The Phoenixville Area Middle School

Richard Schimpf

Construction Management

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April 4th, 2012

Phoenixville Area Middle School

Phoenixville, Pennsylvania

Project Overview

Owner:	Phoenixville Area School District
Total Height:	3 Stories
Total Project Cost:	$55,236,059
Size:	188,500 s.f.
Duration:	May 2010 - May 2012
Architect:	Gilbert Architects
Construction Manager:	Reynolds Construction Management
Geotechnical Engineer:	David Blackmore & Associates
Structural Engineer:	Baker, Ingram and Associated
MEP Engineer:	Snyder Hoffman
Civil Engineer:	Renew Design Group

Architectural Features

- Building seperated into four areas:

Area A - Gymnasium

Area B: Classrooms and Cafeteria

Area C: Classrooms and Library

Area D: Auditorium

- Facade composed of brick, limestone, split and and ground face CMU's
- Construction based on sequencing of the four areas to allow trades to work simula-neously

MEP Systems

- Heated by 3 gas powered condensing heaters, electric cabinet heaters, and electric wall and unit heaters
- Water source heat pumps used throughout building
- VAV boxes control supply air to 42 different rooms
- Four rooftop heat recovery units service entire building
- Power supplied by four transformers operating at 480/277 V and 208/120 V
- Lighting in all rooms controlled by motion sensors

Structural System

- Shallow foundation used with reinforced concrete column piers and wall footings and reinforced slab-on-grade
- HSS and wide flange steel columns used to carry load
- Area B and C floors supported by steel wide flange beams
- Area A and D roofs supported by steel barrel truss es
- Floors composed of 2” 20 GA metal decking with 3 1/2” concrete topping
- Roof decking composed of 1 1/2” 20 GA acoustic metal roof deck

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Executive Summary

Construction on the Phoenixville Area Middle School began in June of 2010, and is scheduled for completion by June of 2012. Phoenixville, Pennsylvania is a town located in Eastern Pennsylvania. The project is an 188,500 square foot building costing roughly $40 million. Upon its completion, the existing middle school will be demolished. This report is an analysis of the project, as well as four in depth studies on topics based on it.

The first analysis will examine the Separations Act of 1913, a Pennsylvania State law requiring school districts to deliver projects using the multiple prime delivery method. In this study, I will be examining the history of this law, recent changes, and the current status of legislation. Also included will be a comparison between single and multiple prime delivery in terms of risk, responsibility, cost, and other factors. In the end I will give my recommendation on the future of the Separations Act for the best possible solution to the law that has caused so much controversy.

In the second depth study I propose an alternative HVAC system for the middle school. By implementing a geothermal heat pump design over the current water source system, I will attempt to prove that it provides better long term value for the project. This will be done by examining the schedule, constructability, cost, and performance differences between the two systems. Includes is a mechanical breadth study analyzing the energy use differences between the two systems. Ultimately, I will show whether or not a geothermal heat pump system would benefit the project.

The third topic concerns the use of BIM in delivering the Phoenixville Area Middle School. The project team use BIM in minimum areas, only to model the architectural and structural design of the building. By examining the constraints of multiple prime delivery in using BIM, as well as addressing issues on the project that would have benefitted from its uses, I will choose uses from the BIM Execution Plan developed by Penn State that would have been helpful.

The fourth and final research area concerns the implementation of a precast façade in certain areas of the middle school. This will replace the masonry and metal stud assembly. I will design the precast system and determine all the requirements that go with it. This will include examining the schedule, cost, and constructability impacts, as well as others. In the end I will weigh the schedule reduction against any cost increases, and determine whether it could have benefitted the project. Included in this section is my second breadth study, a structural redesign of the strip footings for the weight of the precast panels.

Credit and Acknowledgements

Thank you to my family, friends, and fellow architectural engineering students in helping me on my journey through the Penn State Architectural Engineering Program the past five years.

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Mary Taylor – President

Balfour Beatty Construction

Kurt Maldovan – Assistant Process Manager

Penn State Architectural Engineering Faculty

Dr. Robert Leicht

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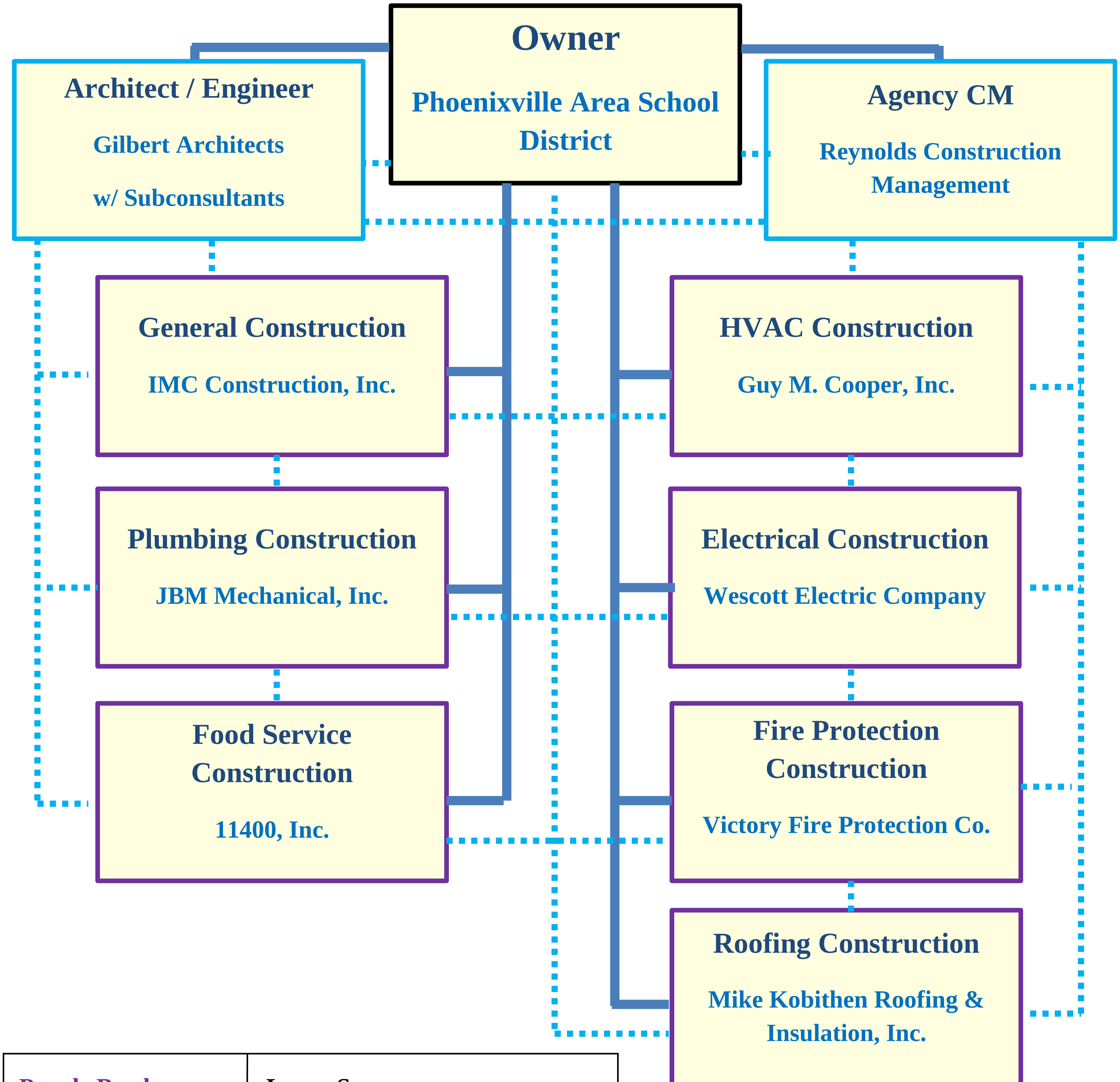
Introduction

The Phoenixville Area Middle School is being built to provide the student with a more modern facility that could fulfill the program requirements set forth by the school district. It is the first phase of four in a campus wide upgrade that included renovating athletic facilities, demolishing the existing middle school, and building a new district of administration building.

The total project value for all phases is roughly $55 million, however slightly less than $40 million of that is for the new middle school. Typical of Pennsylvania schools, the project is being delivered with multiple prime. A total of seven prime contractors are on the job, each representing a different trade.

Details regarding all areas of the project are on the following pages. Included is the project organizational chart, description of design, cost data, and schedule.

Project Delivery System



Purple Border	Lump Sum
Light Blue Border	Fee
Solid Line	Contract Held Between Parties
Dashed Line	Line of Communication

The delivery method for the Phoenixville Area School District is Design-Bid-Build. This publicly bid type of project delivery is required for any project funded by the State of Pennsylvania. Reynolds Construction Management is acting as an Agency CM for the project, and is paid a fee in return for advising the owner, managing the program and planning the construction process. Reynolds Construction received the contract based on their ability to save money, reduce project costs, and bring the project in on schedule at a cost that was within the school district's budget.

Once awarded the contract, Reynolds worked with Gilbert Architects and the Phoenixville Area School District to develop the design of the project. Upon the completion of construction documents, the owner sent out a request for bids. Another requirement of State funded projects in Pennsylvania is the minimum requirement of Prime Contracts held between contractors and the owner. The minimum is four – General Construction, Electrical, HVAC and Plumbing. However, for this project a total of seven prime contracts were issued. Along with the previous four, these include Food Services Equipment, Roofing, and Fire Protection. Along with the new Middle School, the school district is building a new District Administration Office building. Potential bidders were given the option to bid on just the middle school or administration office, or to combine their bids for both. One reason for this was to give smaller companies the opportunity to bid on one or the other to increase the number of contractors applying. The other is for the potential of cost savings when bidders reduce their fee when bidding on the two buildings combined. Of all the Prime Contracts, the General Construction, Roofing, Fire Protection and Electrical are for both buildings. This method provided reduced project costs by increasing competition an allowing economy of scale to be used between the two buildings.

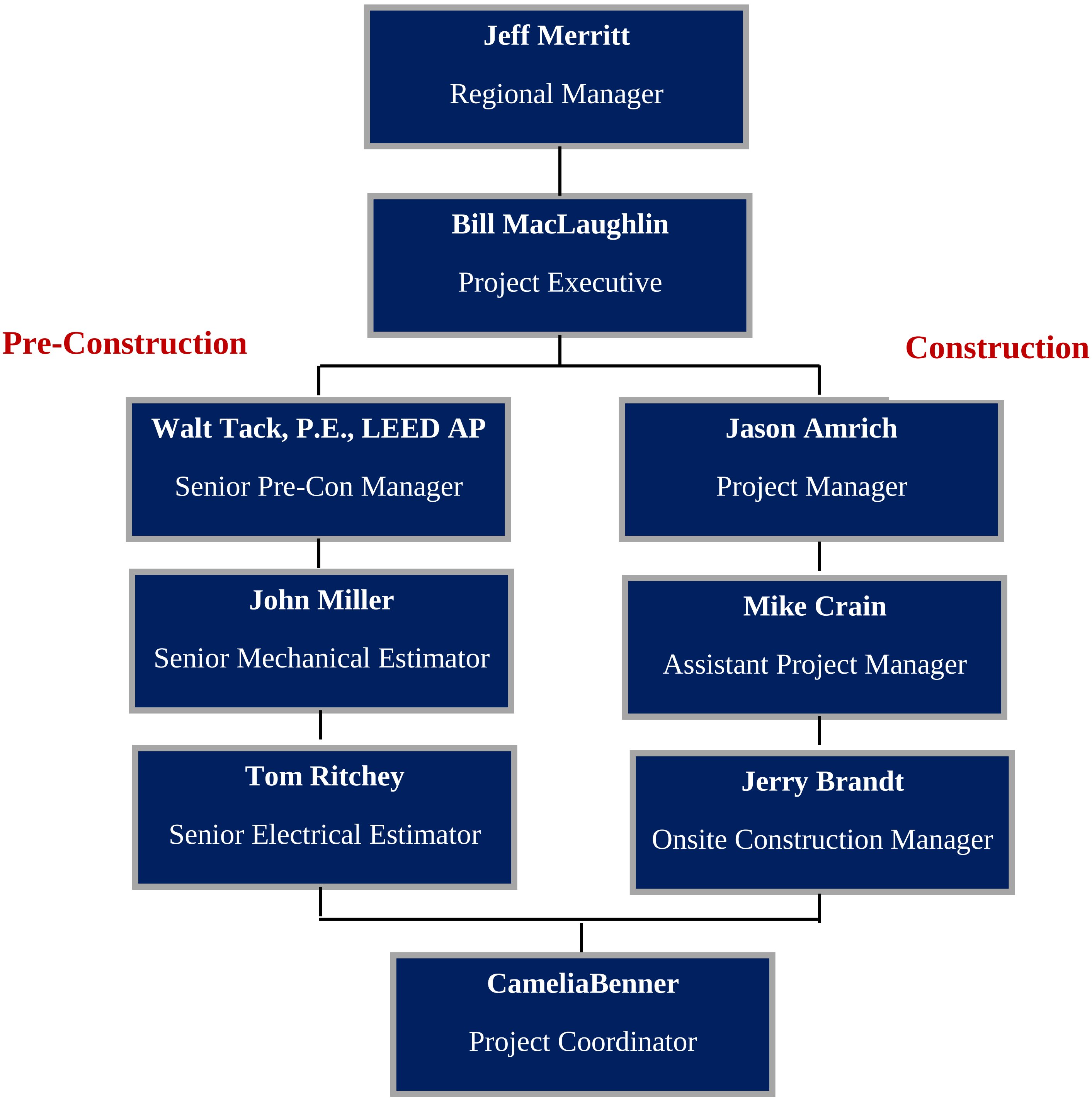
The lump sum contracts were bid based on drawings and specifications, and included select bid allowances and unit prices as determined by the project team. The bid states that the contractor is responsible to visit the site prior to issuing a bid. Along with submitting the bid form, each bid was required to contain a bid bond or a certified good faith check worth 10% of the total contract value (as bid). This is reserved by the school district in the event the contractor fails to execute the contract. The performance bond and payment bond are required to be from carriers listed in the most recent U.S. Treasury Department Circular.

Since there is no general contractor on the job, the Prime Contractors are responsible for communication between the different trades, with coordination assistance from the Agency CM. This requirement is specified, and is represented on the organizational chart by the dotted lines. The Agency CM certainly helps in this regard, but liability ultimately lies with the contractors.

The contract types and delivery method are appropriate for this project, and not only because it is required by law. The Phoenixville Area School District had many options to upgrade their facilities. The total project includes renovations to athletic facilities and utilities as well. By developing a complete scope early on, the program was controlled to avoid scope and program increase (creep). This approach allowed the district to remain on budget (and in fact reduce its budget), while accomplishing the goals identified early on.

Staffing Plan

Reynolds Construction Management



Site Layout Planning

Existing Conditions

The Phoenixville Area Middle School building site is located on the campus grounds along with the existing high school, middle school, track and field, and tennis courts. Phoenixville Area High School is located in the Northern-central portion of campus, and the existing Phoenixville Area Middle School is in the South-eastern corner. The campus is bordered by roads on three different sides: Carlisle Ave to the East, City Line Ave to the North, and State Road to the West. To the South of Campus lies Meadow Brook Golf Club. The existing utilities are shown on the existing site plan found in Reference. The building footprint for the new middle school is in the South-western corner of campus. As shown in the image below, that area is currently a green space bordered by tennis courts and a baseball field. The construction of the middle school will require the relocation of the baseball field to the opposite side of campus. The single tennis court will have to be demolished, but the group of six will remain intact and accessible throughout construction. Pedestrian and vehicle paths are not a big issue for this project, since the building site does not disrupt roads or parking lots. A temporary road will be put in place to give teachers and students access to the parking lot behind the high school. New utilities will be run for trailers when establishing the site.

Figure 1 - Aerial Image of PASD grounds from Bing Maps

Excavation Site Layout

The excavation site layout shows changes to the school grounds established during the general conditions portion of the schedule. Trailers were set up along Carlisle Ave and connected to the necessary utilities. The main construction entrance is located by a crushed stone temporary road off of Beechwood Lane. This is the road buses take to drop students of, and there is no site access here for construction vehicles from 7:00 – 8:00 a.m. and 2:00 – 3:00 p.m. A site fence borders all construction activity to prevent students from entering the job site. Tree protection is included along the border of the job site, and erosion control is part of the fence in all areas. Construction parking for this phase is located right by the tennis court to provide easy access to the soil stockpile area. The excavation begins in the South-eastern part of the building footprint, and progress towards the opposite end. This allows the excavators to work backwards towards the stockpile area. A temporary road along the perimeter of the property allows vehicle movement from one end of the site to the other. The foundation wall did not require structural support. Since there was enough space, the walls were sloped back at a grade of 1: 1.5. This layout is an efficient use of space during this process. Since there is not much going on at this time except excavation, there is not much complexity to the logistical challenges posed here. The only possible criticism is the decision to make the main construction entrance from Beechwood Lane. Construction vehicles must travel across campus to reach the site entrance, and the hours that are reserved for bus traffic must be worked around. However, this could be due to regular vehicle traffic on City Line Ave where teachers arrive and parents drop of students.

Superstructure Site Layout

This portion of the construction process is where the structural steel is erected. In this plan the different areas of the middle school are shown to demonstrate the phasing of the project. Working from Area A and progressing towards Area D, while the steel members and decking are being erected other trades can begin mobilizing on site. Not much has changed from the excavation site layout, except that a crane has been brought on-site. The crane works from two main areas as shown in the plan. At this point, all of the dumpsters have arrived on site. Contractor parking has moved to the area near the trailers. The previous parking area is now used as a shake-out area for steel. This layout is effective in that the steel is erected in a manner that allows other trades to being work as certain areas are completed. The space is utilized in a way that allows simultaneous work between two trades that usually cannot operate at the same time. The roof of Area A, the gymnasium and locker rooms, is metal deck. By setting this and moving to the next area, other trades can begin work on the interior and building shell since the roof provides some shelter from the elements.

Finishes Site Layout

The finishes plan represents the busiest portion of the project. At this point, the majority of Area A work has been completed, structural steel is still going up in Area D. Area B and C have a nearly complete building shell and work has started on the interiors. The interiors of B and C take the longest since they contain the kitchen, classrooms and laboratories. The site layout is basically the same as the superstructure stage, except there are many more contractors on site. The crane is still on site to erect structural steel and lift large MEP system components to the mechanical area. Site access remains the same, as well as parking and staging areas. This layout is an effective way to manage all the different trades working at once. By starting the interior work of Area B and C before the rest of the structure is completed, a lot of time is saved on the schedule. The relatively short duration of the project can be attributed to this sequencing. The only problem with this layout is the potential for congestion on the road bordering the property line. While trades are working from all sides, site access and mobility are limited by the sheer number of workers. By expanding the site into the parking lot, and creating the temporary access road from the drop of circle, more space could be created. This limits the risks that come with a congested site.

Local Conditions

The building site for the new Phoenixville Area Middle School is located on a field in the Southwest corner of school grounds, with no structures immediately surrounding it. Surrounding the school grounds are residential areas on three sides, and a golf course on the fourth. Located in the Eastern edge of Pennsylvania, the area experiences a full four season throughout the year. These had to be accounted for when planning the construction of the new middle school.

The school grounds are split by a boundary line seperating the Schuykill Township from the Borough of Phoenixville.The Borough of Phoenixville is a public facilities zone, and the Schuykill Township is a medium residential zone. The design of the overall Phoenixville School project had to be approved by the boards of both councils. Part of the season for this is that the schools are open to use of non-student groups to hold meetings. Along with the design of the actual buildings, areas of concern to the council were the erosion and sediment control during construction. Also, the water runoff down the hills from the landscaping and work to athletic facilities after the completion of the middle school needed to be addressed. The project team had to manage the concerns of both councils in the design and logistics of the project. Since the school grounds are surrounded by residential areas, noice pollution had to be restricted. Repetitve, high level impact noice is only permitted between the hours 8:00 a.m. to 6:00 p.m. These activities can not reach certain decibal levels for more than 12 minutes per any hour, and any added costs to stay within these limits can not be charged to the owner by contract. All employed workers through out the project are required to go through the following background checks:

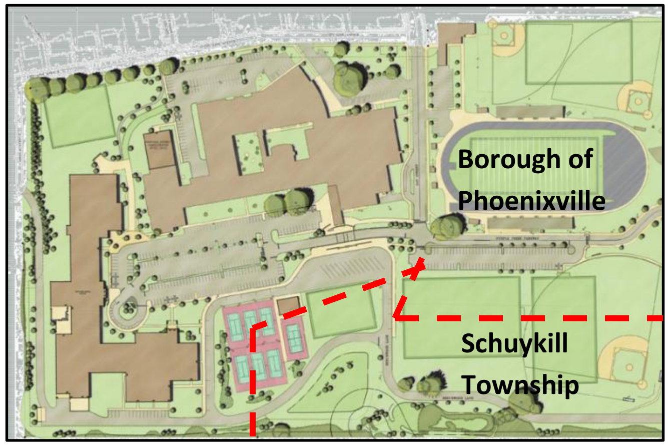


Figure 2 - Completed project rendering courtesy of PASD

1. Pennsylvania State Police Request for Criminal Records Check (Act 34).

2. Department of Public Welfare Child Abuse History Clearance (Act 151).

3. Federal Criminal History Record Information (CHRI) (Act 114) in manner prescribed by

   Department of Education.

It is the responsibility of all contractors to submit their employees for review. The school district is then responsible to review the employees and verfiy they are fit to work on school grounds. These background checks are typical for any construction project involving schools.

The site conditions and construction methods are typical of the area, and the materials used in design are common for high schools. Steel framing allows for a relatively quick duration for erecting the superstructure. Brick with CMU backing is a cost effective way to create an attractive façade that will last a long time. The area is not very densely populated relative to places closer to Philadelphia. This makes transporting things such as material and heavy duty equipment much simpler, as there is not as much traffic in the region. The school grounds itself provide access from three different points. Two of the entrances are very close to the site, and the open field space surrounding the building footprint provides options for construction logistics. Construction parking on-site is located by the trailers set up by for the different contractors at the Northwest area of the school grounds, as well as the Eastern portion of the construction site. The parking by the trailers can be accessed by the gate entrance off of Carlisle Ave, or by the entrance off of City Line Ave. A temporary road provides access to the other area, which is a sectioned off portion of the existing high school parking lot. During the summer months of construction, there is an abundance of parking areas since school is out of session. Large construction vehicles can use any of the three entrances. However, the entrance from Carlisle Ave is discouraged due to the proximity of houses, and is only used when absolutely needed. The entrance at the Southeast corner off of State Road is closed to construction vehicles during bus hours, meaning the hours right before and after a school day.

The use of recycled building materials and recycling of disposed materials is required by the contract held between contractors and the Phoenixville Area School District. While not a LEED certified building, green initiatives are a focus in the design of the middle school. The building materials are required to be separated into thirteen different categories based on the local and regional recycling facilities. Contractors must also make use of such organizations as the National materials exchange network and Habitat for Humanity. All rebates, tax credits or other savings obtained through the use of recycled materials or recycling of building materials is credited to the contractor. However, the decision on where to bring the materials was left to the contractors, and any monetary value of compensation for recycling is unknown. Dumpsters on site are located North of the building footprint near the stockpile of soil. The cost of dumpsters is contained in the contract of the general construction contractor, IMC Construction. While tipping fees are not known, the total contractual value for dumpsters and hauling for the duration of the project is $105,000.

Soil records indicate the site soils to be of the Bucks, Penn and Readington Series as identified in the Soil Survey for Chester and Delaware Counties, Pennsylvania. The Bucks Series is a deep, well-drained soil underlain by Triassic red shale and sandstone. These soils typically have a reddish brown silt loam surface layer with reddish-brown silty clay loam subsoil. The on-site variation is the Bucks silt loam, 3-8 percent slopes, moderately eroded. This type represents most of the soils on site. The geotechnical drilling program performed by SVEI for the subsurface evaluation included 20 test borings. These occurred at locations all over the school grounds to get an idea of subsurface conditions. The soils were found to be a mix of silty sands with gravel, sandy silts with gravel, and silty gravel with sand. The topsoil is 6 to 13 inches thick. The fill material of Stratum IMF was encountered at all the boring locations. This is the remnant of passed construction, and was recommended to be removed by the geotechnical engineer. The presence of this material led the site to be categorized as “disturbed”. Groundwater was encountered at eleven of the twelve borings. While it was not expected to be an issue when digging foundations, there was a chance of some flowing into the site. However, the small amount has a minor impact on the construction process, since it can easily be pumped out.

Building Systems Description

Architecture

The Phoenixville Area Middle school makes use of traditional building materials seen in educational facilities around the United States. The brick and limestone façade is periodically penetrated with glazing throughout the elevations. The limestone trim spans the entire first floor elevation around the central main entrance. As the building progresses towards the outer wings, this trim becomes a thinner border around the brick and glass. Thin limestone courses cut through the brick in a grid like manner. The building footprint is in the shape of an L. At the ends of this L the roof becomes arched and the box like form of the middle section gives way to more intricate forms. This design allows for an efficient layout of classrooms in the middle of the building, and a little more decoration for areas such as the gymnasium and auditorium. Each entryway is shaded by an arched overhang with limestone columns.

Structural

The Phoenixville Area Middle School rests on a shallow reinforced concrete foundation. The spread footings, piers, and slab on grade have a 28 day compressive strength requirement ranging from 3000 – 4000 psi. The spread footings for the masonry walls typically are 2’ 8” wide by 1’ 0” deep, and are reinforced with #4 and #5 rebar. The foundation slab on grade is 4” thick, and rests on 6” of stone drainage fill. A vapor retarder rests above the stone, and it is reinforced with 6 x6 – W2.9x2.9 WWF. Vertical crack and construction joints are specified at no more than 30’ apart.

The superstructure is composed of steel framing, composite metal decking, and concrete masonry sheer walls. Typical steel columns are hollow structural steel members dimensioned at 8” x 8” x 3/8”, conforming to ASTM A36 code. Some areas have slightly different dimensions for the HSS columns or are designed with a wide flange beam. The metal decking is supported by a web of varying size wide flange steel beams conforming to ASTM A992. Roofs in areas such as the gymnasium and auditorium are supported by custom barrel trusses made of steel members. Steel members typically are joined by bolted shear connections; however some welding is done for certain members.

The floors are 2” – 20 GA composite metal deck with a 3 ½” concrete topping reinforced with 6 x 6 – W2.1 WWF, with a total thickness of 5 ½”. The decking is designed for 3 span condition un-shored construction. The decking is welded to a bent plate at columns. In general, the roof metal decking is 1 ½” 20 GA galvanized acoustic metal rood deck, the be finished with paint. The concrete slab on deck has a strength requirement of 3500 psi. It is a normal weight concrete reinforced with WWF. The contractors used pumping equipment to get the concrete to the upper levels of the building. There it was manually leveled off to the uniform thickness specified. Running electrical conduit through the slab on deck is not permitted.

Fire Protection (active, passive, construction type by code)

The fire protection system is a wet-pipe system conforming to NFPA 13 and IBC 2006. Each sprinkler head is not permitted to cover more than an area of 225 square feet.

Electrical

The PECO primary overhead electric line enters the middle school at the South-western corner of the building. Here it encounters four transformers serving different areas. The ratings of these transformers are 500 KVA, 300 KVA, 300 KVA, and 150 KVA. The primary voltages are 480 V, with a secondary voltage of 208/120 V, 3 phases and 4 wires. These transformers distribute power to the entire building. A 230 KW diesel driven backup generator operates at 480/ 277 V, with 3 phases and four wires. In the event of power failure, this begins operating and ensures the critical safety systems of the building stay online.

Mechanical

The mechanical system utilizes water source heat pumps throughout the middle school to efficiently regulate the indoor environment. Two large water source heat pumps operate on the roof, serving the administration room and media center. Nine different console water source heat pumps serve larger rooms and stairwells. A total of 78 smaller scale water source heat pumps serve individual rooms. Four rooftop heat recovery units operate on the rooftop. Variable air volume boxes and individual room controls allow each classroom to achieve the desired climate.

Cooling is provided with closed circuit cooling towers and fifteen split air conditioning units. Heating is provided by three gas powered condensing heaters, along with electric units throughout the building. The ductwork on the roof is specified as McGill rectangular galvanized duct with 1 ½” fiberglass liner and perforated inner line. Elbows are mitered with double thickness vanes. They are insulated with 2” rigid insulation. They are weatherproofed with white EPDM roofing.

Project Cost Analysis

Construction Cost

The construction cost for the actual building was determined by reviewing the payment applications of the seven prime contractors for the project. The contracts are based on unit cost for quantities, therefore there is no contingency fee involved in a contractor's bid since any differing quantities result in an automatic contract adjustment. Things such as bonding, site work and general conditions are excluded. Finally, an estimated fee of 5% is excluded from the contractor's schedule of values to account for profit. This percentage is an estimate, and is not by any means based on any real fee charged by those holding contracts.

Construction Costs Phoenixville Area Middle School			
Prime Contract	**PAMS Cost**		**Adjusted Amount**
Electric	$2,595,090.00	0.95	$2,465,336
Fire Protection	$264,210.00	0.95	$251,000
Food Service	$539,008.00	0.95	$512,058
General Construction	$19,722,071.00	0.95	$18,735,967
HVAC	$5,521,734.00	0.95	$5,245,647
Plumbing	$1,985,391.00	0.95	$1,886,121
Roofing	$1,328,400.00	0.95	$1,261,980
Total Construction Cost	$31,955,904.00		$30,358,109
Total Construction Cost S.F.			$161.05

Figure 3. Cost Breakdown by Trade

Total Project Cost

Total project cost is the current total project cost to date, including all line items and phases of construction.

***Total Project Cost* = $44,536,059.00**

***Project Cost per Square Foot* = $44,536,059.00/188,500 s.f. = $236.27**

*This cost was calculated by neglecting the SOV items for the District Administration Offices, landscaping and work to athletic facilities. It only reflects the line items for the PAMS.

Major Building Systems Costs

Building System	Total Cost	S.F. Cost
Mechanical	$5,778,734.00	$30.66
Electrical	$2,595,090.00	$13.77
Plumbing	$1,985,391.00	$10.53
Structural	$9,525,411.00	$50.53

Figure 4. Major Systems Cost

The contracts bid jointly only contain costs associated with the Phoenixville Area Middle School.

Square Foot Estimate

RS Means Costworks was used to create this square foot estimate. The information used in arriving at the estimate can be found in appendix A:

Total Building Cost: $36,811,000.00

Cost per Square Foot: $195.28

Assemblies Estimate

The following costs were determined using data from the RS Means Construction Assemblies Cost 2011. The references are listed in detail in appendix B:

Building System	Total Cost	S.F. Cost
Mechanical	$5,350,515.00	$28.38
Electrical	$2,779,620.50	$14.75
Plumbing	$1,141,762.50	$6.06

Figure 5. Assemblies Estimate of Major Systems

When substituting these values into their respective square foot estimate divisions:

New S.F. Cost: $206.78 *New Total Cost*: $38,978,020.00

Fire Protection was included in this assembly estimate due to its general inclusion in mechanical systems contracts. It is listed separately because the contract for mechanical work was split between HVAC and Fire Protection.

Cost Comparison

Total Project Cost:	$44,536,059.00
Cost of Construction:	$30,358,109.00
Square Foot Estimate:	$36,811,000.00
SF with MEP Assemblies:	$38,978,020.00

The total project cost is significantly more than any of the estimates done. The square foot estimate is off by roughly $8 million, and the MEP Assembly adjusted estimate is off by $6 million. An estimating error such as this would mean a loss if these were to be the bids submitted for the job. These errors can be attributed to a few factors. First and most importantly, the error in doing square foot estimates is always high, and it is not used for more than early design cost analysis. Second, certain MEP items were not the exact matching item from the construction documents. This was due to line items that did not match in RS Means, but the closest was taken. Finally, the difference in the total project cost and cost of construction is extremely large. This means a lot of general conditions and site work costs. New utilities must be run from the existing all over the site. Site fencing and paving were not included in this estimate, yet each prime contractor is responsible for their own general condition items. This may be hard to estimate using the RS Means Data as the only resource. The differences in these estimates demonstrate the importance of an experienced estimating team.

Schedule Summary

Preconstruction

The preconstruction phase of the Phoenixville Area Middle School took roughly fourteen months before construction started, starting in February of 2009. The project planning started with the school board's hire of Gilbert Architects. After a short period, Reynolds Construction was brought on as the agency CM to help with scope development and cost estimating. During this phase, the project team worked with the school district to finalize the scope of the overall project. During the summer of 2009, an overall project scope was agreed upon that met the needs of the district while coming in within their budget range. After the details were designed, the project was released for bid in early 2010. The Notice to Proceed was issued on May 21st, 2010, beginning the construction of the Phoenixville Area Middle School.

Preconstruction/ Procurement	**Mon 2/2/09**	**Fri 4/9/10**
Schematic Design	Mon 2/2/09	Thu 5/14/09
Design Development	Mon 4/13/09	Thu 8/20/09
Construction Documents	Wed 7/8/09	Wed 1/13/10
Bidding and Award Contracts	Thu 1/14/10	Fri 4/9/10

Figure 6 – Preconstruction Activities

General Conditions

General Conditions	**Fri 5/21/10**	**Tue 8/10/10**
E&S Controls, Tree Protection, Fencing:	Fri 5/21/10	Mon 6/14/10
Contractor Staging	Wed 6/9/10	Mon 6/21/10
Site Utilities	Fri 6/18/10	Fri 7/9/10
Strip Topsoil and Stockpile	Fri 6/18/10	Thu 6/24/10
Bulk Excavation and Fill	Wed 7/14/10	Tue 8/10/10
Install Temp. Site/ Student Access Ways	Fri 6/25/10	Sun 7/25/10

Figure 7 – General Conditions Activities

Site mobilization started on May 21st, 2010 with the establishment of site boundaries. Safety, which is critical to any successful construction project, was a big concern considering the added risks associated with doing work in such close proximity to a school. Temporary access roads were put in place for both construction site access and for the teachers and students who need to park behind the high school. Excavation began towards the end of this phase, and its completion marked the beginning of the foundation construction.

Construction Phase

The project start date was dictated by the academic calendar. This allowed a maximum amount of time throughout the construction process for work to be done during the summer months when school is not in session. The team was given the completion deadline of the summer of 2012 to have the new middle school ready for occupancy. To accomplish this, the project team developed a sequence of construction that would allow for a maximum amount of trades to operate at one time. Given the building footprint shape, open space available on the school grounds, and several different access roads, Reynolds Construction determined a logistical plan to make this happen. The design of the building allows for the school to be broken into four different areas. These are referred to as Area A – Gymnasium, B – Classrooms and Kitchen, C – Classrooms and Library, and D – Auditorium and Music Rooms. The project schedule located in Appendix B is broken down by this method of phasing. The following narrative explains the manner by which trades are scheduled to perform work throughout the construction process.

Area A Summary Schedule		
Foundation	8/20/10	9/9/10
Slab on Grade	9/23/10	10/28/2011
Structure	11/5/10	11/29/10
Masonry Veneer	1/21/11	3/17/11
Enclosure	4/15/11	
Interior Walls	4/18/11	5/13/11
MEP Systems	4/18/11	10/11/2011
Interior Finishes	8/3/2011	11/21/2011
Final Clean	11/15/11	

Figure 8 – Significant Dates of Area A

Area B Summary Schedule		
Foundation	9/9/10	10/13/10
Slab on Grade	9/20/10	12/20/10
Structure	12/29/10	3/16/11
Masonry Veneer	3/17/11	7/18/11
Enclosure	8/29/11	
Interior Walls	7/5/11	9/6/11
MEP Systems	4/29/11	2/16/11
Interior Finishes	8/16/11	12/26/11
Final Clean	4/3/12	

Figure 9 – Significant Dates of Area B

Area C Summary Schedule		
Foundation	10/14/10	11/20/10
Slab on Grade	12/29/10	2/2/2011
Structure	2/10/11	4/27/11
Masonry Veneer	4/28/11	7/18/11
Enclosure	10/11/11	
Interior Walls	7/5/11	9/6/11
MEP Systems	6/13/11	3/15/12
Interior Finishes	9/28/11	3/20/12
Final Clean	4/17/12	

Figure 10 – Significant Dates of Area C

Area D Summary Schedule		
Foundation	11/18/10	12/20/10
Slab on Grade	12/22/10	2/23/11
Structure	3/17/11	5/18/11
Masonry Veneer	4/28/11	8/19/11
Enclosure	9/20/11	
Interior Walls	6/24/11	8/26/11
MEP Systems	6/13/11	2/29/12
Interior Finishes	9/20/11	1/18/12
Final Clean	4/25/12	

Figure 11 – Significant Dates of Area D

The foundation system of the Phoenixville Area Middle School is a shallow reinforced concrete system. The general construction contractor, IMC Construction, is the only one working at this time. The concrete work continues on with the slab on grade. At this point, steel is brought on-site and store on the North-Eastern side of the building footprint. As the concrete is curing a crane is brought on site in anticipation of the steel erection. The superstructure phase beings on November 11th, 2010 with the gymnasium columns. The steel structure portion of the schedule is the most critical to maintain of the entire project. Since the gymnasium and locker rooms require the least out of any areas in terms of finish work or MEP systems, the majority of construction in this area by schedule days in structural activities. The foundation and slab on grade are started immediately in the next area after the completion of Area A's. After steel is completed and there are decks in place in Area A, the superstructure of the next area begins. Masonry workers start in Area A once it is free on the crane. No other work can take place in an Area that has an operating crane in it. The walls are built while the foundation, slab on grade and steel is constructed in Area B. The glazing comes towards the end of the masonry in A. The steel in area B and masonry in Area A are scheduled to be completed simultaneously on March 16th, 2011. While these two trades progress, the building envelope of Area A is completed. Once the building is contained, the MEP and interior contractors begin work on April 18th. The systems contractors (HVAC, Electric, Plumbing, Fire Suppression) do the interior fit-outs while studs and masonry interior walls are installed. Work continues on the interior of the gymnasium until its final clean on November 15th.

In general, the masonry follows immediately after the foundation, concrete slab on grade and steel. The steel is nearly complete in Area C by the time the interior trades come on site to start work in Area A. This was done to allow the interior trades to have a half of site the jobsite to work with when they mobilized. This system put in place allows the mechanical, plumbing, electric, and fire protections trades to get an early start on their work. Safety is not compromised since the large jobsite leaves plenty of open room for maneuverability.

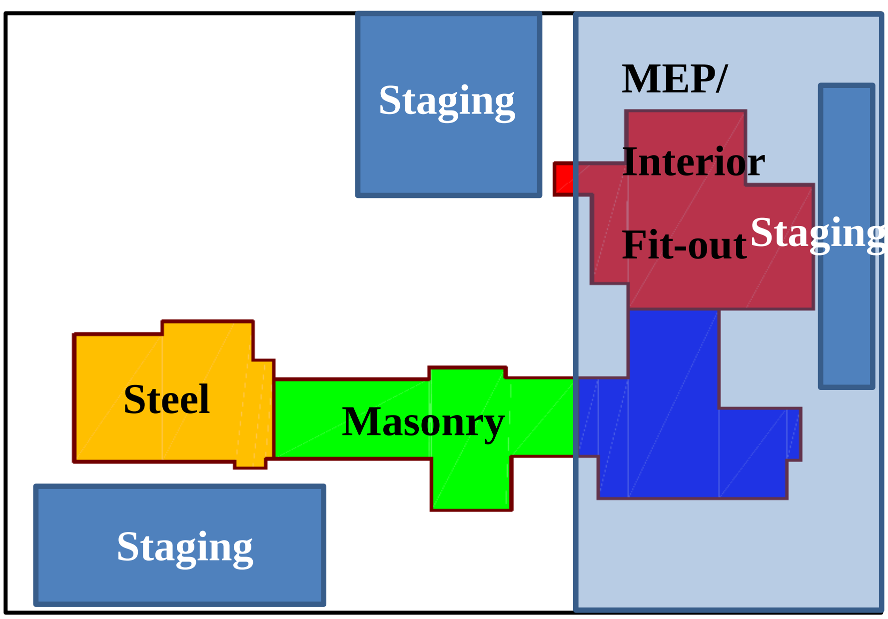


Figure 12 – Site Layout March 2011

In Areas B and C, the interior work is done from the top floor down. Work starts on the third floor weeks or months earlier for mechanical, plumbing, electrical, and the interior fit-out and finishes construction. At first this was confusing considering that it is generally the opposite for construction. However, reasons for the top to bottom method could be due to the proximity of Area A and B, and the similarities of the areas in terms of rooms contained. Both have classrooms on the second and third floors, while the first floors have administration offices, the library or kitchen, and open areas. The is a higher density of rooms on the higher floors, so that means more mechanical and electrical controls and runs since each room is individually controlled. MEP fit-out starts prior to the interior walls, so it could be that these trades get in first to these Areas to get these intricate runs set up prior to the presence of other trades.

Analysis 1: Study of Pennsylvania Separations Act of 1913

Problem Identification

Pennsylvania School Districts currently are required to solicit a minimum of four separate bids for construction projects under the Separations Act of 1913. Historically the multiple prime delivery method has been regarded as the most cost effective way of structuring projects. Considering the large quantities of taxpayer's money spent on construction, choosing the most cost effective option is a necessary policy. As building systems' design has become increasingly complex over the past two decades, this requirement has been criticized for its limitations. Paramount amongst these complaints is the lack of communication amongst prime contractors and the resulting burden placed on the public entity managing the project. While the multiple prime system commonly is the best choice for structuring projects, the idea that one delivery method is the best solution to managing projects in every situation is an outdated position. There are several types of delivery methods utilized in both private and public construction. Each of these is determined to be appropriate based on the project and ownership involved. It is then logical to assume that states limited to the multiple prime delivery need to revise litigation to allow for the best method to be chosen.

Pennsylvania did allow an exemption from the Separations Act for a period of time starting in 2000. However this was done on a case-by-case basis and the law allowing the opportunity expired in June of 2010. This study will examine the reasons school districts applied for exemption, the key players involved in making the decision, and the process for getting the approval to use other delivery methods. This will be done through researching the application requirements, actual submitted applications, and the report made by the Pennsylvania Board of Education. Single prime delivery is the only alternative to have been used by school districts in Pennsylvania, and therefore will be the only other method compared to multiple prime. Several studies demonstrating the cost impacts of the differing methods will be used to form a conclusion on the impact contracting has on final project cost. After comparing the benefits and shortcomings of the two methods, the types of projects potentially benefitting from multiple prime exemption will be identified.

States Requiring Separation of Contracts

Currently four states still maintain the contractor separation requirement for public funded projects: Pennsylvania, New York, Illinois, and North Dakota. In response to widespread opposition these laws have been revised to a varying degree in each state. For example, under the Wicks Law passed in 1912 and expanded in 1946, New York State projects over $50,000 were required to have separate plumbing, mechanical, and electrical contracts. This was amended in 2008 to raise the limit to $3 million in New York City projects, $1.5 million in Nassau, Suffolk, and Westchester counties, and $500,000 in the rest of the state. Projects in which a project labor agreement is made beforehand are excluded from the separate bid requirement. School districts in certain municipalities, such as New York City and Buffalo, can be granted exemption as well.

In contrast, the Illinois Procurement Code requires 5 prime contractors for projects exceeding $250,000 under Article 30, Construction and Construction-Related Professional Services. After years of studying the impacts of delivery method on the cost of public works, the state legislature passed Public Act 96-0795, a revision effective on July 1st, 2010. Along with increasing qualification and transparency requirements for contractors, the bill allows publicly funded projects over $15 million the opportunity to apply for an exemption waiver. These projects must be managed by the Capitol Development Board, Illinois' project management organization.

The revisions made to these laws have been met with mixed reviews. Those opposing state mandated contract separation feel the cost limits for exemption-eligible projects have not been adequately adjusted for inflation and rising construction costs. Those supporting multiple prime fear the changes will force out small contractors and reduce competition. The difficulties in data collection and project cost comparisons make identifying a single best method impossible. For this reason, most states allow or require public entities such as school districts to solicit bids for single and multiple prime. The most appropriate method is then chosen based on cost and conditions.

Pennsylvania Separations Law

Pennsylvania continues to require multiple prime contracting for publicly funded projects. Currently, school construction contracting is dictated by the Pennsylvania School Code of 1949 Section 751. This law requires public school projects to have a minimum of four prime contractors. This means separate specifications, drawings, bids, and contracts for typically:

1) Plumbing
2) Heating, Ventilation and Air Conditioning
3) Electrical
4) General Construction

At the time the law was passed multiple prime contracting demonstrated the most efficient, inexpensive method for getting projects completed on schedule. The involvement of the public entity in managing the project was thought to enhance contractor compliance. The increased competition for contracts and reduction of overhead fees meant lower direct costs. However, the advancement of building design, evolution of the construction industry, and negative experiences of project teams have challenged the validity of this assumption in recent decades. While multiple prime may often be the best option for project delivery, many felt that in some situations projects would benefit from an alternative approach.

In response to school districts petitioning the multiple prime contracting requirements, the state legislature introduced the Mandate Waiver Program in 2000 as part of the Education Empowerment Act (Pennsylvania Act 16). This allowed school districts to apply for waivers granting exemption from the separate contract requirements for building construction or renovation. However, this bill expired on July 30th, 2010 and has not been renewed since. Despite the fact it is currently not in effect, many different groups are calling for its renewal. For this reason the Mandate Waiver Program is described in detail below, as well as the response and repercussions it had in Pennsylvania.

Mandate Waiver Program

This law gave school districts in Pennsylvania the opportunity to apply for exemption from state regulations concerning several educational policies if a direct benefit using alternative methods could be proven. As reported by the Task Force on Mandate Waivers in February 2009, the waiver for multiple prime contracting was one of the most frequently requested. From 2008 – 2009, 128 applications were received, with a total of 80 approved. The other construction waiver was the request to raise the cost threshold for small ($4,000 - $10,000) projects in order to avoid a variety of contract regulations. Of the 175 received for threshold adjustment, 130 were approved. The total number of the two construction waiver types combined to represent 40% of all submitted waiver applications.

Reason for Applying

The decision to apply for a mandate waiver is made by the school board. While a successfully granted waiver allows exemption for the Separations Act, the district may still choose to use the typical multiple prime method despite the opportunity to use an alternative means. Ultimately the decision is based on studies done with the aid of an architect or consultant. Bids are solicited from contractors for both single and multiple prime deliveries. While the bid cost comparison is a major factor in the decision, other considerations such as schedule, design complexity, and past experience play a role. These must be measurable in some form in order to account for differences amongst the two methods. Of the 128 applications submitted from 2000 – 2008, the savings estimated by applicants for single prime ranged from $4,000 to $28.3 million. It should be noted that these were projected savings early in the project, and the actual project costs were not listed in the report.

Approval Process

All waivers had to be submitted to the Department of Education using the standardized mandate waiver program application. Included is the cost estimate detailing project cost with and without the waiver. A non-district source, generally the architect, must include a letter indicating how the project savings will occur. Projects that were not competitively bid were not eligible for approval.

The process for approval was given 60 days from the day of submittal. The review board determines the legality and feasibility of the law(s) being waived. The Secretary of Education ultimately signs off on all applications. The end result is either approval, denial, or a request for revision.

Opposition

The implementation of the Mandate Waiver Program was met with mixed reviews. School districts that were granted the waiver generally preferred the single prime delivery due to the significant reduction in management responsibilities. However, some groups negatively impacted by single prime delivery worked to have the bill repealed. A group of contractors brought a suit in Commonwealth Court contesting the right of the Secretary of Education to grant waivers exempting school districts from the Separations Act. In 2003 and 2004 the court ruled in favor of the contractors. The case was brought to the Supreme Court, and on November 21st, 2007 ruled that multiple prime contractor waivers were legal, reversing the lower court's decision (Mechanical Contractors Association v. Pennsylvania Department of Education and the School District of Philadelphia, 934 A.2d 1262).

During the period between the initial cases and Supreme Court trial the Department of Education did not accept any applications for waivers. It resumed again in 2007 after the case until the expiration of the bill June 30th, 2010.

Evaluating the Mandate Waiver Program

It is difficult to identify the effectiveness of single prime contracting in lowering construction costs on Pennsylvania school projects. As is the case with all construction, every project is different in design, contractors, and management. Making a comparison between any two projects is misleading based on the major differences impacting the final product. Another issue complicating the data analysis is the limited amount of available data for comparison. The short period that the program was in effect was made shorter by the lawsuits challenging its legality. A total of 80 applications were approved, but according to the report by the Department of Education in 2009 less than two dozen of these were completed with final cost data.

Positive and Negative Impacts for Single Prime

While it is generally accepted that multiple prime contracting results in the lowest bids on projects, there are many more considerations that factor into the optimal delivery method. The final cost of projects is rarely if ever the same as the prices bid initially. Things such as change orders, schedule overrun, and litigation can potentially increase cost. Also to consider is the management of the project, both for the school district's time commitment and whether or not an agent construction manager firm is brought on. This impacts who is at risk for the project's completion, quality control, coordination and safety.

Organizational Differences

The communication and responsibility structure of single prime delivery places the general contractor as a middle man between school district executives and the subcontractors. While adding a middle man means paying additional money, placing the project management in the hands of professionals has its benefits. The communication and contract structure of the two different delivery methods are as follows, with the lines representing contracts held between parties:

Multiple Prime Delivery Method

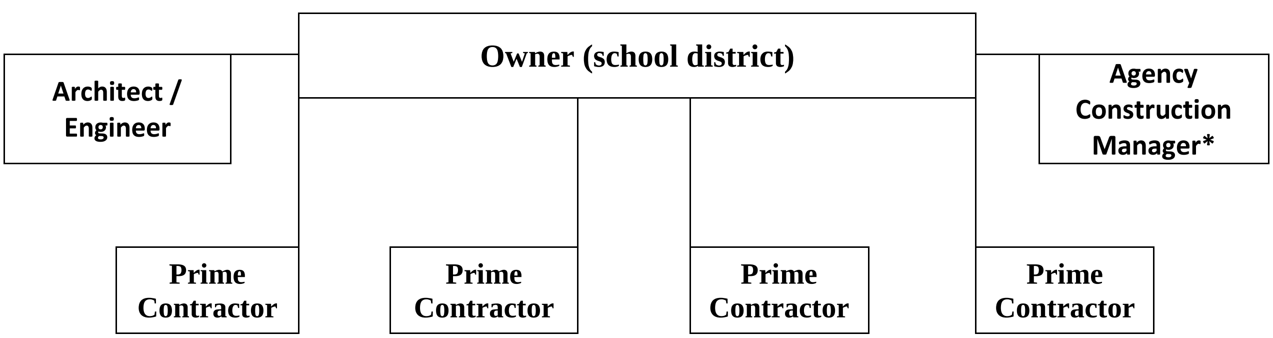


Figure 14. Organizational Chart of Multiple Prime Delivery

*not required, however commonly hired to assist in project development and management

Multiple prime contracting means the owner holds separate contracts with all parties involved. An agency construction manager can be used to assist with design development, construction planning, and safety planning amongst other things. However, since there is no contract between the construction manager and the prime contractors, they are limited in managing the actual construction of the project.

Single Prime Delivery Method

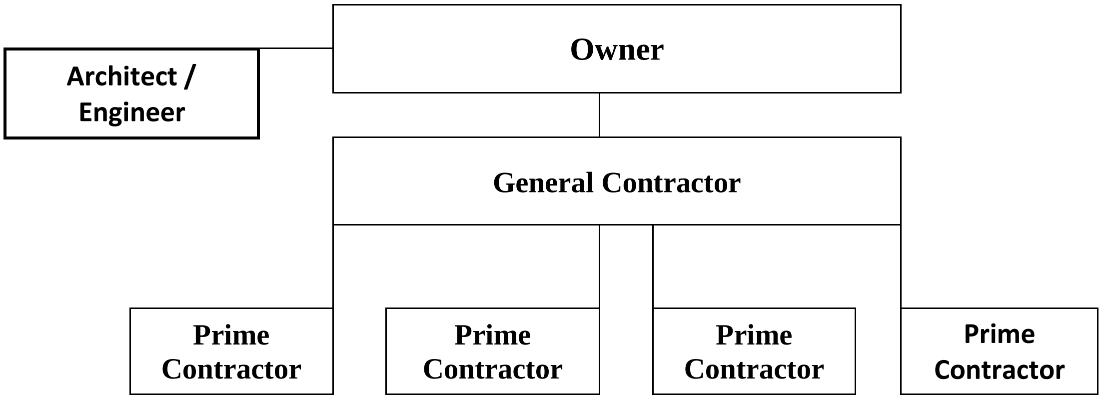


Figure15. Single Prime Delivery Organizational Chart

In this format the owner only holds contracts with the architect / engineer and the general contractor. The general contractor accepts the risk for the successful completion of the project.

Single Prime Differences:

The following are the perceived pros and cons of single prime delivery. Since data is difficult to obtain for these topics, there is no monetary or statistical backing for the stated differences. These are commonly held beliefs about single prime delivery from members of the construction industry. Since they are a generalization of typical results, outcomes are not guaranteed for any specific project.

Benefits of Single Prime:

Decrease in Risk: The general contractor accepts the responsibility for delivering the project on schedule and within budget. Since the project is bid as a lump sum, it is in their financial interest to construct the project efficiently.

Less Management Burden: Since the general contractor is managing the project, the school project executives have much less of a time commitment.

Fewer Lawsuits: Parties involved in a construction project can only sue those that they have a contract with. In multiple prime delivery the school district holds separate contracts with all parties, meaning the only option for contractors to pursue action is against them. Single prime significantly reduces this risk since the subcontractors do not hold contracts directly with the owner.

Better Communication: With only a single point of contact communication becomes a much simpler process. Subcontractor communication is no longer the responsibility of the school district.

Fewer Change Orders*:* In an effort to increase profit margins, subcontractors often attempt to maximize the amount of change orders on projects. School district executives managing a project in a multiple prime delivery may be victimized by contractors preying on their inexperience. Single prime puts a professional organization in control of change orders, and is commonly thought to decrease the average amount for projects.

Schedule Reduction: The increase in contractor coordination, and therefore construction planning, means a higher probability the project it completed ahead of schedule.

Negatives of Single Prime:

Less Competition: In order for a general contractor to bid a project as the only prime contractor they must be bonded for the entire project value. There are not as many companies capable of fulfilling this requirement, resulting in fewer bids and less competition for projects. This can be associated with an overall increase in costs.

Delayed Subcontractor Payment: General contractors historically have withheld payment to subcontractors for periods of time, as well as retaining a percentage of payment until the completion of work. If this is done for an excessively long period subcontractors must act as their own bank in financing projects until payment.

Direct Cost Increase: Bids submitted for single prime delivery are generally higher than multiple prime. The added cost of management, plus allowances for contingency and bonding add money to construction costs. This amount is explored in the following section.

Construction Cost Comparisons:

Some cost comparisons exist from the limited data available for school construction during the period the Mandate Waiver Program was in effect. Two different types of comparisons are used in this report:

1. Bid Pricing for Single and Multiple Prime Delivery Methods
2. Final Construction Costs of School Projects for Single and Multiple Prime

Despite the small sample sizes of these comparisons, they can be used to show the amount by which projects vary in cost for the two delivery methods. By using cost data for bid prices and final project cost the indirect factors affecting projects can be quantified on a limited basis. It should be noted that the data used in these comparisons are from completely different sets of projects, and were collected from unrelated organizations.

Bid Price Comparison

Study by Reynolds Construction Management

This data reflects a study done by Reynolds Construction Management in October of 2008. It includes five public school projects bid between May and September of 2008. The types of projects include both renovation / addition work and new construction. The school budget and bids for both delivery methods are included.

Construction Type	Budget	Multiple Prime Bid	Single GC Bid
Renovation / Addition	$696,700.00	$1,273,002.00	$1,347,660.00
Renovation / Addition	$9,900,000.00	$12,567,400.00	$13,680,000.00
New Construction	$18,436,180.00	$18,643,440.00	$18,710,000.00
New Construction	$16,605,000.00	$20,831,700.00	$21,645,000.00
Renovation	$27,910,000.00	$29,321,400.00	$34,407,000.00

Figure 16. Cost Analysis Data From Study Done by Reynolds Construction Management

Here is the data showing the percentage increase over the budget for both multiple and single prime, as well as the percentage increase of the single prime bid over the corresponding multiple prime bid:

Construction Type	Multiple Prime Bid	Single GC Bid	$ Increase for Single Prime
Renovation / Addition	182.72%	193.43%	$74,658.00
Renovation / Addition	126.94%	138.18%	$1,112,600.00
New Construction	101.12%	101.49%	$66,560.00
New Construction	125.45%	130.35%	$813,300.00
Renovation	105.06%	123.28%	$5,085,600.00

Figure 17. Calculated Values Based on Data

Combining and organizing the data into new construction and renovation work gives the following percentage values:

Construction Type	Multiple Prime Bid	Single GC Bid	% Increase for Single Prime
Renovation / Addition	138.24%	151.63%	110.69%
New Construction	113.29%	115.92%	102.13%

Figure 18. Data Organized by Construction Type

Despite the small sample size, there seems to be a trend of bid discrepancy between the two for renovation work that is greater than new construction. The two percent difference for new construction is roughly within the typical overhead fees charged by general contracting firms.

Final Project Cost Comparison

Report to the Governor & General Assembly, Task Force on Mandate Waivers, February 2009

In an attempt to identify the benefits of single prime delivery for school projects, the Task Force on Mandate Waivers examined the final cost date on fourteen completed projects with available final cost data. The data is presented as seven different final cost comparisons of projects, each with differing delivery methods. The staff doing the analysis controlled key factors for each comparison, sorting comparison criteria into primary and secondary factors. These included the following:

Primary Comparison Points:

- Bid Year
- Building Type
- Type of Construction (new, addition, alteration / renovation)

Secondary Comparison Points:

- Region of the State
- Enrollment
- Expenditures
- Structural Costs
- Architectural Area
- Square Foot Cost

The following tables display the data of the included projects. Each comparison shows the delivery method, construction type, bid price, final price, and the percentage increase of the final cost compared to the bid.

	Delivery Method	Construction Type	Bid Price	Final Cost	% Increase
1	Single Prime	New Elementary	$12,787,250.00	$14,626,868.00	114.39%
	Multiple Prime	New Elementary	$12,749,130.00	$13,970,994.00	109.58%
2	Single Prime	New Elementary	$11,013,909.00	$11,226,517.00	101.93%
	Multiple Prime	New Elementary	$12,208,976.00	$14,291,400.00	117.06%
3	Single Prime	New High School	$71,068,610.00	$74,573,052.00	104.93%
	Multiple Prime	New High School	$39,558,845.00	$38,554,328.00	97.46%
4	Single Prime	Addition / Renovation	$7,452,739.00	$7,331,307.00	98.37%
	Multiple Prime	Addition / Renovation	$6,874,130.00	$7,375,596.00	107.29%
5	Single Prime	Addition / Renovation	$9,060,312.00	$10,858,755.00	119.85%

	Multiple Prime	Addition / Renovation	$9,808,989.00	$9,778,714.00	99.69%
6	Single Prime	Addition / Renovation	$32,046,370.00	$33,123,185.00	103.36%
	Multiple Prime	Addition / Renovation	$12,385,406.00	$12,964,481.00	104.68%
7	Single Prime	Addition / Renovation	$21,345,610.00	$21,227,168.00	99.45%
	Multiple Prime	Addition / Renovation	$8,721,953.00	$8,558,181.00	98.12%

Figure 19. Data Taken from Study

Data in the following two tables is again organized by new construction and renovation projects:

Total Results for New Construction			
Delivery Method	**Total Bid Price**	**Total Final Cost**	**Percentage Increase**
Single Prime	$94,869,769.00	$100,426,437.00	105.86%
Multiple Prime	$64,516,951.00	$66,816,722.00	103.56%

Total Results for Addition / Renovation			
Delivery Method	**Total Bid Price**	**Total Final Cost**	**Percentage Increase**
Single Prime	$69,905,031.00	$72,540,415.00	103.77%
Multiple Prime	$37,790,478.00	$38,676,972.00	102.35%

Figure 20. Data Organized by Delivery Method

The final construction cost differences of 2.3% and 1.42% are roughly within the region of typical general contractor overhead fees. The wider gap between single and multiple prime costs for renovation work is not the case in this data.

Conclusion

Given current industry practice in catering project delivery to each project, it seems obvious that the multiple prime requirement is detrimental to the total value obtained by Pennsylvania's schools in funding construction. Obviously, most school districts would prefer the single prime delivery method for the benefits associated with it. The overall reduction in managerial responsibilities and risk make it easier for school personnel to tend to their non-construction related duties. In placing control in the hands of the general contractor the chances of a successfully delivered project increase. However, the deciding factor for the ideal delivery method often comes down to cost. Every situation should be analyzed for the best possible way to contract out work based on all significant factors.

Despite the brief period the Mandate Waiver Program was in effect, enough schools were granted a waiver of exemption from the Separations Act to provide some useful data for analysis. Multiple prime proponents state that bid prices are always lower with separately bid prime contracts. While this is true based on the data, it is not the only factor for success. The reduction in litigation, schedule overrun, and change orders for single prime on average must be accounted for. Pennsylvania, like most governments, spends a high volume of taxpayer money on construction work. This means a large amount of projects, which increases the probability one or more of these setbacks will occur at some point. While some things are unavoidable regardless of delivery method, the general contractor will be held accountable for occurrences such as worker safety lawsuits, coordination related claims, and schedule overrun. Even one lawsuit avoided would be a significant reduction in state expenditure. On average, the state would spend less over an extended period of time when examining multiple projects. This is without even considering the unquantifiable production increase for school district staff who would otherwise be working to manage the construction in multiple prime projects.

However, just as multiple prime is not always the best choice, single prime delivery should not be used for all projects. As shown in the data, the bid prices of some single prime projects were much greater than the comparison. The types of projects that would benefit the most from the single prime delivery must be identified in order to maximize the gains of each method. The strengths of single prime can be used to infer the ideal project types for its utilization.

Given that many of the advantages in single prime come from decreases in risk, projects with a higher risk of problems occurring would be best for its implementation. Risk analysis must take into account design complexity, construction concerns, coordination requirements, schedule margin of error, and the capabilities of the school district staff. If a building is complex in system or architectural design, the need for detailed planning would be greater. Construction concerns and coordination requirements follow the same general idea. A general contractor would be better suited for this task since they are professionals. Schedule margin of error is commonly an issue for both new and renovation work for schools since work must adhere to the academic calendar. The coordination increase with single prime means more chance of a project being delivered on time. Finally, some school districts are more experienced than others in delivering projects. If they have the staff and experience, school districts would most likely be better off with multiple prime.

The data located in the bid price comparison of the report showed a wider margin for single prime in renovation work than for new construction (roughly 10% vs. 2.15%). However, the final cost data showed a closer margin for renovation work than new construction (1.77% vs 2.35%). While the data is limited, this is a rough example of the benefits of coordination and schedule maintenance in single prime. Renovation projects are frequently slow moving, painstaking processes. There are commonly inaccurate drawings and unforeseen conditions, making work difficult to plan. With a general contractor, the increase in communication and an updated set of drawings circulated to all subcontractors could possibly explain this change.

These factors are all important to consider, and if Pennsylvania does renew the Mandate Waiver Program in some form it should require all projects to solicit bids for both delivery methods. The differences in the bid value of single and multiple prime must be weighed against the previously stated factors. An informed decision can then be made to maximize total value. Pennsylvania could require data to be collected for each project. This would allow the state to develop models with adequate data to determine with greater accuracy the appropriate conditions to select one delivery method over the other. In doing so, millions of dollars could be saved in construction spending while improving the quality of publicly funded projects.

Geothermal Heat Pump Alternative

Introduction

Given the rapid increase in energy costs observed over the past decade, energy efficiency was a major design objective for the Phoenixville Area Middle School. Schools typically are occupied as long as possible to maximize the investment of taxpayer dollars in funding a new building, so a long term approach to cost is necessary to determine best value. Efficiency can be addressed in many ways, including daylighting, exterior façade composition, and equipment performance. A significant portion of building energy consumption comes from the heating and cooling of spaces. While designing systems with higher performance equipment cuts down on power use, initial costs can rise significantly. It is for this reason that less efficient, lower cost systems are often chosen.

Background

The design chosen for this project was a water source heat pump system with closed circuit cooling towers and electric wall heaters. This was chosen in the value engineering process over traditional systems for its superior performance. However, the HVAC design could go further in lowering the energy used in heating and cooling the middle school. By utilizing a geothermal system in place of the cooling towers, the overall energy performance of the school would be improved.

Research Goals

This research is aiming to identify what impacts a geothermal system would have compared to the current water source heat pump system in terms of:

- Direct construction cost to owner
- Energy performance of middle school
- Construction schedule impacts
- Constructability of middle school

Geothermal Heat Pumps

Geothermal heat pump systems are becoming more popular amidst the growing trend of sustainability in the construction industry. They consist of a fluid flowing through a loop of piping run through the ground which is tied into a heat exchanger located within the building. The loops can be run horizontally or vertically in the ground, depending on design constraints. This fluid can be water, a chemical refrigerant, or a mixture of water and refrigerant. The amount and length of pipe runs are determined by the load of the building.

The idea behind geothermal systems is to utilize the nearly constant temperature of the ground at eight feet or lower below the surface. For Pennsylvania, this temperature is on average 52 degrees Fahrenheit year round regardless of climate conditions. In summer months when cooling is needed, the fluid is cooled while flowing in the underground pipes. In winter it has the opposite effect, extracting ground heat and bringing it into the building.

Advantages of Geothermal System

Both systems basically use the same heat pump equipment and have a relatively equivalent COP (coefficient of performance). However, a geothermal system would replace the boiler and cooling tower of the current water source system. The loops would serve as the heating and cooling agents. The boiler and cooling tower run on fossil fuels to operate. By utilizing the unlimited supply of energy in the ground the building will consume less. Also, since there are no cooling towers or boilers, there is not a need for sump heaters, tower water chemicals and make-up water. Both operate at around 90 degrees Fahrenheit in the summer time. However, the winter design operating conditions are lower for geothermal systems. Water source boiler / tower systems typically are designed for 60 or 70 degrees Fahrenheit, but geothermal can be below freezing at 25 to 30 degrees Fahrenheit. In cooling, a lower operating temperature means heat pumps will function more efficiently.

Design

The design of the geothermal system was based off of the heating load requirements of the middle school. The reasoning behind this was that heating loads in Eastern Pennsylvania are the dominant load based on climate and the occupancy of the building based on the time of year. These loads were determined by summing the heat pump heating capacities for the current system, in thousands of British Thermal Units per Hour. These are the maximum capacities of the system, and provide a conservative value to base design of off.

The bore hole array and depth were determined using the Ground Loop Design Commercial Version 2012 software by GLD. Since the system was calculated based on the inexact loading such details as pipe size and fluid were left as the default. Pipe size inner diameter is 1.550 inches. The fluid is assumed to be water. Ground temperature was entered as 55 degrees Fahrenheit. This yielded the following result:

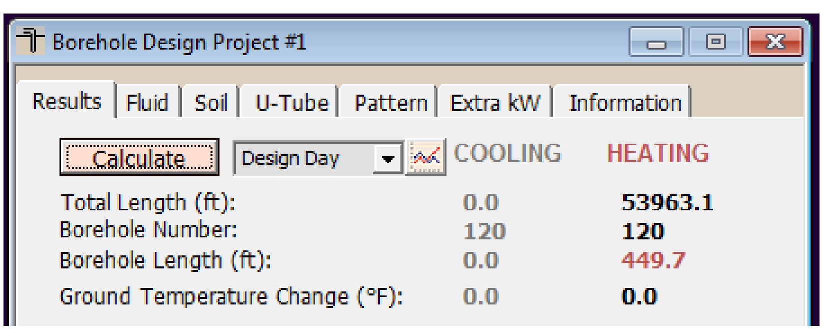


Figure 21. Borehole Design Findings

The geothermal boreholes will be a 10 x 12 array. The boreholes are 5" in diameter, and the pipes are to be grouted upon installation. The borehole lengths will be 449.7 feet deep, with a total pipe length of 53,963 feet. An average spacing between boreholes was used, with 20 feet between each. This means a minimum of 200 x 240 feet is required for the borehole array.

The logical place to put the geothermal system is the parking lot located next to the site. This would present issues with student parking during the school year. However, all other surrounding areas are needed for construction related activities. The array can be located far enough from the building and the tennis court to be maintained throughout construction.

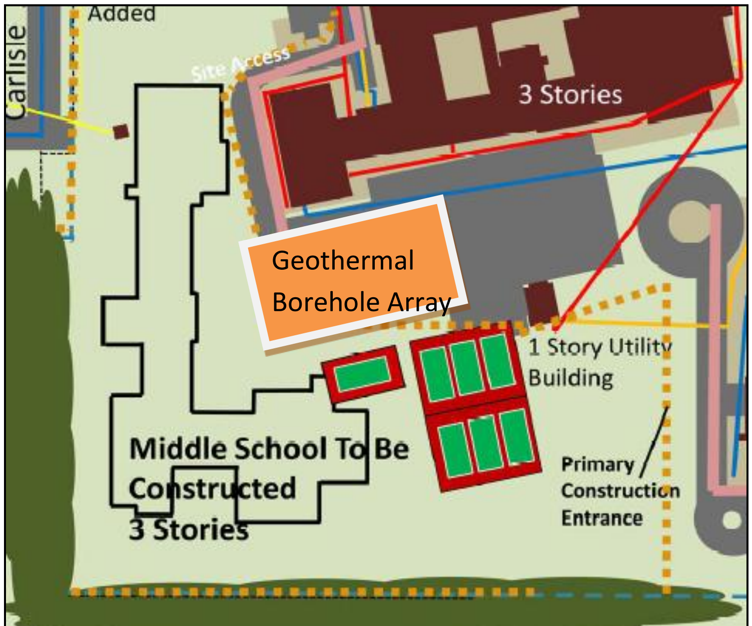


Figure 22. Location of Geothermal Loops

Connecting Ground Loops to Building

The current system has the water source heat pumps serving individual areas connected in a loop to the cooling towers and boilers. The ground source system would connect the vertical ground loops to these heat pumps directly. There are two total loops connecting the all of the heat pumps to the equipment in the existing design. In order to maintain the current number of pumps to push water through the system, two loops will connect all water source heat pumps in the system. These loops will enter the building through the mechanical room, and loop through the plenum space to the heat pumps served.

Schedule and Constructability Impacts

The drilling process would have to take place as soon as possible after the end of the 2010 – 2011 school year. A realistic start date would be June 11th, immediately following the scheduled time for contractor staging. An estimated duration for the borehole drilling is roughly 2 boreholes a day, meaning a total drilling duration of 60 days. The drilling process does not require extensive space, so it would not impact the activities scheduled to occur at the time period. Other activities for this time period would temporary paving, excavation, and the reinforced concrete foundation. While the drilling process would not interfere with these activities, tying into the building system would require coordination with the foundation. Running underground pipe from the borehole array to the building would require excavation to install the pipe. This would add an additional two weeks to the excavation activity which is on the critical path. Therefore this would add two weeks to the overall project duration.

Energy Performance

Breadth Study 1: Performance of Ground Source Heat Pumps over Water Source

The two systems operate using the same heat pump equipment, and only truly vary in performance in cooling buildings. However, given the climate and occupancy of the middle school, the differences in actual energy performance in heating and cooling the building is not based on the energy use of the HVAC system. However, the heating and cooling is done with different types of "equipment", meaning one uses a combination of cooling towers and boilers and the other uses the ground. This will form the basis of the comparison. It should be noted that any increase in pump power had been neglected from this comparison, and the current cooling tower pumps will be adequate for the geothermal system. Only the two condensing boilers are included in the analysis. The electrical heaters also have been neglected from this comparison, and are assumed to be part of the new geothermal system.

Cooling Towers (2 total):

Primary Fan: 20 Horse Power

Tower Pump: 10 Horse Power

Sump Heater: 2 @ 6 kW

Condensing Boilers (2 total):

Gas Input: 3000 MBH

These are the maximum operating levels of the systems, so a conservative estimate of 30% will be used for the cooling towers in this analysis. A factor on 80% will be used for boilers. This accounts for the various needs based on climate throughout the year, along with limited summertime occupancy. Given the daily occupancy of roughly ten hours, plus a five day week, another factor of (10/24) x (5/7) = 0.2976, or roughly 0.3, will be multiplied to the value.

Converting all units to kilo-watt hours:

Cooling Towers:

Primary Fan: 20 Hp = 14.914 kilowatt hours

Tower Pump: 10 Hp = 7.4570 kilowatt-hours

Condensing Boilers:

Gas Input: 3000 KBtu / hr = 877.75 kilowatt-hours

Yearly Energy Consumption:

Cooling Towers = 2 x (14.914 + 7.4570 + 12) x 30% = 20.62 kWh daily

Condensing Boilers: 2 x (877.75) x 80% = 1404.4 kWh daily

Total = 1425 kWh daily

1425 kWh x (5 days/ 7 day week) x (10 hours / 24 hour / day) x 52 weeks/ year = 22,053 kWh per year.

The resulting reduction in annual energy consumption is estimated at roughly 22,053 kilowatt-hours per year.

Note: The accuracy of this estimate is not guaranteed. It was done with many assumptions, neglections, and estimated values. Given my area of study in construction management, the focus of this comparison is not the mechanical data and calculation but rather the method in comparing the two.

Cost Comparison

Direct Cost

The direct costs of the two systems must account for changes in equipment and construction between water source and geothermal. The ground loops replace the cooling towers and condensing boilers as the means of heating and cooling. All other equipment is the same for both systems. It is assumed that the pumps are the same for both systems since the pressure requirements of the geothermal are offset by the lack of head loss associated with the cooling tower equipment. Pipe length inside the building is always assumed to be the same. This is due to the fact that the number of loops is the same, and the change in running up from the mechanical room is offset by the removal of pipe running to the roof. Under the assumption that all system equipment is the same between the two besides the heating / cooling equipment, a direct cost comparison is as follows:

Removal of Heating / Cooling Equipment:

These values are taking directly from payment applications of the mechanical contractor.

Cooling Tower (2):

Material: $247,000

Labor: $10,500

Condensing Boilers (2):

Material: $10,666

Labor: $5,333

Total Cost Reduction: $273,500

The bulk of cost reduction is from the removal of the cooling towers from the system.

Cost of Geothermal System:

The cost of the geothermal system is more difficult to estimate considering there is no actual design to base it off of. For this reason, a more generic estimate based on unit pricing done by a mechanical contractor on a similar project in the Philadelphia, Pennsylvania are will be used. This pricing is from 2009 for a vertical loop geothermal system for new construction at a community college. The values are not adjusted for inflation because the growing popularity of geothermal systems may have affected the price.

Underground Loop Unit Cost:

Cost per L.F.: $18.00

Total Cost: 54,000 l.f. x (18.00) = $972,000

The direct cost of the geothermal system is much higher than that of the equipment in the existing HVAC design. In examining the overall difference in the mechanical contractors total value of work, the changes are accounted for in the total as follows:

Original Mechanical Contract Value:	$5,778,734.00
Subtracted Cost of Cooling Towers and Unit Heaters:	$273,500
Added Cost of Geothermal Ground Loops:	$972,000
Adjusted Contract Value for Proposed Change:	$6,477,234.00
Percent Change in Total Contract Value:	112.09%

As previously noted, the design and cost estimate of the geothermal was very generic, meaning the accuracy and details are unreliable. It was anticipated that the direct construction costs of the system would be higher than the water source system currently in place. The benefits of geothermal heat pump systems come from the energy benefits of the efficient system in heating and cooling the building. These are explored in the following section:

Long Term Costs:

As previously shown the breadth study on energy performance, geothermal systems outperform the ordinary heat pump systems in terms of limiting energy use. By doing a long term cost analysis on this advantage, the payback period of the system can be established. Only the energy savings will be included in this analysis. Factors such as maintenance and controls are omitted based on the lack of quality data to quantify any gains.

A twenty-year life cycle is used for the geothermal system. This is not because it is the expected life span of the system, but is generally accepted as the time before problems are experienced and system performance drops off.

In order to quantify cost savings from energy reduction, a value for the price per kilowatt-hour is needed. The United Stated Energy Information Administration had the following graph:

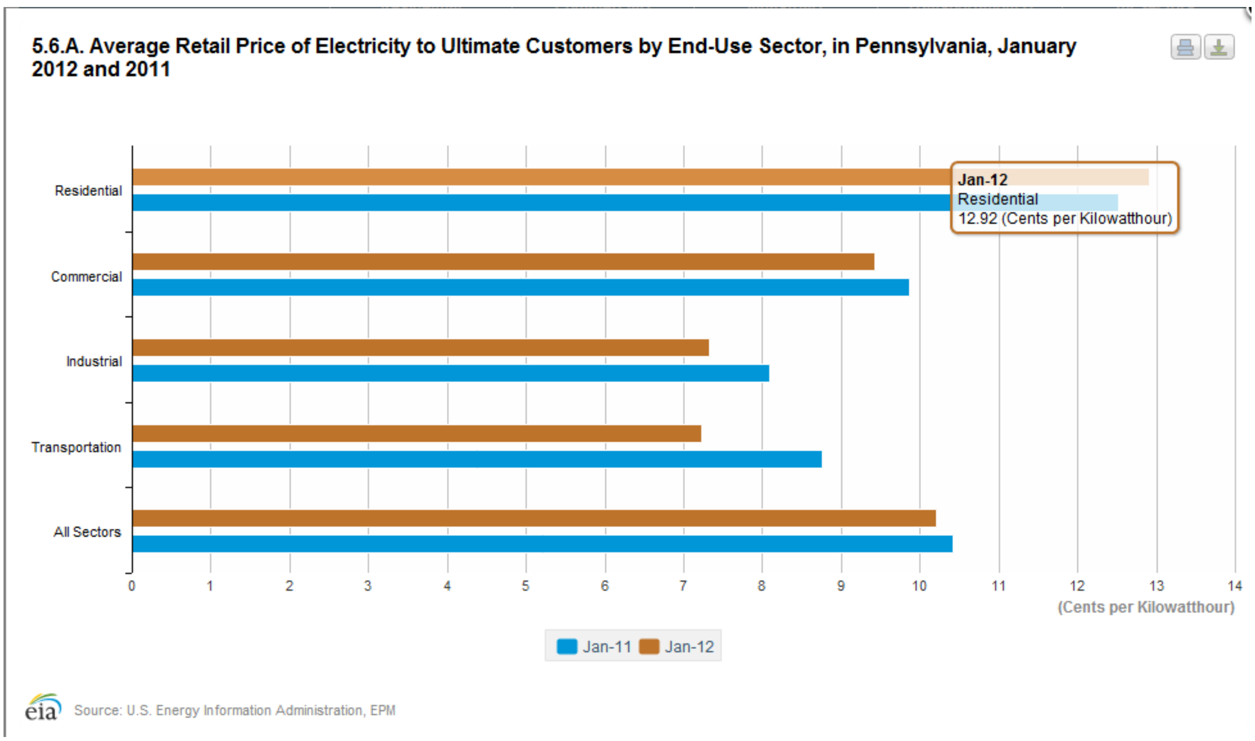


Figure 23. Average electricity cost per kilowatt-hour by EIA

Based on this data, a rough estimate of the average electricity price can be made. Over the past ten years, energy costs have risen roughly have a cent per kWh. An average of 20 cents a kilowatt-hour will be used for this analysis. This will account for rises in the next twenty years, and omits changes such as privatization of electricity and the natural gas industry being developed in Pennsylvania.

Annual Energy Savings per Year: 22,053 kWh / year

Annual Cost Savings per Years: 22,053 kWh x $0.20 = $4,410 saved annually

$4,410 per year x 20 years = $88,214

Payback Period: Cost Geothermal – Savings From Equipment Removal / Annual Energy Savings

(972,000 - $273,500) = $698500 / $4410 = 158 years ($698,5000 >>> $88,214)

Conclusion

Based on the long term analysis of the two systems, the project team made the correct choice in going with the water source heat pump system with cooling towers and boilers. The installation of the geothermal heat pump system costs too much to make it an economical choice. While this analysis was a generic comparison of the two systems, it is obvious from the data used that it is not feasible. This comparison even neglected indirect costs such as schedule enlargement and logistics considerations.

Analysis Two: Application of BIM to Project Delivery

Problem Identification

The use of building information modeling (BIM) for the Phoenixville Area Middle School was only used in the early design phase of the project. Gilbert Architects and Baker, Ingram & Associates were the only two project members to utilize it. They are the architectural and structural engineering firm on the project. They designed the architectural and structural elements in Autodesk Revit, and used the program to print construction documents. Coordination with BIM was limited to these two parties.

The use of BIM beyond design modeling was not seen as a necessary requirement for the project. According to the agency construction manager on the project, Reynolds Construction Management, this is typical for Pennsylvania school construction. BIM is growing in popularity in other types of construction, but has not reached this specific client yet. Its uses are still being defined, and it is still difficult to determine the impacts it has on projects. Typically it is used for complex construction with integrated delivery project teams sharing data. Elementary and High School buildings typically are designed as economically as possible, limiting the complexity of the design. BIM as a tool for logistics planning is not usually necessary for this reason. Also, Pennsylvania schools are required to use multiple prime delivery by the Pennsylvania State Separations Act. Since the responsibility is divided amongst the prime contractors it is difficult to place the coordination responsibilities with one party. However, there are many potential uses of BIM that have benefits in all phases of the project. Early project design and development involves fewer groups than the construction process. Typically it is the owner, architect, engineers and the agency construction manager. By examining BIM uses that take place early in the design process, potential uses that could benefit the overall success can be identified.

Background

In order to identify potential strategies for BIM in the early stages the concerns, issues, and decision making must be identified.

Feasibility Study

In the beginning phases of the project, the Phoenixville Area School District conducted a feasibility study with the help of the architectural firm. The study was to identify the cost and program differences between renovating and adding to the existing middle school vs. building entirely new. Based on requirements of the school district in upgrading their campus facilities, a comparison was made based on conceptual pricing. Along with the middle school facility, there were several other smaller phases to the overall campus project to be included. A new district administration office was needed for more office space. Athletic fields needed to be renovated or built new as well. Finally, storm water drainage needed to be addressed to improve the campus system. Ultimately, the decision was made to build a new middle school and demolition the existing.

Design Development

In developing the design of the middle school, the architect had to be careful to fulfill all the program needs developed by the school district. Requirements included meeting the occupancy requirements of the gymnasium and auditorium, providing enough classroom and lab space, and making the building fit on the campus. When the final design was developed, the estimate for construction came out over the budget for the school district. It had to be reduced to fit the budget.

Another cost concern for the district was energy efficiency of the building. The design team had to strike a balance between an efficient system and direct cost amount of the system. This was a subject of debate in the value engineering phase.

Construction Considerations

Construction of the Phoenixville Area Middle School had to be scheduled around the academic school year. The construction began right at the beginning of summer and had to be ready a year and a half after. Site logistics on campus had to be accounted for as well since student safety is such a concern.

BIM Execution Guide

The BIM Execution Guide is a list of the potential uses of BIM for projects. Only a few of these are of potential use on the Phoenixville Area Middle School.

Building Maintenance Scheduling	**Design Authoring**
Building Systems Analysis	**Engineering Analysis**
Asset Management	**Sustainability Evaluation (LEED)**
Space Management and Tracking	**Code Validation**
Disaster Planning	**Design Reviews**
Record Modeling	**Programming**
Site Utilization Planning	**Site Analysis**
Construction System Design	**Phase Planning (4D Modeling)**
Digital Fabrication	**Cost Estimation**
3D Control and Planning (Digital Layout)	**Existing Conditions Modeling**
3D Coordination	

Figure 24. BIM Execution Guide Uses

The most promising of the uses listed above include building systems analysis, space management and tracking, and cost estimation. These uses will be examined for their potential impacts on the Phoenixville Area Middle School.

Space Management Tracking

In developing the program and design for the middle school, there was a constant tug of war between the project cost and fulfilling the requirement set forth by the school district. In trying to fit in the square footage of the gym and auditorium, student requirements, and sustainability goals the project continually needed examination. In order to do this, the construction manager had to work out estimates for every potential change. With a model in place, the project team would be able to do this rapidly rather than waste time with detailed estimates.

This would benefit multiple parties by having a model in place. The agency cm, Reynolds Construction Management, would share the responsibility of the model with the architect and engineer. The would be able to examine changes in much less time by using this. The quicker it was in determining changes to design and the resulting impacts, the quicker a design can be finalized. This would minimize the preconstruction efforts of the team and lead to a quicker project out for bid.

Building Systems Analysis

One of the main topics of debate in the value engineering process was the HVAC system. Direct cost of construction is always an issue for school districts, and was the case on the middle school. The school district wanted a efficient design, but didn't want to overspend on it. The project team felt the water source heat pump design was most efficient, but only had historical data to back it up. With a model to analyze the building system, not only could the pay back period be determined more accurately, but the system performance could be maximized to produce the best value.

Cost Estimation

One of the main criticisms of multiple prime delivery is the owners ability to manage the bids of contractors. A solution to this problem is using a BIM model for cost estimation. This applies not only to initial design estimate, but to any change taking place throughout the project. A cost model would provide owners with a visual reference and hard data to make educated decisions about the project.

Conclusion

The Phoenixville Area Middle School did not necessarily suffer due to the lack of BIM implementation. The project has gone smoothly, is on budget and schedule, and includes everything required in the program set out by the school district. As BIM continues to spread throughout the industry, it will eventually become common practice at all construction companies. These uses will be the most beneficial to multiple prime projects since they can work in a project with an unclear leader. As data continues to accrue for projects utilizing BIM, the financial impact it has on projects will determine just how beneficial it is.

Analysis Four: Precast Concrete Facade

Problem Identification

The schedule of the Phoenixville Area Middle School starts in late May of 2010 and reaches substantial completion on May 31st, 2012. The building must be ready for the academic school year starting in late August of 2012. Despite the three month window from completion to the start of school, many things must happen in this period. Commissioning must be completed on all building systems in this time period, as well as move in for the faculty. The facilities managers must also become familiar with the new building. Any schedule delays can result in negative impacts on the school's ability to function in educating its students. In developing ways to accelerate the schedule and mitigate this risk, one potential scenario is to use a precast façade in the classroom sections of the buildings.

Background

Currently the façade in the classroom areas consists of split face masonry veneer with either reinforced concrete masonry or metal stud backing. These areas, referred to as area B and C, are on the critical path of the project schedule. The exterior wall construction begins on March 17th 2011 in area B and is completed in area C on August 29th, 2011. The bulk of the MEP work is dependent on the completion of the façade. By reducing the schedule, the project can benefit in several ways.

Goal

The goal of this analysis is to determine the impacts of a precast concrete façade on the project. Through consultation with contractors and the project team, the following will be determined:

- Design of precast façade
- Schedule impacts of precast façade
- Constructability impacts of precast façade
- Cost impacts of precast façade

Also included is a structural breadth study for the redesign of the typical reinforced concrete strip footing based on the changed loading.

Actual Construction Sequence

The façade start date was dependent on the steel superstructure erection in areas B and C. In general, the construction of the middle school began in the gymnasium (area A), and progressed along the building to the final area D (auditorium). Once the steel members and metal decking were in place, the cranes used to lift them were moved to the next areas. No work could be done in an area when cranes were in use for safety reasons.

First, a starter course was laid out for the masonry. Then the concrete masonry unit or metal stud backing was put into place. During this time, the only other work in the area was for MEP hangars and outdoor equipment. Once the backing was in place, the façade was installed. This was done progressing along the building following the same sequence as previously described. Scaffolding was put in place to do work at elevated levels. The significant dates of the façade construction are shown below:

Area B	**Start**	**Finish**
CMU Backup Masonry	3/17/2011	5/2/2011
Metal Stud Backup	4/12/2011	6/14/2011
Masonry Veneer and Clean	5/24/2011	7/19/2011
Area C		
CMU Backup Masonry	4/29/2011	5/19/2011
Metal Stud Backup	5/24/2011	7/27/2011
Masonry Veneer and Clean	7/7/2011	8/29/2011

The total duration for the façade is 121 days, or a little over 24 weeks. This duration is for work days, and does not include weekends in the total.

Precast Concrete Panel Design

The proposed design for the exterior façade in areas B and C would only be for the exterior walls spanning all three floors. Other areas, such as the transition space between area A and B, are only one story making a substitution to precast unnecessary. By limiting the areas for precise to only the three story areas, the time to build up three stories of masonry and scaffolding are removed. Also, ordering precast pieces will be much simpler due to the consistency of members.

Upon consulting Mark Taylor of Nitterhouse Concrete Products, Inc., the panels will span all three floors of the building. The maximum width of panels will not exceed 12'. This is for shipping considerations, as any panel being transported that exceeds this width requires a permit. The panels are 10" insulated precast with thin brick.

Panels will connect to the structural steel frame of the building using welded metal flanges. The structural analysis to determine the structures ability to carry this load is not included in this research.

The cross section is as follows:

Figure 25. Cross section of designed precast panel

The minimum compressive strength of the precast concrete after 28 days is 5,000 psi. Given the minimal structural requirements for the exterior façade, this is more than adequate. The panels will be grouted using non-shrink, premixed grout. The panels will bear on multi-monomer plastic strips. An example of the façade elevation is shown below:

(panels 42 feet in height)

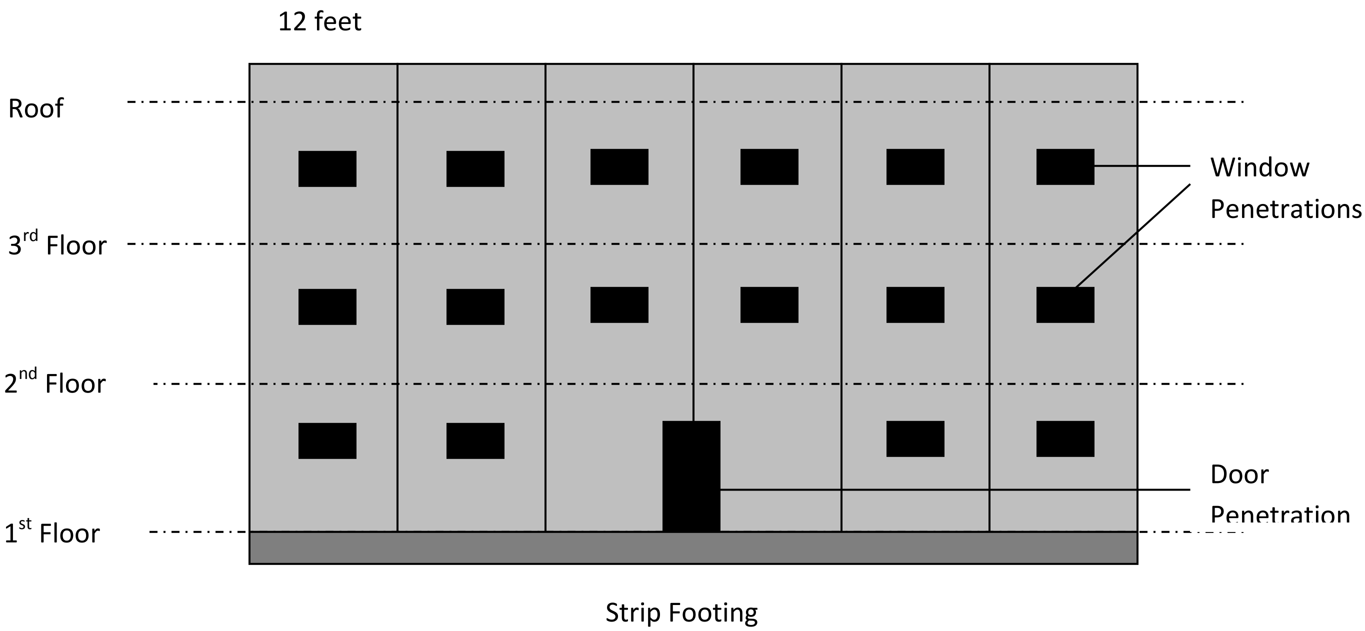


Figure 26. Elevation of Designed Precast Facade

Wall Perimeter for Precast

The following is a basic illustration of the walls to be composed of precise concrete panels. Only included are the dimensions and drawings of the walls spanning all three floors.

The blue lines represent the division between areas.

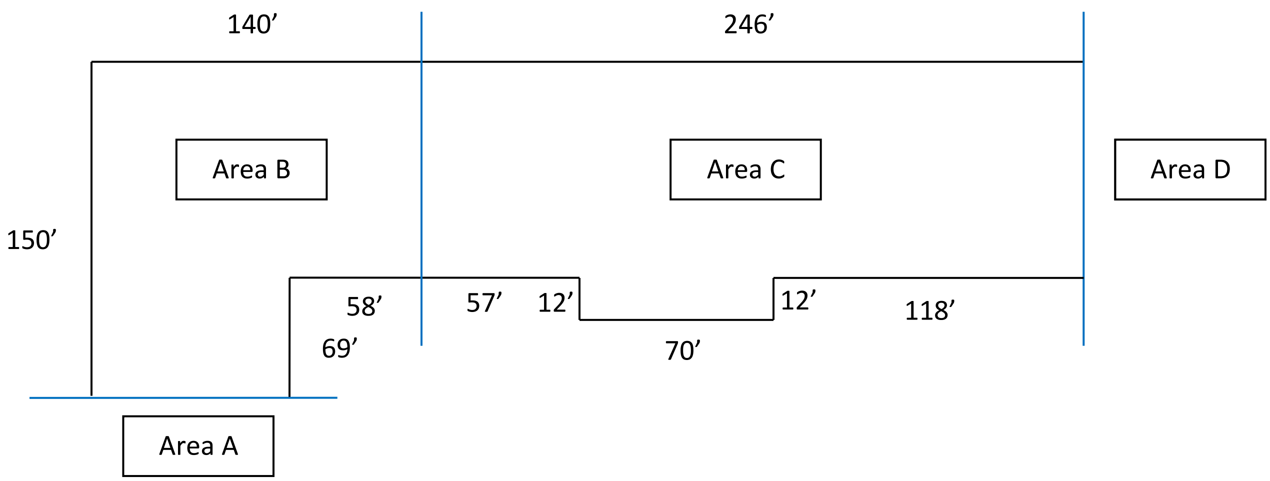


Figure 27. Dimension of Precast Façade Perimeter

Panel Quantity Calculation

The amount of panels needed for the façade will be calculated based on exterior perimeter. Divisions between sections will not line up with panel grout joints.

69’ / 12 = **5** 12 ft wide panels and one 9 ft wide

58’ + 57’ / 12 = **9** 12 ft wide panels and one 7 ft wide

2 panels at 12’

70’ / 12 = **5** 12 ft wide panels and one 10 ft wide

118’ / 12 = **9** 12 ft wide panels and one 10 feet wide

242’ + 140’ / 12 = **32** 12 ft wide panels

150’ / 12 = **12** 12 ft wide panels and one 6 ft wide

Total:

A total of 79 precast panels.

Seventy Four (74) Twelve Foot Wide

Two (2) Ten Foot Wide

One (1) Seven Foot Wide

One (1) Nine Foot Wide

One (1) Six Foot Wide

Construction Sequence

The precast façade is dependent on the structural steel frame in order to begin installation. Since the façade in these two areas is more critical to the schedule than the steel in area D, installation will begin upon the completion of the superstructure in areas B and C. The two cranes used for the superstructure will be used to lift the panels. The construction sequence will follow the typical pattern of moving from area B to C. The panels will be installed in succession and braced as needed for temporary support. Welding, grouting and detailing will take place once the frames in area B have been installed. Once all panels are installed in both areas the crane will move back to installing the steel in area D.

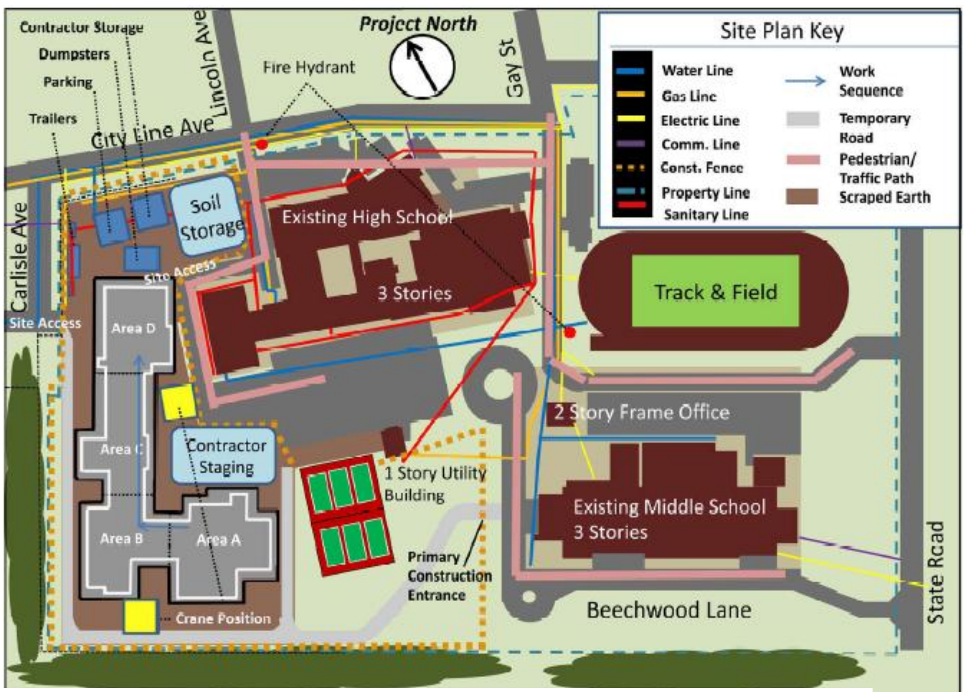


Figure 28. Plan View of Construction Site for Superstructure Phase

Deliveries will enter the site through the south-eastern entrance off of State Road. This is the primary construction entrance, and provides more room for the delivery to turn around. Deliveries will come straight from the factory to the site. Site storage is available on either side of area A. The layout at this point in construction is shown above.

A truck can carry four twelve foot panels in one load. Installers are capable of setting 15 to 20 panels a day, so four deliveries need to be made daily. In picking the panels up, steel straps will be used to attach the panels to the crane. The straps will wrap around the outside edges in a manner that puts the force in the vertical direction of the panels to avoid breaking.

Schedule Impacts

The lead time for precast panels is typically 5 to 6 months from award of project to delivery start. The panels cannot be installed until the steel is complete in areas B and C. This means a start date for installation of April 28th, 2011. The order for the panels would have to be in six months before, meaning by late October 2010. The submittals for equipment for the project on the current construction schedule are all approved by early September, so the precast submittal process poses no problems in this area.

As previously noted, 15-20 panels can be installed each day. Assuming four loads carrying four panels each are brought in daily, 16 are installed each day. This conservative estimate accounts for the time in moving cranes and bringing in deliveries. With a total of 79 panels, this means \ just under five days of installation. Accounting for the weekend, this would mean the façade would be complete by May 5th, 2011. Another month must be included for grouting, welding, and detailing, however after put in place the exterior façade in these areas allows other trades to work in the area, removing it from the critical path.

In comparison to the masonry façade schedule:

Masonry in Areas B and C:

Start: 3/17/2011	End: 8/29/2011	Duration: 121 days

Precast in Areas B and C:

Start: 4/29/2011	End: 5/5/2011	Duration: 5 days

This duration reflects the amount of time it takes to reach full enclosure of the two areas, and does not account for the grouting, welding, and detailing of the precast façade. The precast system cuts the end date of the facade by 73 days, over two months.

Impact on other trades:

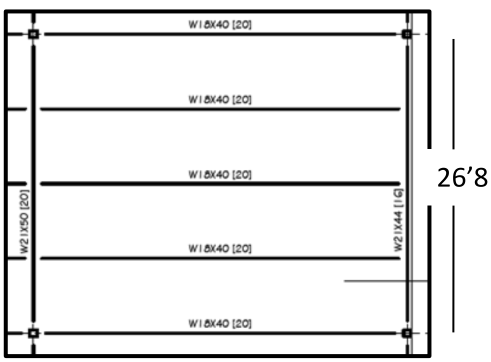
Originally the MEP work could began the rough-in stage on April 29th, 2011. However, equipment could not be brought in until the completion of the façade backup. This meant it couldn’t be installed until July 13th, 2011. It is dependent on the back up work on the façade being complete. . While the rough-in work would be stopped for five days to install the precast , equipment could be brought in much earlier. Rough-in work in area C does not begin until June

13th. By using a precast façade, the work can take place simultaneously in both areas. By working in both areas at once the MEP work can be completed more quickly. A precast façade means less clutter on the job site since there won't be as much masonry storage needed. As the exterior is completed in Area D, the focus in all other places moves to interior work. In completing the interiors of Area B and C more quickly, the contractor can use more labor to work in the final area D. However, it is difficult to predict schedule impacts for this.

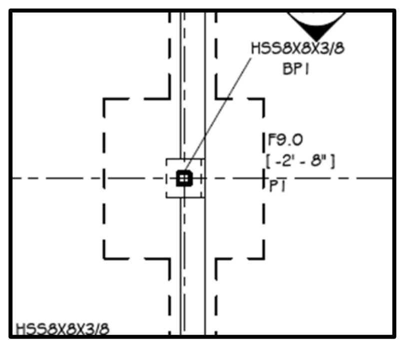
Breadth Study 2: Structural Redesign of Exterior Steel Columns

This breadth study will identify the required increase in size for structural steel columns used to support the precast panels on the exterior of the building. This will be done in Areas B and C of the building, and will focus of the areas where the panels span up to the third floor. The reason that these are the only columns included is that the other areas (A and D) were previously designed with masonry shear walls which rested on the concrete strip footings. They do not require a redesign.

This analysis will be done for the typical bay frame in these areas. The design is shown below:



Figure



Figure

The typical bay contains a HSS8x8x3/8" steel column every 26' 8". This is the size of the column at all levels.

Design Loads:

The cross-section of the precast panels contains a total of 7" of concrete with 3" of insulation. In order to provide a conservative estimate on the redesign, the square foot weight of the panels will be determined by treating the panels as a 7" thick concrete member that does not have any penetrations or graps in the wall area. This will account not only for insulation weight, but will provide a conservative estimate for the resizing. unit weight of 150 pounds per cubic foot will be used for concrete.

(7" / 12" / ft) x (150 lbs per cubic foot) = 87.5 lbs per square foot.

In these areas which span three floors, the columns carry the weight of all three stories of panels. The panels go up to the roof level at 44', so the loading per linear foot is:

(87.6 lbs / s.f.) x (44') = 3850 lbs / l.f.

Finally, times a length of 26'8":

3850 lbs x 26'8" = 102666.7 lbs = 102.7 kips

Assumptions:

It is assumed that the connections at the top and bottom of the columns can be treated at pin connections. Since the columns were designed to be exactly the same size, the result of this analysis will be used to upsize all of them. Correspondingly, the bottom column will be the only analyzed since it will carry the most load.

Since the total loading used for designing the columns in unknown, the columns will be treated as being sized as little as allowable. There, the additional loading will be used to decide how much bigger they need to be.

From AISC Manual Steel Construction

Load and Resistance Factor Design 3rd Edition, pg. 4 – 117:

For 8 x8 x 3/8" HSS Column, with a KL value of 12', maximum axial loading is 352 kips.

352 kips + 102.7 = 404.7 kips

The columns must be redesigned in order to account for this added load. This means increasing cross sectional area, either by increasing thickness or dimensions. I chose to increase the thickness to avoid any complications that would come with changing dimensions.

New Column: HSS 8x8x1/2" (maximum axial design load of 432 kips at kl = 12)

Steel Cost Change

Upsizing the columns will bring added costs to the project. The size increase was done for a typical frame, however not all frames follow that design. The overall steel cost increase will be done by determine the percent increase require for steel columns in the typical frame, and using this as a factor to multiple all columns located in Areas B and C.

Increase in steel from HSS 8x8x3/8" to HSS 8x8x1/2": 101.91%

56 columns per floor, average for 12' column of 601 pounds of steel, 3 floors.

(3 floors x 56 columns x 601 lbs) = 100, 968 lbs of steel.

100, 968 lbs x 101.91% = 102, 896 lbs (increase of 1928.5 lbs)

Cost will be determined by using this increase in pounds of steel and multiplying it by the unit cost per pound.

Cost data was obtained from RS Means Facilities Construction Cost Data 2012.

05 12 23 – Structural Steel for Buildings 5300 Structural Tubing, Rectangular, 7-10”, Heavy

Cost per pound: $1.74 / lb.

Cost Increase: 1928.49 lbs * $1.74 / lb = $3,355.57

Cost Impacts of Precast Façade

The typical cost including fabrication, delivery, and installation of precast is roughly $20 per square foot. Each panel is 42’ in height, so the total cost of the system is:

74 panels @ 12’ x 42’: $745,920

2 panels @ 10’ x 42’: $16800

1 panel @ 9’ x 42’: $7560

1 panel @ 7’ x 42’: $5880

1 panel @ 6’ x 42’: $5040

Total Precast Cost: $781,200

Increase in Steel Cost: $3,355.57

Total Cost: $784,555.57

Cost of Masonry:

Area B	Façade Back Up: Labor	$182,391.95
Area B	Façade Back Up: Material	$94,575.00
Area C	Façade Back Up: Labor	$182,391.95
Area C	Façade Back Up: Material	$94,575.00
Area B	Face CMU: Labor	$52,000.00
Area C	Face CMU: Material	$88,752.00
	Total Cost:	$694,685.90

Conclusion

The overall reduction in schedule is not enough to justify the addition costs of the precast façade. It costs nearly $100,000, and does not cut enough off the project schedule. The way the project is phased by area makes for a swift construction process. Schedule acceleration is not necessary, however should the need arise the best method would be to increase crew size or work overtime.

Conclusions

Examination of Pennsylvania Separations Act of 1913

This section found that the Separations Act has been met with growing opposition in recent years. Pennsylvania remains one of only four states to implement such legislature. The Mandate Waiver Act allowed school districts to apply for exemption from the multiple prime requirement for delivering school projects. After its expiration in 2010, many groups are calling for its renewal, or an end to the limiting Separations Act altogether. The data from projects using single prime delivery did not reveal much in terms of cost impact. However, many school districts prefer the organization that comes with single prime over the managerial burden placed on them with multiple prime. It was determined that Pennsylvania should renew the Mandate Waiver Program, at the very least in an attempt to collect some more data for better analysis.

Geothermal Heat Pump System

This section examined the impacts to project cost, constructability, schedule, and system performance by adding a ground loop system to the project. This replaced with heating and cooling equipment of the current design. A borehole and ground loop array of 12 x 10 holes was designed, and the resulting impacts were determined. After a comparison of direct and long term costs, it was decided that the geothermal heat pump system would not be worth the investment up front due to a large payback period.

BIM Application to Project Delivery

This section examined the uses of BIM that could benefit the project. These were chosen from the list of possible uses in the BIM Execution Guide developed by Penn State. After considering the project limitations, multiple prime delivery method, and issues that came up in design development, it was decided that Space Planning, Building Systems Analysis, and Cost Estimating were the best uses based on these factors.

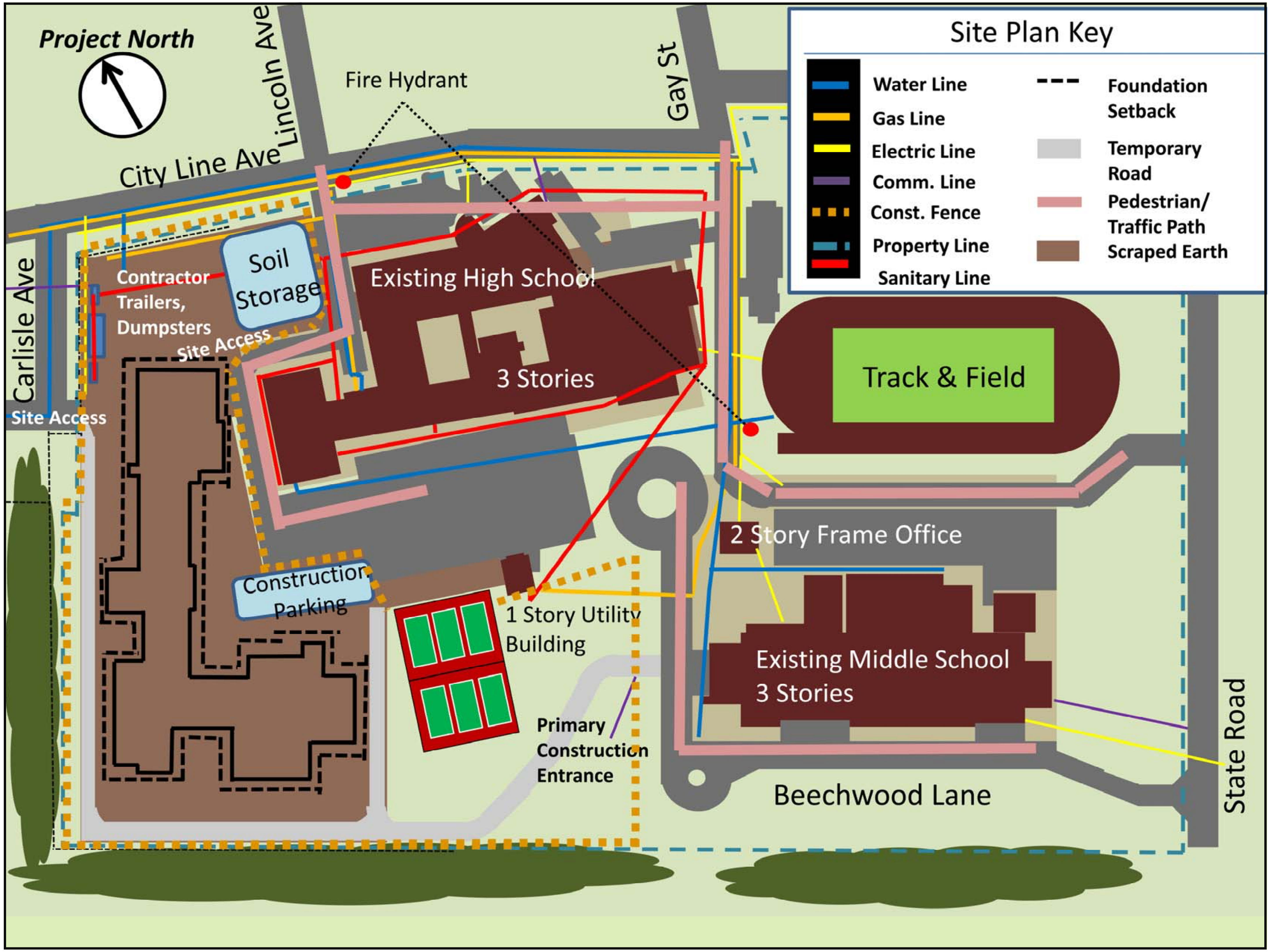
Precast Concrete Façade

After designing the exterior precast façade to replace the existing masonry, the cost, schedule, and constructability impacts were analyzed. Despite trimming time off of project schedule, the cost of the precast system was too high to justify its implementation.

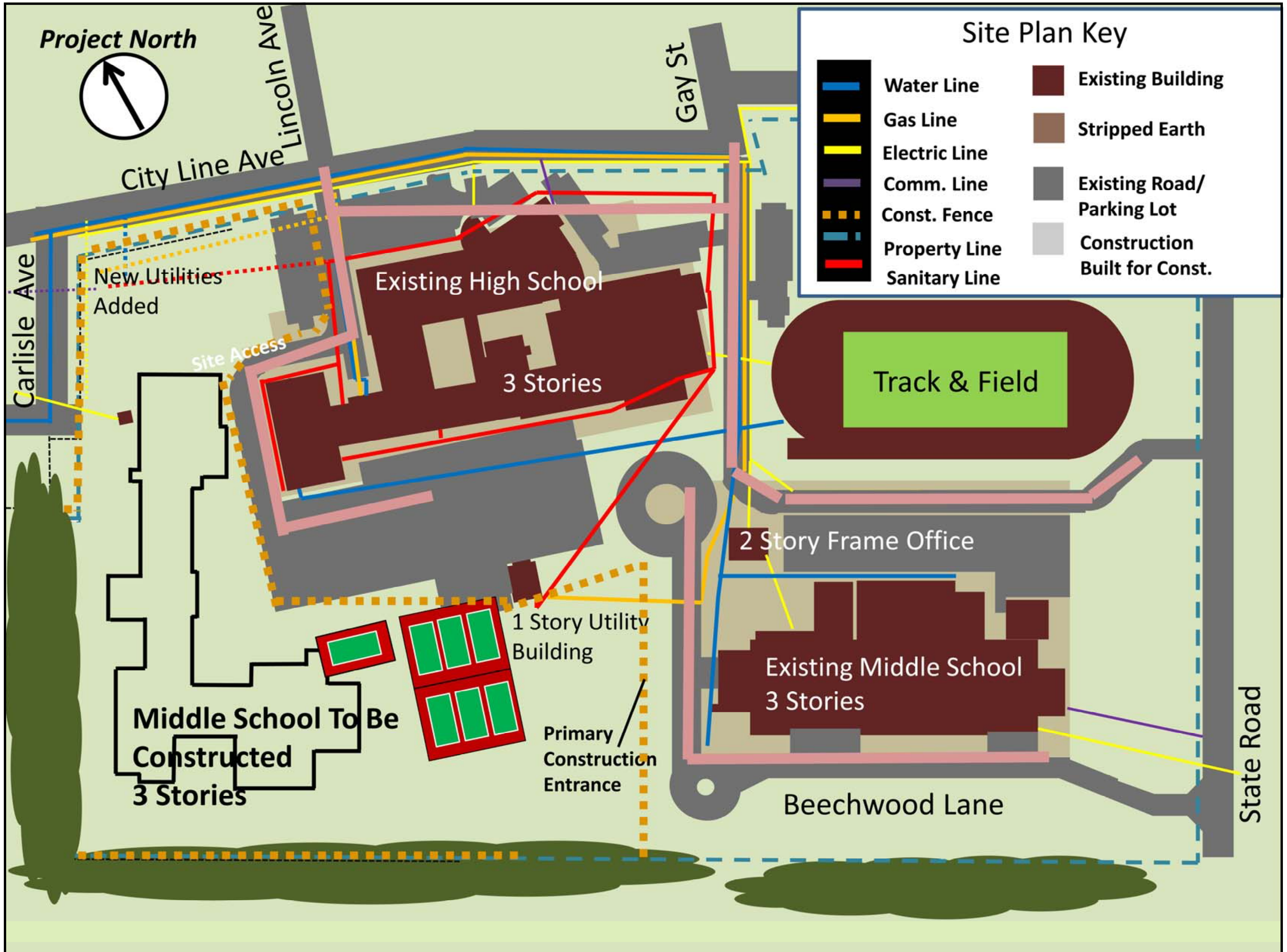
Appendix A: Site Layout Diagrams

The following pages show the site layout for existing conditions, excavation, superstructure, and finishes.

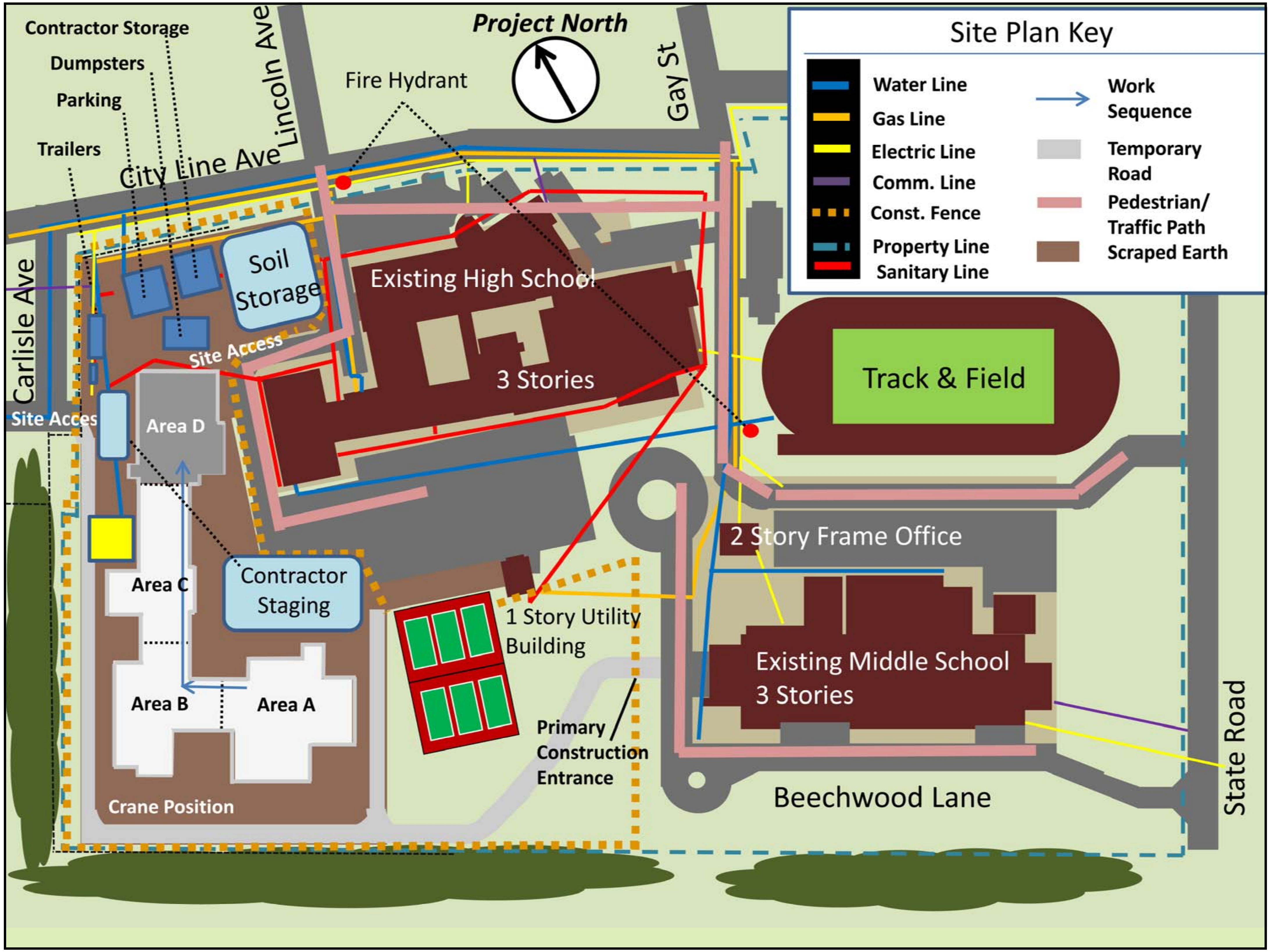
Appendix B: Project Schedule



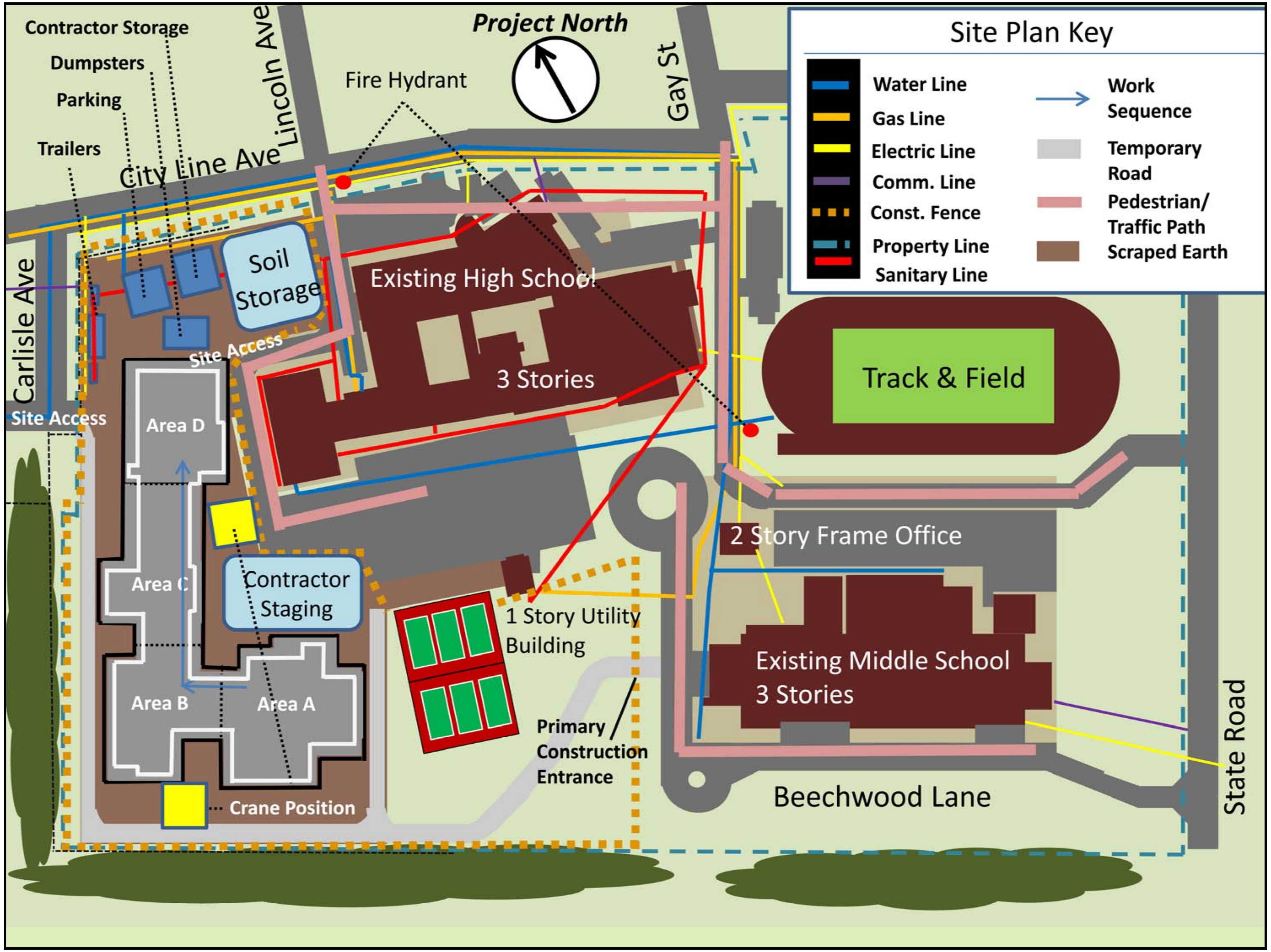
Project: Phoenixville Area Middle School	Location: Phoenixville, PA	Richard Schimpf
Drawing Title: Excavation Plan	Date: 9/23/2011	Scale: NTS



Project: Phoenixville Area Middle School	Location: Phoenixville, PA	Richard Schimpf
Drawing Title: Existing Site Plan	Date: 9/23/2011	Scale: NTS

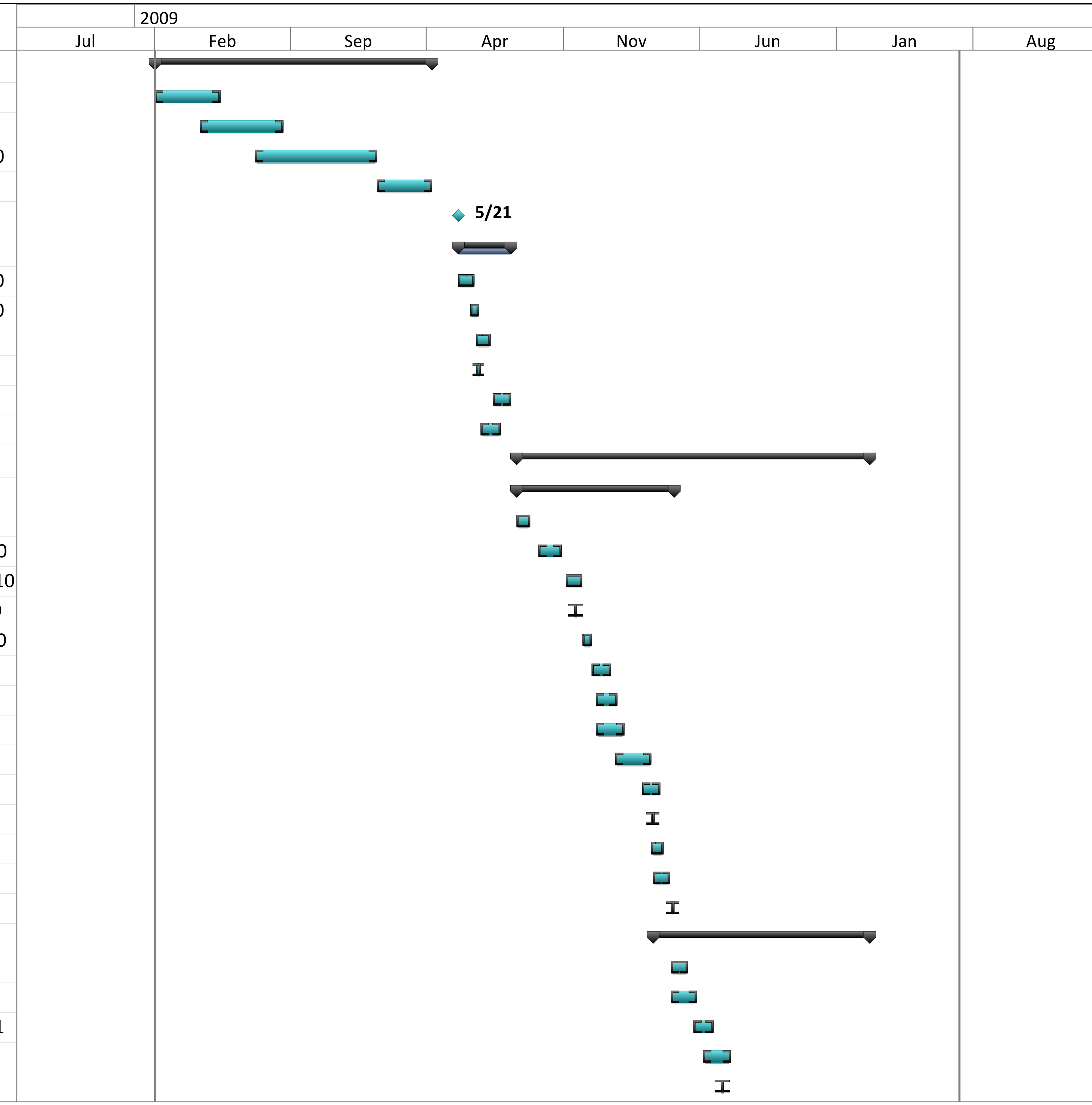


Project: Phoenixville Area Middle School	Location: Phoenixville, PA	Richard Schimpf
Drawing Title: Finishes Plan	Date: 9/23/2011	Scale: NTS



Project: Phoenixville Area Middle School	Location: Phoenixville, PA	Richard Schimpf
Drawing Title: Superstructure Plan	Date: 9/23/2011	Scale: NTS

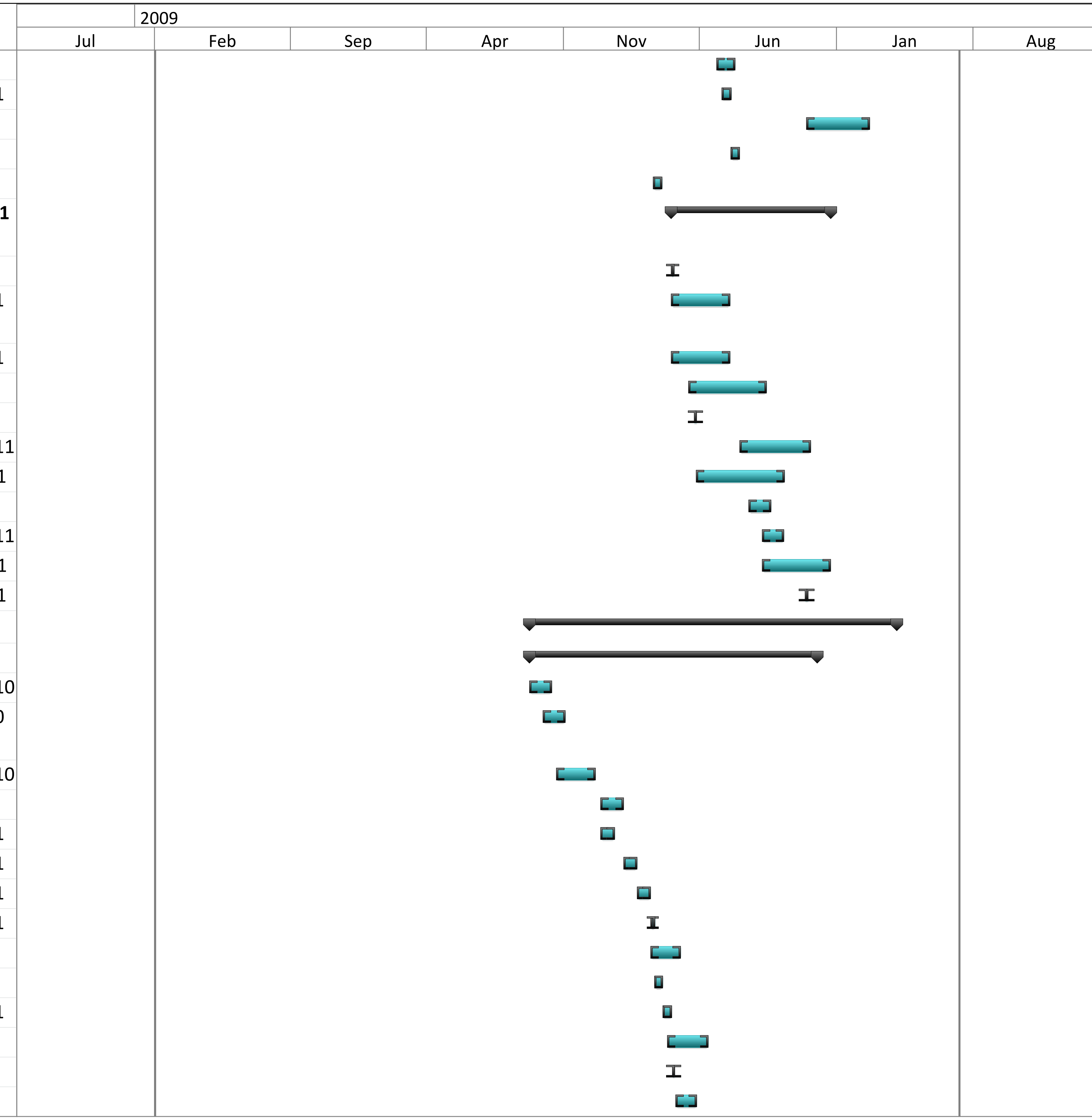
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Preconstruction/ Procurement**	**310 days**	**Mon 2/2/09**	**Fri 4/9/10**
2		Schematic Design	74 days	Mon 2/2/09	Thu 5/14/09
3		Design Development	94 days	Mon 4/13/09	Thu 8/20/09
4		Construction Documents	136 days	Wed 7/8/09	Wed 1/13/10
5		Bidding and Award Contracts	62 days	Thu 1/14/10	Fri 4/9/10
6		**NTP - Construction Start**	0 days	Fri 5/21/10	Fri 5/21/10
7		**General Conditions**	**58 days**	**Fri 5/21/10**	**Tue 8/10/10**
8		E&S Controls, Tree Protection, Fencing:	17 days	Fri 5/21/10	Mon 6/14/10
9		Contractor Staging	9 days	Wed 6/9/10	Mon 6/21/10
10		Site Utilities	16 days	Fri 6/18/10	Fri 7/9/10
11		Strip Topsoil and Stockpile	5 days	Fri 6/18/10	Thu 6/24/10
12		Bulk Excavation and Fill	20 days	Wed 7/14/10	Tue 8/10/10
13		Install Temp. Site/ Student Access Ways	22 days	Fri 6/25/10	Sun 7/25/10
14		***Area A***	**393 days**	**Fri 8/20/10**	**Tue 2/21/12**
15		**Building Shell**	**176 days**	**Fri 8/20/10**	**Fri 4/22/11**
16		Reinforced Concrete Foundation Footings	15 days	Fri 8/20/10	Thu 9/9/10
17		Slab on Grade	26 days	Thu 9/23/10	Thu 10/28/10
18		Erect Steel and Joists	17 days	Fri 11/5/10	Mon 11/29/10
19		Erect Barrel Trusses	2 days	Fri 11/19/10	Sat 11/20/10
20		Steel Bolt-up, Detailing	10 days	Wed 12/1/10	Tue 12/14/10
21		Steel Roof Decking/ Metal Roof	22 days	Wed 12/15/10	Thu 1/13/11
22		MEP Perimeter Rough-in	24 days	Wed 12/22/10	Sun 1/23/11
23		Perimeter Masonry	32 days	Wed 12/22/10	Thu 2/3/11
24		Masonry Veneer and Clean	40 days	Fri 1/21/11	Thu 3/17/11
25		Entrances	20 days	Fri 3/4/11	Thu 3/31/11
26		Barrel Vaulted Canopy Steel	3 days	Fri 3/18/11	Tue 3/22/11
27		Aluminum Window Systems	13 days	Fri 3/18/11	Tue 4/5/11
28		Insulation, Built-up Roofing	20 days	Mon 3/21/11	Fri 4/15/11
29		Set Roof-Top HVAC/ Electric Equipment	5 days	Mon 4/18/11	Fri 4/22/11
30		**Main Gym - Systems and Finishes**	**242 days**	**Mon 3/21/11**	**Tue 2/21/12**
31		Interior Masonry, Metal Frames & Studs	20 days	Mon 4/18/11	Fri 5/13/11
32		MEP Interior Rough-in	30 days	Mon 4/18/11	Fri 5/27/11
33		PA, Fire Alarm Installation	23 days	Mon 5/23/11	Wed 6/22/11
34		Interior Finish & Paint	31 days	Tue 6/7/11	Tue 7/19/11
35		Pour Equipment Pads	2 days	Wed 7/6/11	Thu 7/7/11



Project: PAMS Schedule
Date: Fri 10/21/11

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

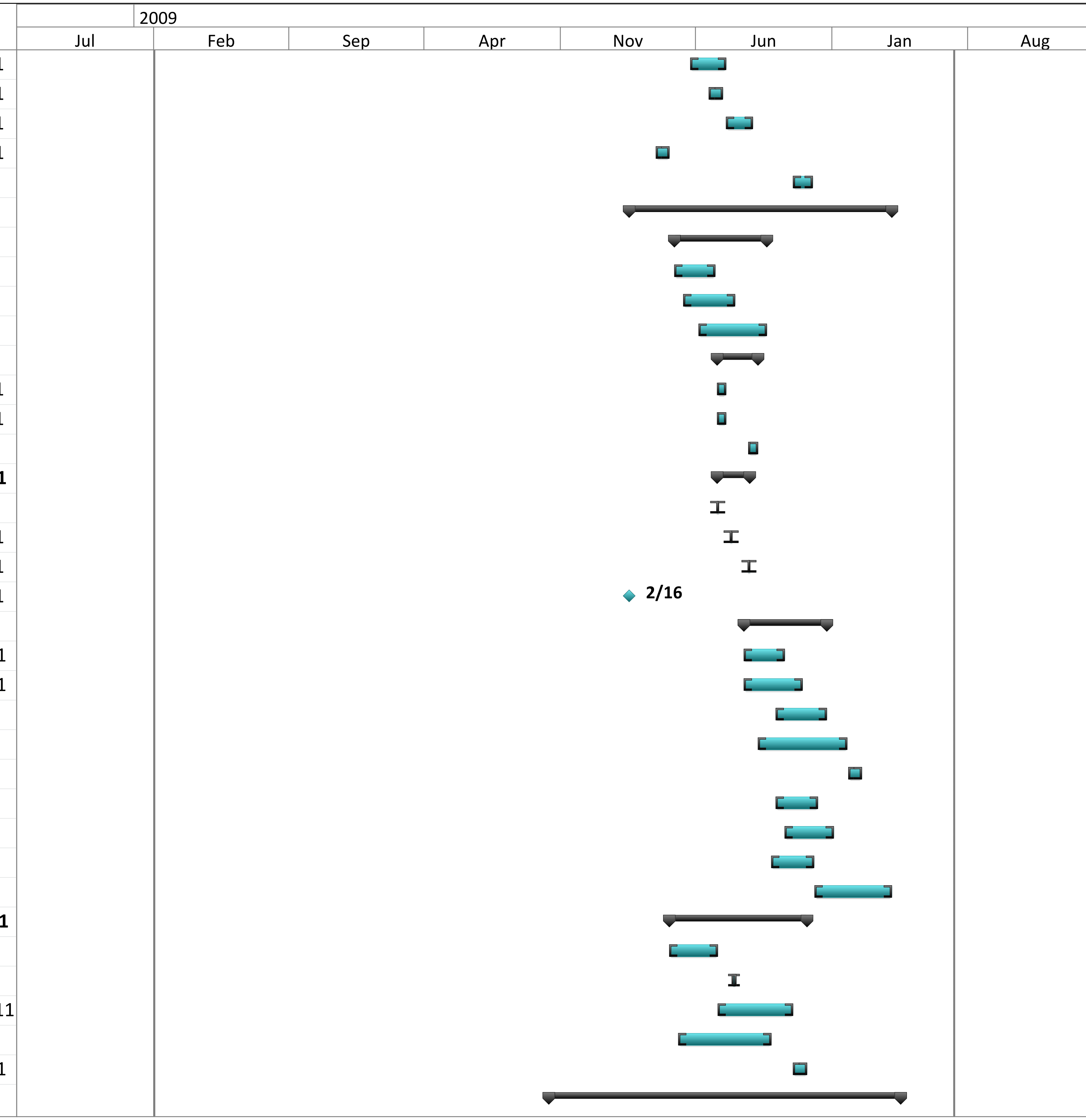
ID	Task Mode	Task Name	Duration	Start	Finish
36		MEP Equipment Installation & Finish	21 days	Tue 6/28/11	Tue 7/26/11
37		Lighting Gymnasium	11 days	Wed 7/6/11	Wed 7/20/11
38		Wood Flooring System	71 days	Tue 11/15/11	Tue 2/21/12
39		Gymnasium Equipment/ Casework	10 days	Wed 7/20/11	Tue 8/2/11
40		Final Cleaning	11 days	Mon 3/21/11	Sun 4/3/11
41		**Aux. Gym, Locker Rooms System and Finishes**	**179 days**	**Mon 4/18/11**	**Thu 12/22/11**
42		Spray-on Fireproofing	5 days	Mon 4/18/11	Fri 4/22/11
43		Interior Masonry, Metal Frames and Studs	66 days	Mon 4/18/11	Mon 7/18/11
44		MEP Interior Rough-in	66 days	Mon 4/18/11	Mon 7/18/11
45		PA, Fire Alarm Installation	88 days	Sun 5/15/11	Tue 9/13/11
46		Pour Equipment Pads	2 days	Wed 5/25/11	Thu 5/26/11
47		Interior Finish &Painting	79 days	Wed 8/3/11	Mon 11/21/11
48		MEP Equipment Installation & Finish	98 days	Fri 5/27/11	Tue 10/11/11
49		Lighting	25 days	Wed 8/17/11	Tue 9/20/11
50		Flooring Systems	24 days	Wed 9/7/11	Mon 10/10/11
51		Equipment/ Casework	77 days	Wed 9/7/11	Thu 12/22/11
52		Final Cleaning	1 day	Tue 11/15/11	Tue 11/15/11
53		***Area B***	**409 days**	**Thu 9/9/10**	**Tue 4/3/12**
54		**Building Shell**	**321 days**	**Thu 9/9/10**	**Thu 12/1/11**
55		Reinforced Concrete Foundation Footings	25 days	Thu 9/9/10	Wed 10/13/10
56		Elevator Shaft/ Stair Tower Excavate/ Masonry	25 days	Thu 9/30/10	Wed 11/3/10
57		Slab on Grade	43 days	Thu 10/21/10	Mon 12/20/10
58		Erect Steel and Joists	26 days	Wed 12/29/10	Wed 2/2/11
59		Erect Metal Pan Stairs	16 days	Wed 12/29/10	Wed 1/19/11
60		Steel Bolt-up, Detailing	15 days	Thu 2/3/11	Wed 2/23/11
61		Steel Decking/ Studs	15 days	Thu 2/24/11	Wed 3/16/11
62		Install Equipment Curbs	5 days	Thu 3/17/11	Wed 3/23/11
63		CMU Backup Masonry	33 days	Thu 3/17/11	Mon 5/2/11
64		2nd Floor Slab on Deck	9 days	Wed 3/23/11	Mon 4/4/11
65		3rd Floor Slab on Deck	10 days	Tue 4/5/11	Mon 4/18/11
66		Metal Stud Back-up (1st, 2nd, 3rd flr.)	46 days	Tue 4/12/11	Tue 6/14/11
67		Set Roof-top Equipment	2 days	Thu 4/21/11	Fri 4/22/11
68		MEP Rooftop Connections	25 days	Mon 4/25/11	Fri 5/27/11



Project: PAMS Schedule
Date: Fri 10/21/11

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

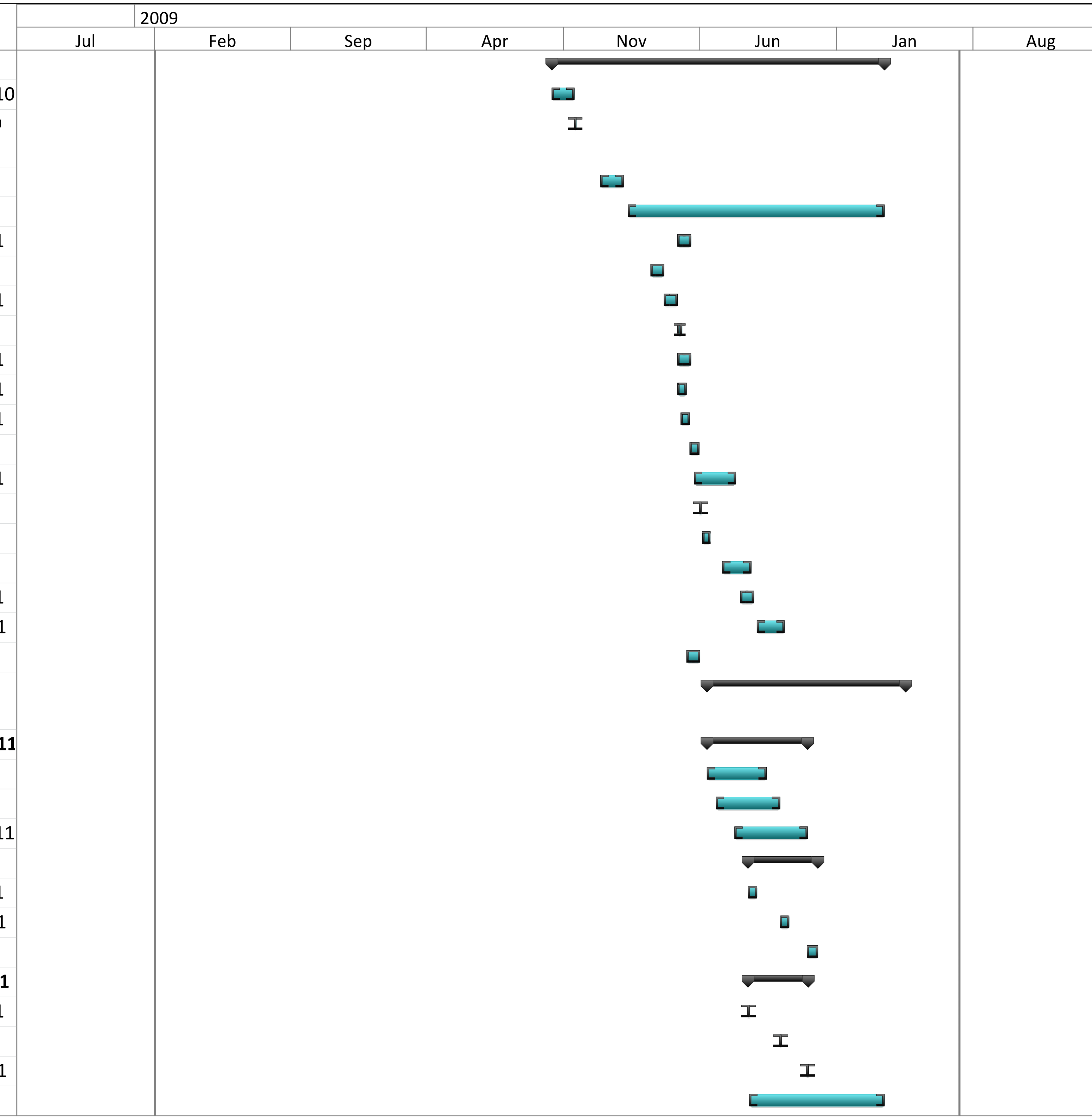
ID	Task Mode	Task Name	Duration	Start	Finish
69		Masonry Veneer and Clean	40 days	Tue 5/24/11	Mon 7/18/11
70		Metal Roofing	16 days	Wed 6/22/11	Wed 7/13/11
71		Aluminum Entrances, Windows	30 days	Tue 7/19/11	Mon 8/29/11
72		Insulation, Built-up Roofing	15 days	Thu 3/31/11	Wed 4/20/11
73		Elevator Installation	23 days	Tue 11/1/11	Thu 12/1/11
74		**Classrooom, Kitchen Systems and Finishes**	**294 days**	**Wed 2/16/11**	**Tue 4/3/12**
75		**MEP Rough-in**	**103 days**	**Fri 4/29/11**	**Tue 9/20/11**
76		Third Floor:	46 days	Fri 4/29/11	Fri 7/1/11
77		Second Floor:	57 days	Fri 5/13/11	Mon 8/1/11
78		First Floor:	77 days	Mon 6/6/11	Tue 9/20/11
79		**Interior Studs**	**46 days**	**Tue 7/5/11**	**Tue 9/6/11**
80		Third Floor:	10 days	Tue 7/5/11	Mon 7/18/11
81		Second Floor:	10 days	Tue 7/5/11	Mon 7/18/11
82		First Floor:	11 days	Tue 8/23/11	Tue 9/6/11
83		**Pour Concrete Equipment Pads**	**37 days**	**Tue 7/5/11**	**Wed 8/24/11**
84		Third Floor:	2 days	Tue 7/5/11	Wed 7/6/11
85		Second Floor:	2 days	Tue 7/26/11	Wed 7/27/11
86		First Floor:	2 days	Tue 8/23/11	Wed 8/24/11
87		MEP Equipment Installation & Finish	0 days	Wed 2/16/11	Wed 2/16/11
88		**Interior Finish and Paint**	**94 days**	**Tue 8/16/11**	**Fri 12/23/11**
89		Third Floor:	46 days	Tue 8/16/11	Tue 10/18/11
90		Second Floor:	66 days	Tue 8/16/11	Tue 11/15/11
91		First Floor:	58 days	Wed 10/5/11	Fri 12/23/11
92		Casework	100 days	Wed 9/7/11	Tue 1/24/12
93		Set Kitchen Equipment	15 days	Fri 1/27/12	Thu 2/16/12
94		PA, Fire Alarm Installation	48 days	Wed 10/5/11	Fri 12/9/11
95		Classroom Flooring	55 days	Wed 10/19/11	Tue 1/3/12
96		Lighting Fixtures	49 days	Wed 9/28/11	Sat 12/3/11
97		Final Cleaning	87 days	Mon 12/5/11	Tue 4/3/12
98		**Mechanical Room 1st/ 2nd Floor**	**154 days**	**Thu 4/21/11**	**Tue 11/22/11**
99		MEP Rough-in	54 days	Thu 4/21/11	Tue 7/5/11
100		PA, Alarm Installation	5 days	Thu 7/28/11	Wed 8/3/11
101		Install MEP Equipment	84 days	Wed 7/6/11	Mon 10/31/11
102		Hardware and Finishes	104 days	Thu 5/5/11	Tue 9/27/11
103		Final Cleaning	16 days	Tue 11/1/11	Tue 11/22/11
104		***Area C***	**394 days**	**Thu 10/14/10**	**Tue 4/17/12**



Project: PAMS Schedule
Date: Fri 10/21/11

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

ID	Task Mode	Task Name	Duration	Start	Finish
105		**Building Shell**	**371 days**	**Thu 10/14/10**	**Thu 3/15/12**
106		Reinforced Concrete Foundation Footings	25 days	Thu 10/14/10	Wed 11/17/10
107		Elevator Shaft/ Stair Tower Excavate/ Masonry	3 days	Thu 11/18/10	Sat 11/20/10
108		Slab on Grade	26 days	Wed 12/29/10	Wed 2/2/11
109		Erect Steel and Joists	286 days	Thu 2/10/11	Thu 3/15/12
110		Erect Metal Pan Stairs	15 days	Thu 4/28/11	Wed 5/18/11
111		Steel Bolt-up, Detailing	15 days	Thu 3/17/11	Wed 4/6/11
112		Steel Decking/ Studs	15 days	Thu 4/7/11	Wed 4/27/11
113		Install Equipment Curbs	5 days	Thu 4/28/11	Wed 5/4/11
114		CMU Backup Masonry	15 days	Thu 4/28/11	Wed 5/18/11
115		2nd Floor Slab on Deck	10 days	Thu 4/28/11	Wed 5/11/11
116		3rd Floor Slab on Deck	10 days	Tue 5/3/11	Mon 5/16/11
117		Metal Stud Back-up (1st, 2nd, 3rd flr.)	11 days	Tue 5/17/11	Tue 5/31/11
118		Set Roof-top Equipment	47 days	Tue 5/24/11	Wed 7/27/11
119		MEP Rooftop Connections	2 days	Thu 6/2/11	Fri 6/3/11
120		Masonry Veneer and Clean	10 days	Mon 6/6/11	Fri 6/17/11
121		Metal Roofing	33 days	Thu 7/7/11	Sat 8/20/11
122		Aluminum Entrances, Windows	15 days	Thu 8/4/11	Wed 8/24/11
123		Insulation, Built-up Roofing	31 days	Tue 8/30/11	Tue 10/11/11
124		Elevator Installation	15 days	Thu 5/12/11	Wed 6/1/11
125		**Classroom, Media Center Systems and Finishes**	**222 days**	**Mon 6/13/11**	**Tue 4/17/12**
126		**MEP Rough-in**	**113 days**	**Mon 6/13/11**	**Wed 11/16/11**
127		Third Floor:	67 days	Mon 6/13/11	Tue 9/13/11
128		Second Floor:	72 days	Mon 6/27/11	Tue 10/4/11
129		First Floor:	82 days	Tue 7/26/11	Wed 11/16/11
130		**Interior Studs**	**79 days**	**Tue 8/16/11**	**Fri 12/2/11**
131		Third Floor:	10 days	Tue 8/16/11	Mon 8/29/11
132		Second Floor:	10 days	Wed 10/5/11	Tue 10/18/11
133		First Floor:	13 days	Wed 11/16/11	Fri 12/2/11
134		**Pour Concrete Equipment Pads**	**68 days**	**Tue 8/16/11**	**Thu 11/17/11**
135		Third Floor:	2 days	Tue 8/16/11	Wed 8/17/11
136		Second Floor:	2 days	Wed 10/5/11	Thu 10/6/11
137		First Floor:	2 days	Wed 11/16/11	Thu 11/17/11
138		MEP Equipment Installation & Finish	151 days	Thu 8/18/11	Thu 3/15/12



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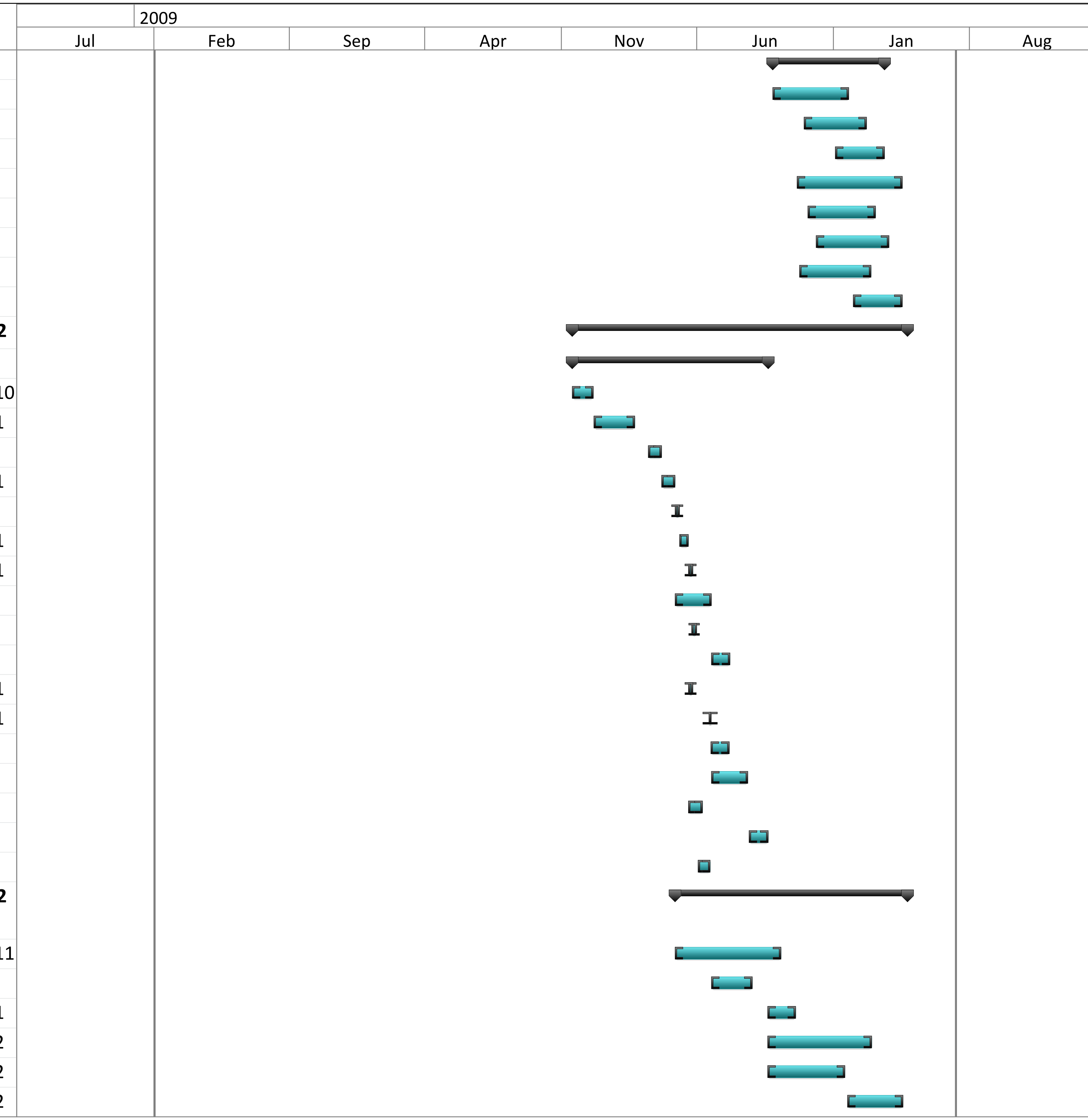
Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress

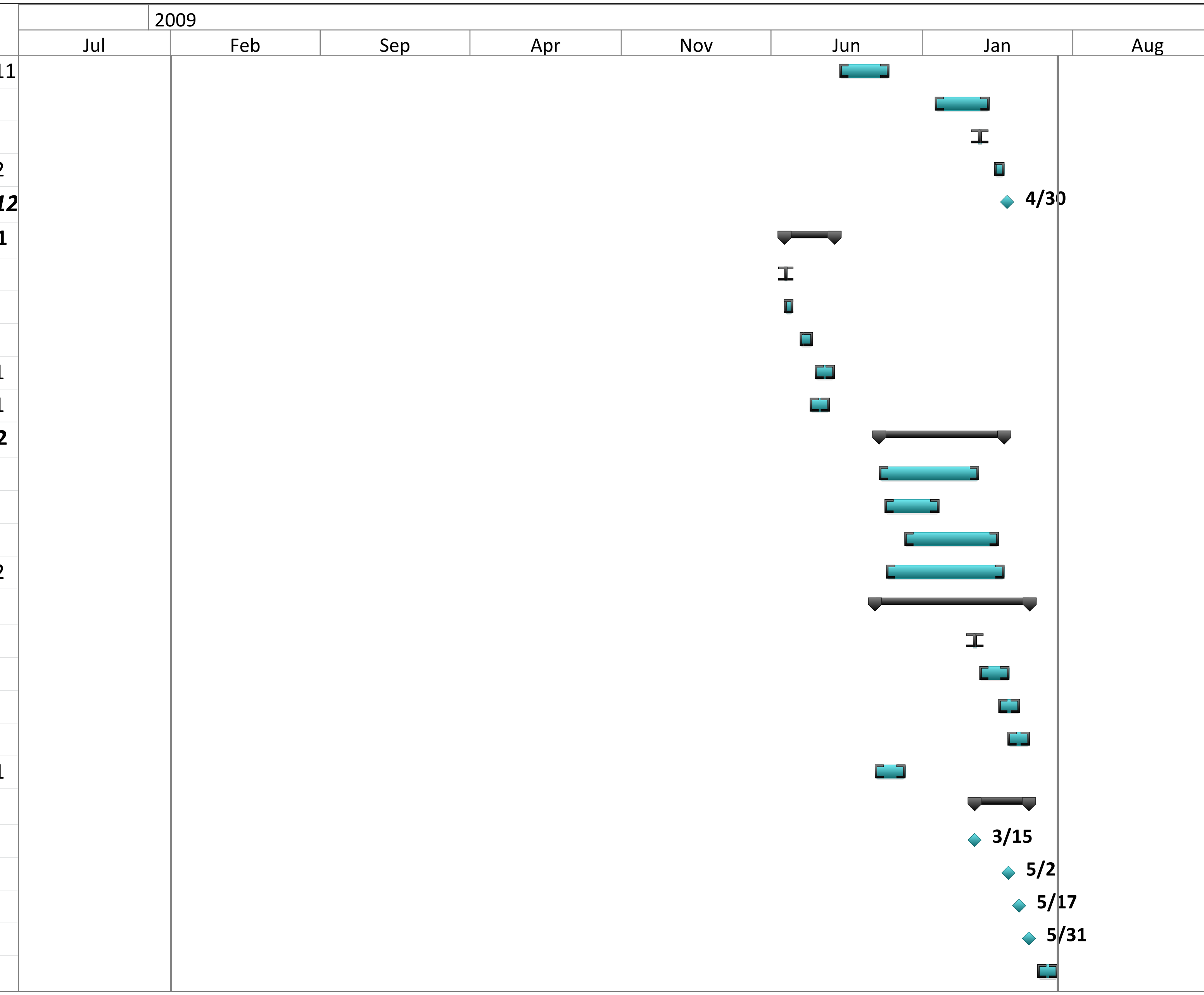
ID		Task Mode	Task Name	Duration	Start	Finish
139			**Interior Finish and Paint**	**125 days**	**Wed 9/28/11**	**Tue 3/20/12**
140			Third Floor:	85 days	Wed 9/28/11	Tue 1/24/12
141			Second Floor:	70 days	Wed 11/16/11	Tue 2/21/12
142			First Floor:	55 days	Wed 1/4/12	Tue 3/20/12
143			Casework	118 days	Sat 11/5/11	Tue 4/17/12
144			PA, Fire Alarm Installation	76 days	Tue 11/22/11	Tue 3/6/12
145			Classroom Flooring	82 days	Mon 12/5/11	Tue 3/27/12
146			Lighting Fixtures	80 days	Wed 11/9/11	Tue 2/28/12
147			Final Cleaning	55 days	Wed 2/1/12	Tue 4/17/12
148			***Area D***	**375 days**	**Thu 11/18/10**	**Wed 4/25/12**
149			**Building Shell**	**219 days**	**Thu 11/18/10**	**Tue 9/20/11**
150			Reinforced Concrete Foundation Footings	23 days	Thu 11/18/10	Mon 12/20/10
151			Slab on Grade	46 days	Wed 12/22/10	Wed 2/23/11
152			Erect Steel and Joists	15 days	Thu 3/17/11	Wed 4/6/11
153			Steel Bolt-up, Detailing	15 days	Thu 4/7/11	Wed 4/27/11
154			Auditorium Risers	5 days	Thu 4/28/11	Wed 5/4/11
155			Steel Decking/ Studs	10 days	Thu 5/5/11	Wed 5/18/11
156			Install Equipment Curbs	5 days	Thu 5/19/11	Wed 5/25/11
157			Perimeter Masonry	41 days	Thu 4/28/11	Thu 6/23/11
158			2nd Floor Slab on Deck	6 days	Tue 5/24/11	Tue 5/31/11
159			Metal Pan Stairs	21 days	Fri 6/24/11	Fri 7/22/11
160			Metal Studs/ Wooden Framing	5 days	Thu 5/19/11	Wed 5/25/11
161			Set Roof-top Equipment	2 days	Tue 6/21/11	Wed 6/22/11
162			MEP Rooftop Connections	21 days	Thu 6/23/11	Thu 7/21/11
163			Masonry Veneer and Clean	41 days	Fri 6/24/11	Fri 8/19/11
164			Metal Roofing	16 days	Thu 5/19/11	Thu 6/9/11
165			Aluminum Entrances, Windows	22 days	Mon 8/22/11	Tue 9/20/11
166			Insulation, Built-up Roofing	13 days	Fri 6/3/11	Tue 6/21/11
167			**Auditorium, Music Classroom Systems and Finishes**	**260 days**	**Thu 4/28/11**	**Wed 4/25/12**
168			MEP Rough-in	118 days	Thu 4/28/11	Mon 10/10/11
169			Interior Studs, Masonry	46 days	Fri 6/24/11	Fri 8/26/11
170			Auditorium Sound System	32 days	Tue 9/20/11	Wed 11/2/11
171			MEP Equipment Installation & Finish	117 days	Tue 9/20/11	Wed 2/29/12
172			Interior Finish and Paint	87 days	Tue 9/20/11	Wed 1/18/12
173			Casework	63 days	Mon 1/23/12	Wed 4/18/12



Project: PAMS Schedule
Date: Fri 10/21/11

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

ID		Task Mode	Task Name	Duration	Start	Finish
174			PA, Fire Alarm Installation	50 days	Tue 9/6/11	Mon 11/14/11
175			Flooring	55 days	Thu 1/19/12	Wed 4/4/12
176			Lighting Fixtures	1 day	Thu 3/22/12	Thu 3/22/12
177			Final Cleaning	10 days	Thu 4/12/12	Wed 4/25/12
178			***Substantial Completion***	***0 days***	***Mon 4/30/12***	***Mon 4/30/12***
179			**Final Site Work**	**51 days**	**Mon 6/20/11**	**Mon 8/29/11**
180			Rough Grade Site	4 days	Mon 6/20/11	Thu 6/23/11
181			Construct New Drop Off Loop	10 days	Mon 6/20/11	Fri 7/1/11
182			Parking Lots, Driveways	14 days	Tue 7/12/11	Fri 7/29/11
183			Sidewalks	20 days	Tue 8/2/11	Mon 8/29/11
184			Spread Topsoil, Landscape & Seed	20 days	Tue 7/26/11	Mon 8/22/11
185			**Start Up, Testing and Balancing of Systems:**	**127 days**	**Tue 11/1/11**	**Wed 4/25/12**
186			Area A	101 days	Tue 11/1/11	Tue 3/20/12
187			Area B	55 days	Wed 11/9/11	Tue 1/24/12
188			Area C	95 days	Wed 12/7/11	Tue 4/17/12
189			Area D	119 days	Fri 11/11/11	Wed 4/25/12
190			**Prepare, Distribute, Work Punch List**	**157 days**	**Wed 10/26/11**	**Thu 5/31/12**
191			Area A	1 day	Thu 3/15/12	Thu 3/15/12
192			Area B	30 days	Thu 3/22/12	Wed 5/2/12
193			Area C	22 days	Wed 4/18/12	Thu 5/17/12
194			Area D	23 days	Tue 5/1/12	Thu 5/31/12
195			Exterior Punchlist	31 days	Wed 10/26/11	Wed 12/7/11
196			**Complete Construction**	**55 days**	**Thu 3/15/12**	**Thu 5/31/12**
197			Area A Complete	0 days	Thu 3/15/12	Thu 3/15/12
198			Area B Complete	0 days	Wed 5/2/12	Wed 5/2/12
199			Area C Complete	0 days	Thu 5/17/12	Thu 5/17/12
200			Area D Complete	0 days	Thu 5/31/12	Thu 5/31/12
201			**Occupy Middle School**	21 days	Tue 6/12/12	Tue 7/10/12



Project: PAMS Schedule
Date: Fri 10/21/11

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