	23-Feb-10	08-Mar-10
General / No Floor Associated	10	23-Feb-10	08-Mar-10
Owner Move Out of Existing Gym	10	23-Feb-10	08-Mar-10
Sitework / Demolition	15	09-Mar-10	29-Mar-10
Lower Level	10	09-Mar-10	22-Mar-10
Demolition LL - Ex Gym	10	09-Mar-10	22-Mar-10
Entry Level	15	09-Mar-10	29-Mar-10
Demolition EL - Ex Gym	15	09-Mar-10	29-Mar-10
Upper Level	3	25-Mar-10	29-Mar-10
Demolition UL - Ex Gym	3	25-Mar-10	29-Mar-10
Structure	5	06-Apr-10	12-Apr-10
Lower Level	5	06-Apr-10	12-Apr-10
Repair Floor Slab LL - Ex Gym	5	06-Apr-10	12-Apr-10
Facade	35	23-Mar-10	10-May-10
Lower Level	20	23-Mar-10	19-Apr-10
Install New Windows/Doors LL - Ex Gym	20	23-Mar-10	19-Apr-10
Entry Level	33	25-Mar-10	10-May-10
Install New Windows/Doors EL - Ex Gym	33	25-Mar-10	10-May-10
Upper Level	5	06-Apr-10	12-Apr-10
Install New Windows at South End UL - Ex G	5	06-Apr-10	12-Apr-10

Actual Work · Critical Remaining Work · Summary
Remaining Work · Milestone

Activity Name	Original Duration	Start	Finish
MEP	87	23-Mar-10	21-Jul-10
Lower Level	87	23-Mar-10	21-Jul-10
Underground Plumbing LL - Ex Gym	10	23-Mar-10	05-Apr-10
Ductwork & VAV LL - Ex Gym	20	23-Mar-10	19-Apr-10
Plumbing In-Wall Rough-in LL - Ex Gym	15	26-Mar-10	15-Apr-10
Elec In-Wall Rough-in LL - Ex Gym	15	26-Mar-10	15-Apr-10
Elec Ceiling Rough-in LL - Ex Gym	20	26-Mar-10	22-Apr-10
Mech Piping LL - Ex Gym	15	06-Apr-10	26-Apr-10
Sprinkler Mains & Branch Lines LL - Ex Gym	20	13-Apr-10	10-May-10
Lighting LL - Ex Gym	15	23-Apr-10	13-May-10
Plumbing Fixtures LL - Ex Gym	20	23-Jun-10	21-Jul-10
Fire Alarm Devices LL - Ex Gym	15	23-Jun-10	14-Jul-10
Entry Level	39	23-Mar-10	14-May-10
Sprinkler Mains & Branch Lines EL	10	23-Mar-10	05-Apr-10
Mech Piping EL - Ex Gym	5	25-Mar-10	31-Mar-10
Elec Wall Rough-in EL - Ex Gym	3	25-Mar-10	29-Mar-10
Elec Ceiling Rough-in EL - Ex Gym	2	25-Mar-10	26-Mar-10
Lighting EL - Ex Gym	4	05-Apr-10	08-Apr-10
Fire Alarm Devices EL - Ex Gym	4	11-May-10	14-May-10
Finishes	88	19-Mar-10	20-Jul-10
Lower Level	88	19-Mar-10	20-Jul-10
Establish Control & Layout Walls LL - Ex Gy	5	19-Mar-10	25-Mar-10
CMU Partitions LL - Ex Gym	20	13-Apr-10	10-May-10
Ceilings LL - Ex Gym	10	11-May-10	24-May-10
Wall Finishes LL - Ex Gym	20	25-May-10	22-Jun-10
Floor Finishes LL - Ex Gym	20	09-Jun-10	07-Jul-10
Specialties LL - Ex Gym	20	22-Jun-10	20-Jul-10
Entry Level	61	30-Mar-10	22-Jun-10
Repair Existing Walls EL - Ex Gym	10	30-Mar-10	12-Apr-10
Finishes EL - Ex Gym	10	13-Apr-10	26-Apr-10
New Gym Floor - Ex Gym	20	18-May-10	15-Jun-10
Reinstall Existing Bleachers - Ex Gym	5	16-Jun-10	22-Jun-10
Upper Level	10	27-Apr-10	10-May-10
Finishes UL - Ex Gym	10	27-Apr-10	10-May-10
Commissioning & Close-out	32	22-Jul-10	03-Sep-10
General / No Floor Associated	32	22-Jul-10	03-Sep-10
Final Inspections - Ex Gym, Ex Fitness Area,	10	22-Jul-10	04-Aug-10
Substantial Completion - Ex Gym, Ex Fitness	0		04-Aug-10*
Final Completion - Overall Project	0		03-Sep-10*

Actual Work | Critical Remaining Work | Summary | Remaining Work | Milestone

APPENDIX C – Site Layout Plans



LEGEND:

SYMBOLS:

- CONSTRUCTION TRAFFIC..........
- CONSTRUCTION FENCE.............
- COVERED EGRESS.........................
- CONSTRUCTION GATE...............
- GC FIELD TRAILER.........................
- SUBCONTRACTOR TRAILER.......
- TOOL STORAGE SHED.................
- DUMPSTER.......................................
- TEMPORARY TOILETS...................
- TOWER CRANE BASE....................
- CONCRETE PUMP LOCATION....
- TEMPORARY/PERMANENT........ TRANSFORMER LOCATION

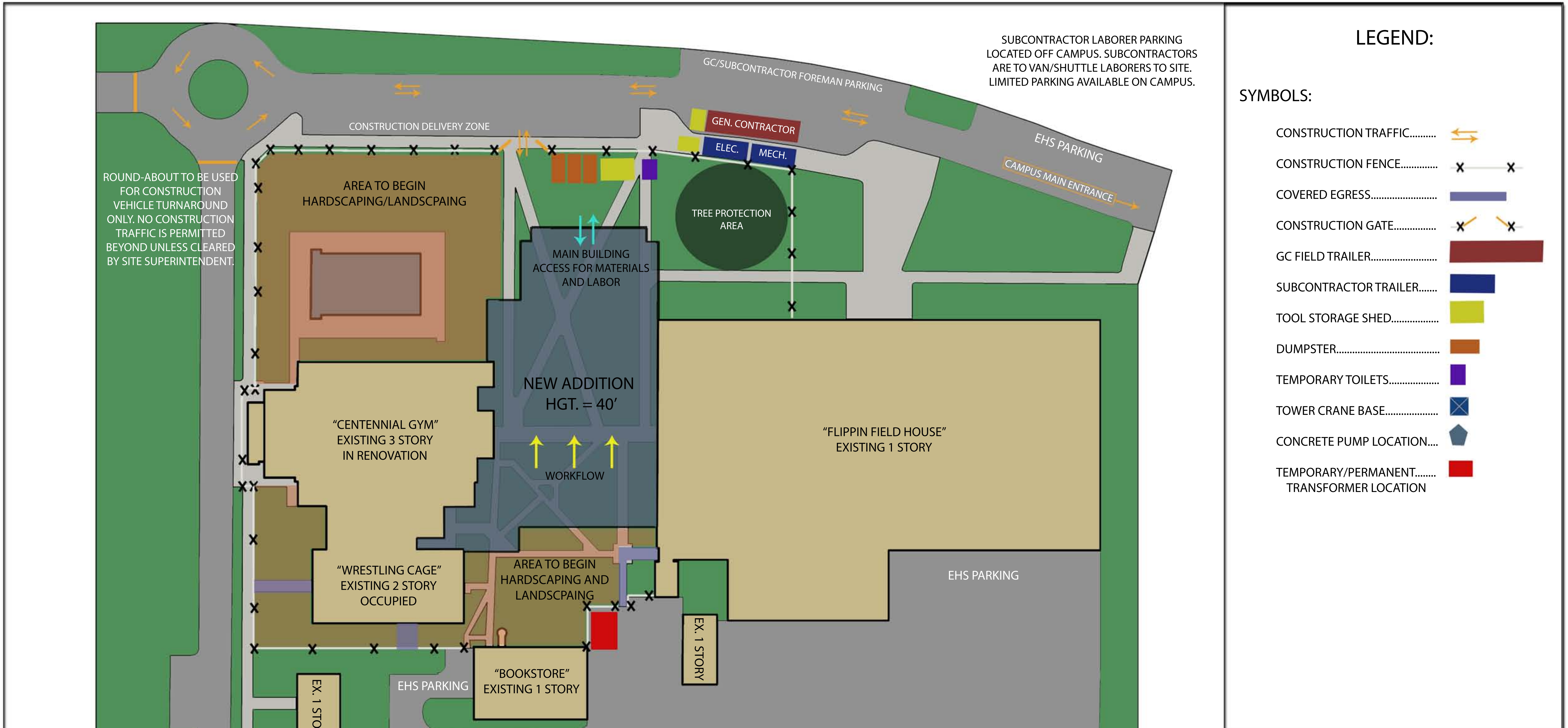
EPISCOPAL HIGH SCHOOL CENTENNIAL GYMNASIUM

SUPERSTRUCTURE PHASE PLAN

CONCRETE, STEEL AND MASONRY

OCTOBER 28, 2009

ERIC FEDDER - CM



EPISCOPAL HIGH SCHOOL CENTENNIAL GYMNASIUM

MEP/INTERIOR FINISHES PHASE PLAN

OCTOBER 28, 2009

ERIC FEDDER - CM

APPENDIX D – General Conditions Estimate

SUPERVISION and PERSONNEL				
LINE ITEM	**UNIT RATE**	**UNIT**	**QUANTITY**	**COST**
Vice President	$2,200.00	WEEK	37.5	$82,500.00
Project Executive	$1,824.00	WEEK	37.5	$68,400.00
Senior Superintendent	$3,860.00	WEEK	85	$328,100.00
Project Manager	$2,580.00	WEEK	95	$245,100.00
Assistant Project Manager	$1,520.00	WEEK	105	$159,600.00
Layout Engineer	$580.00	WEEK	55	$31,900.00
Project Administrator	$800.00	MONTH	17.4	$13,920.00
Safety Coordinator	$146.00	WEEK	65	$9,490.00
Project Scheduler	$202.00	WEEK	45	$9,090.00
Estimating Expenses	$42,000.00	LS	1	$42,000.00
Site Labor	$1,250.00	WEEK	75	$93,750.00
			TOTAL	**$1,083,850.00**

CONSTRUCTION FACILITIES and EQUIPMENT				
LINE ITEM	**UNIT RATE**	**UNIT**	**QUANTITY**	**COST**
Field Office Trailer Set-up	$2,000.00	LS	1	$2,000.00
Field Office Trailer Rental	$1,000.00	MONTH	17.4	$17,400.00
Field Office Trailer Removal	$2,500.00	LS	1	$2,500.00
Construction Site Fence	$600.00	MONTH	18.5	$11,100.00
Storage Trailer	$140.00	MONTH	18.5	$2,590.00
Survey/Layout Equipment	$200.00	MONTH	17.5	$3,500.00
Gang Box	$55.00	MONTH	18.5	$1,017.50
Tools/Equipment	$650.00	MONTH	18	$11,700.00
Clean-up Equipment	$25.00	WEEK	70	$1,750.00
Fire Extinguishers	$75.00	MONTH	18.5	$1,387.50
Field Copier/Fax/Printer	$400.00	MONTH	16	$6,400.00
Computer/LAN Equipment	$2,432.43	MONTH	18.5	$45,000.00
Mobile Phones	$325.00	MONTH	18.5	$6,012.50
Personal Protective Equipment	$100.00	MONTH	18	$1,800.00
Signage	$2,600.00	LS	1	$2,600.00
Dumpsters	$550.00	WEEK	57	$31,350.00
			TOTAL	**$148,107.50**

TEMPORARY UTILITIES				
LINE ITEM	**UNIT RATE**	**UNIT**	**QUANTITY**	**COST**
Field IT/Network Set-up	$4,500.00	LS	1	$4,500.00
Field Telephone Hook-up	$1,500.00	LS	1	$1,500.00
Field Telephone Service	$100.00	MONTH	17.4	$1,740.00
Temporary Power Installation	$15,000.00	LS	1	$15,000.00
Temporary Power Consumption	$12,000.00	MONTH	6	$72,000.00
Temporary Water/Sanitary Supply	$2,100.00	LS	1	$2,100.00
Temporary Toilets	$975.00	MONTH	18.5	$18,037.50
Potable Water	$60.00	MONTH	18.5	$1,110.00
			TOTAL	**$115,987.50**

MISCELLANEOUS COSTS				
LINE ITEM	**UNIT RATE**	**UNIT**	**QUANTITY**	**COST**
Occupancy Permit	$1,000.00	LS	1	$1,000.00
Trade Permits	$1,000.00	LS	1	$1,000.00
Progress Photographs	$350.00	MONTH	17.5	$6,125.00
Document Reproduction	$35,000.00	LS	1	$35,000.00
Travel Expenses (Staff Vehicles)	$4,100.00	MONTH	18.5	$75,850.00
Delivery/Shipping Expenses	$300.00	MONTH	15	$4,500.00
Clean-up Expenses	$490.00	WEEK	70	$34,300.00
Misc. Field Expenses	$1,000.00	MONTH	18.5	$18,500.00
Insurance	$87,500.00	LS	1	$87,500.00
			TOTAL	**$263,775.00**

GENERAL CONDITIONS SUMMARY				
LINE ITEM	**UNIT RATE**	**UNIT**	**QUANTITY**	**COST**
Supervision and Personnel	$14,451.33	WEEK	75	$1,083,850.00
Construction Facilities and Equipment	$1,974.77	WEEK	75	$148,107.50
Temporary Utilities	$1,546.50	WEEK	75	$115,987.50
Miscellaneous Costs	$3,517.00	WEEK	75	$263,775.00
TOTAL	**$21,489.60**		**TOTAL**	**$1,611,720.00**

APPENDIX E – Precast Façade Take-Off

ELEVATION	ITEM	ACTION	QUANTITY	WIDTH	HEIGHT	SF	COST/SF	TOTAL COST
South	Precast A	Add	9.00	9.50	14.00	1197.00	$50.00	$59,850.00
(A312)	Precast A-1	Add	9.00	9.50	5.00	427.50	$50.00	$21,375.00
	Precast B	Add	4.00	6.25	14.00	350.00	$50.00	$17,500.00
	Precast B-1	Add	4.00	6.25	5.00	125.00	$50.00	$6,250.00
	Precast C	Add	7.00	6.75	5.25	248.06	$50.00	$12,403.13
	Precast C-1	Add	7.00	6.75	5.00	236.25	$50.00	$11,812.50
	Precast C-2	Add	7.00	6.75	2.25	106.31	$50.00	$5,315.63
	Precast D	Add	3.00	7.33	14.00	307.86	$50.00	$15,393.00
	Precast D-1	Add	1.00	7.33	5.00	36.65	$50.00	$1,832.50
	Precast E	Add	2.00	4.75	5.33	50.64	$50.00	$2,531.75
	Precast E-1	Add	2.00	4.75	5.00	47.50	$50.00	$2,375.00
	Precast E-2	Add	2.00	4.75	3.33	31.64	$50.00	$1,581.75
	Precast E-3	Add	2.00	4.75	5.75	54.63	$50.00	$2,731.25
	Precast E-4	Add	2.00	4.75	1.50	14.25	$50.00	$712.50
	Precast F	Add	6.00	2.70	14.00	226.80	$50.00	$11,340.00
	Precast F-1	Add	2.00	2.70	5.00	27.00	$50.00	$1,350.00
	Precast G	Add	1.00	6.67	IRR.	28.00	$50.00	$1,400.00
	Precast G-1	Add	1.00	6.67	5.00	33.35	$50.00	$1,667.50
	Precast G-2	Add	1.00	6.67	3.33	22.21	$50.00	$1,110.56
	Precast G-3	Add	1.00	6.67	5.75	38.35	$50.00	$1,917.63
	Precast H	Add	3.00	6.00	14.00	252.00	$50.00	$12,600.00
	Precast H-1	Add	1.00	6.00	5.00	30.00	$50.00	$1,500.00
	Precast I	Add	2.00	2.00	14.00	56.00	$50.00	$2,800.00
	Precast I-1	Add	1.00	2.00	6.25	12.50	$50.00	$625.00
	Precast J	Add	1.00	3.25	5.33	17.32	$50.00	$866.13
	Precast J-1	Add	1.00	3.25	6.25	20.31	$50.00	$1,015.63
	Precast J-2	Add	2.00	3.25	3.25	21.13	$50.00	$1,056.25
	Precast K	Add	1.00	12.00	14.00	168.00	$50.00	$8,400.00
	Precast K-1	Add	1.00	12.00	3.00	36.00	$50.00	$1,800.00
		TOTAL	**86.00**			**4222.25**		**$211,112.68**
		MASONRY DEDUCT						($316,669.02)
		TOTAL SAVINGS						($105,556.34)

ELEVATION	ITEM	ACTION	QUANTITY	WIDTH	HEIGHT	SF	COST/SF	TOTAL COST
North	Precast A	Add	1.00	9.50	14.00	133.00	$50.00	$6,650.00
(A314)	Precast A-1	Add	1.00	9.50	5.00	47.50	$50.00	$2,375.00
	Precast A-2	Add	1.00	9.50	IRR.	32.00	$50.00	$1,600.00
	Precast B	Add	6.00	6.25	14.00	525.00	$50.00	$26,250.00
	Precast B-1	Add	4.00	6.25	5.00	125.00	$50.00	$6,250.00
	Precast B-2	Add	1.00	6.25	IRR.	17.00	$50.00	$850.00
	Precast B-3	Add	1.00	6.25	IRR.	26.00	$50.00	$1,300.00
	Precast B-4	Add	1.00	6.25	IRR.	46.00	$50.00	$2,300.00
	Precast C	Add	4.00	6.75	5.25	141.75	$50.00	$7,087.50
	Precast C-1	Add	6.00	6.75	5.00	202.50	$50.00	$10,125.00
	Precast C-3	Add	1.00	6.75	IRR.	25.00	$50.00	$1,250.00
	Precast C-4	Add	2.00	6.75	IRR.	182.00	$50.00	$9,100.00
	Precast C-5	Add	1.00	6.75	IRR.	22.00	$50.00	$1,100.00
	Precast C-6	Add	1.00	6.75	IRR.	53.00	$50.00	$2,650.00
	Precast C-7	Add	1.00	6.75	5.75	38.81	$50.00	$1,940.63
	Precast D	Add	3.00	7.33	14.00	307.86	$50.00	$15,393.00
	Precast D-1	Add	1.00	7.33	5.00	36.65	$50.00	$1,832.50
	Precast E	Add	2.00	4.75	5.33	50.64	$50.00	$2,531.75
	Precast E-1	Add	2.00	4.75	5.00	47.50	$50.00	$2,375.00
	Precast E-2	Add	2.00	4.75	3.33	31.64	$50.00	$1,581.75
	Precast E-3	Add	2.00	4.75	5.75	54.63	$50.00	$2,731.25
	Precast E-5	Add	2.00	4.75	5.50	52.25	$50.00	$2,612.50
	Precast F	Add	6.00	2.70	14.00	226.80	$50.00	$11,340.00
	Precast F-1	Add	2.00	2.70	5.00	27.00	$50.00	$1,350.00
	Precast G	Add	1.00	6.67	IRR.	28.00	$50.00	$1,400.00
	Precast G-1	Add	1.00	6.67	5.00	33.35	$50.00	$1,667.50
	Precast G-2	Add	1.00	6.67	3.33	22.21	$50.00	$1,110.56
	Precast G-3	Add	1.00	6.67	5.75	38.35	$50.00	$1,917.63
	Precast G-4	Add	1.00	6.67	5.50	36.69	$50.00	$1,834.25
	Precast H	Add	3.00	6.00	14.00	252.00	$50.00	$12,600.00
	Precast H-1	Add	1.00	6.00	5.00	30.00	$50.00	$1,500.00
	Precast I	Add	2.00	2.00	14.00	56.00	$50.00	$2,800.00
	Precast I-1	Add	1.00	2.00	6.25	12.50	$50.00	$625.00
	Precast J	Add	1.00	3.25	5.33	17.32	$50.00	$866.13
	Precast J-1	Add	1.00	3.25	6.25	20.31	$50.00	$1,015.63
	Precast J-2	Add	2.00	3.25	3.25	21.13	$50.00	$1,056.25
	Precast K	Add	2.00	12.00	14.00	336.00	$50.00	$16,800.00
	Precast K-1	Add	1.00	12.00	3.00	36.00	$50.00	$1,800.00
	Precast L	Add	4.00	20.00	5.00	400.00	$50.00	$20,000.00
	Precast L-1	Add	2.00	20.00	IRR.	430.00	$50.00	$21,500.00
	Precast L-2	Add	2.00	20.00	IRR.	240.00	$50.00	$12,000.00
		TOTAL	**81.00**			**4461.38**		**$223,068.81**
		MASONRY DEDUCT						($334,603.21)
		TOTAL SAVINGS						($111,534.40)

ELEVATION	ITEM	ACTION	QUANTITY	WIDTH	HEIGHT	SF	COST/SF	TOTAL COST
East	Precast B-6	Add	2.00	6.25	4.00	50.00	$50.00	$2,500.00
(A313)	Precast B-7	Add	1.00	2.70	14.00	37.80	$50.00	$1,890.00
	Precast D-2	Add	2.00	7.33	IRR.	132.00	$50.00	$6,600.00
	Precast D-3	Add	2.00	7.33	IRR.	162.00	$50.00	$8,100.00
	Precast D-4	Add	2.00	7.33	IRR.	190.00	$50.00	$9,500.00
	Precast D-5	Add	2.00	7.33	IRR.	216.00	$50.00	$10,800.00
	Precast G	Add	7.00	6.67	IRR.	28.00	$50.00	$1,400.00
	Precast G-1	Add	2.00	6.67	5.00	66.70	$50.00	$3,335.00
	Precast G-2	Add	9.00	6.67	3.33	199.90	$50.00	$9,995.00
	Precast G-6	Add	5.00	6.67	11.50	383.53	$50.00	$19,176.25
	Precast G-7	Add	2.00	6.67	4.00	53.36	$50.00	$2,668.00
	Precast G-8	Add	5.00	6.67	17.00	566.95	$50.00	$28,347.50
	Precast G-9	Add	2.00	6.67	IRR.	36.00	$50.00	$1,800.00
	Precast G-10	Add	2.00	6.67	IRR.	82.00	$50.00	$4,100.00
	Precast G-11	Add	1.00	6.67	IRR.	59.00	$50.00	$2,950.00
	Precast I	Add	5.00	2.00	14.00	140.00	$50.00	$7,000.00
	Precast I-2	Add	2.00	2.00	8.33	33.32	$50.00	$1,666.00
	Precast M	Add	16.00	5.00	14.00	1120.00	$50.00	$56,000.00
	Precast M-1	Add	4.00	5.00	5.00	100.00	$50.00	$5,000.00
	Precast M-3	Add	4.00	5.00	17.00	340.00	$50.00	$17,000.00
	Precast M-4	Add	2.00	5.00	IRR.	46.00	$50.00	$2,300.00
	Precast M-5	Add	2.00	5.00	IRR.	80.00	$50.00	$4,000.00
	Precast N	Add	1.00	16.33	5.33	87.04	$50.00	$4,351.95
	Precast O	Add	2.00	4.00	8.25	66.00	$50.00	$3,300.00
	Precast O-1	Add	2.00	4.00	14.00	112.00	$50.00	$5,600.00
	Precast O-2	Add	4.00	4.00	17.00	272.00	$50.00	$13,600.00
		TOTAL	**90.00**			**4659.59**		**$232,979.69**
		MASONRY DEDUCT						($349,469.54)
		TOTAL SAVINGS						($116,489.85)

ELEVATION	ITEM	ACTION	QUANTITY	WIDTH	LF	SF	COST/SF	TOTAL COST
Corners	Precast CRN	Add	1.00	4.00	477.75	1911.00	$65.00	$124,215.00
		TOTAL	**1.00**			**1911.00**		**$124,215.00**
		MASONRY DEDUCT						($143,325.00)
		TOTAL SAVINGS						($19,110.00)

ELEVATION	ITEM	ACTION	QUANTITY	WIDTH	HEIGHT	SF	COST/SF	TOTAL COST
West	Precast B	Add	2.00	6.25	14.00	175.00	$50.00	$8,750.00
(A314)	Precast B-5	Add	2.00	6.25	6.25	78.13	$50.00	$3,906.25
	Precast D-2	Add	2.00	7.33	IRR.	132.00	$50.00	$6,600.00
	Precast D-3	Add	2.00	7.33	IRR.	162.00	$50.00	$8,100.00
	Precast D-4	Add	2.00	7.33	IRR.	190.00	$50.00	$9,500.00
	Precast D-5	Add	2.00	7.33	IRR.	216.00	$50.00	$10,800.00
	Precast G	Add	4.00	6.67	IRR.	28.00	$50.00	$1,400.00
	Precast G-1	Add	3.00	6.67	5.00	100.05	$50.00	$5,002.50
	Precast G-2	Add	8.00	6.67	3.33	177.69	$50.00	$8,884.44
	Precast G-5	Add	2.00	6.67	6.25	83.38	$50.00	$4,168.75
	Precast I	Add	8.00	2.00	14.00	224.00	$50.00	$11,200.00
	Precast I-1	Add	2.00	2.00	6.25	25.00	$50.00	$1,250.00
	Precast I-2	Add	2.00	2.00	8.33	33.32	$50.00	$1,666.00
	Precast J	Add	2.00	3.25	5.33	34.65	$50.00	$1,732.25
	Precast J-1	Add	2.00	3.25	6.25	40.63	$50.00	$2,031.25
	Precast J-2	Add	4.00	3.25	3.25	42.25	$50.00	$2,112.50
	Precast M	Add	12.00	5.00	14.00	840.00	$50.00	$42,000.00
	Precast M-1	Add	4.00	5.00	5.00	100.00	$50.00	$5,000.00
	Precast M-2	Add	2.00	5.00	6.25	62.50	$50.00	$3,125.00
	Precast N	Add	1.00	16.33	5.33	87.04	$50.00	$4,351.95
	Precast N-1	Add	1.00	16.33	6.25	102.06	$50.00	$5,103.13
	Precast N-2	Add	1.00	16.33	3.33	54.38	$50.00	$2,718.95
	Precast O	Add	2.00	4.00	8.25	66.00	$50.00	$3,300.00
		TOTAL	**72.00**			**3054.06**		**$152,702.96**
		MASONRY DEDUCT						($229,054.43)
		TOTAL SAVINGS						($76,351.48)

TOTALS:	
Pieces	429.00
SF	18308.28
Precast Cost	$944,079.13
Masonry Savings	($1,373,121.20)
Total Savings	($429,042.07)

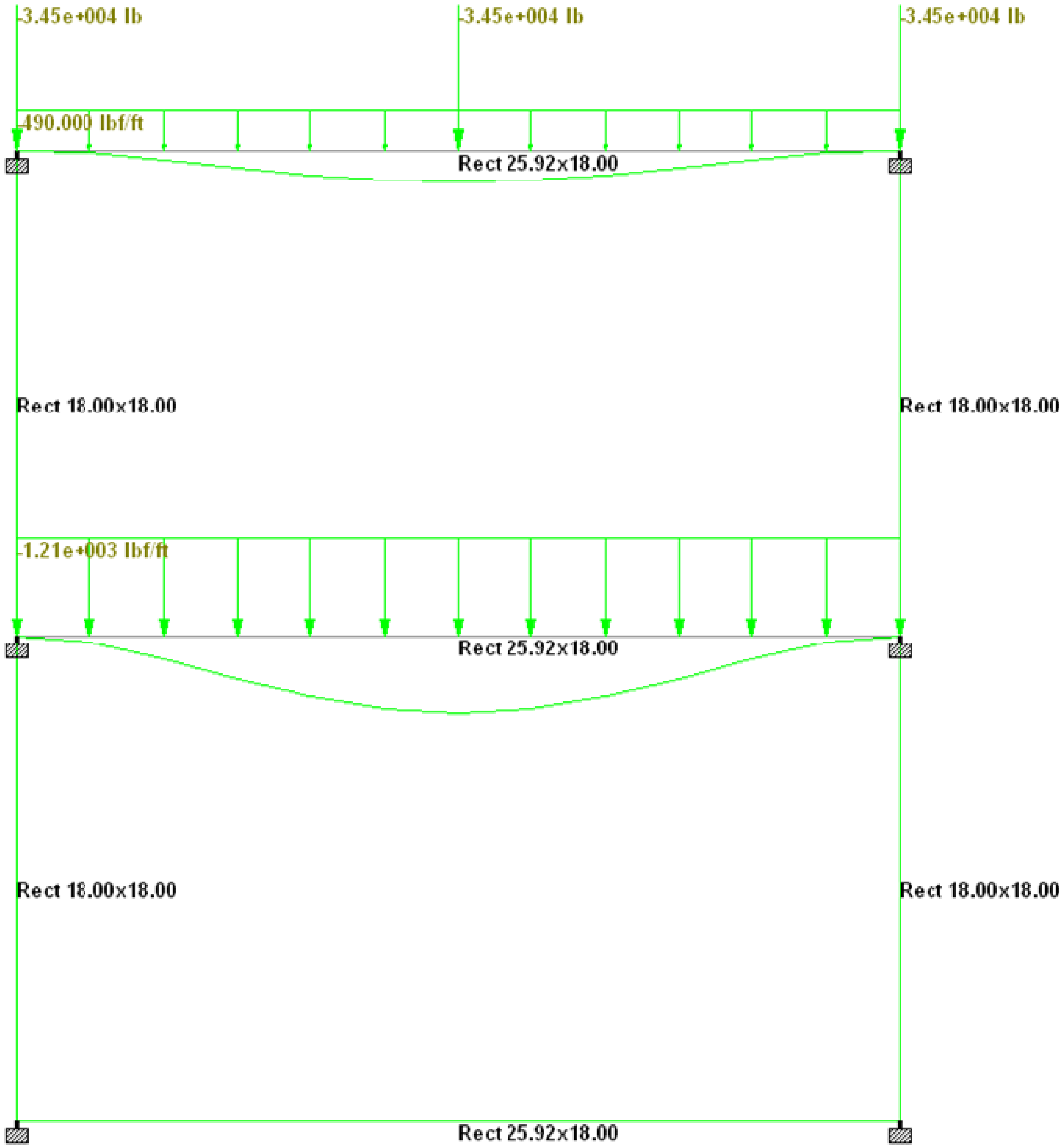
APPENDIX F – Spandrel Beam Deflection Charts and Diagrams

DEFLECTION AT SPANDREL BEAMS (2.16'x1.5')					
BEAM	**LOAD CASE**	**DISTANCE (FT)**	**X DEFLECTION (IN.)**	**Y DEFLECTION (IN.)**	**RESULTANT DEFLECTION (IN.)**
Upper	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.015	0.015
		12.75	0	-0.027	0.027
		19.125	0	-0.015	0.015
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.01	0.01
		12.75	0	-0.017	0.017
		19.125	0	-0.01	0.01
		25.5	0	0	0
Roof	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.006	0.006
		12.75	0	-0.011	0.011
		19.125	0	-0.006	0.006
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.004	0.004
		12.75	0	-0.007	0.007
		19.125	0	-0.004	0.004
		25.5	0	0	0

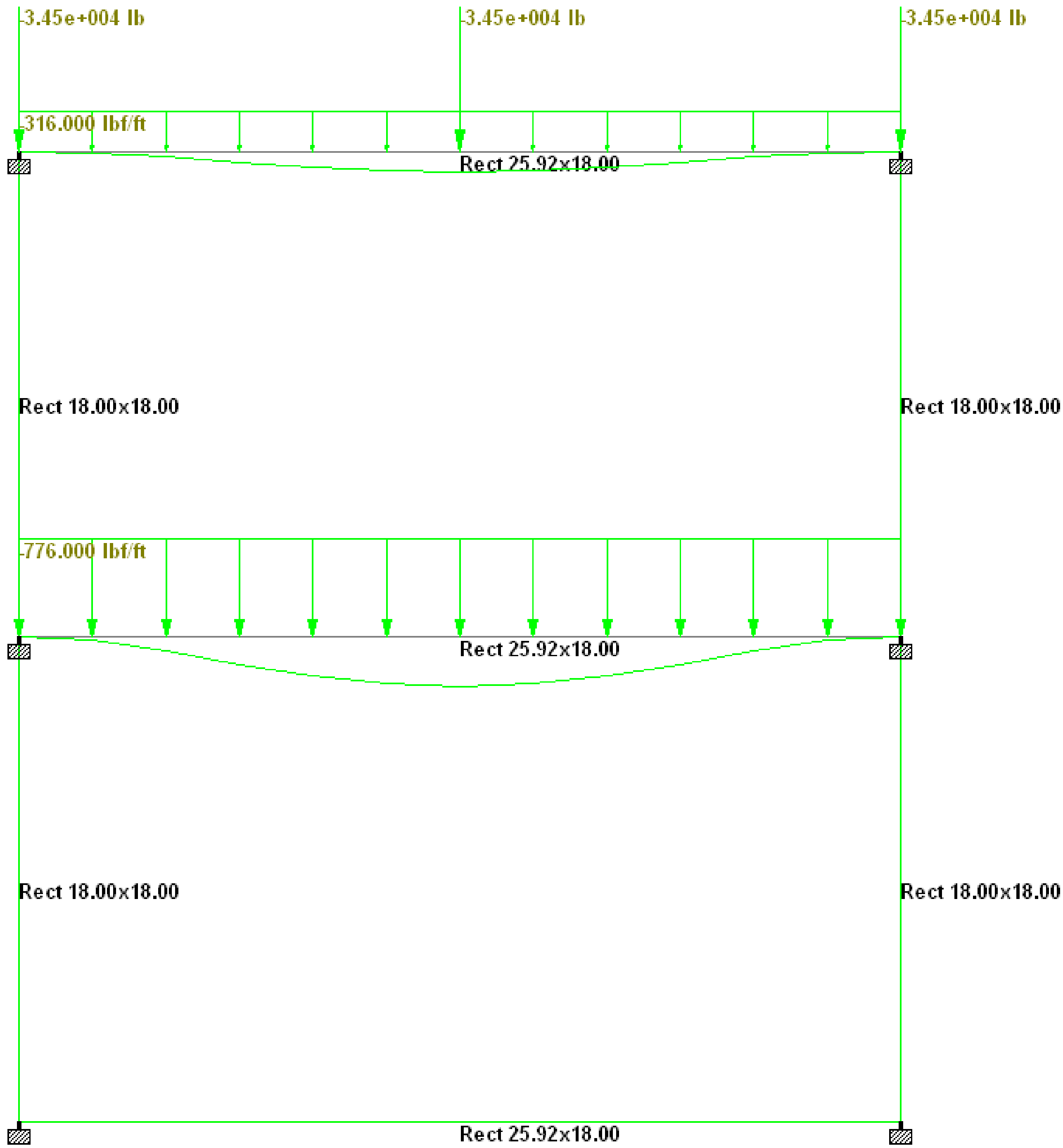
DEFLECTION AT SPANDREL BEAMS (2.0'x1.0')					
BEAM	**LOAD CASE**	**DISTANCE (FT)**	**X DEFLECTION (IN.)**	**Y DEFLECTION (IN.)**	**RESULTANT DEFLECTION (IN.)**
Upper	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.029	0.029
		12.75	0	-0.051	0.051
		19.125	0	-0.029	0.029
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.018	0.018
		12.75	0	-0.033	0.033
		19.125	0	-0.018	0.018
		25.5	0	0	0
Roof	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.012	0.012
		12.75	0	-0.021	0.021
		19.125	0	-0.012	0.012
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.007	0.007
		12.75	0	-0.013	0.013
		19.125	0	-0.007	0.007
		25.5	0	0	0

DEFLECTION AT SPANDREL BEAMS (1.75'x1.0')					
BEAM	LOAD CASE	DISTANCE (FT)	X DEFLECTION (IN.)	Y DEFLECTION (IN.)	RESULTANT DEFLECTION (IN.)
Upper	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.043	0.043
		12.75	0	-0.076	0.076
		19.125	0	-0.043	0.043
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.027	0.027
		12.75	0	-0.049	0.049
		19.125	0	-0.027	0.027
		25.5	0	0	0
Roof	Masonry Wall Loads	0	0	0	0
		6.375	0	-0.017	0.017
		12.75	0	-0.031	0.031
		19.125	0	-0.017	0.017
		25.5	0	0	0
	Precast Panel Loads	0	0	0	0
		6.375	0	-0.011	0.011
		12.75	0	-0.02	0.02
		19.125	0	-0.011	0.011
		25.5	0	0	0

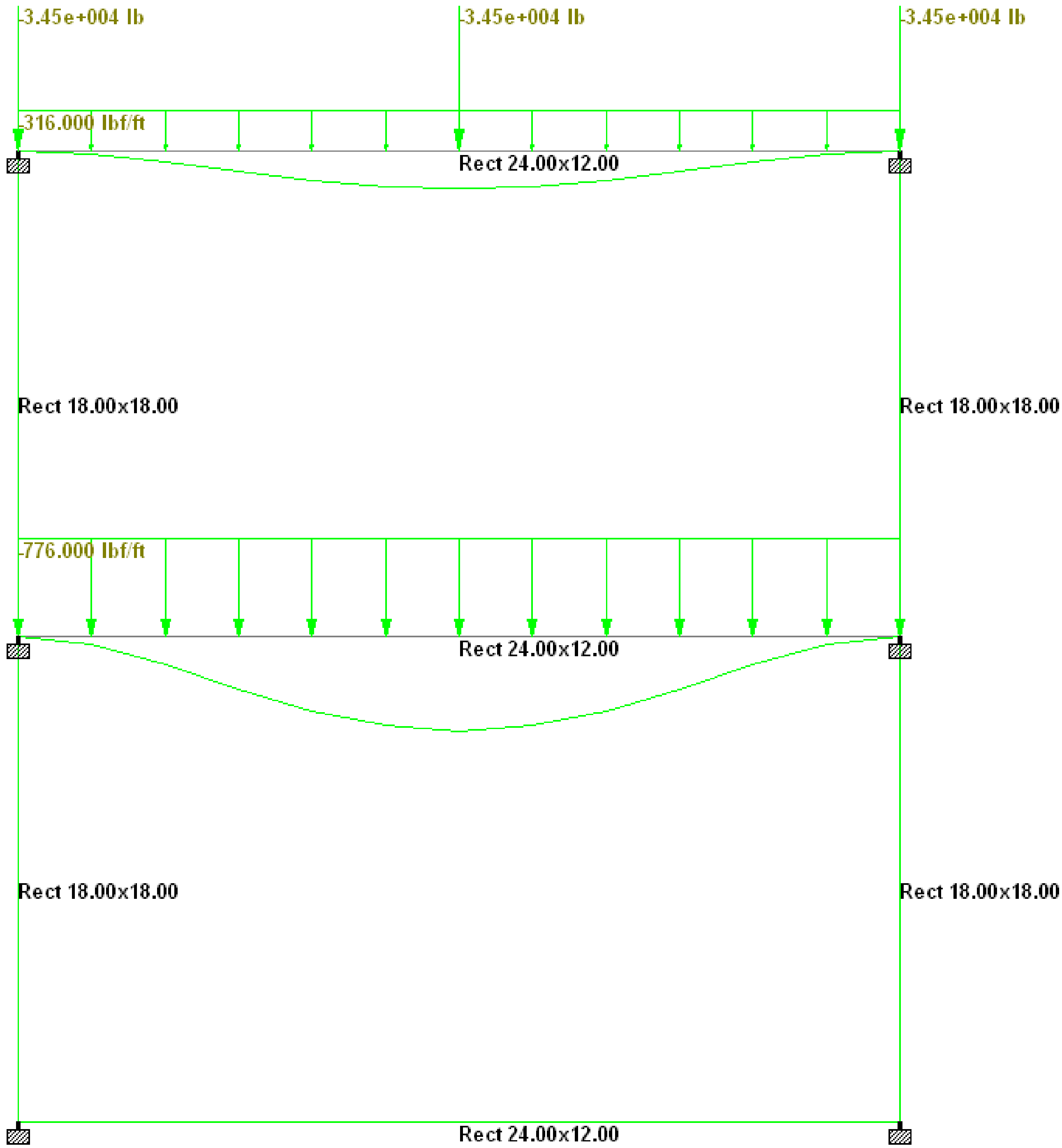
1) DEFLECTION DIAGRAM FOR EXISTING SPANDREL BEAMS UNDER MASONRY WALL LOADS



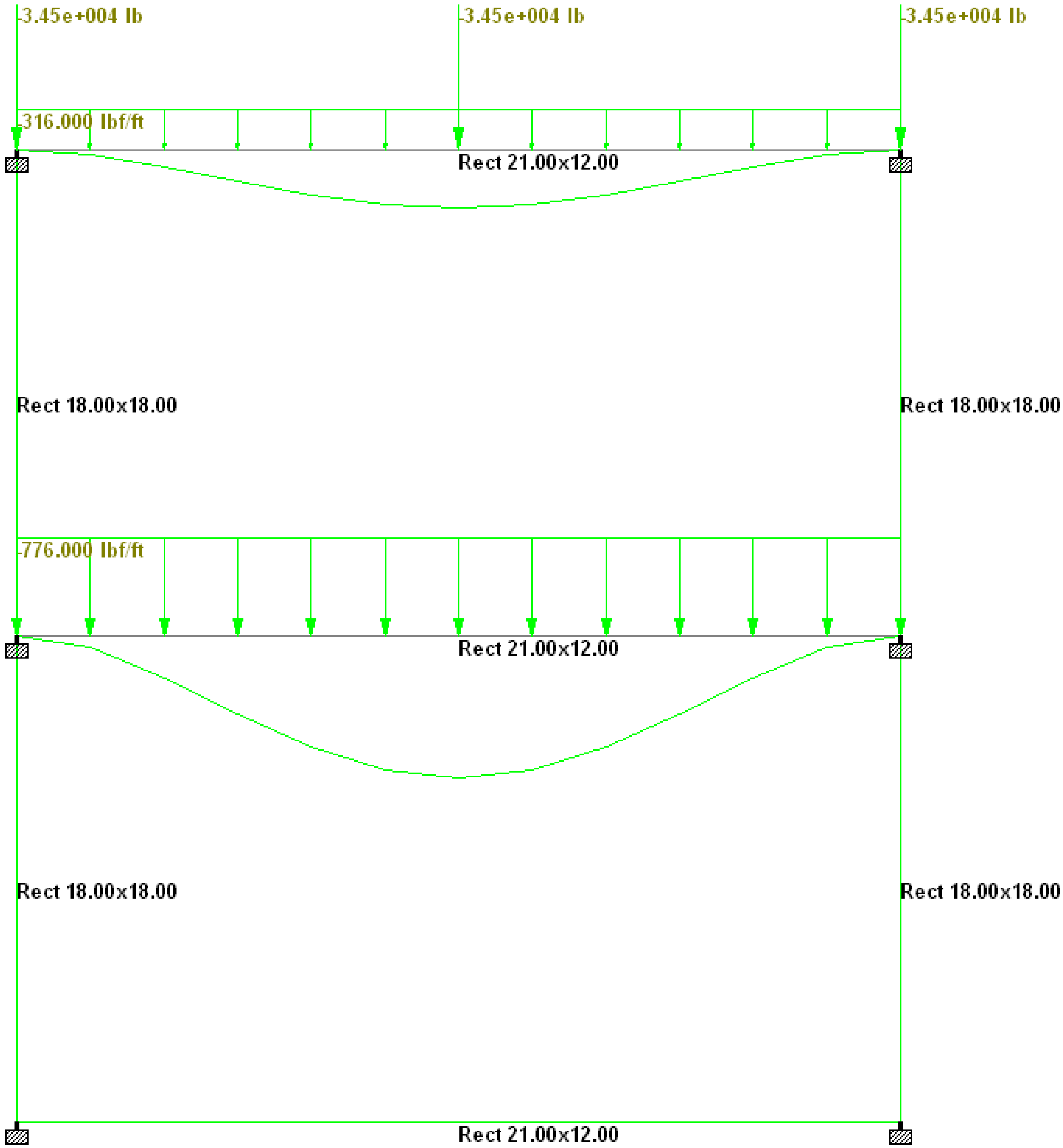
2) DEFLECTION DIAGRAM FOR EXISTING SPANDREL BEAMS UNDER PRECAST PANEL LOADS



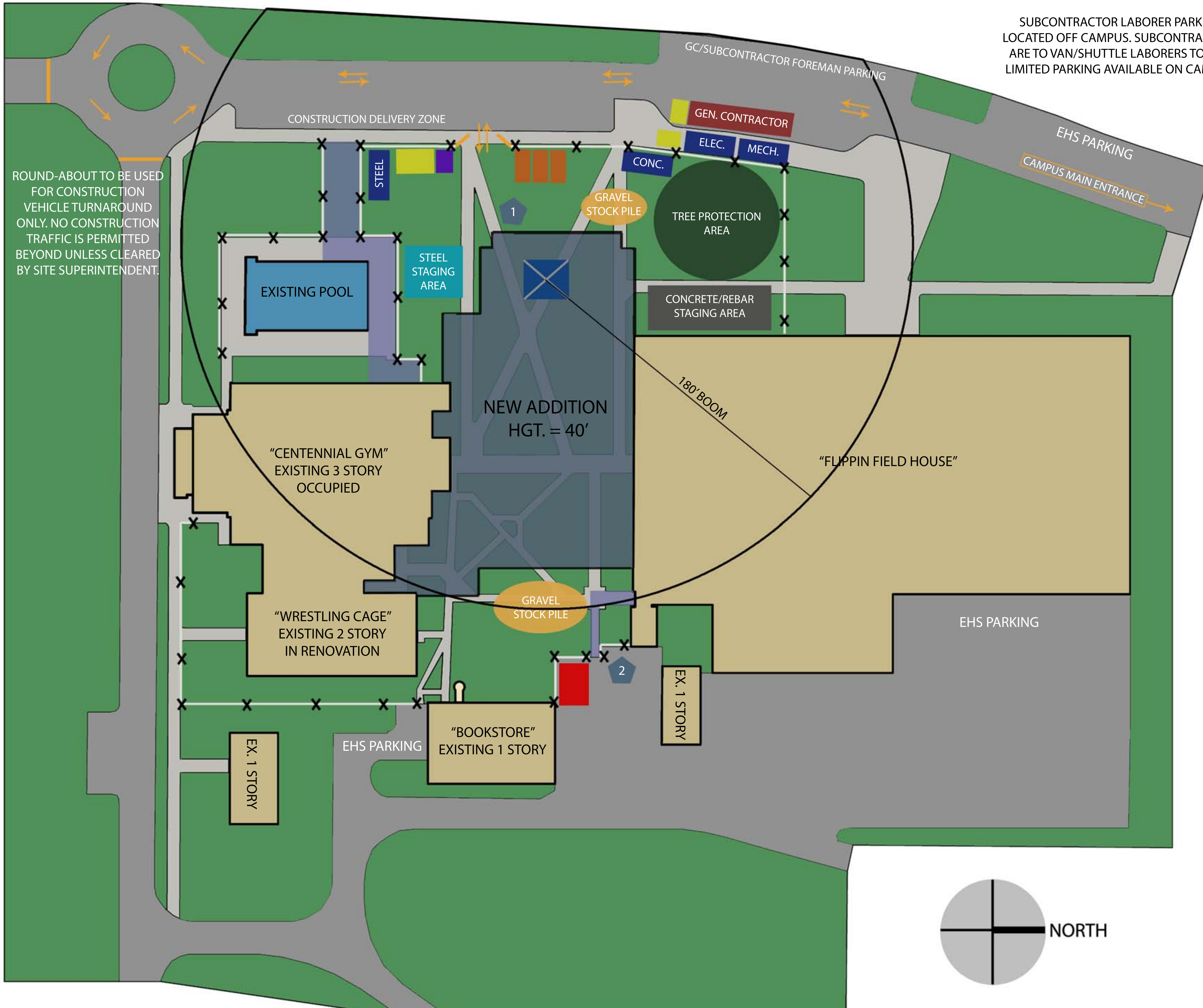
3) DEFLECTION DIAGRAM FOR 2'x1' SPANDREL BEAMS UNDER PRECAST PANEL LOADS



4) DEFLECTION DIAGRAM FOR 1.75'x1' SPANDREL BEAMS UNDER PRECAST PANEL LOADS



APPENDIX G – Site Layout Plans for Precast Façade



LEGEND:

SYMBOLS:

CONSTRUCTION TRAFFIC..........

CONSTRUCTION FENCE.............

COVERED EGRESS..........................

CONSTRUCTION GATE...............

GC FIELD TRAILER..........................

SUBCONTRACTOR TRAILER.......

TOOL STORAGE SHED.................

DUMPSTER.......................................

TEMPORARY TOILETS...................

TOWER CRANE BASE.....................

CONCRETE PUMP LOCATION....

TEMPORARY/PERMANENT........ TRANSFORMER LOCATION

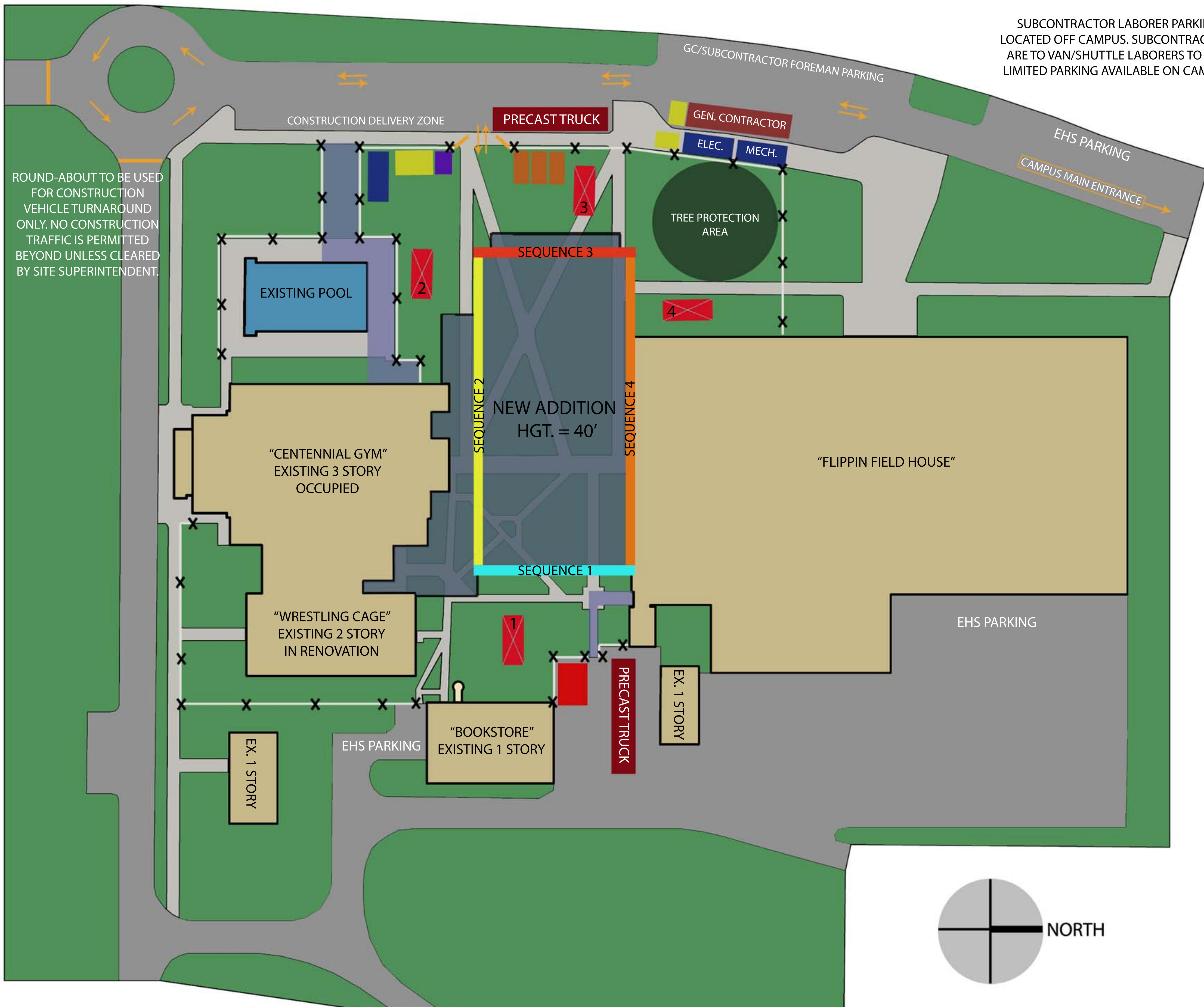
EPISCOPAL HIGH SCHOOL CENTENNIAL GYMNASIUM

SUPERSTRUCTURE PHASE PLAN

CONCRETE and STEEL

APRIL 7th, 2010

ERIC FEDDER - CM



LEGEND:

SYMBOLS:

- CONSTRUCTION TRAFFIC
- CONSTRUCTION FENCE
- COVERED EGRESS
- CONSTRUCTION GATE
- GC FIELD TRAILER
- SUBCONTRACTOR TRAILER
- TOOL STORAGE SHED
- DUMPSTER
- TEMPORARY TOILETS
- TOWER CRANE BASE
- CONCRETE PUMP LOCATION
- TEMPORARY/PERMANENT TRANSFORMER LOCATION
- PRECAST CRANE LOCATION

EPISCOPAL HIGH SCHOOL CENTENNIAL GYMNASIUM

PRECAST FACADE PHASE PLAN
DELIVERY and ERECTION

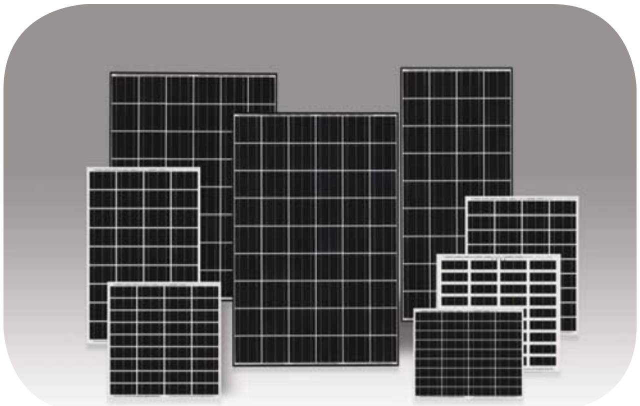
APRIL 7th, 2010

ERIC FEDDER - CM

APPENDIX H – Photovoltaic Array Product Data

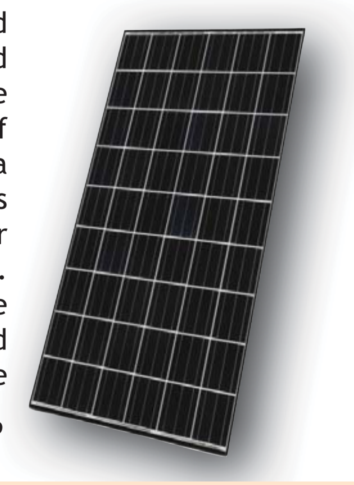
Kyocera Solar Modules [KC/KD]

Kyocera's advanced cell processing technology and automated production facilities have produced multi-crystalline solar cells with efficiencies of over 18.5%. All modules are constructed using a tempered glass front, EVA pottant and a PVF backing to provide maximum protection from the most severe environmental conditions.



KD Module Family

The entire laminate is framed in a heavy duty anodized aluminum frame to provide structural strength and ease of installation. Because Kyocera modules are so efficient less space is required than other solar modules of equal output. This translates to both more wattage per square foot and lower mounting structure cost.



KD 210GX-LP

Features

- KC65T - KC130TM modules have a +10/-5% power tolerance, KC40T-50T: +15/-5%
- KD135GX-LP - KD210GX-LP modules have a +5%/-5% tolerance
- UL listed
- Low iron, tempered glass, EVA encapsulant and anodized aluminum frame construction
- 20 year output warranty on Kyocera modules
- Weather resistant junction box (KC40T-KC130TM) or multi-contact connectors (KD130GX-LP, 180GX-LP, 205GX-LP & 210GX)

Quality Assurance

Kyocera multi-crystal photovoltaic modules exceed government specifications for the following tests:

- Thermal cycling test
- Thermal shock test
- Thermal/Freezing and high humidity cycling test
- Electrical insolation test
- Hail impact test
- Mechanical, wind and twist loading test
- Salt mist test
- Light and water exposure test
- Field exposure test

Product Name and Descriptions	KD 210GX-LP	KD 205GX-LP	KD 180GX-LP	KD 135GX-LP	KC 130TM	KC85T	KC65T	KC50T	KC40T
Part Number	**503091**	**501015**	**501014**	**501013**	**501004**	**703004**	**703005**	**703007**	**703008**
Rate of Power(Watts)	210	205	180	135	130	87	65	54	43
Series Fusing(Amps)	15.0	15.0	15.0	15.0	15.0	7.0	6.0	6.0	6.0
Current at Max. Power(Amps)	7.90	7.71	7.63	7.63	7.39	5.02	3.75	3.11	2.48
Voltage at Max Power(Volts)	26.6	26.6	23.6	17.7	17.6	17.4	17.4	17.4	17.4
Short Circuit Current(Amps)	8.58	8.36	8.35	8.37	8.02	5.34	3.99	3.31	2.65
Open Circuit Voltage(Volts)	33.2	33.2	29.5	22.1	21.9	21.7	21.7	21.7	21.7
Length (Inches)	59.1	59.1	52.8	59.1	56.0	39.6	29.6	25.2	20.7
Width (Inches)	39.0	39.0	39.0	26.3	25.7	25.7	25.7	25.7	25.7
Depth of Frame (Inches)	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Depth including j-box	1.4	1.4	1.4	1.4	2.2	2.2	2.1	2.1	2.1
Shipping Weight (lbs.)	45.8	45.8	41.4	33.0	33.0	24.0	18.0	16.0	13.0

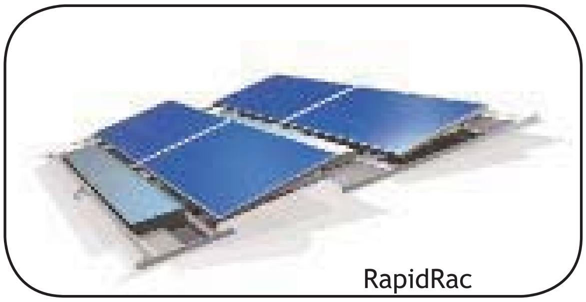
Replacement bypass diodes for Kyocera J-Box equipped modules are sold in packs of 25; part number 705070

All specification at 25°C. cell temperature, 1.5 AM and 1000W/m2. KC "T" and "TM" modules have a conduit ready junction box. "GX" modules have locking multi-contact connectors. See Appendix A for module dimensions and shipping information.

UNIRAC®
The New Standard in PV Module Racks™

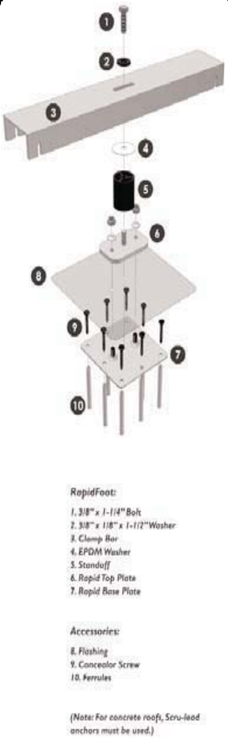
RAPIDRAC™ G10

The RapidRac G10 combines innovative technology with experienced customer input to deliver requirements for reduced installation time and increased labor savings, along with lighter weight and minimal penetration. The unique design of the RapidRac G10 allows installation in less than half the time as the primary competitive products, requiring only 2 tools and 6 parts to complete the install, a significant reduction over current offerings. The flexibility of design allows it to meet most weight, height and wind conditions. The RapidRac G10 accommodates most PV modules, providing the market with tremendous versatility and choice. 10 year limited product, 5 year limited finish warranty.



RapidRac

Product Name and Description	Part Number	RapidRac Part Number	Price	Shipping Weight
1 Bay RapidRac/KD210GX-LP (ballast Frame only)	707637	310351-0911	$99.00	8.0
1 Bay RapidRac/KD210GX-LP (With module mount)	707638	310355-0911	$198.00	12.0
1 Bay RapidRac/KD205GX-LP (ballast Frame only)	707641	310351-0909	$99.00	8.0
1 Bay RapidRac/KD205GX-LP (With module mount)	707642	310355-0909	$198.00	12.0
1 Bay RapidRac/KD180GX-LP (ballast Frame only)	707643	310351-0912	$99.00	8.0
1 Bay RapidRac/KD180GX-LP (With module mount)	707644	310355-0912	$198.00	12.0
1 Bay RapidRac/KD135GX-LP (ballast Frame only)	707636	310351-0914	$99.00	8.0
1 Bay RapidRac/KD135GX-LP (With module mount)	707635	310355-0914	$198.00	12.0
1 Bay RapidRac/KD130TM (ballast Frame only)	707639	310351-0910	$99.00	8.0
1 Bay RapidRac/KD130TM (With module mount)	707640	310355-0910	$198.00	12.0
RapidFoot assembly	706022	310370	$68.50	5.0
Galvalume Flashing #1	706026	990120	$6.68	1.0
Patch, EPDM Blk	706025	990160	$3.19	1.0
Patch, EPDM Blk, Peal & Stick	706023	990161	$6.68	1.0
Concealor Screw 1.5”(14ga or less, wood/metal)	706015	990430-100pk	$24.00	5.0
Concealor Screw 2” (14ga or less, wood/metal)	706014	990431-100pk	$26.50	5.0
Concealor Screw 3” (14ga or less, wood/metal)	706000	990432-100pk	$34.50	5.0
Concealor Screw 4” (14ga or less, wood/metal)	706010	990433-100pk	$42.00	5.0
Concealor Screw 4.5”(14ga or less, wood/metal)	705999	990434-100pk	$48.50	5.0
Concealor Screw 5” (14ga or less, wood/metal)	705997	990435-100pk	$54.00	5.0
Concealor Screw 6” (14ga or less, wood/metal)	705996	990436-100pk	$66.00	5.0
Concealor Screw 7” (14ga or less, wood/metal)	706994	990437-100pk	$75.50	5.0
Concealor Screw 1.375” (12ga or less, metal)	706016	990410-100pk	$51.50	5.0
Concealor Screw 2.75” (12ga or less, metal)	706013	990411-100pk	$53.50	5.0
Concealor Screw 3.75” (12ga or less, metal)	706011	990412-100pk	$59.50	5.0
Concealor Screw 4.75” (12ga or less, metal)	705998	990413-100pk	$71.50	5.0
Concealor Screw 5.75” (12ga or less, metal)	706017	990414-100pk	$77.50	5.0
Concealor Screw 6.75” (12ga or less, metal)	705995	990415-100pk	$83.00	5.0
Concealor Screw 7.75” (12ga or less, metal)	705993	990416-100pk	$90.50	5.0
Ferrules #1, 4ft.	706027	310450	$22.50	1
Anchors #14 - 25pk	706028	310440	$16.20	6.0
Anchors #14 - 100pk	706029	310445	$64.50	22.0



RapidFoot

- 10 year standard warranty
- Prewired at factory for 3-phase utility interconnection
- Integrated load-break rated lockable AC/DC disconnect switch
- Internet-ready with Sunny WebBox
- Improved CEC efficiency
- Integrated fused series string combiner
- Sealed electronics enclosure & Opticool™
- Ideal for commercial applications
- Rugged stainless steel outdoor-rated enclosure
- UL 1741/IEEE-1547 compliant

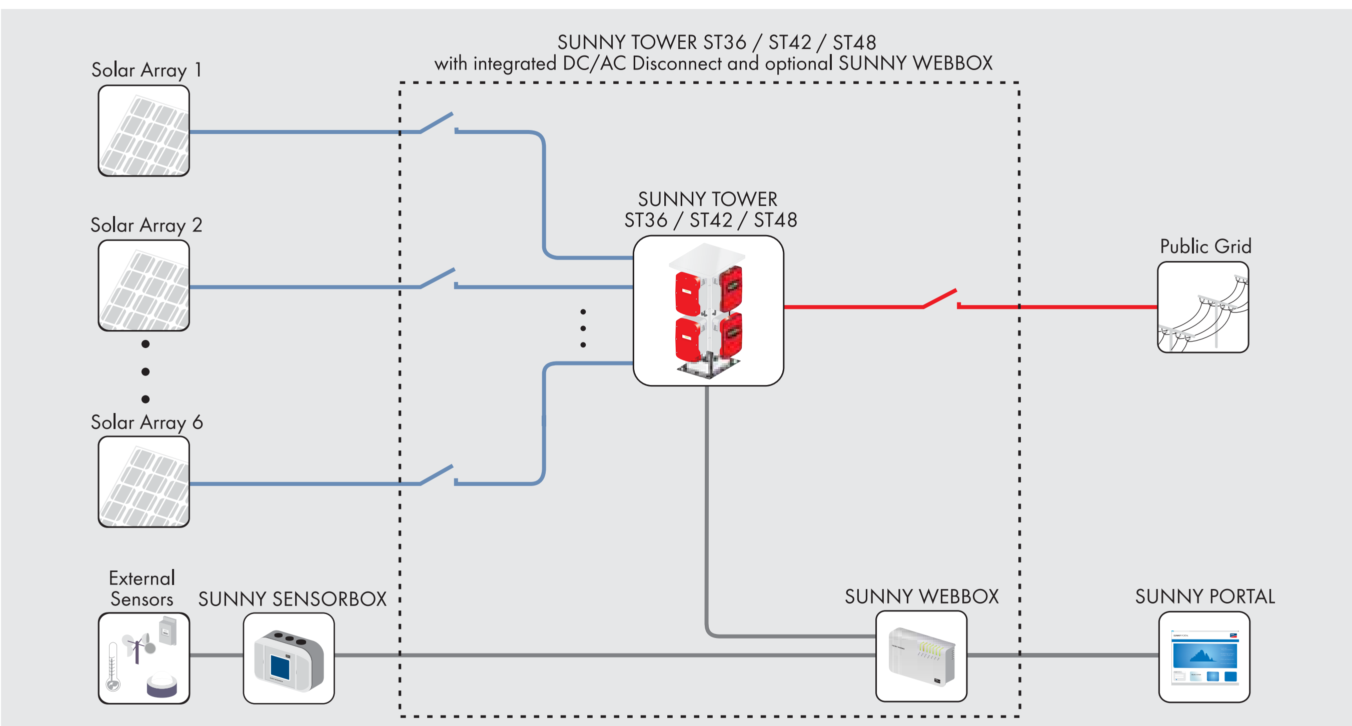
SUNNY TOWER 36 / 42 / 48

The flexible solution for commercial PV systems

SMA brings you the best in commercial inverter solutions: the Sunny Tower. Designed with the installer in mind, we've combined ease of installation, lowest specific cost ($/watt), and the highest efficiency to maximize rebates and power production while minimizing your payback period. The Sunny Tower combines all the advantages of string inverters with the installation advantages of central inverters. The Sunny Tower offers you the flexibility and reliability you've come to expect from SMA.

Technical Data

	Sunny Tower with 6 Sunny Boy 6000US	Sunny Tower with 6 Sunny Boy 7000US	Sunny Tower with 6 Sunny Boy 8000US
Recommended Maximum PV Power (Module STC)	45.0 kW	52.5 kW	60 kW
DC Maximum Voltage	600 V	600 V	600 V
Peak Power Tracking Voltage	250 – 480 V	250 – 480 V	300 – 480 V
DC Maximum Input Current	150 A	180 A	180 A
Number of Fused String Inputs	24 x 15 A (AC / DC disconnect)	24 x 15 A (AC / DC disconnect)	24 x 15 A (AC / DC disconnect)
PV Start Voltage (Adjustable)	300 V	300 V	365 V
AC Nominal Power / Maximum Power*	36.0 kW / 36.0 kW	42.0 kW / 42.0 kW	48.0 kW/ 48.0 kW
AC Maximum Output Current (3-Phase Only) (per phase @ 208 V, 240 V, 277 V)	100 A, 87 A, 44 A	117 A, 101 A, 51 A	N/A, 116 A, 58 A
AC Nominal Voltage Range (3-Phase Only)	187 – 229 V @ 208 V Delta or WYE 211 – 264 V @ 240 V Delta 244 – 305 V @ 277 V WYE	187 – 229 V @ 208 V Delta or WYE 211 – 264 V @ 240 V Delta 244 – 305 V @ 277 V WYE	N/A @ 208 V 211 – 264 V @ 240 V Delta 244 – 305 V @ 277 V WYE
AC Frequency: nominal / range	60 Hz / 59.3 – 60.5 Hz	60 Hz / 59.3 – 60.5 Hz	60 Hz / 59.3 – 60.5 Hz
Power Factor (Nominal)	0.99	0.99	0.99
Peak Inverter Efficiency	97.0%	97.1%	96.5%
CEC Weighted Efficiency	95.5% @ 208 V, 240 V 96.0% @ 277 V	95.5% @ 208 V 96.0% @ 240 V, 277 V	N/A @ 208 V 96.0% @ 240 V, 277 V
Dimensions: W / H / D in inches	43.3 / 70.5 / 39	43.3 / 70.5 / 39	43.3 / 70.5 / 39
Weight: Tower / 6 Inverters / Total Shipping	330 lbs / 846 lbs / 1388 lbs	330 lbs / 846 lbs / 1388 lbs	330 lbs / 888 lbs / 1430 lbs
Ambient Temperature Range	−13 to 113 °F	−13 to 113 °F	−13 to 113 °F
Power consumption at night	0.6 W	0.6 W	0.6 W
Topology	LF transformer	LF transformer	LF transformer
Cooling Concept	OptiCool™, forced active cooling	OptiCool™, forced active cooling	OptiCool™, forced active cooling
Mounting Location: indoor / outdoor (NEMA 3R)	● / ●	● / ●	● / ●
LCD Display	●	●	●
Communication: RS485 / wireless	❍ / ❍	❍ / ❍	❍ / ❍
Warranty: 10-year	●	●	●
Compliance: IEEE-929, IEEE-1547, UL 1741, UL 1998, FCC Part 15 A & B	●	●	●
NOTE: US inverters ship with gray lids.			
● Standard ❍ Optional			
Data at nominal conditions			
*ST48 is current limited to 46kW @ 240 V			
Type Designation	ST36	ST42	ST48



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www.SMA-America.com

SMA America, LLC

APPENDIX I – PV System Feasibility Analysis

CASE ONE: 0% Borrowed Up-Front

FEASIBILITY ANALYSIS FOR PV SYSTEM - CASE ONE		
MARKET RATES		
Retail Cost of Electricity	0.082	$/kWh from electricitypricecomparison.org/
Elec. Rate increase	1.00%	
AECs Value	0.2	$/kWh
LOAN		
Percentage Borrowed	0.00%	
Loan Value	$0.00	
Interest Rate	2.00%	APY
Period	25	Years
CRF	0.004238543	Capital-Recovery Factor (CRF) = r(1+r)^n/[(1+r)^n-1]
Monthly Payments	**$0.00**	
Total Loan cost	$0.00	
Cost of Capital	$0.00	
REBATES/INCENTIVES		
Federal Tax Credit	30.00%	of gross installation cost
VA State Energy Program	$20,000.00	$2000/kW up to 10kW
SYSTEM SIZE		
Size	52.5	kW DC
Cost/W	$7.50	$/W
Total Cost	$393,750.00	
PVWatts Factor	1234	Based on 30 deg. Tilt in 22301 at 180 deg. Azimuth
Annual AC production	64785	kWh
SAVINGS		
Monthly Savings/Rev	$1,522.45	year 1
25 Year Savings/Rev	$473,963.33	
OVERALL VALUE		
Up Front Expense	$255,625.00	
Loan Cost	$0.00	
Total Expense	$255,625.00	
25 Year Value	**$218,338.33**	

CASE TWO: 50% Borrowed Up-Front

FEASIBILITY ANALYSIS FOR PV SYSTEM - CASE TWO		
MARKET RATES		
Retail Cost of Electricity	0.082	$/kWh from electricitypricecomparison.org/
Elec. Rate increase	1.00%	
AECs Value	0.2	$/kWh
LOAN		
Percentage Borrowed	50.00%	
Loan Value	$147,812.50	
Interest Rate	2.00%	APY
Period	25	Years
CRF	0.004238543	Capital-Recovery Factor (CRF) = r(1+r)^n/[(1+r)^n-1]
Monthly Payments	**$626.51**	
Total Loan cost	$187,952.91	
Cost of Capital	$40,140.41	
REBATES/INCENTIVES		
Federal Tax Credit	30.00%	of gross installation cost
VA State Energy Program	$20,000.00	$2000/kW up to 10kW
SYSTEM SIZE		
Size	52.5	kW DC
Cost/W	$7.50	$/W
Total Cost	$393,750.00	
PVWatts Factor	1234	Based on 30 deg. Tilt in 22301 at 180 deg. Azimuth
Annual AC production	64785	kWh
SAVINGS		
Monthly Savings/Rev	$1,522.45	year 1
25 Year Savings/Rev	$473,963.33	
OVERALL VALUE		
Up Front Expense	$107,812.50	
Loan Cost	$187,952.91	
Total Expense	$295,765.41	
25 Year Value	**$178,197.92**	

CASE THREE: 100% Borrowed Up-Front

FEASIBILITY ANALYSIS FOR PV SYSTEM - CASE THREE		
MARKET RATES		
Retail Cost of Electricity	0.082	$/kWh from electricitypricecomparison.org/
Elec. Rate increase	1.00%	
AECs Value	0.2	$/kWh
LOAN		
Percentage Borrowed	100.00%	
Loan Value	$255,625.00	
Interest Rate	2.00%	APY
Period	25	Years
CRF	0.004238543	Capital-Recovery Factor (CRF) = r(1+r)^n/[(1+r)^n-1]
Monthly Payments	**$1,083.48**	
Total Loan cost	$325,043.30	
Cost of Capital	$69,418.30	
REBATES/INCENTIVES		
Federal Tax Credit	30.00%	of gross installation cost
VA State Energy Program	$20,000.00	$2000/kW up to 10kW
SYSTEM SIZE		
Size	52.5	kW DC
Cost/W	$7.50	$/W
Total Cost	$393,750.00	
PVWatts Factor	1234	Based on 30 deg. Tilt in 22301 at 180 deg. Azimuth
Annual AC production	64785	kWh
SAVINGS		
Monthly Savings/Rev	$1,522.45	year 1
25 Year Savings/Rev	$473,963.33	
OVERALL VALUE		
Up Front Expense	$0.00	
Loan Cost	$325,043.30	
Total Expense	$325,043.30	
25 Year Value	**$148,920.03**	

25 YEAR FINANCIAL CALCULATIONS							
YEAR	COST $/kWh	SAVINGS/YR	AECs	TOTAL/YR	MONTHLY SAVINGS	CUMULATIVE SAVINGS	SYSTEM COST
1	0.082	$5,312.37	$12,957.00	$18,269.37	$1,522.45	$18,269.37	$255,625.00
2	0.083	$5,365.49	$12,957.00	$18,322.49	$1,526.87	$36,591.86	$255,625.00
3	0.084	$5,419.15	$12,957.00	$18,376.15	$1,531.35	$54,968.01	$255,625.00
4	0.084	$5,473.34	$12,957.00	$18,430.34	$1,535.86	$73,398.35	$255,625.00
5	0.085	$5,528.07	$12,957.00	$18,485.07	$1,540.42	$91,883.43	$255,625.00
6	0.086	$5,583.35	$12,957.00	$18,540.35	$1,545.03	$110,423.78	$255,625.00
7	0.087	$5,639.19	$12,957.00	$18,596.19	$1,549.68	$129,019.97	$255,625.00
8	0.088	$5,695.58	$12,957.00	$18,652.58	$1,554.38	$147,672.55	$255,625.00
9	0.089	$5,752.54	$12,957.00	$18,709.54	$1,559.13	$166,382.08	$255,625.00
10	0.090	$5,810.06	$12,957.00	$18,767.06	$1,563.92	$185,149.14	$255,625.00
11	0.091	$5,868.16	$12,957.00	$18,825.16	$1,568.76	$203,974.31	$255,625.00
12	0.091	$5,926.84	$12,957.00	$18,883.84	$1,573.65	$222,858.15	$255,625.00
13	0.092	$5,986.11	$12,957.00	$18,943.11	$1,578.59	$241,801.26	$255,625.00
14	0.093	$6,045.97	$12,957.00	$19,002.97	$1,583.58	$260,804.23	$255,625.00
15	0.094	$6,106.43	$12,957.00	$19,063.43	$1,588.62	$279,867.66	$255,625.00
16	0.095	$6,167.50	$12,957.00	$19,124.50	$1,593.71	$298,992.16	$255,625.00
17	0.096	$6,229.17	$12,957.00	$19,186.17	$1,598.85	$318,178.33	$255,625.00
18	0.097	$6,291.46	$12,957.00	$19,248.46	$1,604.04	$337,426.80	$255,625.00
19	0.098	$6,354.38	$12,957.00	$19,311.38	$1,609.28	$356,738.17	$255,625.00
20	0.099	$6,417.92	$12,957.00	$19,374.92	$1,614.58	$376,113.10	$255,625.00
21	0.100	$6,482.10	$12,957.00	$19,439.10	$1,619.93	$395,552.20	$255,625.00
22	0.101	$6,546.92	$12,957.00	$19,503.92	$1,625.33	$415,056.12	$255,625.00
23	0.102	$6,612.39	$12,957.00	$19,569.39	$1,630.78	$434,625.51	$255,625.00
24	0.103	$6,678.52	$12,957.00	$19,635.52	$1,636.29	$454,261.03	$255,625.00
25	0.104	$6,745.30	$12,957.00	$19,702.30	$1,641.86	$473,963.33	$255,625.00
	TOTAL	$150,038.33	$323,925.00	$473,963.33			