Final Report

Twin Rivers Elementary & Intermediate School

McKeesport, PA

This report summarized the construction analyses and related breadth that were studied during Fall 2013 and Spring 2014 semester on the Twin Rivers Elementary & Intermediate School, aka McKeesport School Project.

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AE 481W- Spring 2014
Senior Thesis Project Report
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CPEP Website: http://www.engr.psu.edu/ae/thesis/portfolios/2014/qyl5028/index.html

TWIN RIVERS ELEMENTARY INTERMEDIATE SCHOOL

Cherry Q. Lu Construction Option Advisor: Ray Sowers AE Thesis Project

Project Team

Owner: McKeesport Area School District
Architect: JC Pierce LLC.
Construction Manager: PJ Dick, Inc.
General Contractor: Gurtner Construction
Civil Engineers: Phillips & Associates, Inc.
Structural & MEP Engineers: Loftus Engineers
Environmental Engineers: American Geosciences, Inc.

Architecture

Location: 1600 Cornell St, McKeesport, PA
Occupancy: Educational
Total Levels: 3 stories
Size: 127,000 square feet

Construction

Dates of Construction: February 2013-January 2014
Building Cost: $28 million
Project Delivery Method: Design-Bid-Build

Mechanical

Ventilation: Dedicated Outdoor Air System
Heating: Geothermal system, hot water boiler
Cooling: Geothermal system, cooling tower

Structural

Foundation: 4" Spread footing shallow foundation
Superstructure: Structural Steel with concrete slab
Roofing System: Comprised structural steel system with metal deck

LEED Implementation

- Geothermal System
- Grey Water Capture System
- Solar Shading
- Day Lighting
- Wind Turbines

Lighting/Electrical

Supply: 480/277 V from supply with 208/120 step-down transformer
Lighting: Fluorescent with LED, HID, incandescent
Controls: Astronomical timer control for exterior; occupancy sensors for interior

Executive Summary

The AE Senior Thesis Proposal is the commutation of multiple technical analyses developed through Fall 2013 to Spring 2014 with the knowledge gained in the Architectural Engineering curriculum as well as through industry member experience. This report focuses on the construction of the Twin Rivers Elementary/Intermediate School in McKeesport, PA. Four analyses were executed in an effort to provide possible improvement to project schedule, cost and long term operation and maintenance plan. The construction of public educational facilities and the implementation of innovation construction theory and criteria are also analyzed in this report.

Analysis 1: LEED Implementation

One of the owner's goals for Twin River's School project is to build a district scientific educational facility as well as housing two schools. This project is aiming for a LEED Gold Certificate by completion. There are a lot of LEED features incorporated in the design. However, in current design some LEED features are only incorporated for showcase purpose. The possibility of using the renewable energy produced on-site was studied. Life cycle cost analysis was conducted to compare the cost and benefits of both systems.

Analysis 2: Value Engineering

The owner, the project team and the designer have worked together on this project to implement value engineering. In this analysis, the possibility of cost reduction from sizing up the electrical distribution system was studied as the electrical breadth. The impact from the proposing use of roof-top wind turbine units to the structural system was analyzed as the structural breadth.

Analysis 3: Schedule Acceleration

The construction of Twin River's School is scheduled to be completed within 21 months. Due to this project is the construction of a public school, the substantial completion date was extremely important to the owner. Three possible scenarios were studied for schedule acceleration purpose, including implementation of SIPS method and LEAN construction. The results showed that there will the significant cost and schedule saving with the implementation of a precautionary and reaction plan for unexpected impacts.

Analysis 4: BIM Implementation

There were several key activities and change of design that caused increased costs and schedule delays. These problems could have been overcome with the utilization of BIM to facilitate cooperation between different trades. BIM could be used as an alternative construction method through phase planning, information management; as well as for operation and maintenance planning after turn over. The implementation of BIM would also help to realize owner's goal to make this project a role model of high performance educational facility. A BIM execution plan was lay out and significant improvements for project schedule and cost are seen.

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Gurtner Construction LLC

Special Thanks:

David Nitchkey

Ryan Mangan

The Twin Rivers Elementary/Intermediate School Project Team

PACE Industry Members

My Family and Friends

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Project Introduction

The construction project of McKeesport Elementary/Intermediate School is a public school construction project on the site of demolished Cornell Elementary School at McKeesport, PA. The original Cornell School was established in 1916. The project is located along the west side of the 1600 block of Cornell Street, in McKeesport. Due to advancements in building technologies, growing need of educational facilities, McKeesport School District decided to demolish the old Cornell Elementary School and construction a new campus for the use of both an elementary and an intermediate school. The construction of this project is part of the plan to consolidate the district's five elementary facilities into three. The school district believes the Twin Rivers Elementary/Intermediate School is of an innovative design that will thrust the old steel town of McKeesport into the future. The new school will accommodate approximately 750 students and serve as the Mathematics and Science Academy for the McKeesport Area School District. The project has two stories above ground with a clearstory level add up to a total of 127,000 square feet.

Client Information

The McKeesport Area School District is the owner of the project. The construction of a combined education facility that houses an elementary school, an intermediate school and a science education center was settled after a lot of hearings of the School District Board. In 2009, the local school district decided to consolidate its five elementary facilities into three. The architect engineering firm, JC Pirece was hired to help with the development of such plan. In 2010, the plan of renovating two existing schools and the construction of the Twin Rivers Elementary/Intermediate School was made. The demolishing of the previous Cornell Elementary School was separately bided and executed prior to the construction of the Twin Rivers Elementary/Intermediate School.

Existing Conditions

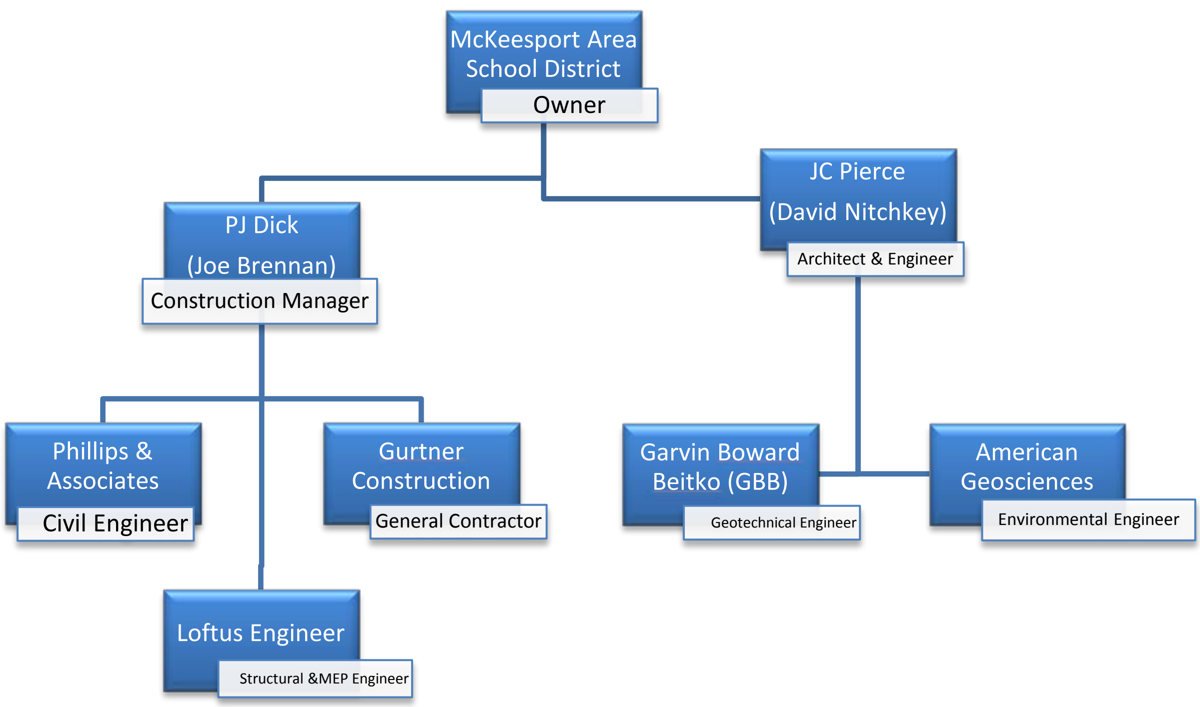
The project site takes up an entire block. There are no neighboring buildings which would affect the day lighting of this building. The fire hydrants are located to the north-east corner and the southwest corner of the block. Vehicular access to the site will occur from Cornell Street, and will include a paved access road encircling the entire building. Student bus drop-off will occur along the east/front side, while vehicular student drop-off will take place along the north and south side of the building. The site logistics plan is attached as Appendix D .

Project Delivery Method

The project delivery method of the Twin Rivers Elementary/Intermediate School construction project is Design-bid-build. This is the traditional and common approach for a public construction project. Under this kind of project delivery method, the best interests of the owners would be ensured. A reasonable price will be established and the quality and efficiency of the project delivery would be improved for owner given the competition brought by the contractual relationship of the bidder and the subcontractors.

Please see Appendix A for Project Organization Chart.

Staffing Plan



Building Systems

Structural System

Foundations

Foundation system will be shallow spread footings down to the frost line. Ground level slabs will be 4” deep concrete slabs-on-grade.

Floor Framing

At the 2nd Floor the framing system will be structural steel columns and beams in-filled with open-web steel joists spaced 2’-0” on center and a 3” concrete slab with ½” form deck.

Roof Framing

At the flat roof areas the roof framing will be comprised of structural steel columns and beams in-filled with open-web steel joists spaced 4’-0” to 5’-0” on center and a 1-1/2” deep, wide-ribbed, galvanized metal roof deck. Mechanical roof top units will be located on the flat roof areas and supported directly on the open-web roof joists. At the classroom wings rigid bents will be used to frame the sloped roofs over the classrooms. At the classroom wing corridors light gage metal or metal-plated wood trusses spaced 2’-0” on center will be used to frame the high corridor roofs.

Exterior Walls

The exterior closure walls of the classroom wings will be framed with 8” deep light gage metal, 18 gage, light gage metal studs and 16” on center. The perimeter closure walls of the gymnasium will be 12” block with reinforcing bars spaced either 16” on center or 32” on center.

Mechanical System

General

The overall design will be based on achieving a 30% energy savings compared to a baseline HVAC design per ASHRAE 90.1-2007. ASHRAE’s Advanced Energy Design Guide for K-12 School Buildings will be used as a guideline for design. This will assist in earning points toward the desired LEED Silver rating.

Geothermal System

The HVAC system will utilize a vertical, closed loop, earth coupled water loop connected to water-to-air heat pumps providing heating and cooling for building spaces. Individual heat pumps will be provided for perimeter and interior classroom zones. Units will be concealed either in the return air plenum above the ceiling or closets for sound attenuation. Each unit will be provided with an individual room sensor. The ground source heat pumps will be two-stage horizontal extended range units equipped with variable speed fans. A solenoid valve at each heat pump shall stop tempered water flow when the compressor is off. Heat pumps shall utilize HFC 410A refrigerant (Non CFC type.)

The geothermal field design will be a central loop, vertical well type. Supply and return piping will extend from the well field to a pump room closet inside the school. Variable speed, in-line pumps shall circulate tempered water through a closed loop piping system to the individual heat pumps. One pump will operate in normal mode with the other in standby. Pump speed shall be controlled by differential pressure across the supply and return mains.

Geothermal conductivity testing is to be performed to determine whether the site is suitable for a closed-loop ground source heat pump system. In the event that the site is not suitable, the system design will be based on a “hybrid” design comprised of a hot water boiler and air-cooled cooling tower which would change the ground source heat pump loop into a water source heat pump system.

If the geothermal system is advisable for the site, the installation of a hot water boiler will be considered since it could reduce the number of geothermal wells required and overall closed-loop length. Additionally, since the system will be predominantly that of heating (since the school will not be in use over the summer during the peak cooling season), a thermal imbalance could occur with more heat being “pulled” from the ground for building heating and less heat being rejected to the ground during building cooling mode. Over time, this could lower the overall ground temperature, thus reducing the amount of heat available for the heat pumps to draw from in the heating season. As such, an auxiliary hot water boiler will be installed. The boiler may utilize either natural gas or electricity as a fuel source. This has not been determined at this time.

Electrical System

Power Source & Metering

Voltage: 208/120V, 3-Phase, 4 Wire

Capacity: As required (approximately 10 watts per square foot)

Primary Power Distribution

The primary distribution system will be 208/120V, 3-Phase, 4 wire. A 480 volt distribution system will be reviewed for cost effectiveness. The 480/277V system will likely not be a cost saving approach for the size of building under consideration.

Secondary Power Distribution

The secondary distribution system will be 208/120V, 3-Phase, 4 wire.

Emergency/Standby Power

A Diesel Generator set is recommended since this ensures that a source of power is always available independent of utility sources.

Power for Mechanical/Plumbing Loads

Power for loads over 2 HP will be 208V, 3-Phase. Loads between ½ HP and 2 HP will be 208V, 1-Phase, loads less than ½ HP will be 120V. Mechanical will provide starters/VFD's/control panels for mechanical equipment. Electrical will add local disconnect switches or motor protector switches where not provided by mechanical.

Site Study

This project is located at the site of a previous elementary school. The old school was demolished before the start of this project. The site of this project takes up the entire block. The site logistics plan for this project is relatively straight-forward since the site has a fair amount of space and the structure is only 2 floors above ground with partial clearstory level. Three site layout plans were attached here in Appendix VI: Site Traffic Plan; Steel Erection Plan; and Finish Phase Site Plan.

Major site utilities including temporary power, chiller, sewer-lines are marked on the plans. The site traffic plan emphasis on the traffic route and direction, noted by red arrows; the location of material staging and delivery are marked. The pedestrian traffic ways are also marked. The steel erection noted the zoning of steel erection. Different locations of mobile cranes are also marked. The locations of the geothermal wells are also noted on this plan to prevent overloading the well fields. The travel route of delivery trucks is also marked. The finish phase site plan is to note the site condition when the project is moving into the close-out phase. The landscaping area is marked along with the parking space.

There is no major trade conflict due to logistics reasons on this project. The only major concern regarding the project site is the sedimentation and erosion control due to continuous rainy weather. The material of the access road to the site was changed from sand and loose gravel to granular rock.

LEED Summary

One of the owner's goals for Twin River's School project is to build a district scientific educational facility as well as a campus two schools. This project is aiming for a LEED Gold Certificate by completion. There are a lot of LEED features incorporated in the design. As a team, JC Pierce and National Geosciences worked to get the project up to LEED standards.

Part of the exterior walls is curtain wall to improve day lighting. Louvers and metal mesh covers will be installed to control solar gain. Grey water capture system will be installed to collect and recycle rainwater for use in toilets. Geothermal heating and cooling system will be utilized in addition to the hot water boilers to support the heating system. A glass-framed mechanical room will be used to demonstrate portion of the geothermal system and be used as an educational facility.

Two small-scale pole mounted wind turbines will be installed to the northeast corner of the building for educational usage. However the wind turbines will only be used as showcase purpose. Since the pole-mounted wind turbines are already incorporated in the design, there is a possibility of produce energy out of it without too much additional cost. The cost and benefit of this change will be studied in Analysis I. This report will also study the potential of incorporating the roof-top wind turbines in the design. After careful investigation, the project could have achieved LEED Platinum Certification based on the LEED 2009 BC+D Program. An analysis of current LEED scoring can be seen in Figure 1.

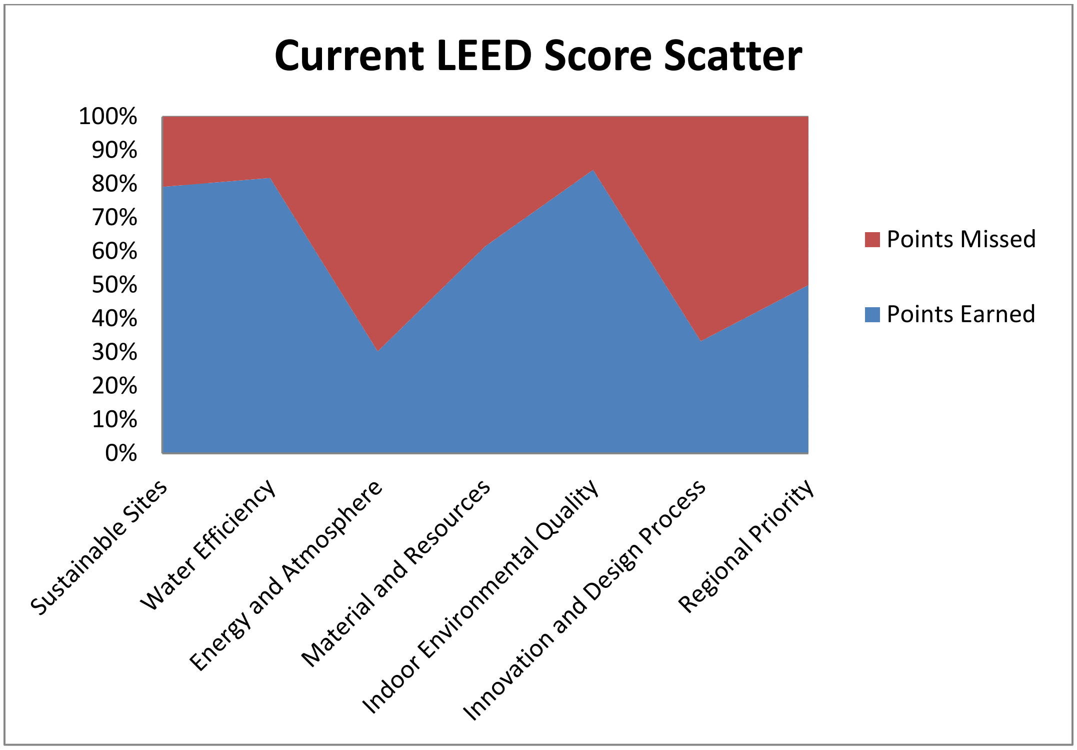


Figure 1

Current Design	Points Earned	Points Missed
Sustainable Sites	19	5
Water Efficiency	9	2
Energy and Atmosphere	10	23
Material and Resources	8	5
Indoor Environmental Quality	16	3
Innovation and Design Process	2	4
Regional Priority	2	2
Total Points	66	

Table 1

Schedule Overview

The project summary schedule included reflects critical milestones and durations of the activities for the project. The project is executed in the sequence of Area A, Area B, Area D, Area C. The schedule of Area A for both floors is the most detailed. The divisions of areas are relatively equal resulting very close duration of similar items for four areas. Thus, for the interior fit out section of the schedule of Area C and D are relatively brief. The detailed project schedule is attached in Appendix I.

Table 2

Schedule Breakdown			
Phase	**Start Date**	**End Date**	**Duration**
Project Planning Phase	3/24/2009	12/9/2009	260
Schematic Design Phase	12/9/2009	6/1/2010	139
Design Development Phase	3/1/2010	9/6/2010	144
Construction Documents Phase	4/23/2010	5/5/2011	270
Bidding Phase	5/25/2010	8/225/11	328
Construction Administration Phase	7/8/2010	3/24/2014	968
Construction Phase	5/3/2012	12/13/2013	648
Substantial Completion	12/13/2013	12/13/2013	1
Project Close-out	13/13/2013	3/24/2014	110

Sequencing

The work flow of this project is the same as the erection sequence of the project, as talked about, Area A, Area B, Area D, and Area C. The original plan was from Area A, Area B, Area C, and Area D. But due to some reasons the plan was changed after structural of Area A was done. Detailed reasons of the change will be discussed in constructability issues section.

This project has only two floors above ground. As shown in the schedule, the sequencing of the work general is start the first floor of one area, 2/3 way in the first floor of the next area will start. While the second floor of the prior area will be done sequentially following the first floor.

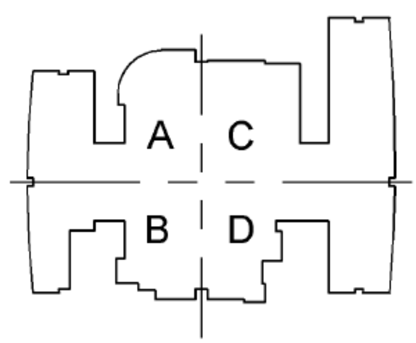


Figure 2

Features

Longer interior fit-out time

The schedule of this project has a significant feature of longer interior fit-out time compared to other similar projects. The reason behind this is a lot of the material and equipment used are very specifically LEED oriented. Another reason is that some equipment used needs more time for installation and testing than regular building fit-out since they are more technologically intense. There is more lead time involved with some of the materials. Such material and equipment include classroom projectors, gymnasium equipment and music room acoustic systems. This also resulted in the wide spread work for the fit-in of different trades.

Longer planning phase

The planning phase of this project is much longer compared to other similar projects. There were a lot of hearings meetings involved. Because of the fact that this project is part of the consolidation of five public schools into three, the discussion and decision making process was much longer on this project. The building permitting phase also took a long time. The demolition of the previous school, Cornell Elementary School, at the current site was treated as another project. So it did not affect this project.

Wide spread work sequence for MEP

Similar to the reason discussed in “longer interior fit-out time”, the work sequence of the mechanical, electrical and plumbing are very spread out. Several activities under one trade are worked in the meantime when several activities in the other trades are performing; instead of one trade would finish the majority of its job and towards the end another trade would start working. This is because on this project, there is very many specific work to supplement the final furnish of teaching equipment, LEED implementation, etc.

Cost Overview

Table 3

Project Financial Data			
Construction Cost	$23,450,000	Total Cost	$ 28,084,000.00
Construction Cost/Sq Ft	$184.65	Total Cost/Sq Ft	$ 221.13

Major Building System Cost		
Trade	**Value**	**Value/Sq Ft**
Concrete	$7,035,000.0	$55.39
Earthwork	$2,814,000.00	$22.16
Electrical	$4,924,500.00	$38.78
Mechanical & Plumbing	$3,986,500.00	$31.39
Equipments	$2,814,000.00	$22.16
Others	$1,876,000.00	$14.77

Overall, the McKeesport Elementary/Intermediate School is a great project to study the construction of public education facility with innovation construction methods and concepts. It has some uniqueness given its tight construction schedule; while it also indicates the near future of the construction of education facilities.

Analysis 1: LEED Implementation

Problem Identification

As outlined by the LEED Summary sections of this report, it was expected that after a reasonable update of the LEED implementation on the Twin Rivers School Project could achieve LEED Platinum Certificate and also reduce the long-term operation and maintenance cost of the school. One of the owner's goals for Twin River's School project is to build a district scientific educational facility as well as a campus for two schools. This implementation will further help the achievement of this goal with minimal cost and schedule influence.

In the original design, there are a lot of systems that realizing LEED features including curtain wall, grey water capture system, geothermal system, and two pole-mounted wind turbines. However, the pole-mounted wind turbine system was not planned to be used for energy production. Since the pole-mounted wind turbines are already incorporated in the design, there is a possibility of produce energy out of it without too much additional cost. The cost and benefit of this change will be studied carefully. This report will also study the potential of incorporating the roof-top wind turbines in the design with an expectation of reduction of long term operation cost for the school.

Background Research

At the beginning of this research, LEED implementation in public education facility will be studied in general; in terms of the incentives and the existing distribution of LEED public school projects throughout the country. This analysis will demonstrate the driving factor of LEED implementation and provide recommendations for LEED in future public schools.

Research shows that rooftop wind turbine units have relatively low initial and maintenance costs compared with pole-mounted units which are already incorporated in current design. They also have the advantage of easy installation for multiple units. The addition of rooftop wind turbine units should be able to greatly increase the amount of self-produced energy and reduce additional energy purchase; thus reducing building operation cost in the long run. The noise level caused by the units is as long as the noised produced by a refrigerator. The vibration or other structural impacts from the system are also minimal.

Case studies will be conducted in order to study the potential cost savings from renewable energy sources from wind turbines in public schools.

Analysis Components

The possibility of adding rooftop wind turbine units to increase the self-produced energy will be studied. An initial cost versus life cycle analysis will be performed to examine the chances of cost reduction in energy purchase for this project. Additional electrical distribution panel may be beneficial for the electricity produced in the showcase room to be distributed for building use. LEED implementation among northeastern public schools will be studied. The effectiveness of the current design compared to the design with intelligent dynamic day-lighting system will be analyzed. The ControLite® Intelligent Dynamic Day-lighting Systems is proposed to substitute the curtain wall with metallic panels.

Methodology

The following steps will be taken to successfully conduct this analysis:

- Collect cost and electricity production information of current design of wind turbine
- Research two to three case of public school with LEED Sliver, Gold or Platinum Certificate
    - Develop a case study comparing the energy cost and other cost savings with or without the LEED system
- Create a spreadsheet documenting the potential initial cost savings and life cycle cost savings
- Research the possible equipment for the rooftop wind turbine units and the additional electrical distribution panel
- Interview at least one member of the construction team and one member of the electrical construction team regarding the advantages and disadvantages of re-design or re-routing of the distribution system
- Interview the member of the construction team regarding the constructability concerns of installing rooftop wind turbine units and updating the distribution system in terms of project schedule and constructability problem
- Study the life-cycle cost in comparison to the original design without updating the LEED components
- Recommend improvement of LEED components for this project

LEED Improvement from Rooftop Wind Turbine System

After investigation, the Twin Rivers School Project could have achieved LEED Platinum Certification based on the LEED 2009 Building Design and Construction Program. An analysis of the program showed that project's performance on the category "Energy and Atmosphere" and "Innovation and Design Process" will both be improved. Those were the weakest two categories of the original design. The analysis results are demonstrated in the table below.

Table 4

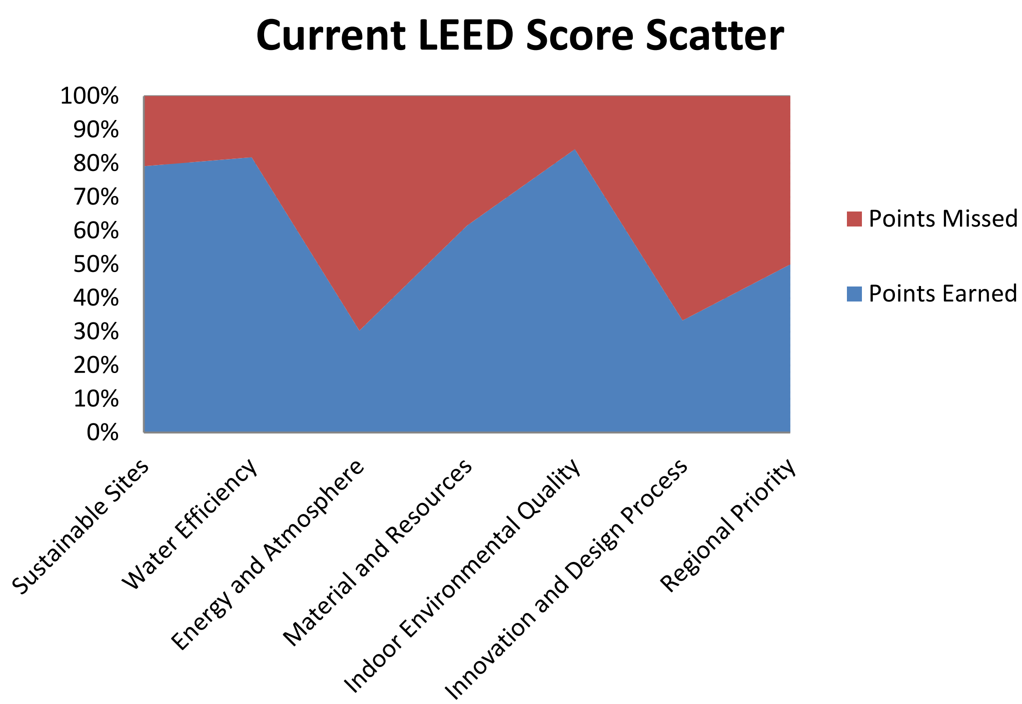
Current Design	Points Earned	Points Missed
Sustainable Sites	19	5
Water Efficiency	9	2
Energy and Atmosphere	10	23
Material and Resources	8	5
Indoor Environmental Quality	16	3
Innovation and Design Process	2	4
Regional Priority	2	2
Total Points	66	

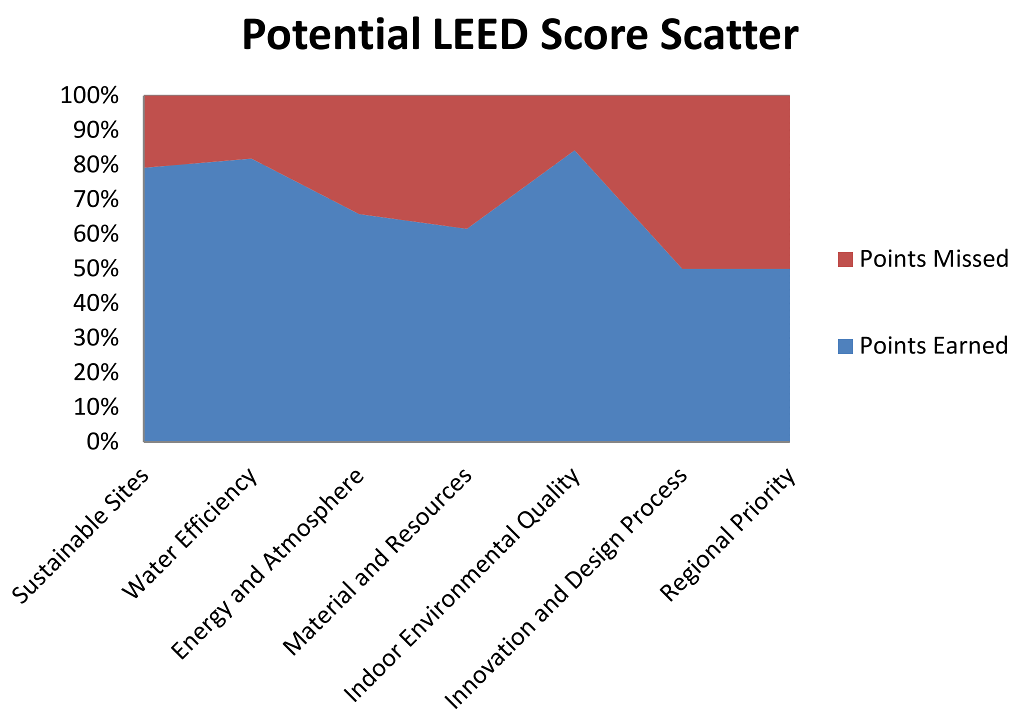
Potential Design	Points Earned	Points Missed
Sustainable Sites	19	5
Water Efficiency	9	2
Energy and Atmosphere	25	13
Material and Resources	8	5
Indoor Environmental Quality	16	3
Innovation and Design Process	3	3
Regional Priority	2	2
Total Points	82	

For the complete LEED checklist, please reference to Appendix E.

As evidenced above, the Twin Rivers School Project would be able to attain roughly 82 LEED points using the 2009 rating program on Building Design and Construction if the design had been updated. The change of design will have influence over project schedule, cost, maintenances, including other building system. These influences will be studied in detail in this report.

Closer investigation into the LEED Scores on this project shows the addition of rooftop wind turbine system will help the project to achieve extra LEED points in the category "Energy and Atmosphere" for further optimizing energy performance and implementing on-site renewable energy. This will also help to improve the project's LEED performance on the category "Innovation and Design Process" for integrated power system.





Case Study

During research, it turns out that Penn State is the host of a program called The Pennsylvania Wind for Schools Program (WFS). The WFS team at Penn State will help a selected number of "host" schools (usually public schools) seek funding from various resources, and provide some technical consults. Current host schools sponsored by the WFS Program include: The Londonderry School, Pequea Valley High School, James Buchannan Middle/High School, Hazelton Area High School, Northwestern High School and Mt. Nittany Elementary/Middle School as shown in Figure4. Penn State works with these host schools to raise funding for and install a small wind turbine while integrating wind energy curricula into their programs.

Figure 4

Case One: Boyce Middle School

Boyce is one of the first LEED-Certified public schools in Allegheny County. Since McKeesport School is also located in Allegheny County, the case of Boyce School is a helpful case to analysis. Boyce Middle is at the council's Silver level, and that designation represents an additional $567,760 in project planning and construction reimbursement from the Pennsylvania Department of Education to the Upper St. Clair District. One unique approach the Upper St. Clair School Board took was to establish a LEED study committee which serves as a vehicle for local business and professional leaders to lend their expertise toward school construction projects. In an interview with the superintendent on the project, Patrick T. O'Toole, "The USC School Board members were driving forces in making the LEED certification happen and should be proud. In addition to the financial benefits, it sends a great message to the students and the community about social responsibility, science and the benefits of a quality learning environment." Similar to the Twin Rivers School Project, the Boyce School Project also went through a decision making and hearing approval process of two years. Although other detailed cost information was not available for this analysis, the approach of involving local business and professional leaders to assist the realization of the technology-intensive project could be a way to go for public school projects like Twin Rivers School Project in the future.

Case Two: Mount Nittany Elementary/Intermediate School

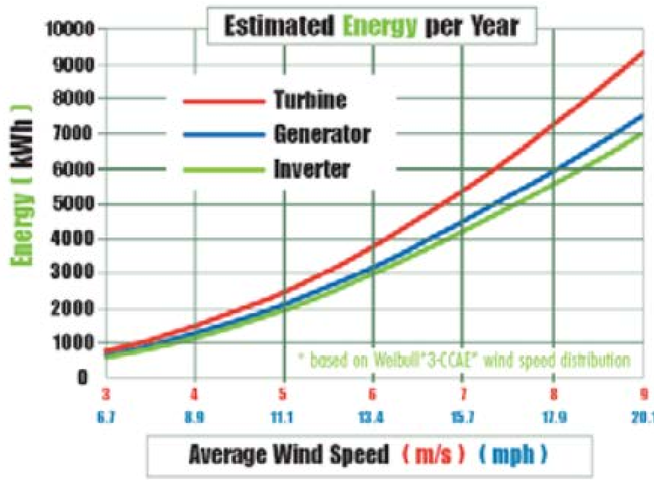
Mount Nittany School is selected as a second case to study in this analysis because it is also a combined elementary and intermediate public school just like the Twin Rivers School. According to a report by the National Renewable Energy Laboratory in January 2013, Mount Nittany School received a total funding of $ 16,000, including $ 5,000 from West Penn Power Sustainable Energy Fund(WPPSEF), $5,000 from Lowes Educational Toolbox, $5,000 from Citizen Power, and $ 1,000 from the Superintendent’s Fund for Instruction Innovation for incorporating wind energy into its design.

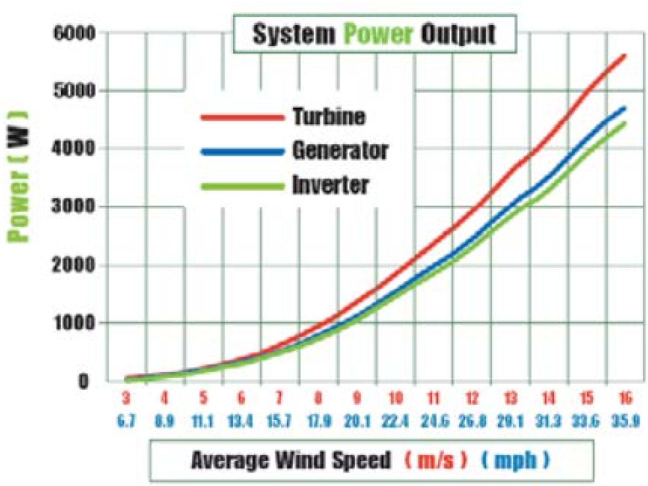
Both the cases show that the realization of using wind powered energy is greatly supported in Pennsylvania. There are a lot funding and opportunities for grants available. The addition of roof-top wind turbine is thus recommended.

The current pole-mounted wind turbines are vertical axis wind turbine produced by Clean Field. To minimize the trouble of in bid invitations and market research, a similar but smaller version of the current turbine type is recommended for installation on the roof.

Table 5

Rated Power	600 w
Maximum Output Power	800 w
Output Voltage	48 V
Rotor Height	1.6 m (5.2 ft)
Rotor Diameter	1.2 m (3.9 ft)
Start-up Wind Speed	1.5 m/s (3.4 mph)
Rated Wind Speed	10 m/s (22.3 mph)
Survival Wind Speed	50 m/s (111.5 mph)
Generator	Permanent Magnetic Generator
Generator Efficiency	>0.96
Turbine Weight	18 kg (39.6lbs)
Noise	<45dB(A)
Temperature Range	-20°C to +50°C
Design Lifetime	20 Years
Warranty	Standard 5 Years





The details of the units can be referenced from Table 4. The Figure above showed the possible energy output and power production from the system of each unit. One unit is planned to be placed for every 4 square feet given its dimension. The impact of the installation to the structural system will be analyzed as the structural breadth.

The total energy production estimation = number of units * maximum production of each unit * operation time * system capacity

Based on research the capacity of a unit from Clean Field is usually 23% of its maximum output.

Thus we have: 18* 800w * 8766hr * 23% = 29033 Kwh

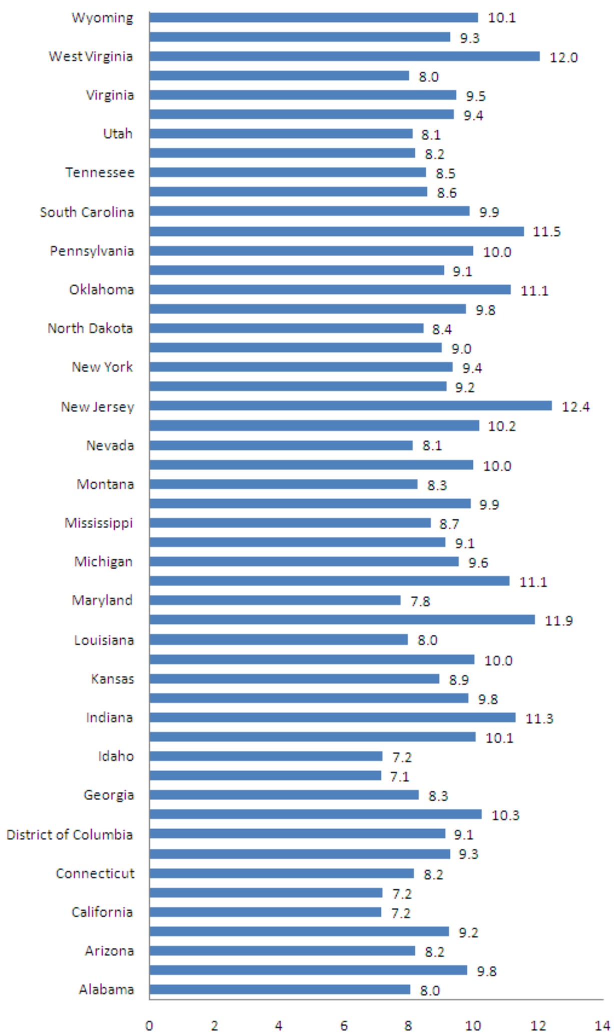
From research, conservative estimate of electricity prices = 0.05 $/Kwh

Therefore, 0.05 * 29033 = $ 1452

There is a cost saving of 1452 dollars per year from the installation of rooftop wind turbine units.

LEED in Public Schools

For the study of LEED implementation in public schools, several generic scenarios were raised regarding the driving factor of LEED Implementation. The climate of the state, GDP of the state, education population of the states were all among the factors considered. Based on data from Center for Education, the number of population for k-12, i.e., population aged between 6-21, is shown in Figure 3 below.

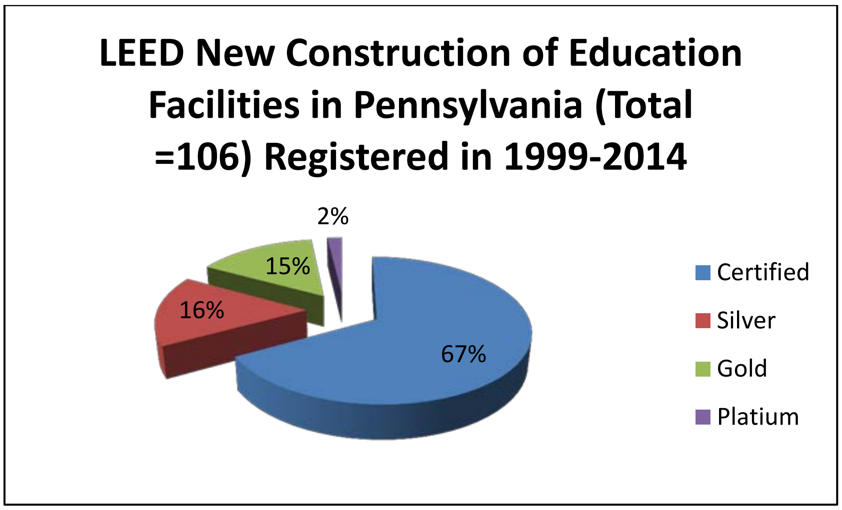


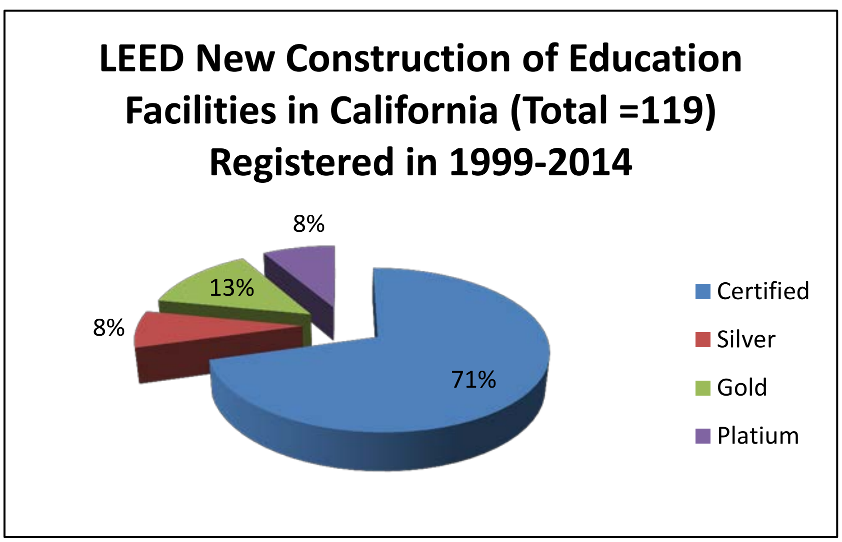
Source: U.S. Department of Education, Office of Special Education Programs, Data Analysis System, Table 1-15.
Note: Percentages shown represent percentage of overall student population.

Figure 3

Compared the LEED School in the maximum 6-21 aged population state and the minimum state, there is no obvious indication of positive relationship between education needed population and the number of LEED schools. Thus, it is concluded, the number of education needed population is not related to the LEED implementation throughout the country.

Then the number of LEED implemented schools is compared with the GDP of each state. Based on the database of registered LEED schools from 1994-2014, the data shows a positive relationship. This indicates the higher the GDP of each state, the state will have more LEED Schools. California ranked the highest in GDP from year 2005-2009 consecutively, while Pennsylvania ranked number six. As the diagrams below shown, the implementation of LEED to public school is very popular in both states.





Conclusion and Recommendation

From the analysis of these scenarios, conclusion can be drawn that government funding and incentives play crucial rules in the implementation of LEED to public schools. From the perspective of the construction management, LEED projects usually means long term saving on operation and maintenance cost; relatively short payback period compared to other high end designs. Thus, the construction management team should be encouraged to raise the awareness of the benefits of LEED implementation to public schools, and try to engage industry donor to assistant with the development of LEED.

For the implementation of roof-top wind turbine on this project, we also see a cost saving of $ 1452 per year from the energy generated with reasonable assumption. Project's value will be even raised if the school chooses to participate in WFS project. The benefit from that will be analyzed in the next section.

Analysis 2: Value Engineering

Problem Identification

As analyzed in Technical Report Three, the owner, the project team and the designer worked together on this project to implement value engineering to the construction of Twin River's School Project. The areas of value engineering implementation include update material and equipment and update design. However, due to the limitation of planning time, some value engineering ideas is restraint to be update of material.

Background Research

The material changes on this project include changing the conduits from EMT to MC cables, changing the drywall framing material, updating the audio visual cable in classroom, updating the acoustic ceiling tiles, changing the gymnasium facilities and so on. The biggest update of design is the change of steel support of the clearstory level, the modification of rain water capture system over the music room and the metal decking over the library room towards the west corner of the core of the project. There is a possibility of redesign of the steel deck might bring a lower total cost than a makeover for the decking over library and a different support over clearstory level.

The second highest value of change of design is changing the conduits from EMT to MC Cable. In order to realize the goal of increase project value, to construct a high performance education facility with relatively low cost, it might be a better idea of substitute the two existing 120V distribution panels by one 480V distribution panel.

Analysis Components

The cost difference of two 120V distribution system versus one 480V system and will be studied. An alternative light-weight metal decking system will be considered instead of the current design of mostly wide-ribbed galvanized metal decking. The impact on construction schedule of both changes would be analyzed. The SIPS implementation would be incorporated in the consideration of both systems to optimize the project schedule and add value to the project. The risk of possible higher equipment maintenance cost should also be analyzed.

Methodology

The following steps will be taken to successfully conduct this analysis:

- Identify and study the major value engineering design update for the project
- Research the possibility of upsizing the electrical system
- Study the schedule change and potential cost savings from the update
- Interview at least one member of the construction team and one member from the electrical designer regarding the advantages and disadvantages of the two options
- Analysis the life-cycle cost for the alternative system
- Studied two cases of Lean method for value engineering purpose on educational facility construction project
- Identify if the current value engineering approach is optimal
- Conclude if the alternative value engineering component is recommended
- Conclude if the current value engineering should be further modified or is recommended

Life-Cycle Cost Analysis

The purpose of this analysis to determine the additional construction and operation costs involved. Once identified, these costs will used in the calculation of the life-cycle cost analysis. The initial equipment costs, installation costs, construction costs, maintenance costs and the energy costs and savings will all be taken into consideration. In the end, a long-term cost comparison between the original system and the proposed system will be developed and analyzed. If the results of the analysis were to show that the additional costs would be compensated by the energy cost saving within 5 years minus the additional operation cost; it would be reasonable to argue that Twin Rivers School Project should have further their implementation of LEED systems and install roof-top wind turbine system for energy production.

Actual Cost Benefit =

Additional Equipment Cost + Additional Construction Cost + Additional Operation Cost

– Energy Cost Saving – Additional Funding for Renewable Energy Source

To calculate the payback period, the additional cost for the equipment and labor are calculated first. In this calculation, the energy produced by the pole-mounted units was not included based on the assumption that those units will be used for showcase purpose only. Although the payback period of the system exceeds 50% of its designed lifetime, the implementation of the system is still recommended; because there also is the invisible benefit of further the LEED usage on public school and the invisible benefit from the multiple funding sources talked about earlier. Due to the uncertainty for obtaining the funding, although it is very likely that the school can get a maximum of $15,000; this amount is not included in the analysis here.

Table 6

Additional Cost of Roof-Top Wind Turbine System			
Item	Unit Cost	Quantity	Cost
Material	800	18	14400
Labor	30	18	540
Equipment (Crane)	283	9	2550

The cost of crane is assumed to be $750 per day plus a cost of $200 per hour.

Total cost from the calculation in Table 5 is $17490.

The total cost is then divided by the cost saving per year. It shows that the payback period of the system is 12 years. This is 60% of the system's designed lifetime.

Given the case that Twin Rivers School Project already has two pole-mounted wind turbines in the design, there is a special program called Affiliate Program available from U.S. Department of Energy that is eligible for Twin Rivers. According to the website of U.S. Department of Energy, WFS Affiliate Project can provide up to $ 10,000 for host school towards wind turbine hardware. In addition to that, $5,000 are very likely to be accessible from the industry donor.

Total cost from the calculation in Table 5 is $17490.

If the funding were to be included, then the total cost of the system will be reduced to $2490 and the payback period will be reduced to only 2 years. With all that being said, the addition of the system is recommended.

The payback period for the system then will be $2490/$1452 = 1.7 = 2 years

2 yrs/20yrs = 10%

This is only 10% of the system's designed lifetime. In this calculation, the energy produced by the pole-mounted units was not included based on the assumption that those units will be used for showcase purpose only as well. But we can see the significant benefit from the system. Thus, it is recommended for Twin Rivers School to join the Wind for School (WFS) program and implement roof-top wind turbine system.

Table 7

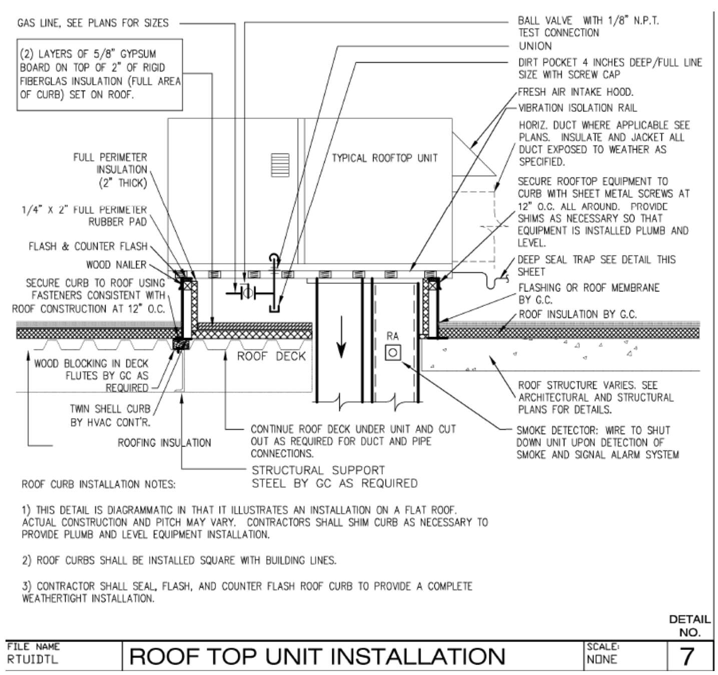
Additional Cost of Roof-Top Wind Turbine System			
Item	**Unit Cost**	**Quantity**	**Cost**
Material	800	18	14400
Labor	30	18	540
Equipment (Crane)	283	9	2550

Structural Breadth: Roof Decking Re-design

One of the biggest updates of design is the change of steel support of the clearstory level, the modification of rain water capture system over the music room and the metal decking over the library room towards the west corner of the core of the project. The potential influence of the rooftop wind turbine weight over the decking system will be studied and an update of the decking system for non-sloped area will be proposed and analyzed. The current system will either have the capability to meet the requirement for the addition of roof top wind turbine system or will have to be updated. Whether the currently designed structure can support the installation of small roof-top wind turbines will be determined by the following calculation.

Impacts from the Roof-Top Wind Turbine System

According to the proposal in LEED Analysis, a Small Vertical Axis Roof-Top Wind Turbine unit will be installed every square feet. Based on the original design, the roof top mechanical units will be supported directly on the open-web roof joists. Assumptions are made that the addition of roof top wind turbine units can be installed using the same methodology as shown in the Figure below.



From the assumption, the roof top wind turbine unites will be sitting on the existing design of roof curb with 3 feet spacing. W= 1.2 (D_L)= 1.2*40 = 48 lbs

48 lbs/(4’*4’) = 3 PSF

Dead Load from Roof Top Mechanical Units and Wind Turbine Units

20 + 3 = 23 PSF

Based on the equipment specification, the vibration caused by the operating equipment is minimal. In this analysis, the vibration will not be considered as a design impact factor.

Current System Capacity Analysis

To analysis the structural capacity, the dead and live loads which the structural members will support the loading are shown in the Figure below. Dead and live loads used for the design of the roof structural system are illustrated.

DESIGN LIVE LOADS (NEW CONSTRUCTION):

THE FOLLOWING DESIGN LIVE LOADS HAVE BEEN USED, AS SPECIFIED IN THE INTERNATIONAL BUILDING CODE, 2006 EDITION, CHAPTER 16, SECTIONS 1603.1.1 THROUGH 1603.1.7.

BASEMENT SLAB-ON-GRADE .... 100 PSF
GUEST ROOMS (WHERE ALTERED).... 50 PSF
VESTIBULES AND LOBBIES .... 100 PSF
STAIRS AND CORRIDORS .... 100 PSF
BALCONIES AND TERRACES .... 100 PSF
MECHANICAL ROOMS .... 100 PSF
PENTHOUSE FLOOR .... 150 PSF
ROOF .... 30 PSF + WEIGHT OF GREEN ROOF

Live & Dead Load on Roof	
Item	**Load (PSF)**
8" Normal Weight Concrete(144 PCF)	96
Mechanical Units Including Roof-Top Turbine Units	23
Build-Up Roofing System	20
Total Dead Load	139
Roof Live Load	20
Total Live Load	20

To further analysis the structural capability of the existing system, a typical column and bay of non-sloped roof which will be supported is chosen. The structural member picked is responsible for supporting the roof top wind turbine unit. After gathering the detailed loading on the roof, distributed load calculation was conducted and the CRSI tables were used to further the analysis of the structural members.

Factored Distributed Load: W = (1.2)(D_L) + (1.6)(L_R)

Thus, we have: W = (1.2)(139PSF) + (1.6)(20PSF) = 198.8 PSF

USE OF FLAT SLAB TABULATED DESIGNS

Direct Applications Within Dimensional Limitations of Tables

These limitations are:

1. Square column sizes as tabulated
2. Square panels
3. Minimum three panels continuous
4. Equal spans
5. Edge of slab flush with outer face of edge column
6. Live load ≤ 2 × dead load (unfactored loads)
7. Concrete in slab, f'_c = 4,000 psi: normal-weight, w = 150 pcf
8. No edge beams
9. Uniformly distributed gravity loads only

The CRSI tables, as shown in Figure 6, were referenced in order to gain a baseline to determine the capability of existing structural members in terms of supporting the rooftop wind turbine system. In

Design Load Requirement

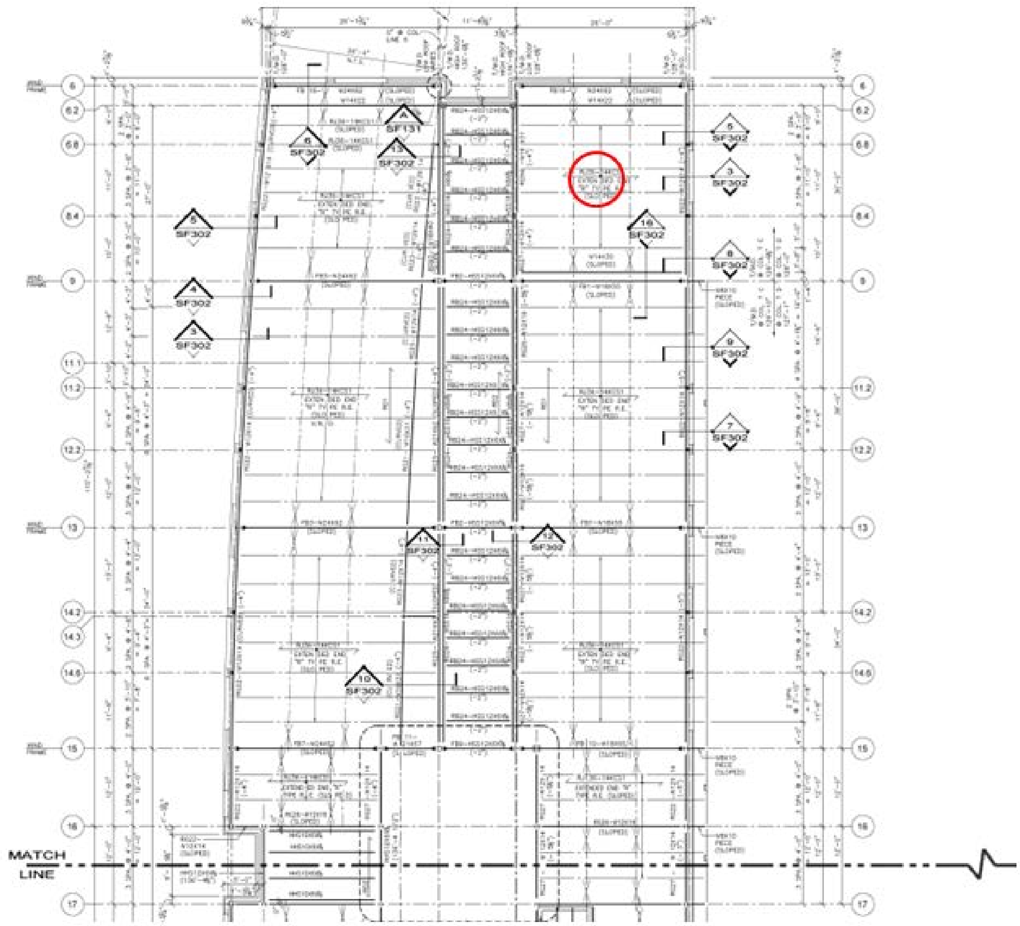


Figure 6

Factored Distributed Load: $W = (1.2)(D_L) + (1.6)(L_R)$

$W_u = (1.2)(139\ PSF) + (1.6)(20\ PSF) = 198.8\ PSF$

Deflection (ACI 318-11): $L_n/33$<Thickness of slab

20'(12"/1')/33 <8" = 7.2727"<8"

Max Vertical Deflection of Roof Deck: 1/240 of span

1/240*20ft*12 in/ft = 1"< TL/180 = 1.39"

Ultimate Shear

V_u = (312 PSF)(18.60' x 18.09') = 64,603 lbs.

Critical Shear $V_c = 4\lambda\, b_o d\ c\ f'$

b_o = 2 (24" + 8") + 2 (21" + 8") = 122"

d= (8 – 0.75)

Vc = 4(1) (122")(8-0.75) = 250,174.3792 lbs. psi 5000

Punching Shear

$V_u < \phi V_c$

64,603 lbs. < (0.75) x (250,174.38 lbs.)

64,603 lbs. < 187,630.78 lbs

According to Structural Concrete Building Code (ACI 318-11)

TABLE 9.5(c)—MINIMUM THICKNESS OF SLABS WITHOUT INTERIOR BEAMS*

	Without drop panels‡			With drop panels‡		
	Exterior panels		Interior panels	Exterior panels		Interior panels
f_y, psi†	Without edge beams	With edge beams§		Without edge beams	With edge beams§	
40,000	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$	$\ell_n/36$	$\ell_n/40$	$\ell_n/40$
60,000	$\ell_n/30$	$\ell_n/33$	$\ell_n/33$	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$
75,000	$\ell_n/28$	$\ell_n/31$	$\ell_n/31$	$\ell_n/31$	$\ell_n/34$	$\ell_n/34$

*For two-way construction, ℓ_n is the length of clear span in the long direction, measured face-to-face of supports in slabs without beams and face-to-face of beams or other supports in other cases.
†For f_y between the values given in the table, minimum thickness shall be determined by linear interpolation.
‡Drop panels as defined in 13.2.5.
§Slabs with beams between columns along exterior edges. The value of α_f for the edge beam shall not be less than 0.8.

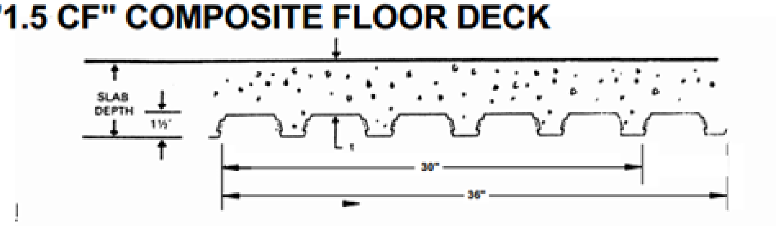
9.5.3.2 — For slabs without interior beams spanning between the supports and having a ratio of long to short span not greater than 2, the minimum thickness shall be in accordance with the provisions of Table 9.5(c) and shall not be less than the following values:

(a) Slabs without drop panels as defined in 13.2.5... 5 in.;
(b) Slabs with drop panels as defined in 13.2.5 .... 4 in.

All Deck Types: Select and design metal deck in accordance with SDI Design Manual.

1 Calculate to structural working; limit; stress design and structural properties specified.
2 Maximum Vertical Deflection of Floor Deck: 1/360 of span.
3 Maximum Vertical Deflection of Roof Deck: 1/240 of span.
4 Maximum Vertical Deflection of Form Deck: 1/360 of span.
5 Maximum Lateral Deflection of Diaphragms: 1/500 of the storey height.

TYPE "1.5 CF" COMPOSITE FLOOR DECK



SECTION PROPERTIES FY=40 KSI

DECK TYPE	DESIGN THICKNESS	WT PSF	I^p IN.^{4}	I^n IN.^{4}	S^p IN.^{3}	S^n IN.^{3}
22	.0295 IN.	1.61	.153	.186	.188	.198
20	.0358 IN.	1.95	.199	.226	.233	.242
18	.0474 IN.	2.56	.288	.300	.316	.320

GENERAL INFORMATION

SLAB THICKNESS	4½"	5"	5¼"	5½"	6"	6¼"	6½"
Vol. Conc. Yds/100SF	1.09	1.24	1.32	1.40	1.55	1.63	1.71
Conc. Wt. PSF (Normal Wt.)	42	48	51	54	60	63	66
Conc. Wt. PSF (Light Wt.)	34	38	41	43	48	50	53
Recommended W.W.F. 6"x6"	W1.4xW1.4	W1.4xW1.4	W1.4xW1.4	W2.1xW2.1	W2.1xW2.1	W2.1xW2.1	W2.1xW2.1

NORMAL WEIGHT CONCRETE (144 PCF)

SLAB DEPTH	DECK TYPE	ALLOWABLE UNSHORED CLEAR SPAN			SUPERIMPOSED LIVE LOAD, PSF CLEAR SPAN, FT.												
		1 SPAN	2 SPAN	3 SPAN	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6	10-0	10-6	11-0	11-6	12-0
4" (t=2½)	22	4-11	6-7	6-8	373	307	255	213	178	150	126	106	88	74	61	49	40
	20	5-8	7-8	7-9	•	379	317	267	226	192	164	140	119	102	86	73	61
	18	6-11	10-3	10-9	•	•	382	361	309	266	230	199	173	150	131	114	99
4½" (t=3)	22	4-8	6-4	6-5	•	371	308	256	214	179	150	125	104	86	70	56	44
	20	5-5	7-4	7-5	•	•	385	323	273	232	197	168	143	121	102	86	72
	18	6-7	8-10	9-0	•	•	•	•	377	323	279	241	209	181	158	137	118
5" (t=3½)	22	4-6	6-0	6-1	•	•	360	299	249	207	173	143	118	96	78	61	47
	20	5-2	7-0	7-1	•	•	•	350	320	271	229	194	165	139	117	97	80
	18	6-3	8-5	8-7	•	•	•	•	•	381	328	283	245	212	183	158	137
5½" (t=4)	22	4-4	5-10	5-11	•	•	•	340	282	234	194	159	130	105	83	64	48
	20	5-0	6-9	6-10	•	•	•	•	366	308	260	220	185	155	129	107	87
	18	6-0	8-1	8-3	•	•	•	•	•	•	377	324	280	241	208	179	153
6" (t=4½)	22	4-2	5-7	5-8	•	•	•	380	313	258	212	173	140	112	87	65	46
	20	4-9	6-6	6-7	•	•	•	•	•	345	290	243	204	169	140	114	91
	18	5-9	7-9	7-11	•	•	•	•	•	•	•	364	313	269	231	198	169

Conclusion on Structural Breadth

Based on the calculations, it has been proved that the existing structural system can meet the loading requirements for the addition of Roof-Top Wind Turbine system per the proposal. The methodology from the structural analysis is adopted from the AE curriculum of Building Structural Systems in Steel and Concrete.

Cost Impact from Structural System Update

Based on the study from structural system, there is no need to update the current roof structural system due to the light-weight and the dimension of the roof-top units. Cost savings from the power produced by the system is showed previously.

Electrical Breadth: Alternative Distribution System

As studied in Technical Report One, existing design of the electrical system have two power distributions of 208Y/120V. The breadth will focus on the possibility of updating the electrical system voltage to 480Y/277V from the existing design of 208Y/120V. For the convenience of comparing system efficiency and cost effectiveness, the impact from the proposing LEED Analysis will not be counted in this analysis; i.e. the addition power from the rooftop wind turbine system will not be included in the analysis here. Because the original system is selected based on a preliminary estimate, the exact electrical load that can be provide with the on-site generator is undefined. Thus, in this analysis, the electric loads will be assumed to meet the designed system.

Theoretically, with the rooftop turbine units and the pole mounted wind turbine, power consumption of the building from the main power supply is expect to decrease and thus reduce the building operation cost in long run. A life cycle cost analysis of the updated system compared to the original design will be done in the Value Engineering Analysis.

Existing Electrical System

As summarized in the building system section of this report, the existing electrical design for the Twin Rivers School Project utilizes two parallel services entrances connects to the switchgears with incoming service voltage of 208Y/120V. The existing switchboard schedule for the

POWER STYLE QED-2 SWITCHBOARD														
SECT NO	CKT NO	GMD HEIGHT	DEVICE/FRAME RATING	TRIP AMP	FUSE/TRIP	#P	DESIGNATION	N/P	LUG INFORMATION				ACCESSORIES
									QTY	PHASE WIRE RANGE	QTY	NEUT. WIRE RANGE	
1	UCT	–	3000A	–	–	–	DUQUESNE LIGHT	No	9	–	9	–	
2	M1	–	NW 3000A Plug A	3000A	A–LSIG	3P	Main Breaker	Yes	–	3/0 – 750 kcmil	–	3/0 – 750 kcmil	GF,SDE1,OF4
3	1	4.5 in	JJ	200A	–	3P	Elevator B	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	2	4.5 in	JJ	200A	–	3P	Elevator A	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	3	4.5 in	JJ	225A	–	3P	Panel M1B	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	4	4.5 in	JJ	225A	–	3P	Panel M2A	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	5	4.5 in	JJ	225A	–	3P	Panel M2B	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	6	7.5 in	LC	600A	–	3P	Motor Control Center	Yes	2	4/0 – 500kcmil	2	4/0 – 500kcmil	
3	7	7.5 in	LC	350A	–	3P	CH – 1	Yes	2	4/0 – 500kcmil	1	#4 – 600 kcmil	
3	8	4.5 in	JJ	225A	–	3P	Panel M1A	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	9	4.5 in	JJ	225A	–	3P	Panel M1C	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	10	4.5 in	JJ	225A	–	3P	DOAS–2	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	11	4.5 in	JJ	225A	–	3P	ATS–LS	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	12	4.5 in	JJ	175A	–	3P	HUMID – 1	Yes	1	1/0 – 4/0 AWG	1	#6 – 350 kcmil	
4	13	4.5 in	HJ	100A	–	3P	Panel LP1B	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	14	4.5 in	HJ	100A	–	3P	Panel LP1D	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	15	4.5 in	HJ	100A	–	3P	Panel MK	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	16	4.5 in	HJ	100A	–	3P	Panel LP2B	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	17	4.5 in	HJ	150A	–	3P	T – KA	Yes	1	#14 – 3/0 AWG	1	#6 – 350 kcmil	
4	18	4.5 in	HJ	150A	–	3P	DOAS – 1	Yes	1	#14 – 3/0 AWG	1	#6 – 350 kcmil	
4	19	4.5 in	HJ	100A	–	3P	Panel LP2A	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	20	4.5 in	HJ	100A	–	3P	ATS – EQ	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	21	4.5 in	HJ	100A	–	3P	Panel LP1C	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	22	4.5 in	HJ	100A	–	3P	Panel LP1G	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	23	4.5 in	HJ	50A	–	3P	EFC – 1	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	24	4.5 in	HJ	70A	–	3P	T – CP1A/CP1D	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	25	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	26	4.5 in	HJ	100A	–	3P	Panel M1G	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	27	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	28	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	29	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	30	4.5 in	HJ	100A	–	3P	Panel LP1A	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	31	4.5 in	HJ	60A	–	3P	TVSS	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	32	4.5 in	HJ	50A	–	3P	EFC – 2	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	

The switchboard schedule shown above is used to determine the loads switchboards need to feed for different sets of feeders. All the feeders feed to lighting panels are assumed to be supplied by 480Y/277V system. The calculations of new feeder sizes are demonstrated below. The new proposed sizes exclude the calculation of grounding wire.

SECT NO	CKT NO	GMO HEIGHT	DEVICE/FRAME RATING	TRIP AMP	FUSE/ TRIP	#P	DESIGNATION	Proposed Size Phase Legs	ORIGNINAL Design			
									QTY	PHASE WIRE RANGE	QTY	NEUT. WIRE RANGE
1	UCT	–	3000A	–	–	–	DUQUESNE LIGHT	-	9	–	9	–
2	M1	–	NW 3000A Plug A	3000A	A-LSIG	3P	Main Breaker	2/0	–	3/0 – 750 kcmil	–	3/0 – 750 kcmil
3	1	4.5 in	JJ	200A	–	3P	Elevator B	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	2	4.5 in	JJ	200A	–	3P	Elevator A	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	3	4.5 in	JJ	225A	–	3P	Panel M1B	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	4	4.5 in	JJ	225A	–	3P	Panel M2A	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	5	4.5 in	JJ	225A	–	3P	Panel M2B	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	6	7.5 in	LC	600A	–	3P	Motor Control	2/0	2	4/0 – 500kcmil	2	4/0 – 500kcmil
3	7	7.5 in	LC	350A	–	3P	CH – 1	2/0	2	4/0 – 500kcmil	1	#4 – 600 kcmil
3	8	4.5 in	JJ	225A	–	3P	Panel M1A	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	9	4.5 in	JJ	225A	–	3P	Panel M1C	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	10	4.5 in	JJ	225A	–	3P	DOAS-2	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	11	4.5 in	JJ	225A	–	3P	ATS-LS	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil

New voltage ratings are modified as showed in the previous table. The wire size is much smaller when sized with conservative criteria. The feeder size differences are very significant after the calculation.

Conclusion on Electrical Breadth

Based on the calculations, also given the condition of Twin Rivers School Project, there is the need and will be benefit if the wires are sized up. The payback periods according to the previous analysis in Value Engineering section are relatively short. Thus the upsizing of the wires are recommended.

Conclusion and Recommendation

Based on the study, cost saving and benefits are reasonable for the improvement of Value Engineering by implementing roof-top wind turbine system. The payback periods are very short assuming the project can obtain funding from the state and industry.

Analysis 3: Schedule Acceleration

Problem Identification

As previous mentioned, project schedule is one of priorities for owner. The construction of Twin River's School is scheduled to be completed within 21 months. Due to this project is the construction of a public school, the substantial completion date was extremely important to the owner, the McKeesport School District, so that the school can start on time. 21 months is a rather tight time frame for a high performance education facility.

Also, the project schedule suffered from the heavy rain impact which caused sedimentation and erosion control problems when the drainage and water capture system was still under construction. The project team received a request of change of design from Pennsylvania's Department of Environmental Protection due to the deficiency of design in sediment and erosion control which ended up with $156,275.00 addition of project value. This analysis studied the three possible scenarios to accelerate project schedule.

The most noticeable schedule accelerator is the time saving having a precaution and reaction plan for extreme weather so that the sedimentation and erosion would be well controlled. This will eliminate the trouble of rearranging project activities and explored what could have been done differently in both preconstruction process and construction phase to minimize or eliminate weather impact on construction. The second scenarios this analysis will study to improve project schedule and construction efficiency is SIPS (Short Interval Production Schedule). Lastly, the Last Planner method will be studied to see its potential to improve the construction of Twin Rivers School Project.

Background Research

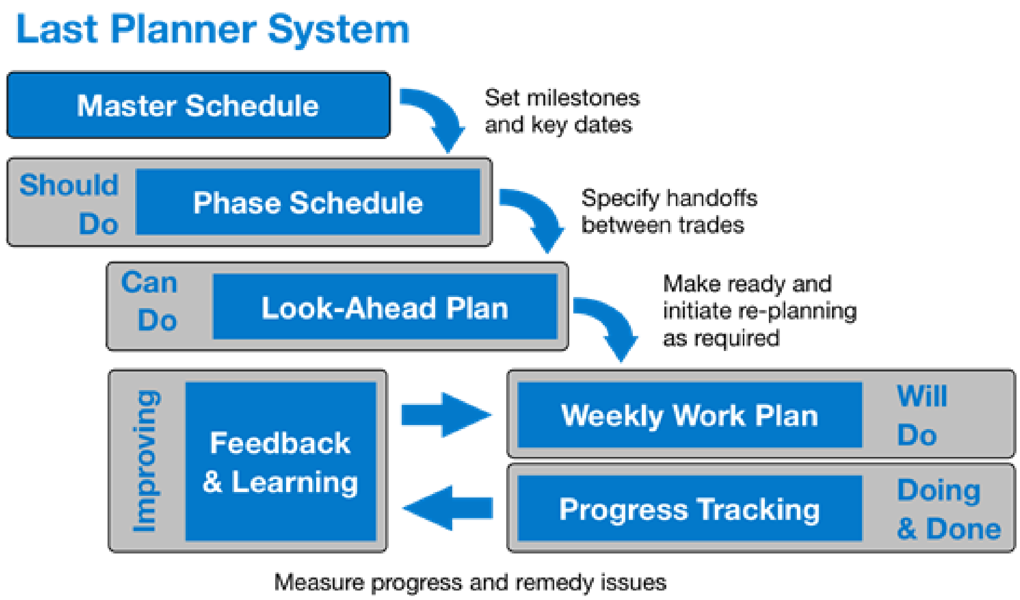
Weather is a factor easily neglected by the project team when construction is planned. When a project has severe influence from weather, there is not too much that can be done. The solutions usually are employing more crew and working overtime to catch up with the schedule. When the delay time can't be made up from working overtime, the construction team will have to extend the construction time. In these cases, extra costs of the construction team will occur. Penalties fees may even occur for some projects. Obviously, this problem cannot be eliminated. Although most of the times weather can be predicted by forecast, there will be times when unexpected weather will hit and affect the construction. Instead, construction team can lay out precaution and reaction plan ahead of the time to minimize the impact of the weather on the project. In this analysis, the possible cost saving from precautionary weather reaction plan will be compared to the additional cost from the change of design.

The symmetry of the building structure and similar design of the two wings create the opportunity for several schedule acceleration techniques. Since the two wings of the building are almost identical, it creates an opportunity for the project construction team to assign several crews to specific tasks, working from one zone to another to increase the efficiency and consequently speedup the schedule. The concept of SIPS schedule can be used to help with the schedule acceleration. Current project schedule has shown relatively long MEP fit-out time. The possibility of overlapping activities and re-sequencing MEP finishing activities will be studied.

For the weather impact on the project schedule, Last Planner system can also facilitate the rearrangement of project schedule to ensure project's turn over time given the case that the delay has already occurred.

Analysis Components

A cost and schedule analysis will be conducted on the precautionary and reaction plan scenario. The implementation of SIPS (Short Interval Production Schedule) method would also be analyzed for its help regarding safety improvements on the site and coordination between trades. improve the project schedule. Fewer conflicts between different trades are expected. The logistics of material staging will be studied to analyze the pros and cons of SIPS on an educational facility. Lean production principles will be applied to study possible scenarios to improve schedule. Last Planner System utilization cases will be studied to seek opportunity of utilization on this project. Each trade will be organized by subcontractor and their tasks. The sequence will be presented using a matrix schedule that highlights the presence of work crews in an area and the duration of time spent there. However, only critical activities will be included in the study.



Methodology

The following steps will be taken to successfully conduct this analysis:

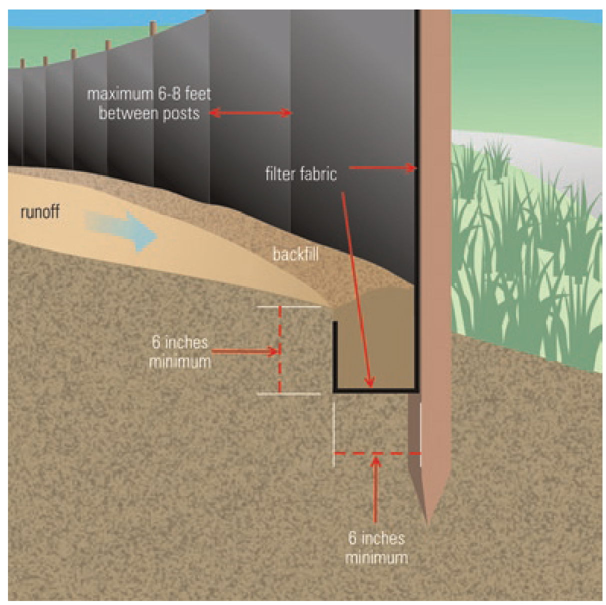
- Identify the area that can be improved the most from current project schedule
- Research two to three case of construction projects that has implemented the Last Planner System
- Create a spreadsheet documenting the advantages and disadvantages of the system
- Research the possibility of using the system on this project
- Study the possibility of overlapping or re-sequencing the MEP fit-out activities
- Analysis the material staging on site to identify the pros and cons for integrating SIPS methodology on construction project of educational facility
- Conclude if SIPS method and Last Planner System have more advantages than disadvantages towards the construction of public educational facility

Scenario 1: Precautionary and Reaction Plan

Twin Rivers School project is located in urban surrounding. The project takes up an entire block, neighboring with private residential properties. This is a challenge to the project team. Access roads and delivery routes to the site are clear and easy to access. There haven't been any material delivery issues. The control of sediment and erosions within the project perimeter however is a critical task the project team didn't executed properly. As shown in the picture, the project site has a relative higher elevation than the neighboring roads. No silt sock or any sedimentation control approach was adopted. The picture was taken a week after the severe rainfall in August 2013. The remaining soils washed down from the site can still be seen on the road off the site.

Two aspects will be analyzed here: prevention of potential damage and reaction plan after severe weather. To evaluate cost and schedule influence of the prevention approach, the cost of using silt fencing is estimated based on RS Means Green Building Cost Data 2014 (31 25 14.16). The estimated cost is then used to compare with the additional cost from the change of design of the erosion plan ordered by the Pennsylvania's Department of Environmental Protection.

The Figure below showed the detail requirements of silt fencing from U.S. Environmental Protection Agency (EPA). When estimating the slope stakes, an interval of 4' is assumed. Normal silt fence is adopted in the estimate; as opposed of reverse silt fence for the case when the site elevation is lower than the surrounding.



31 25 14.16	Stabilization Measures for Erosion and Sedimentation Control										
Item	Daily Output	Labor Hrs	Quantity	Unit	Material	Labor	Equip.	Total	Total Include O&P	Total Cost	Total Days
Slope Stakes (3'-5' Interval)	-	-	739	Ea.	0.11	-	-	0.11	0.12	88.63	-
Silt Fence 3' High	1600	0.01	2954	LF.	0.24	0.37	-	0.61	0.83	2452.09	4

Total Cost of the Precautionary Plan = $88.63 + $2452.09 = $2540.72

The original change of design including a fine for inadequate sediment and erosion control is $156,275.00. The estimate cost of precautionary plan shows a cost saving of 98.37% compared with the update of design using soil cement per EPA's advising recommendation. 87.49% of the cost saving is from the material and labor. With a crew size of four working crews, the additional work can be completed in a day, assuming an eight hour working day.

Total Durations = 30 hours / 8 hours per day = 3.75 days per crew member (round up to 4 days)

Duration with 4 working crews = Total Durations / 4 crew members = 1 day

Compared with the original duration of 20 days, this is a significant improvement. In terms of cost saving and schedule improvement, the project team definitely should have adopted a precautionary sedimentation control plan. The reaction approach will be studied in Scenario 3 using Last Planner System.

Another factor that project team should have been more careful with is to plan the construction with the consideration of weather condition in mind. Weather conditions will not only impact the construction in terms of material staging or building closure, but will also impact the worker's efficiency based on the working condition. It was very unfortunate that on this project, weather created great inconvenience for the construction. Luckily, the project team responded to the incident actively and immediately. There was no need for extension of completion time.

Scenario 2: SIPS Method

A short interval production schedule (SIPS) is based upon repeatable construction activities that can be detailed by tasks and work days and then scheduled sequentially. Due to the equivalent durations of each activity, a matrix can clearly reflect a direct flow of work from one activity to the next in a typical area. As studied in AE curriculum, this method is significantly advantageous to projects with repetitive activities and assemblies. Some of the typical applications include apartments, hotels, or any project includes a fair amount of prefabricated material and building elements. SIPS method is also suitable for projects that need to be fast-tracked and delivered in a short period of time.

As discussed, the symmetry of the building structure and similar design of the two wings create the opportunity for implementing SIPS. Since the two wings of the building are almost identical, specific tasks can be assigned to designated crews, working from one zone to another to increase worker's efficiency and consequently speedup the schedule. After a conversation with the project manager discussing SIPS, he agreed SIPS might demonstrate its advantage in construction planning when applied to the MEP fit-out to this project. "However, the help SIPS might bring along is limited."

The successful implementation of SIPS is attributed to proactive planning and sequencing of the assemblies and tasks, so there are no major conflicts which may hinder the flow of work. The SIPS planning will also work well if the projects are well planned and designed before the start of construction. If there were to be a lot of major change orders, it will be very difficult for the SIPS to be implemented and will only make the scheduling of the project more complicated. Unfortunately, there had been a good amount of change of orders on this project. Some of them are due to value engineering consideration; others are due to reaction plan to the weather incident. Also, the project start date was delayed due to the extension of decision making process by the District. With the delay of the start day, the preconstruction phase was cut short and didn't leave too much time for detailed schedule planning like SIPS. In this sense, the implementation of SIPS on this project has limited benefit and wasn't very realistic.

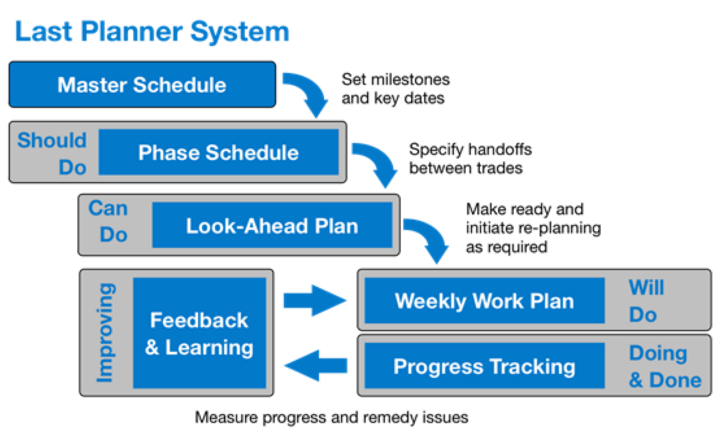
The learning curve will increase construction productivity, as long as the project is repetitive and continuous. However, due to the unforeseen project delay, the benefit of learning curve also didn't have too much value on the Twin Rivers Project. For example, the construction team will have to spend extra time on material staging and start working when the weather was constantly impacting the construction. This was not accounted in the preliminary research for the disadvantages of implementing SIPS on this project. Also the project only has two stories above ground. The extra time consumption and the addition of management team work load might exceed the benefit of SIPS, under the assumption that SIPS will not drastically improve project schedule given the scale.

Scenario 3: Last Planner System

Last Planner System is a very collaborative planning process developed by the Lean Construction Institute. This is a process that works backwards from the project's turnover date and the last activity in the sequence towards the current time and completion stage. The most current activity will be defined an activity further downstream in the activity sequence. This process requires very high commitment and promises from the project team, especially the management team. According to Vicoso Software's webinar on *An Overview of Lean Construction's Last Planner System*, "It's all about removing constraints so that the tasks are ready to start and 'flow smoothly' until completion."

The Last Planner System works particularly well for the Twin Rivers Project when the need for the completion of construction drove the tasks and activities. After the change of order decision on the sediment and erosion control was made, the project team immediately realized the risk of delay of project completion due to the additional work scope including the additional material lead time. As part of a reaction plan, the project team decided to have weekly meeting specially dedicated to update the progress on solving the problem. Possible schedule extension time was calculated and several meeting were held on discussion of overlapping the addition tasks with original activities with extra crews on board. The Last Planner System will work very effectively when not only the project manager, superintendent was involved, but the trade foremen and subcontractors were also actively involved and committed to outline the overall constraints of each task and solve the problem.

When all parties were committed to solve the problem, a new backward inducted project schedule can be developed with updated schedules of each trade. After that, phase schedule, look-ahead plans, and weekly work plans can be developed and followed-up. For the construction project of Twin Rivers School, the Last Planner System is the optimal method to solve the problem of addition of work scope due to unexpected weather condition.



Conclusion and Recommendation

This analysis has evaluated three scenarios of schedule improvement and cost saving to solve the problem of addition of work scope due to unexpected weather condition. The advantages and disadvantages of precautionary and reaction plan, SIPS method, and Lean construction practice of Last Planner System were studied. A summary of the pros and cons of each approach is provided in the following table. Based on estimate, there could have been a 98% of cost saving and 95% of schedule saving if precautionary plan was adopted. It is highly recommended that the precautionary and reaction plan should be adopted. In more detailed, it is recommended for the project team to install normal silt fence around the 2954' project perimeter as shown.

However, there the benefit of implementing SIPS was limited. The implementation of SIPS is not recommended based on four reasons:

- Insufficient planning time: limited preparation.
- Limited project scope: waste of management resource.
- Unforeseen schedule delay: lost value of learning curve.
- Relatively high value of change orders: complication of schedule planning.

The analysis also showed the implementation of Last Planner System will significantly benefit the project with the proactive collaboration of the entire project team to resolve the problem of the addition of work scope.

	Precautionary & Reaction Plan	SIPS	Last Planner
Advantages	Cost Saving Schedule Saving	Learning Curve Collaboration between Trades	Proactive Collaboration of Management Team
Disadvantages	Pre-construction Planning Time	Unforeseen Project Delay Change Orders Detailed Planning	Extra Planning Time
Implementation on Twin Rivers	Huge Cost and Schedule Saving	Unforeseen Project Delay Change Orders Lack of Planning	Proactive Collaboration of Management Team
Implementation on Public Educational Facility	Risks Control of Unexpected Impact on Project	Pre-fabrication Repetitive tasks Collaboration Sufficient Planning	Integration with Critical Path Method

Analysis 4: BIM Implementation

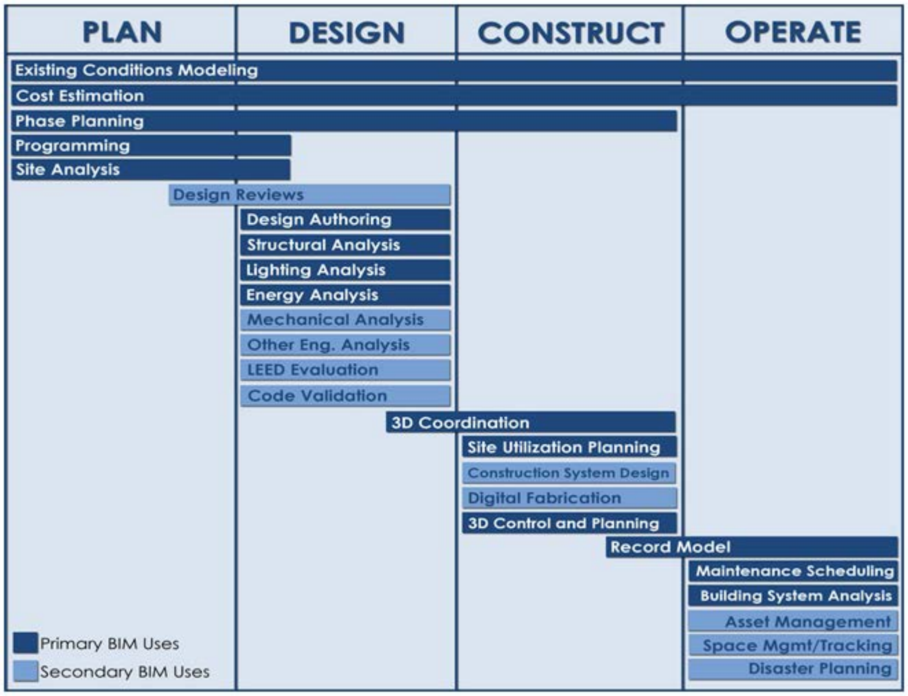
Problem Identification

Although the construction of Twin Rivers School is contracted to be an IPD project, the effort of the integrated practice was minimal in practice until the big addition of project scope forced the project team to sit together and resolve the problem. There was a lot of waste of time when the project team, the owner and the designer are trying to communicate and collaborate due the issue of the ownership of the model and information on Twin River's School Project. Stemming from those major design changes, much additional effort has been required to accommodate the schedule requirement. Although there have been cost savings from value engineering practices, additional project costs were involved from the change of designs. In addition, the owner, McKeesport School District, acts as another layer of approval needed for proposed every design change. Sometimes, multiple hearings would be called for discussion. Project schedule suffered from these problems. An updated project delivery method of implementing Building Information Modeling (BIM) was thus considered to improve the collaboration and reduce the amount of time and effort required to implement the design changes.

The implementation of BIM will also help the owner with operation and maintenance after the turn over. As summarized in the project introduction, the new Twin Rivers School is a high performance LEED building. The LEED systems including grey water capture system, geothermal heating and cooling system and the wind turbine system will all have their respective maintenance requirements. The implementation of BIM will greatly contribute to solve this problem.

Background Research

A background research was conducted after this problem was identified. The primary reasons caused the design changes and delay is the lack of cooperation between different trades. Also, there was no plan regarding site work under extreme weather conditions. The application of BIM could have benefited the overall project cost and schedule. Different BIM uses including clash detection will be considered and compared in terms of potential benefits and ability to increase project value by reducing schedule and reduce unexpected add of project value. The Pennsylvania State University BIM Execution Planning Guide will be used to facilitate the analysis. The possible benefit of reduction of operation and maintenance cost after the project's completion date will also be studied.



Analysis Components

Case studies of public educational facility using BIM will be researched. The analysis of BIM implementation will focus on information management systems on the project to improve the collaboration between different trades and subcontractors. Schedule improvement from BIM compared to the original schedule will be examined. Possible ways to standardize the information management system, ownership and access to the central model, drawings, as-built drawings will be considered. The cost difference and other benefits of using synchronization of programs and tools for information management will be studied. A project remediation plan should be prepared between different trades using BIM method as a reference for extreme site conditions.

Methodology

The following steps will be taken to successfully conduct this analysis:

- Collect information and documentation of current contractual agreements on the project
- Research two to three case studies demonstrating successful educational facility construction projects with BIM Implementation
- Interviews will be conducted with at least two members of the project team to specify potential risks and benefits of BIM approach. The interviews will be conducted concerning:

  - Have you personally had experience with BIM implementation towards the construction of education facility?
  - If yes, is that facility public or private?
  - Do you find the BIM implementation beneficial or risky?
  - What aspects of the BIM implementation do you find the most beneficial?
- Create a spreadsheet documenting advantages and disadvantages between conventional approach and BIM approach towards the construction project of educational facilities
- Study the two cases for possible cost savings in construction and in operation and maintenance after BIM implementation and use the result to study and analysis this project
- Develop a conclusion to specify if BIM implementation are recommended for this project

Case Study of BIM Usage in Public Schools

From the discussion at the PACE Conference, possible solutions for information management are to develop mutual agreement on the ownership of the drawings and model to minimize the inconvenience. This study is expected to show a result of improvement of project schedule and reduction of project cost for activities due to lack of coordination. The primary goal is to see increase of project delivery efficiency. Differences between the traditional construction method and building information model construction method will be thoroughly studies in terms of site planning, information management, as-built drawings construction system design and operation and maintenance plan.

Case 1: American Canyon High School, CA

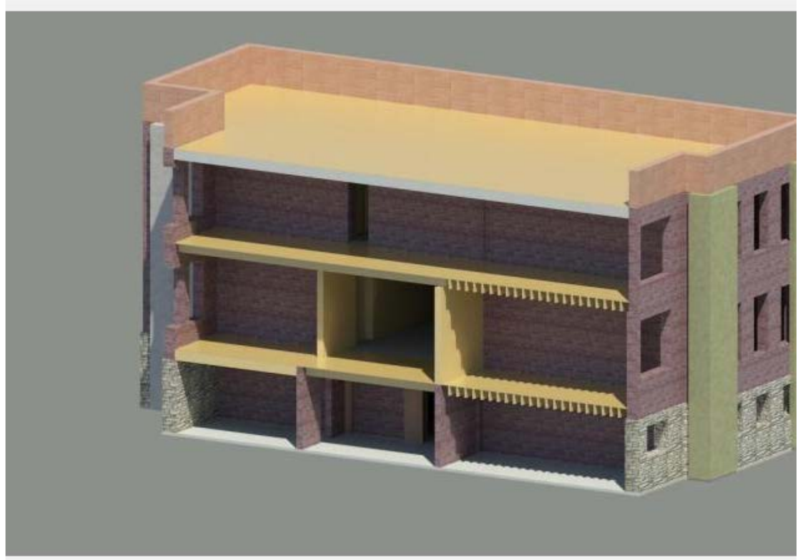
The Napa Valley Unified School District approved the new construction of a high-performance BIM school in 2006. Similar to the construction decision of McKeesport School, this decision was made based on the rapid increase of the city population that was under age 18. The biggest difference of the two projects is the scope. The campus is about 260,000 square foot and house about 2,200 students. The construction budget was approximately $160 million. The project includes 7 two-story buildings arrayed around a central courtyard including a football stadium, baseball and soccer fields and a 400 seat theater. The project construction was completed within 2 years. Similar to McKeesport School project, American Canyon School also incorporates a lot of green features into its design. Geothermal HVAC system and solar photovoltaic system were utilized. The school produces between 60% and 80% of the school’s energy needs. The athletic facilities and the theater are also open for use for the community.

BIM was used from conceptual design to clash detection and building performance testing. The BIM model was also used for the project's daylighting design. It aided in the erection of steel member for the project.

Case 2: Whatcom Middle School, WA

The construction of Whatcom Middle School in Bellingham, Washington is also a re-construction of a previous existing school on the same site. The difference is the previous Whatcom Middle School was destroyed by a devastating fire. After the fire, the school district, the insurer of the property, the design team and the contractor were pulled together by the AE firm Reid Middleton to develop an innovative building replacement strategy. Due to the fast-paced project schedule and the complex nature of the project, the Whatcom School Construction team elected to utilize BIM to design drawings and to clearly and visually communicate.

Color-coded material assignments



Building section

The major use of BIM on this project is during the construction phase. In order to capture the complex amalgam of the building, a three-dimensional BIM of the building with colored-coded material assignments were used. An extremely aggressive schedule was developed to allow classes to return to Whatcom Middle School. BIM's interactive and dynamic modeling characteristics also help with the project team to coordinate closely to resolve the problem of design updates. As shown in the figure, all building materials on the project were color-coded to facilitate the need of the field staff.

Interviews with Project Team

According to Integrated Project Delivery: A Guide by Contract Documents of AIA, "Integrated Project Delivery (IPD) leverages early contributions of knowledge and expertise through the utilization of new technologies, allowing all team members to better realize their highest potentials while expanding the value they provide throughout the project lifecycle." The project manager commented on the implementation of IPD on this project during an interview as, "Although the project is an IPD on paper, there are still a lot of barriers for all the construction documents, drawings and other materials to be shared without holding back or second thoughts. For examples, change orders, even the most minor ones, couldn't be updated on drawings directly from the construction team on site but had to go the architect first, then the engineer. "

The project manager also expressed his opinion on BIM: "Although I know BIM possibly will pay itself in the long run, it is not probably for this technology to be adopted for construction of public educational facilities yet." He expressed that his knowledge of BIM is very limited. During an interview with a project management member for a subcontractor, he even expressed that he has never heard of BIM or have idea what BIM can provide for a high performance project like Twin Rivers.

	BIM	IPD
Advantages	Fast-Paced Schedule	Share Critical Information
Disadvantages	Limited Knowledge	Lack of Actual Coordination
Implementation on Twin Rivers	Fast-Paced Schedule Develop O&M Schedule	Enhance Collaboration
Implementation on Public Educational Facility	Meet Different Project Uses	Improve Project Schedule

Based on the case studies and the interviews, the advantages and disadvantages of the BIM and IPD project delivery are summarized in the table above. In general, the implementation of BIM and IPD on either Twin Rivers or the construction of other public schools has more pros than cons.

BIM Project Execution Plan

To successfully implement BIM on Twin Rivers School Project, a BIM Execution Plan is proposed. This Plan defines uses for BIM on the project including design authoring, cost estimating, and design coordination, along with a plan of BIM execution throughout the project lifecycle.

Owner Involvement Breakdown for Project Phases

Phase	Start Date	End Date	Owner Involvement
Project Planning Phase	3/24/2009	12/9/2009	Y
Schematic Design Phase	12/9/2009	6/1/2010	Y
Design Development Phase	3/1/2010	9/6/2010	Y
Construction Documents Phase	4/23/2010	5/5/2011	Y
Bidding Phase	5/25/2010	8/225/11	Y
Construction Administration Phase	7/8/2010	3/24/2014	Y
Construction Phase	5/3/2012	12/13/2013	Y
Substantial Completion	12/13/2013	12/13/2013	Y
Project Close-out	13/13/2013	3/24/2014	Y

BIM Goals

Priority (1-5) 1 - Very Important	Goal Description/ Value added objectives	Potential BIM Uses
1	Accurate 3D Record Model for Project Team	Record Model, 3D Design/MEP Coordination
1	Increase Effectiveness of Design	Design Authoring, Design Reviews
2	Increase Field Productivity	Design Reviews, 3D /MEP Coordination
3	Increase effectiveness of Sustainable Goals	Engineering Analysis, LEED Evaluation
4	Lay Out Precautionary Reaction Plan for Unexpected Impacts	Design Reviews, Constructability Analysis
5	Preparation for Operation and Maintainance	Record Model, Assest Management

BIM Uses Analysis

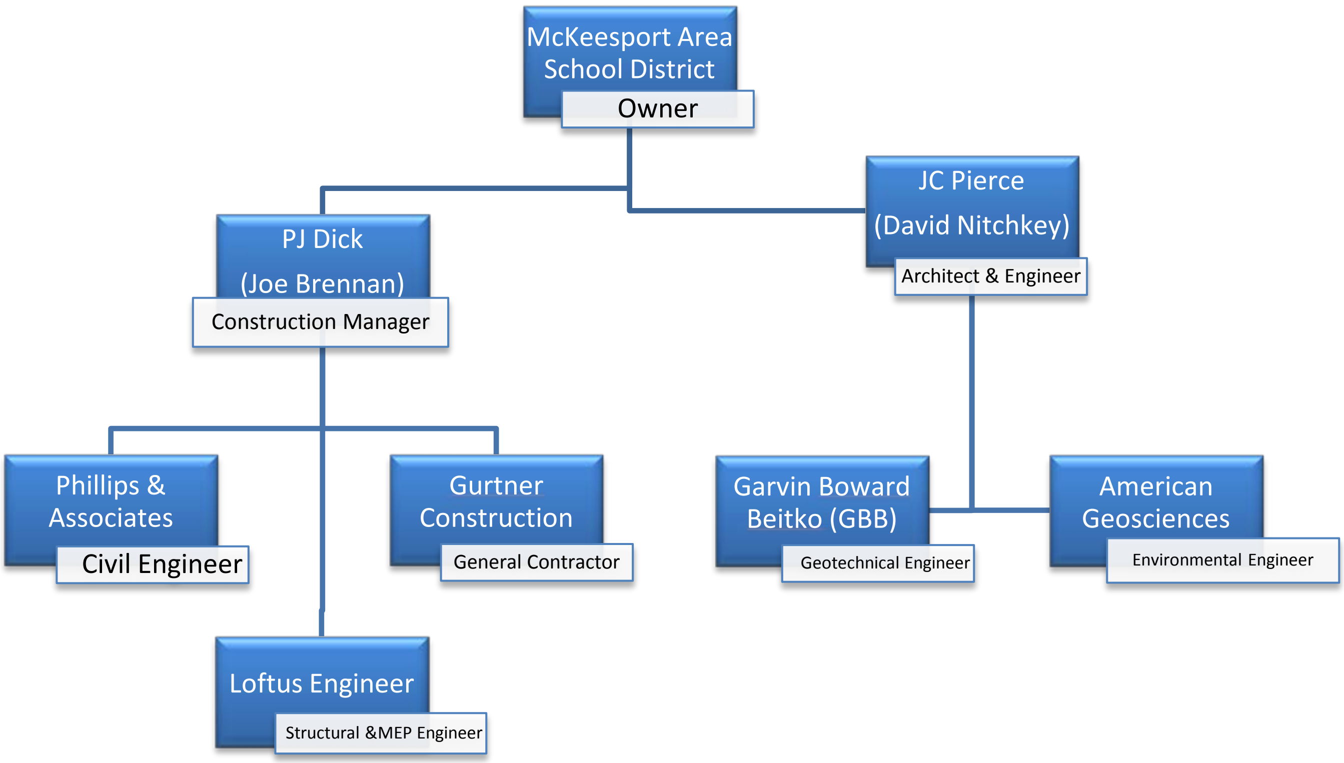
BIM USE Selection						
		Responsible Parties				
BIM Uses per Phase	Desire to Implement (Y/N/Maybe)	Lead Team Member	Addt'l Team Members	Experience Level (1-5) 5=High	Process Map Available?	Comments
Operations Phase						
Record Model	Y	Contractor		2	N	
			MEP Subs	1	N	Responsible for As-Built Model / Info
			A/E	2	N	Provide input on information required
Building System Analysis	Maybe	Contractor		3	N	
Building Maintenance Scheduling	Y	Owner		4		
Construction Phase						
Site Utilization Planning	Maybe	Contractor		3	N	Staging, Temp Utilities, Crane Info
			MEP Subs	2	N	Underground Modeling / Information
3D Control and Planning	N					
3D Design / MEP Coordination	Maybe	Contractor	MEP Subs	4	Y	See Project Map
Design Phase						
Design Authoring	Y	Arch		4	N	Level of Detail Needs Defined
Engineering Analysis	Maybe	Contractor		2		
Planning Phase						

Programming	Maybe	Arch		2	N	Software Requirement
			Owner			Initial Input Required
Site Analysis	Y	Arch	Owner	3		Schedule and Software - see Map
Multi-Phase						
Phase Planning (4D Modeling)	N					
Cost Estimation	Y	Contractor		3	N	Scope Needs Defined
			Arch	3	N	Level of Detail Needs Defined
Existing Conditions Modeling	N					
For detaild regarding each BIM use, reference Appendix C or the BIM Wiki site at : http://bimex.wikispaces.com/						

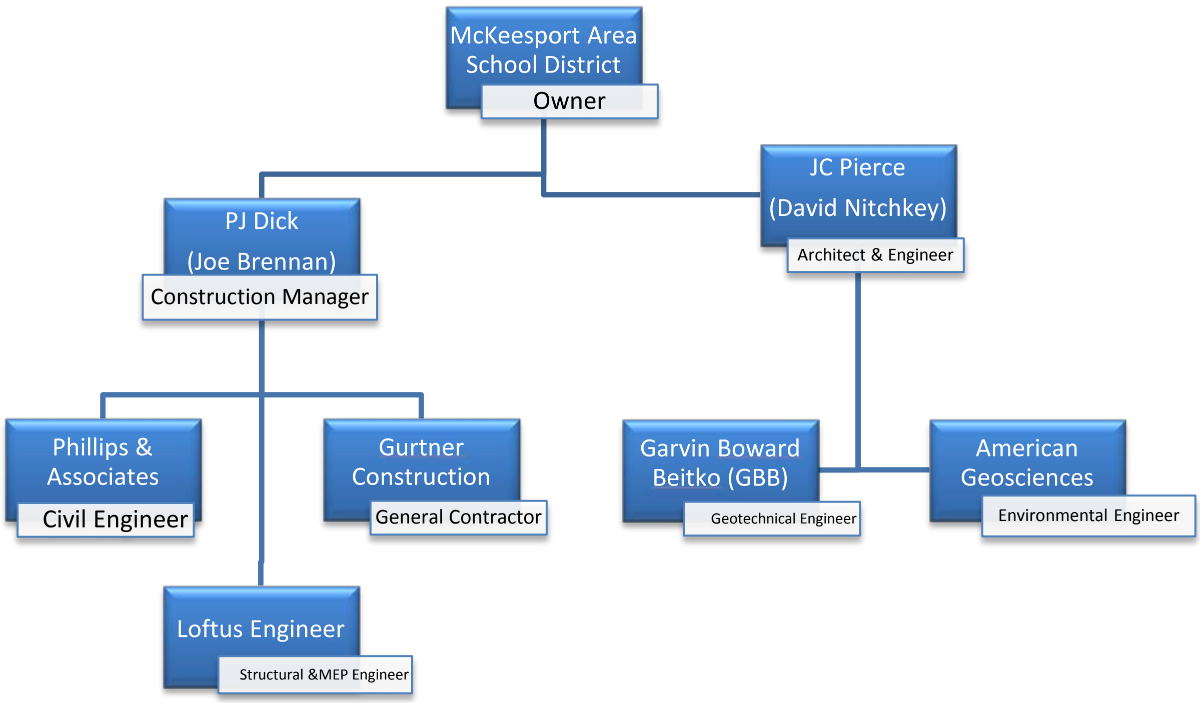
Conclusion and Recommendation

The study of BIM execution plan should that a BIM plan tailed to the construction of Twin Rivers School will have a lot benefits. BIM will not only help the project construction team with the on-time project turnover, but will also help the owner with the operation and maintenance after the project is put in use. Thus, the implementation of BIM is highly recommended.

Appendix A: Project Organization Chart


McKeesport Area School District
Owner
JC Pierce
(David Nitchkey)
Architect & Engineer
PJ Dick
(Joe Brennan)
Construction Manager
Phillips & Associates
Civil Engineer
Gurtner Construction
General Contractor
Garvin Boward Beitko (GBB)
Geotechnical Engineer
American Geosciences
Environmental Engineer
Loftus Engineer
Structural &MEP Engineer

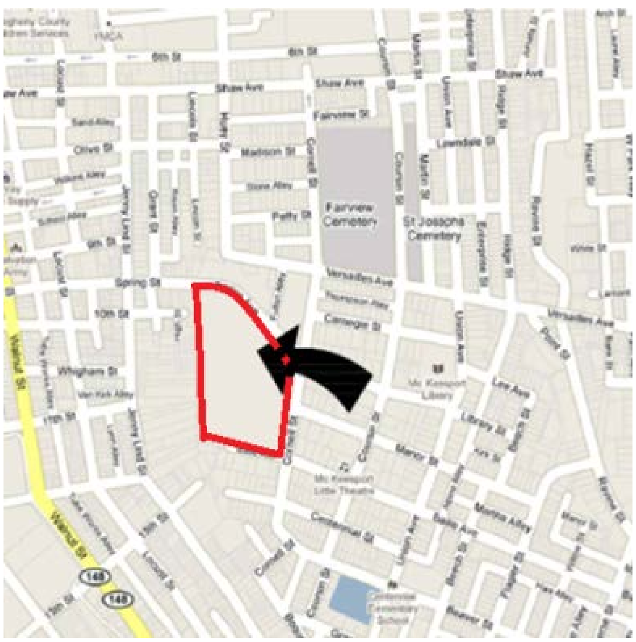
Appendix B: Project Staffing Plan


McKeesport Area School District
Owner
JC Pierce
(David Nitchkey)
Architect & Engineer
PJ Dick
(Joe Brennan)
Construction Manager
Phillips & Associates
Civil Engineer
Gurtner Construction
General Contractor
Garvin Boward Beitko (GBB)
Geotechnical Engineer
American Geosciences
Environmental Engineer
Loftus Engineer
Structural &MEP Engineer

Appendix C: Site Map and Property Line


AREA OF RAZED SCHOOL BUILDING AND FOUNDATIONS
BAILEY AVENUE 40' RIGHT OF WAY
CORNELL STREET 40' RIGHT OF WAY
SPRING AVENUE 40' RIGHT OF WAY
FULTON ALLEY

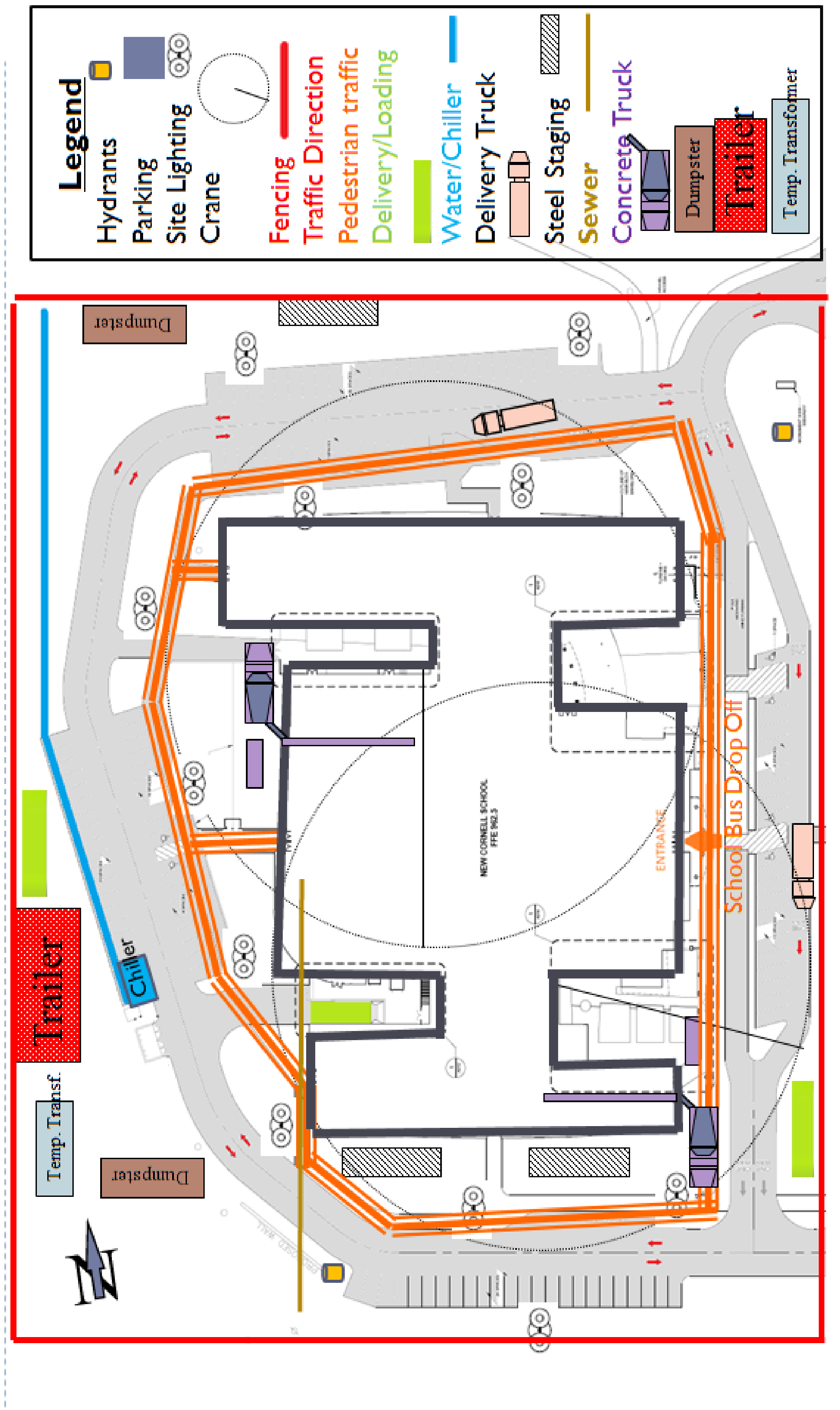
North


Fairview Cemetery
St Josephs Cemetery
Walnut St
148

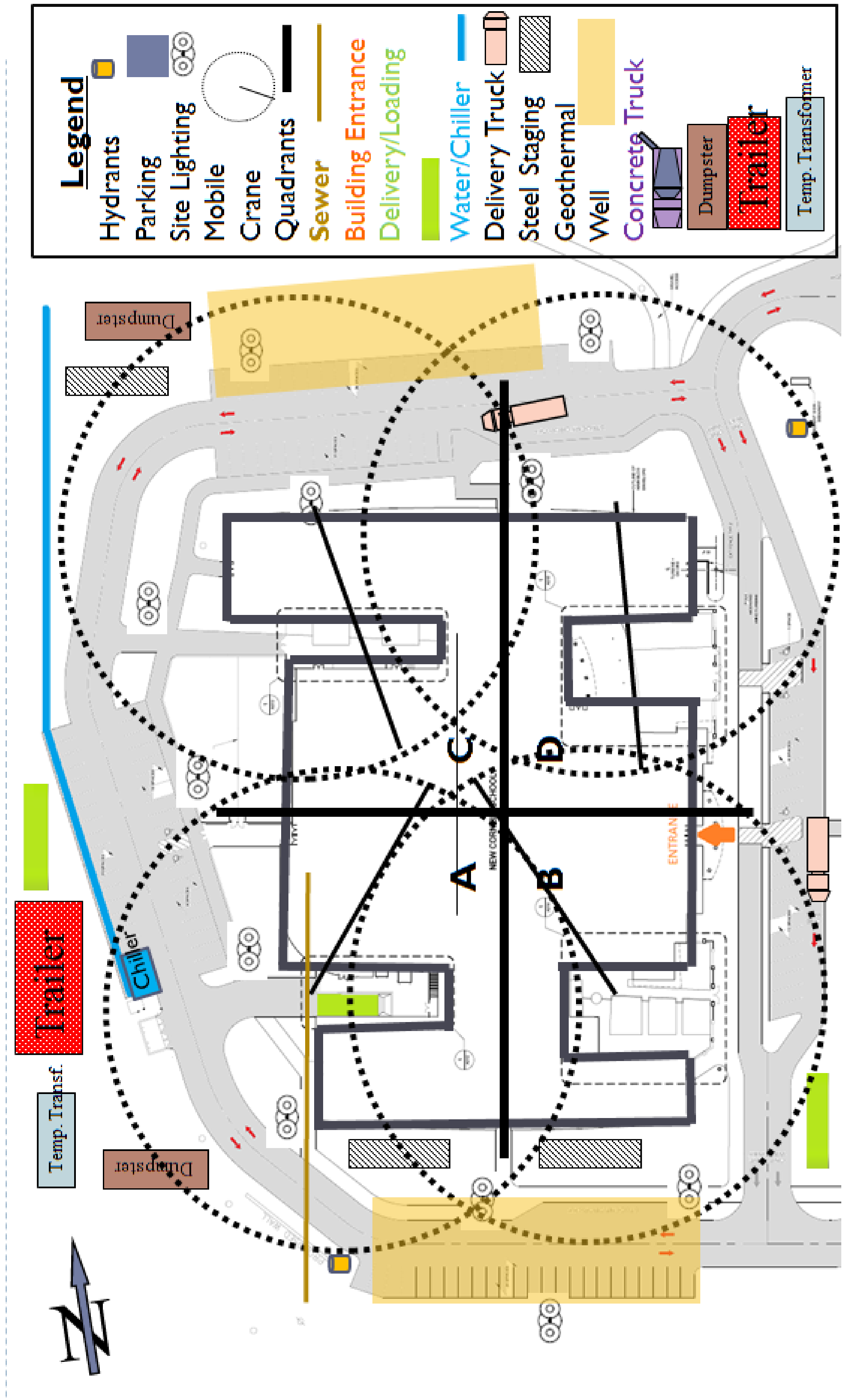
North

Appendix D: Site Logistics and Layout Plan

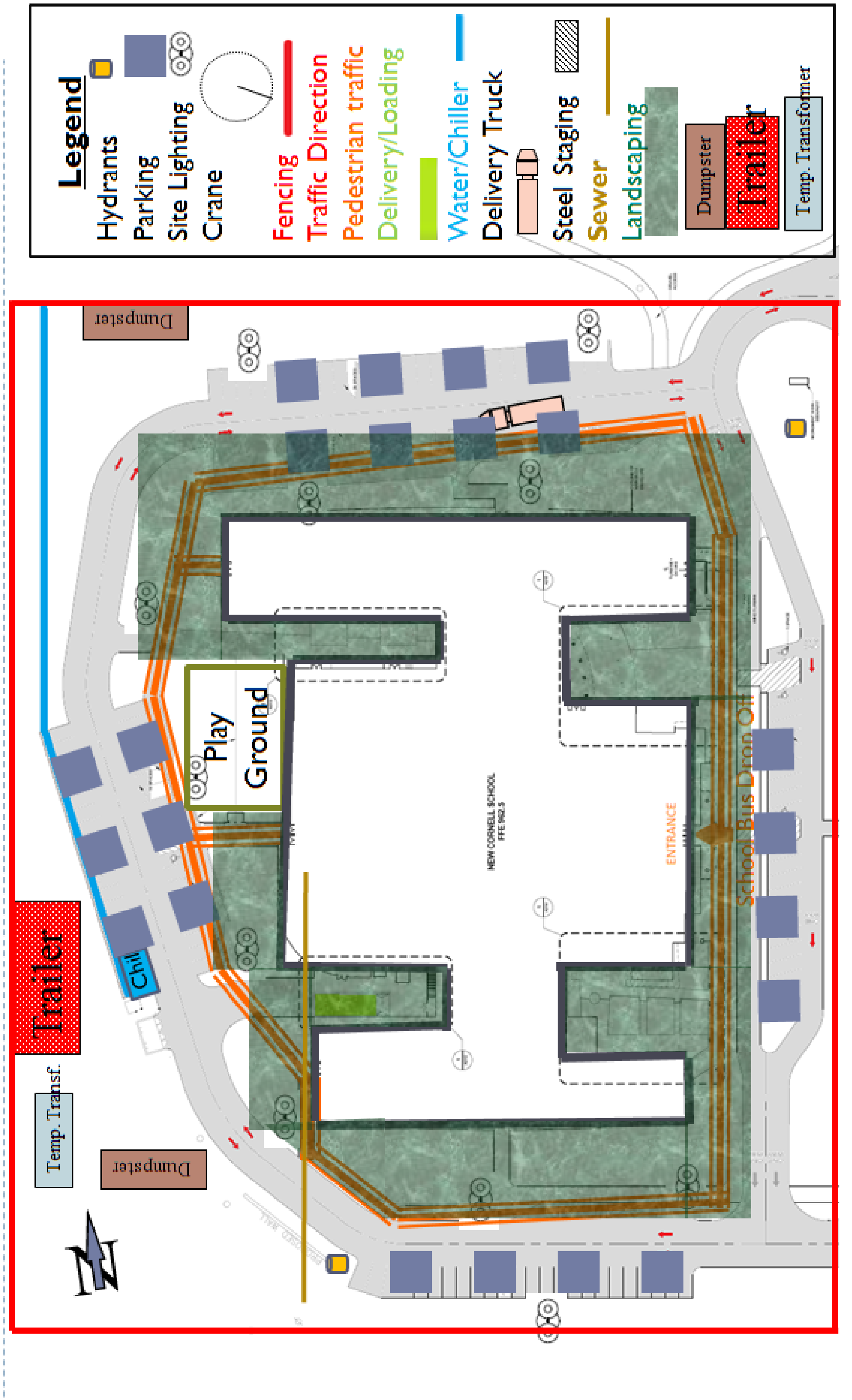
Site Traffic Plan



Steel Erection Plan



Finish Phase Site Plan



Appendix E: Original LEED Scorecard

LEED 2009 for Schools New Construction and Major Renovations

McKeesport Elementary/Intermediate School Project

McKeesport, PA

Y	?	N			Possible Points
19	2			**Sustainable Sites**	Possible Points: 24
Y	?	N			
Y			Prereq 1	Construction Activity Pollution Prevention	
Y			Prereq 2	Environmental Site Assessment	
1			Credit 1	Site Selection	1
4			Credit 2	Development Density and Community Connectivity	4
		N	Credit 3	Brownfield Redevelopment	1
4			Credit 4.1	Alternative Transportation—Public Transportation Access	4
1			Credit 4.2	Alternative Transportation—Bicycle Storage and Changing Rooms	1
	1		Credit 4.3	Alternative Transportation—Low-Emitting and Fuel-Efficient Vehi	2
1	1		Credit 4.4	Alternative Transportation—Parking Capacity	2
1			Credit 5.1	Site Development—Protect or Restore Habitat	1
1			Credit 5.2	Site Development—Maximize Open Space	1
1			Credit 6.1	Stormwater Design—Quantity Control	1
		N	Credit 6.2	Stormwater Design—Quality Control	1
1			Credit 7.1	Heat Island Effect—Non-roof	1
1			Credit 7.2	Heat Island Effect—Roof	1
1			Credit 8	Light Pollution Reduction	1
1			Credit 9	Site Master Plan	1
1			Credit 10	Joint Use of Facilities	1
9	1			**Water Efficiency**	Possible Points: 11
Y			Prereq 1	Water Use Reduction—20% Reduction	
4			Credit 1	Water Efficient Landscaping	2 to 4
2			Credit 2	Innovative Wastewater Technologies	2
3	1		Credit 3	Water Use Reduction	2 to 4
		N	Credit 3	Process Water Use Reduction	1
10	6			**Energy and Atmosphere**	Possible Points: 33
Y			Prereq 1	Fundamental Commissioning of Building Energy Systems	
Y			Prereq 2	Minimum Energy Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
8	4		Credit 1	Optimize Energy Performance	1 to 19
		N	Credit 2	On-Site Renewable Energy	1 to 7
2			Credit 3	Enhanced Commissioning	2
		N	Credit 4	Enhanced Refrigerant Management	1
		N	Credit 5	Measurement and Verification	2
	2		Credit 6	Green Power	2

Y	?	N	Materials and Resources		Possible Points: 13
8					
Y			Prereq 1	Storage and Collection of Recyclables	
		N	Credit 1.1	Building Reuse—Maintain Existing Walls, Floors, and Roof	1 to 2
		N	Credit 1.2	Building Reuse—Maintain 50% of Interior Non-Structural Elements	1
2			Credit 2	Construction Waste Management	1 to 2

Materials and Resources, Continued

Y	?	N			
		N	Credit 3	Materials Reuse	1 to 2
2			Credit 4	Recycled Content	1 to 2
2			Credit 5	Regional Materials	1 to 2
1			Credit 6	Rapidly Renewable Materials	1
1			Credit 7	Certified Wood	1

16	1		Indoor Environmental Quality		Possible Points: 19
Y			Prereq 1	Minimum Indoor Air Quality Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
Y			Prereq 3	Minimum Acoustical Performance	
1			Credit 1	Outdoor Air Delivery Monitoring	1
1			Credit 2	Increased Ventilation	1
1			Credit 3.1	Construction IAQ Management Plan—During Construction	1
1			Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1
3	1		Credit 4	Low-Emitting Materials	1 to 4
1			Credit 5	Indoor Chemical and Pollutant Source Control	1
1			Credit 6.1	Controllability of Systems—Lighting	1
1			Credit 6.2	Controllability of Systems—Thermal Comfort	1
1			Credit 7.1	Thermal Comfort—Design	1
1			Credit 7.2	Thermal Comfort—Verification	1
1			Credit 8.1	Daylight and Views—Daylight	1 to 3
1			Credit 8.2	Daylight and Views—Views	1
1			Credit 9	Enhanced Acoustical Performance	1
1			Credit 10	Mold Prevention	1

2	4		Innovation and Design Process		Possible Points: 6
	1		Credit 1.1	Innovation in Design: Specific Title	1
	1		Credit 1.2	Innovation in Design: Specific Title	1
	1		Credit 1.3	Innovation in Design: Specific Title	1
	1		Credit 1.4	Innovation in Design: Specific Title	1
1			Credit 2	LEED Accredited Professional	1
1			Credit 3	The School as a Teaching Tool	1

2			**Regional Priority Credits**	Possible Points: **4**
1			Credit 1.1 Regional Priority: Specific Credit	1
1			Credit 1.2 Regional Priority: Specific Credit	1
		N	Credit 1.3 Regional Priority: Specific Credit	1
		N	Credit 1.4 Regional Priority: Specific Credit	1
66	14		**Total**	Possible Points: **110**

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

Appendix F: General Condition Estimate

Management & Staffing				
Description	Unit	Quantity	Unit Rate	Cost
Project Executive	wk	35	$ 2,320.00	$ 81,200.00
Project Manager A	wk	74	$ 1,950.00	$ 144,300.00
Project Manager B	wk	45	$ 1,770.00	$ 79,650.00
Superintendent	wk	70	$ 1,640.00	$ 114,800.00
Project Administrator	wk	75	$ 1,480.00	$ 111,000.00
Accountant	wk	30	$ 1,250.00	$ 37,500.00
LEED Consultant	wk	40	$ 2,100.00	$ 84,000.00
Subtotal				$ 663,200.00

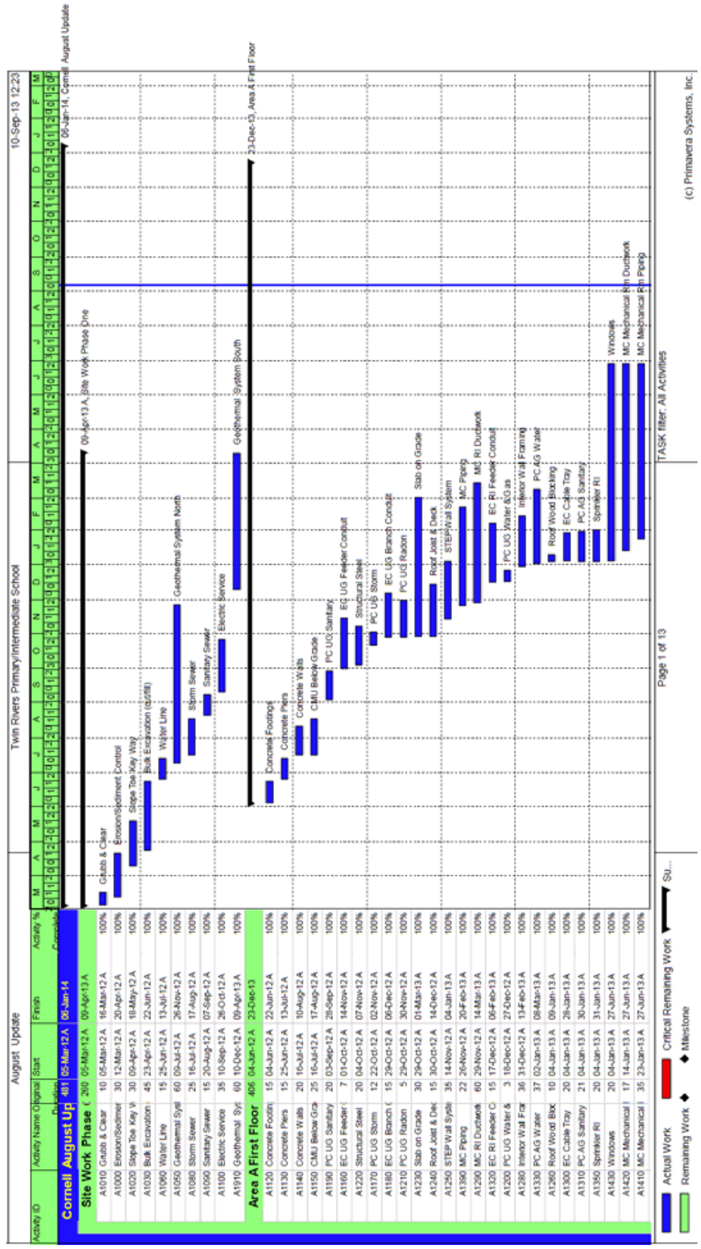
Utilities				
Description	Unit	Quantity	Unit Rate	Cost
Fencing	lf	250	$ 18.00	$ 4,500.00
Temp Water	ls	1	$ 1,200.00	$ 1,200.00
Temp Power	m	60	$ 90.00	$ 5,400.00
Temp Toilets	m	78	$ 60.00	$ 4,680.00
Mobilization	m	40	$ 100.00	$ 4,000.00
Dumpster	m	72	$ 805.56	$ 58,000.00
Subtotal				$ 78,000.00

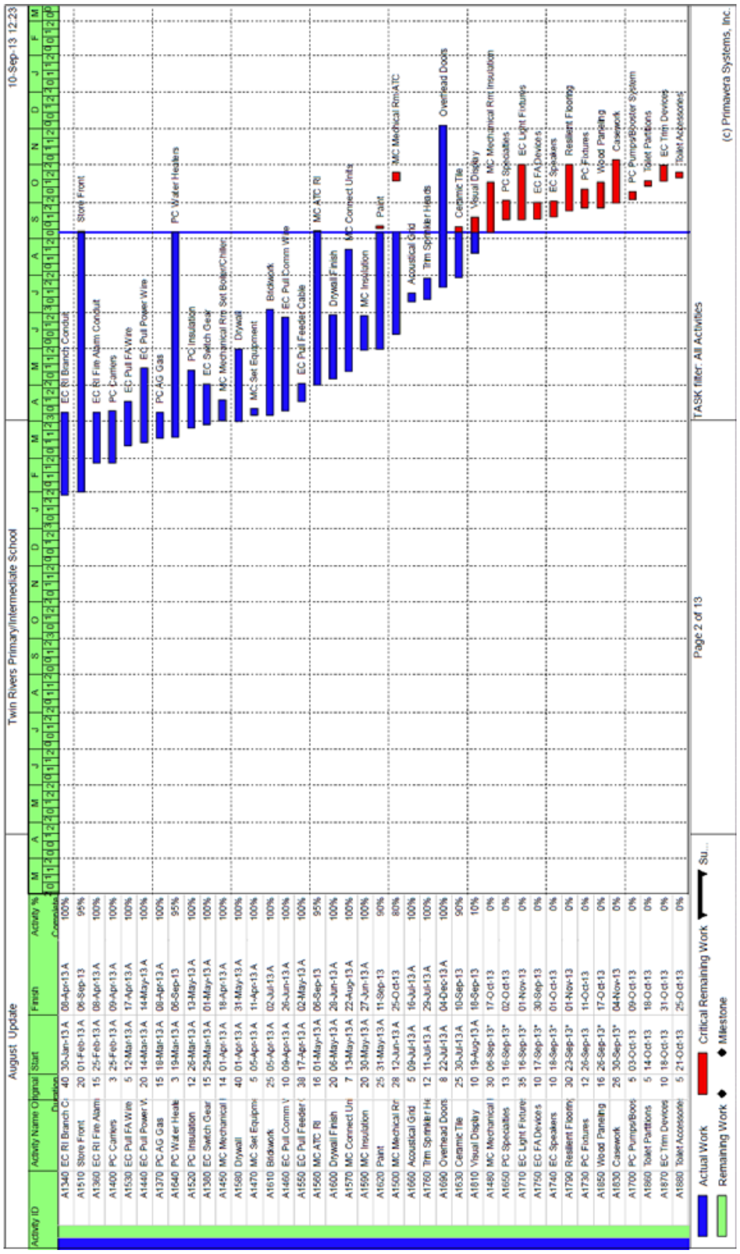
Equipment & Facilities				
Description	Unit	Quantity	Unit Rate	Cost
Trailer Set-up	ls	2	$ 2,000.00	$ 4,000.00
Trailer Removal	ls	2	$ 2,000.00	$ 4,000.00
Trailer	m	60	$ 1,500.00	$ 90,000.00
Storage Trailer	m	60	$ 440.00	$ 26,400.00
Office Equipment	m	74	$ 200.00	$ 14,800.00
Fire Extinguisher	m	78	$ 150.00	$ 11,700.00
E&S Control	m	74	$ 878.38	$ 65,000.00
Subtotal				$ 215,000.00

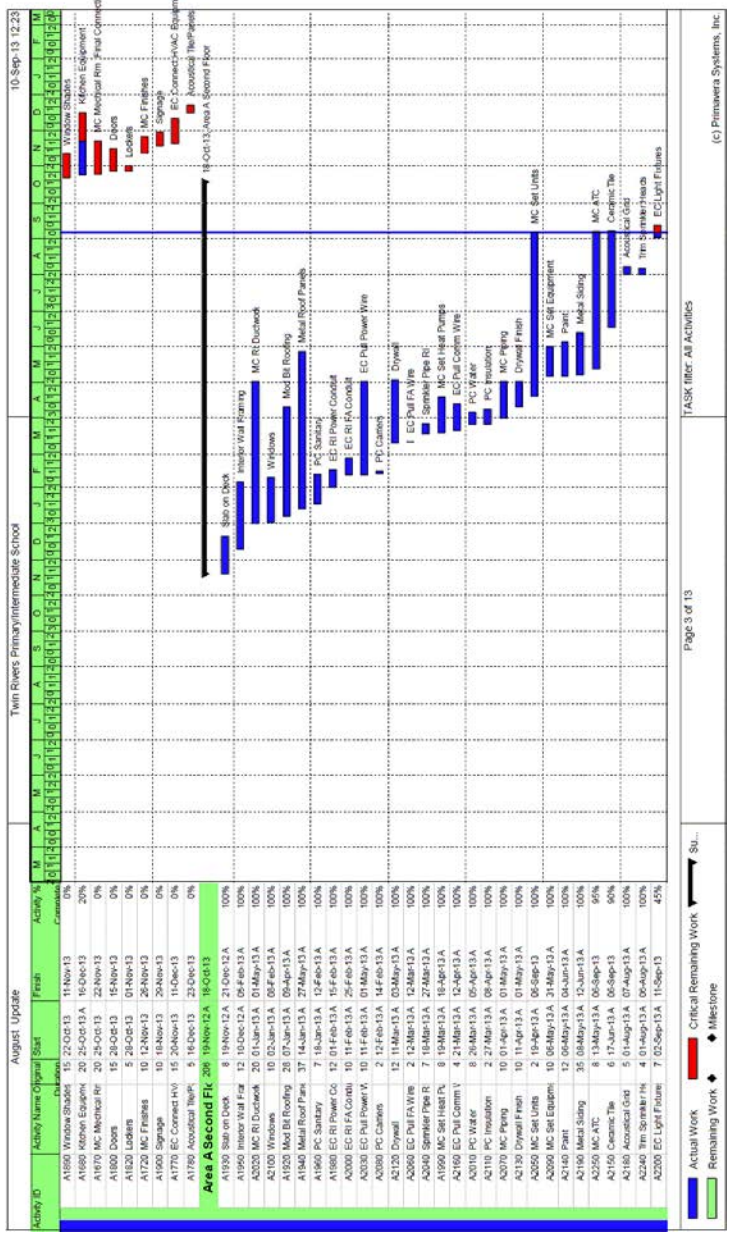
Insurance, Permits & Bonds				
Description	Unit	Quantity	Unit Rate	Cost
Permits	ls	1	$ 290,000.00	$ 290,000.00
Bonds	ls	1	$ 270,000.00	$ 270,000.00
Subtotal				$ 560,000.00

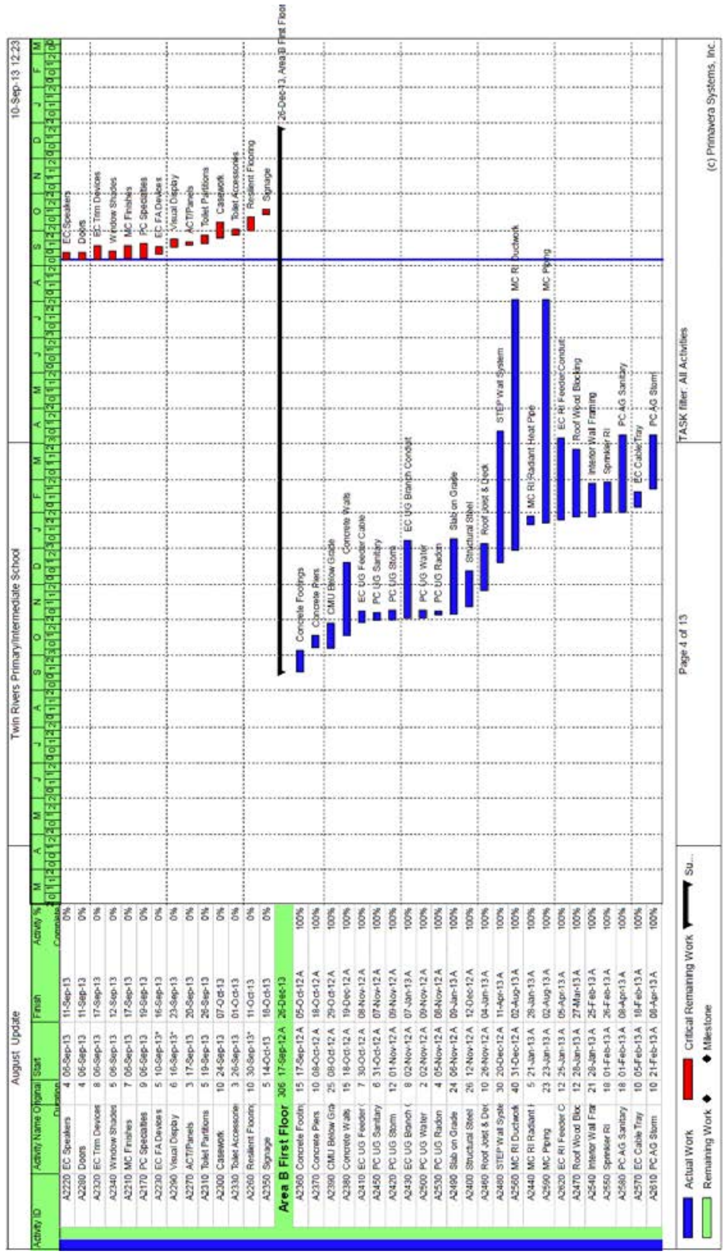
Subtotal	$ 1,516,200.00
Subtotal Per Week	$ 39,900.00

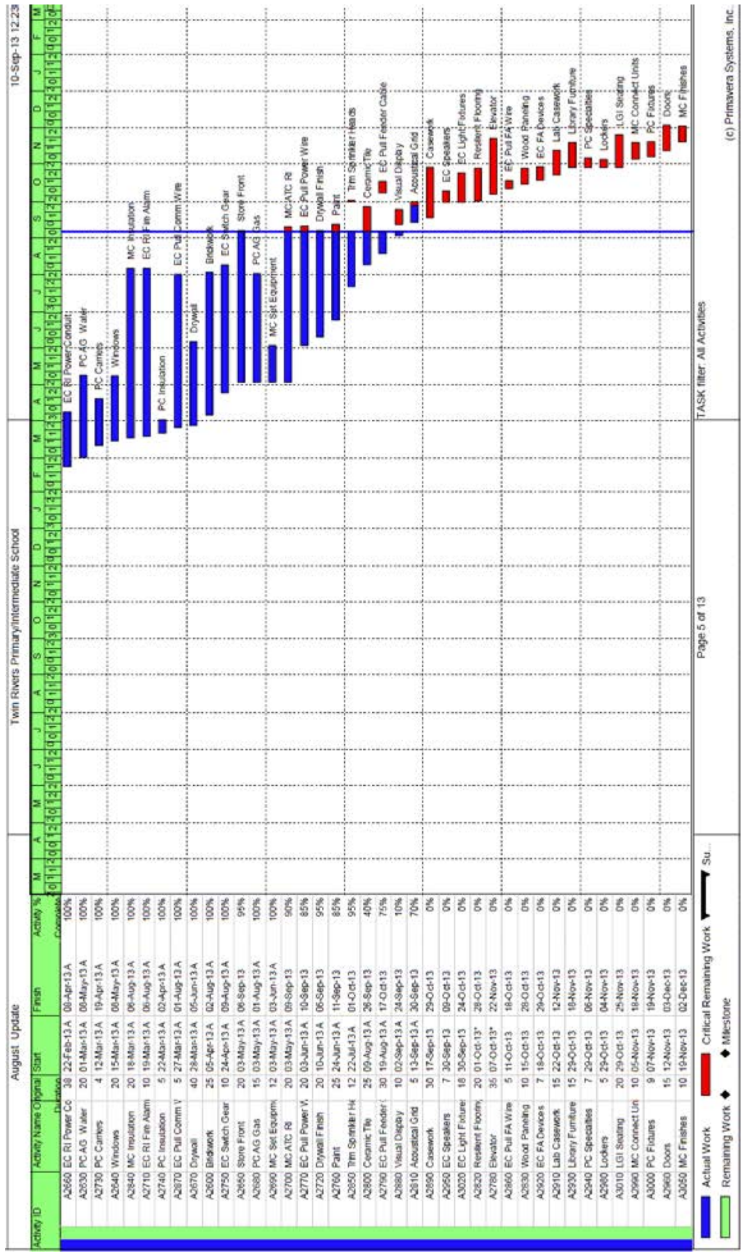
Appendix G: Project Schedule

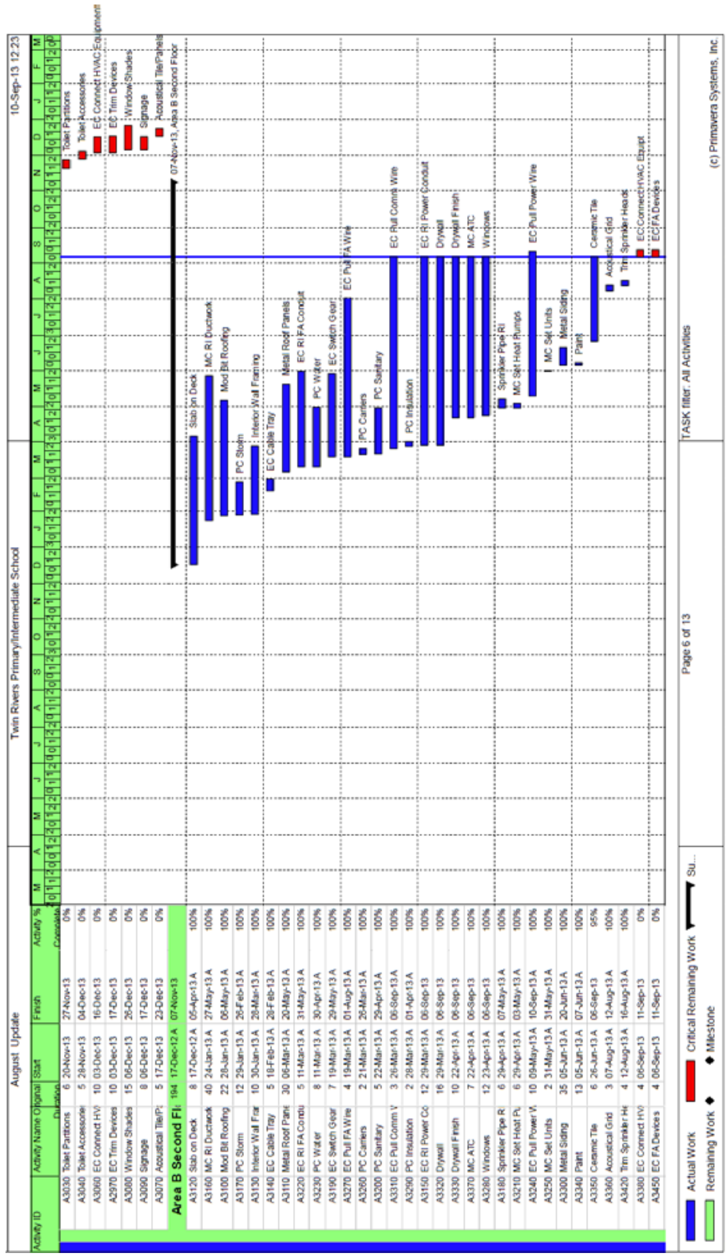



August Update
Twin Rivers Primary/Intermediate School
10-Sep-13 12:23
Activity ID
Activity Name
Original Duration
Start
Finish
Activity % Complete
A1340 EC RI Branch C 40 30-Jan-13 A 08-Apr-13 A 100%
A1510 Store Front 20 01-Feb-13 A 06-Sep-13 95%
A1360 EC RI Fire Alarm 15 25-Feb-13 A 08-Apr-13 A 100%
A1400 PC Carriers 3 25-Feb-13 A 09-Apr-13 A 100%
A1530 EC Pull FA Wire 5 12-Mar-13 A 17-Apr-13 A 100%
A1440 EC Pull Power W 20 14-Mar-13 A 14-May-13 A 100%
A1370 PC AG Gas 15 18-Mar-13 A 08-Apr-13 A 100%
A1640 PC Water Heate 3 19-Mar-13 A 06-Sep-13 95%
A1520 PC Insulation 12 26-Mar-13 A 13-May-13 A 100%
A1380 EC Switch Gear 15 29-Mar-13 A 01-May-13 A 100%
A1450 MC Mechanical 14 01-Apr-13 A 18-Apr-13 A 100%
A1580 Drywall 40 01-Apr-13 A 31-May-13 A 100%
A1470 MC Set Equipme 5 05-Apr-13 A 11-Apr-13 A 100%
A1610 Brickwork 25 05-Apr-13 A 02-Jul-13 A 100%
A1460 EC Pull Comm V 10 09-Apr-13 A 26-Jun-13 A 100%
A1550 EC Pull Feeder 38 17-Apr-13 A 02-May-13 A 100%
A1560 MC ATC RI 16 01-May-13 A 06-Sep-13 95%
A1600 Drywall Finish 20 06-May-13 A 28-Jun-13 A 100%
A1570 MC Connect Un 7 13-May-13 A 22-Aug-13 A 100%
A1590 MC Insulation 20 30-May-13 A 27-Jun-13 A 100%
A1620 Paint 25 31-May-13 A 11-Sep-13 90%
A1500 MC Mechical Rr 28 12-Jun-13 A 25-Oct-13 80%
A1660 Acoustical Grid 5 09-Jul-13 A 16-Jul-13 A 100%
A1760 Trim Sprinkler He 12 11-Jul-13 A 29-Jul-13 A 100%
A1690 Overhead Doors 8 22-Jul-13 A 04-Dec-13 A 100%
A1630 Ceramic Tile 25 30-Jul-13 A 10-Sep-13 90%
A1810 Visual Display 10 19-Aug-13 A 18-Sep-13 10%
A1480 MC Mechanical 30 06-Sep-13* 17-Oct-13 0%
A1650 PC Specialties 13 16-Sep-13* 02-Oct-13 0%
A1710 EC Light Fixture 35 16-Sep-13* 01-Nov-13 0%
A1750 EC FA Devices 10 17-Sep-13* 30-Sep-13 0%
A1740 EC Speakers 10 18-Sep-13* 01-Oct-13 0%
A1790 Resilient Flooring 30 23-Sep-13* 01-Nov-13 0%
A1730 PC Fixtures 12 26-Sep-13 11-Oct-13 0%
A1850 Wood Paneling 16 26-Sep-13* 17-Oct-13 0%
A1830 Casework 26 30-Sep-13* 04-Nov-13 0%
A1700 PC Pumps/Boos 5 03-Oct-13 09-Oct-13 0%
A1860 Toilet Partitions 5 14-Oct-13 18-Oct-13 0%
A1870 EC Trim Devices 10 18-Oct-13 31-Oct-13 0%
A1880 Toilet Accessorie 5 21-Oct-13 25-Oct-13 0%
EC RI Branch Conduit
Store Front
EC RI Fire Alarm Conduit
PC Carriers
EC Pull FA Wire
EC Pull Power Wire
PC AG Gas
PC Water Heaters
PC Insulation
EC Switch Gear
MC Mechanical Rm Set Boiler/Chiller
Drywall
MC Set Equipment
Brickwork
EC Pull Comm Wire
EC Pull Feeder Cable
MC ATC RI
Drywall Finish
MC Connect Units
MC Insulation
Paint
MC Mechical Rm ATC
Acoustical Grid
Trim Sprinkler Heads
Overhead Doors
Ceramic Tile
Visual Display
MC Mechanical Rm Insulation
PC Specialties
EC Light Fixtures
EC FA Devices
EC Speakers
Resilient Flooring
PC Fixtures
Wood Paneling
Casework
PC Pumps/Booster System
Toilet Partitions
EC Trim Devices
Toilet Accessories
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Summary
Page 2 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.






Twin Rivers Primary/Intermediate School
August Update
10-Sep-13 12:23
Page 5 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.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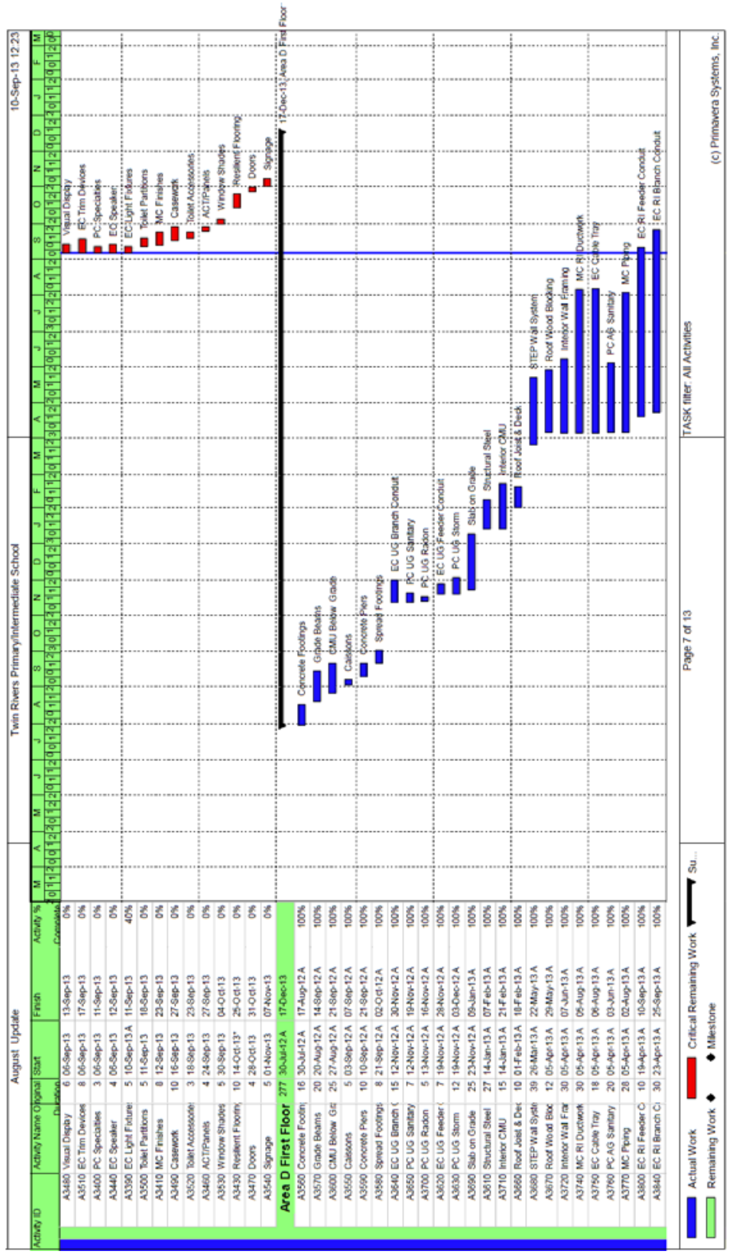
August Update
10-Sep-13 12:23
Page 6 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.


Twin Rivers Primary/Intermediate School
August Update
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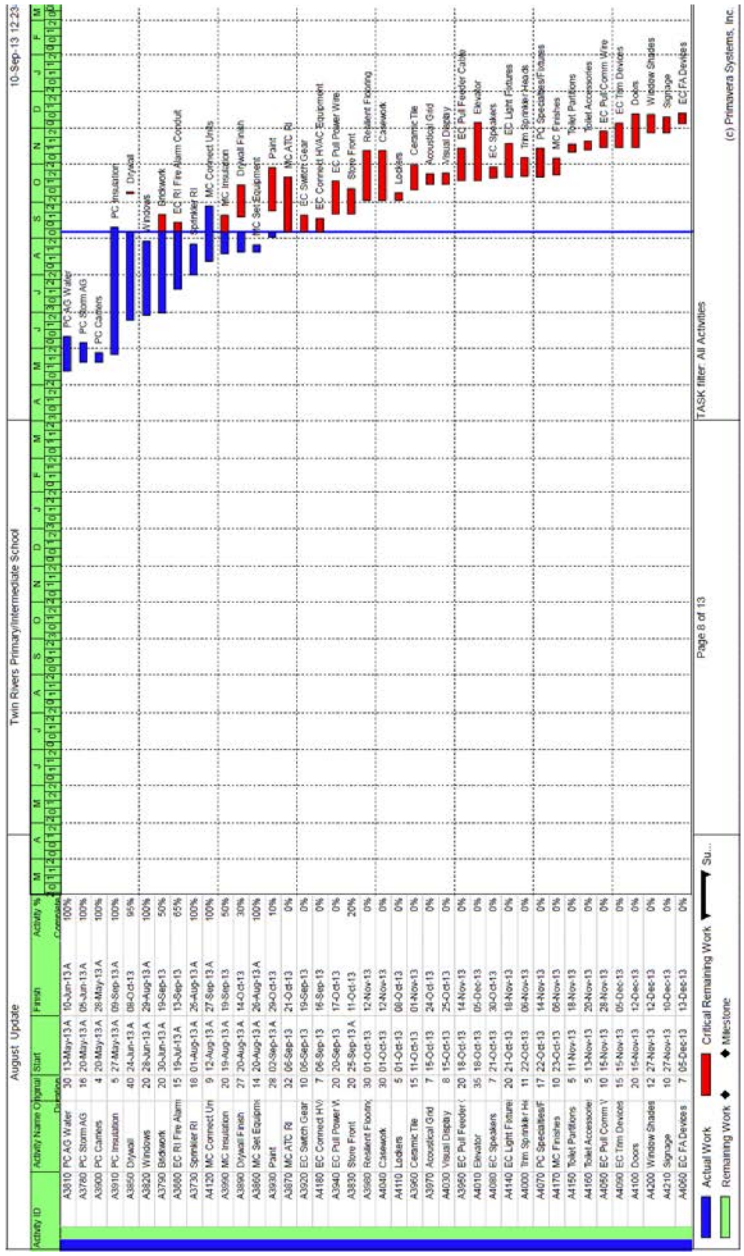
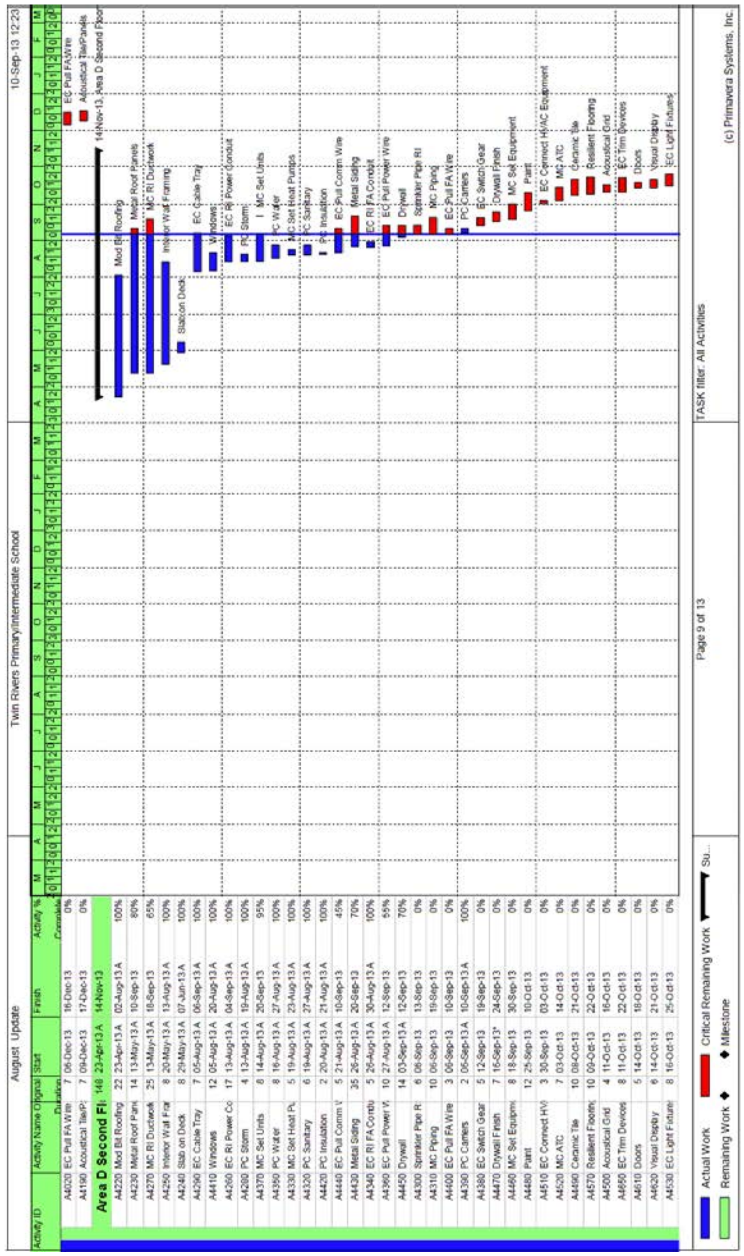
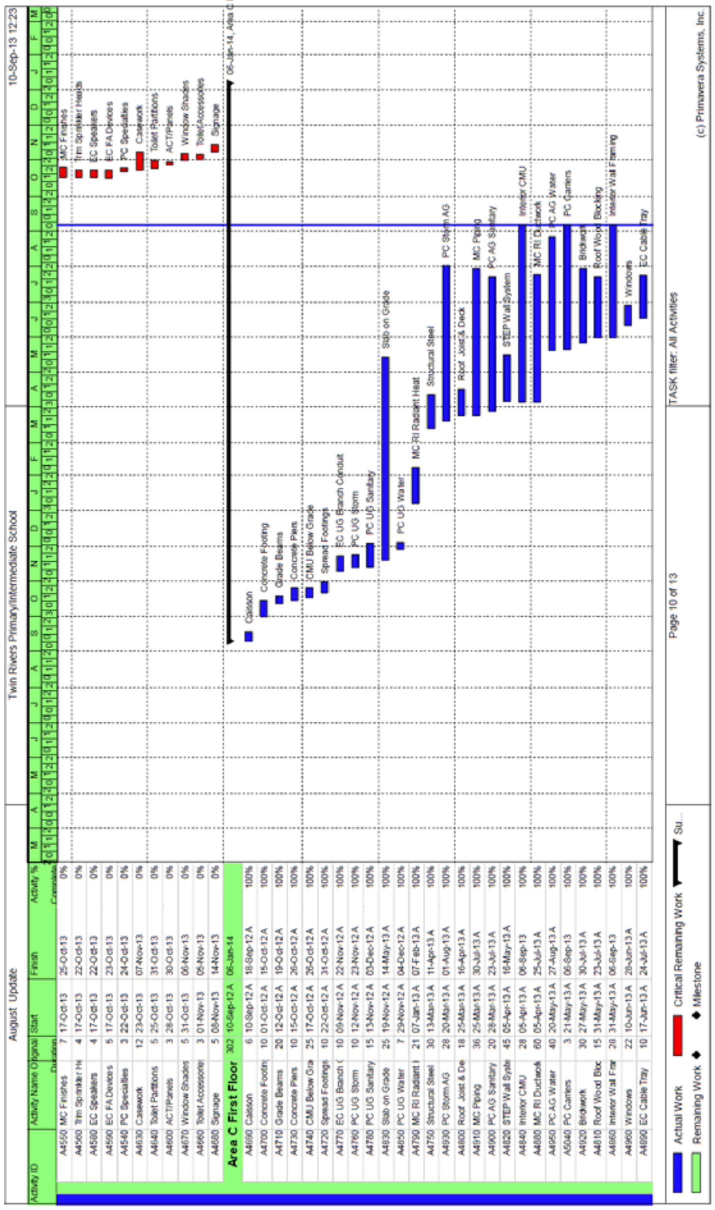
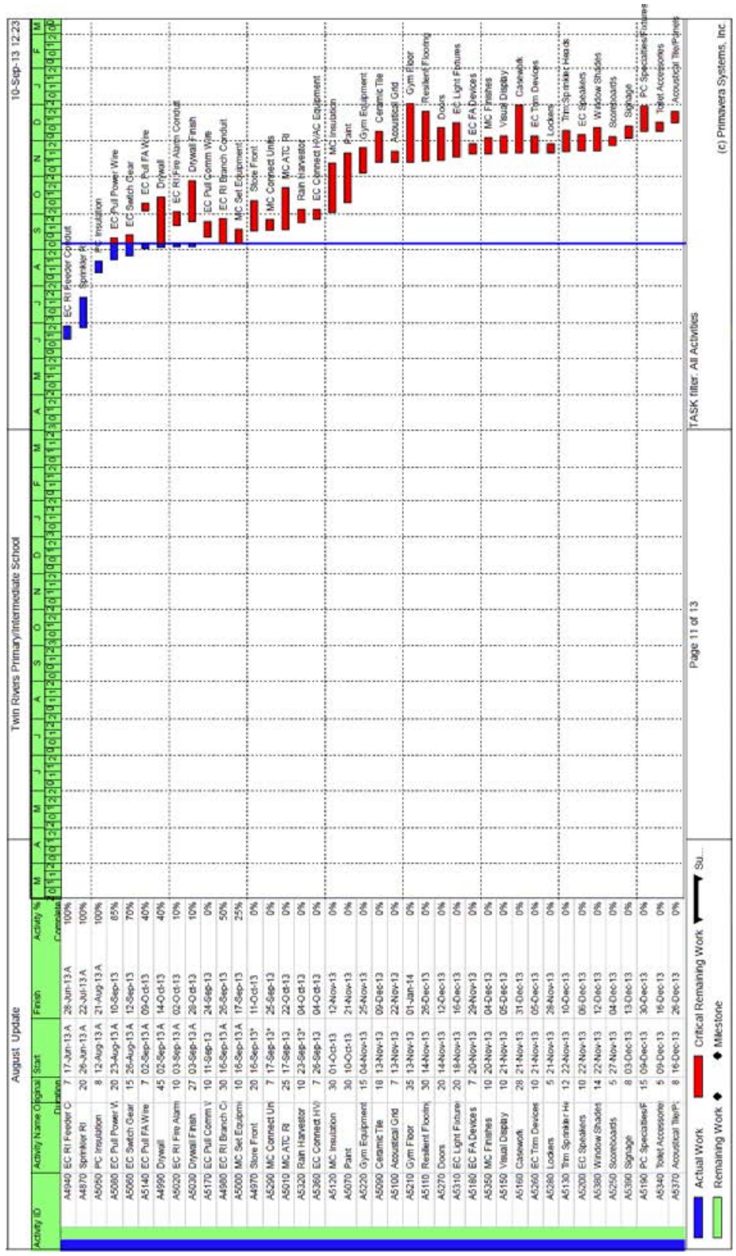
Area D First Floor
Page 7 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.


Twin Rivers Primary/Intermediate School
August Update
10-Sep-13 12:23
Actual Work
Remaining Work
Critical Remaining Work
Milestone
Page 8 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.


Twin Rivers Primary/Intermediate School
August Update
10-Sep-13 12:23
Page 9 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.


Twin Rivers Primary/Intermediate School
August Update
10-Sep-13 12:23
Area C First Floor
Page 10 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.
Actual Work
Remaining Work
Critical Remaining Work
Milestone


Twin Rivers Primary/Intermediate School
August Update
10-Sep-13 12:23
Page 11 of 13
TASK filter: All Activities
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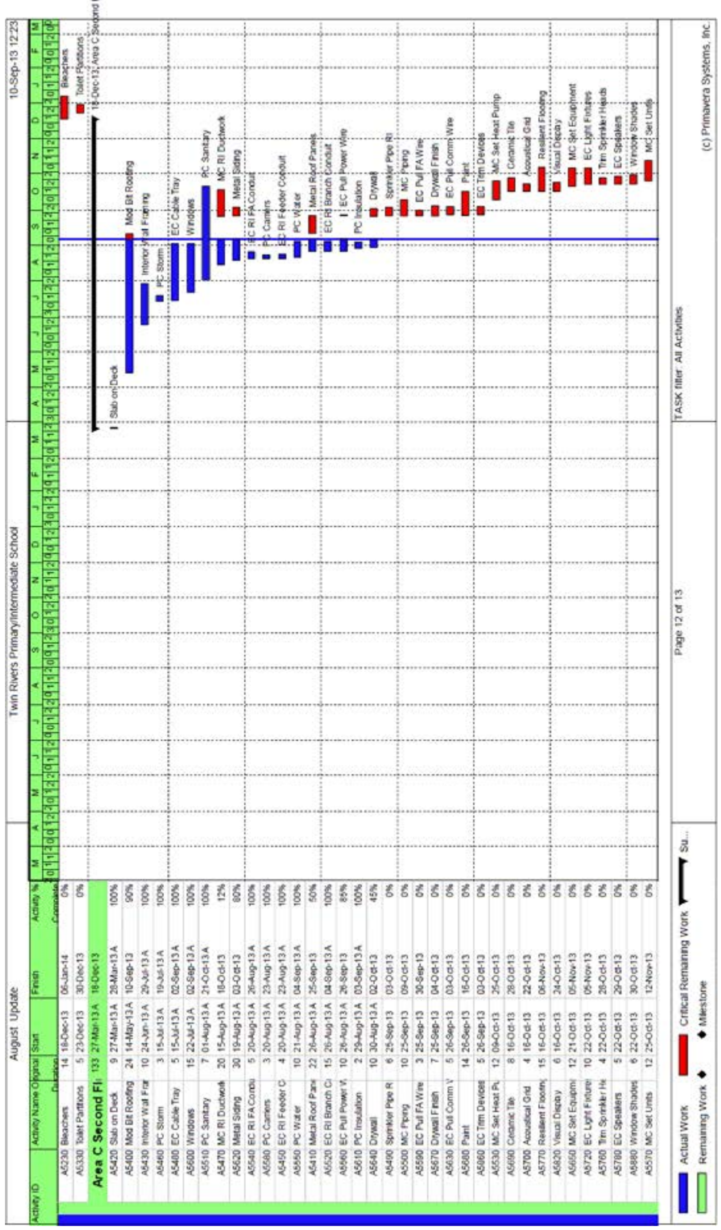
Twin Rivers Primary/Intermediate School
August Update
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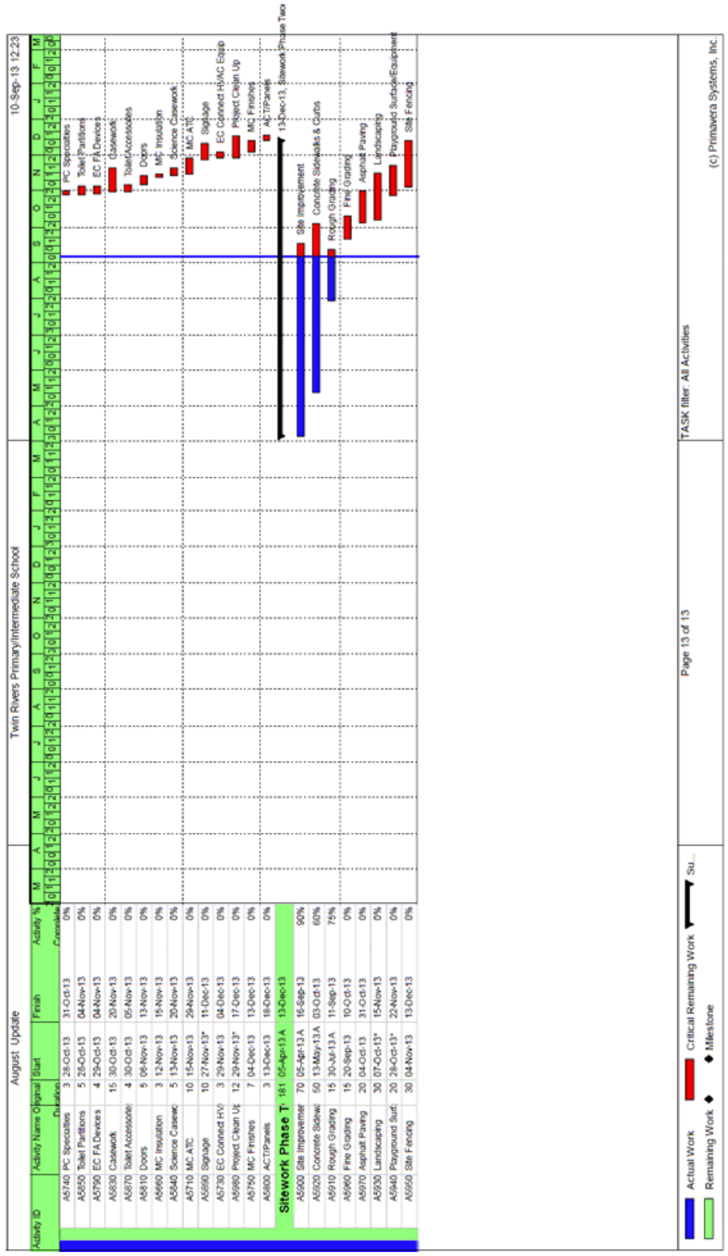
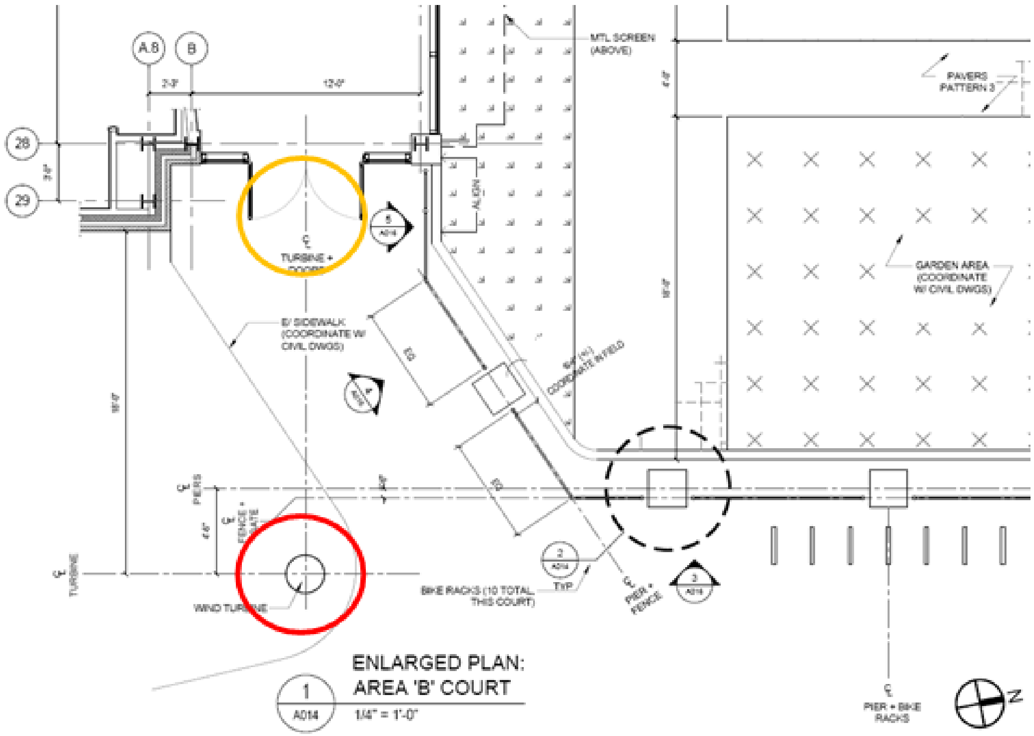
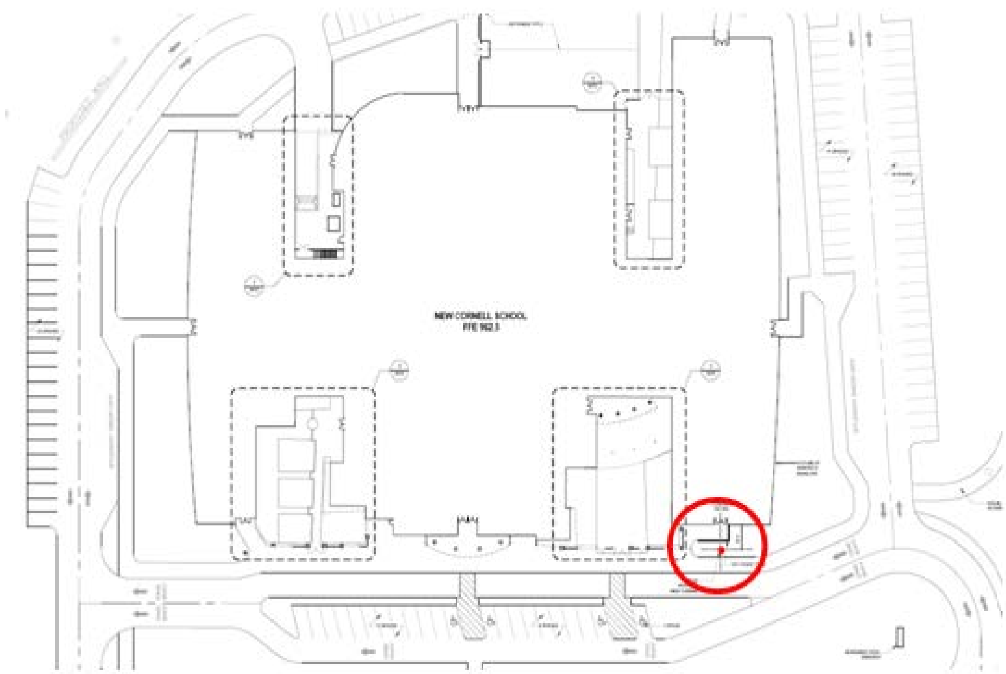
Page 12 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.


Twin Rivers Primary/Intermediate School
August Update
Page 13 of 13
TASK filter: All Activities
(c) Primavera Systems, Inc.

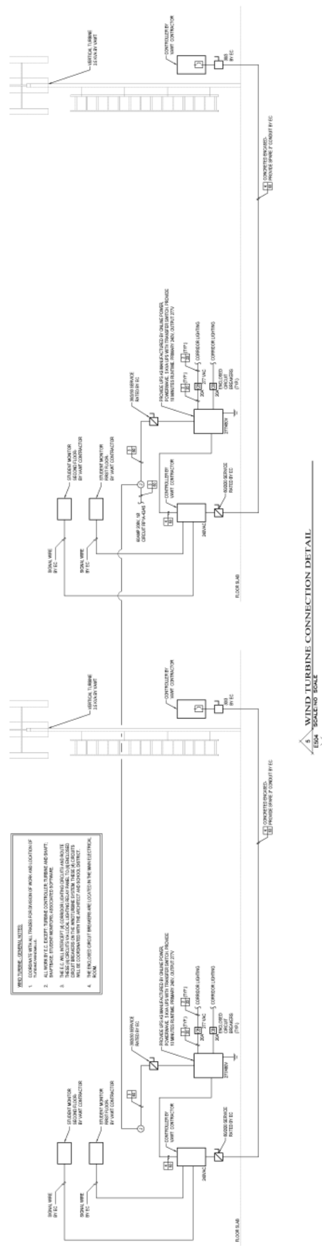
Appendix H: Original Pole-Mounted Wind Turbine





Red circles mark the location of the turbines. Yellow circle marks the mechanical room where the power will be directed to.

Appendix I: Original Single-Line Diagram for Wind Turbine


WIND TURBINE CONNECTION DETAIL

Appendix J: Original Panel Board Schedule

POWER STYLE QED–2 SWITCHBOARD														
SECT NO	CKT NO	GMD HEIGHT	DEVICE/FRAME RATING	TRIP AMP	FUSE/TRIP	#P	DESIGNATION	N/P	LUG INFORMATION				ACCESSORIES
									QTY	PHASE WIRE RANGE	QTY	NEUT. WIRE RANGE	
1	UCT	–	3000A	–	–	–	DUQUESNE LIGHT	No	9	–	9	–	
2	M1	–	NW 3000A Plug A	3000A	A–LSIG	3P	Main Breaker	Yes	–	3/0 – 750 kcmil	–	3/0 – 750 kcmil	GF,SDE1,OF4
3	1	4.5 in	JJ	200A	–	3P	Elevator B	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	2	4.5 in	JJ	200A	–	3P	Elevator A	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	3	4.5 in	JJ	225A	–	3P	Panel M1B	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	4	4.5 in	JJ	225A	–	3P	Panel M2A	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	5	4.5 in	JJ	225A	–	3P	Panel M2B	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	6	7.5 in	LC	600A	–	3P	Motor Control Center	Yes	2	4/0 – 500kcmil	2	4/0 – 500kcmil	
3	7	7.5 in	LC	350A	–	3P	CH – 1	Yes	2	4/0 – 500kcmil	1	#4 – 600 kcmil	
3	8	4.5 in	JJ	225A	–	3P	Panel M1A	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	9	4.5 in	JJ	225A	–	3P	Panel M1C	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	10	4.5 in	JJ	225A	–	3P	DOAS–2	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	11	4.5 in	JJ	225A	–	3P	ATS–LS	Yes	1	3/0 – 350 kcmil	1	#6 – 350 kcmil	
3	12	4.5 in	JJ	175A	–	3P	HUMID – 1	Yes	1	1/0 – 4/0 AWG	1	#6 – 350 kcmil	
4	13	4.5 in	HJ	100A	–	3P	Panel LP1B	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	14	4.5 in	HJ	100A	–	3P	Panel LP1D	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	15	4.5 in	HJ	100A	–	3P	Panel MK	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	16	4.5 in	HJ	100A	–	3P	Panel LP2B	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	17	4.5 in	HJ	150A	–	3P	T – KA	Yes	1	#14 – 3/0 AWG	1	#6 – 350 kcmil	
4	18	4.5 in	HJ	150A	–	3P	DOAS – 1	Yes	1	#14 – 3/0 AWG	1	#6 – 350 kcmil	
4	19	4.5 in	HJ	100A	–	3P	Panel LP2A	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	20	4.5 in	HJ	100A	–	3P	ATS – EQ	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	21	4.5 in	HJ	100A	–	3P	Panel LP1C	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	22	4.5 in	HJ	100A	–	3P	Panel LP1G	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	23	4.5 in	HJ	50A	–	3P	EFC – 1	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	24	4.5 in	HJ	70A	–	3P	T – CP1A/CP1D	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	25	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	26	4.5 in	HJ	100A	–	3P	Panel M1G	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	27	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	28	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	29	4.5 in	HJ	100A	–	3P	SPARE	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	30	4.5 in	HJ	100A	–	3P	Panel LP1A	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	31	4.5 in	HJ	60A	–	3P	TVSS	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	
4	32	4.5 in	HJ	50A	–	3P	EFC – 2	Yes	1	#14 – 3/0 AWG	1	#14 – 1/0 AWG	

Appendix K: Design Principles for Feeder Sizing

BUILDING ELECTRICAL DESIGN PRINCIPLES

TABLE 7 RECOMMENDED MAXIMUM NUMBER OF CONDUCTORS IN METAL (EMT) AND PLASTIC (PVC) CONDUIT FOR CONDUCTORS WITH THWN, THHN, AND THW-2 INSULATION. VALUES SUGGESTED IN THIS TABLE ARE LESS THAN THOSE TYPICALLY ESTABLISHED AS MAXIMUM VALUES IN THE ELECTRICAL CODE. THE RECOMMENDED MAXIMUM VALUES PROVIDED ALLOW FOR LESS CUMBERSOME INSTALLATION (E.G., PULLING CONDUCTORS THROUGH CONDUIT).

		Wire Size (THWN, THHN) Conductor Size																				
		AWG										kcmil										
	Trade Size	14	12	10	8	6	4	3	2	1	1/0	2/0	3/0	4/0	250	300	350	400	500	600	700	750
Metal (EMT)	½	6	5	3	2	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—
	¾	11	8	5	3	2	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—
	1	18	13	8	5	4	2	2	2	1	1	1	1	1	1	1	1	—	—	—	—	—
	1¼	31	23	14	8	6	4	3	3	2	2	1	1	1	1	1	1	1	1	1	1	—
	1½	42	31	19	11	8	5	4	4	3	2	2	1	1	1	1	1	1	1	1	1	1
	2	69	51	32	18	13	8	7	6	4	4	3	3	2	2	1	1	1	1	1	1	1
	2½	121	88	56	32	23	14	12	10	8	6	5	4	4	3	3	2	2	2	1	1	1
	3	182	113	84	48	35	22	18	15	11	10	8	7	6	5	4	3	3	3	2	2	2
	3½	238	174	110	63	46	28	24	20	15	13	10	9	7	6	5	5	4	3	3	2	2
	4	304	222	140	81	58	36	30	26	19	16	13	11	9	8	7	6	5	4	4	3	3

	Ampacity		
Size (AWG or kcmil)	60°C 140°F	75°C 167°F	90°C 194°F
14	15	15	15
12	20	20	20
10	30	30	30
8	40	50	55
6	55	65	75
4	70	85	95
3	85	100	110
2	95	115	130
1	110	130	150
1/0	125	150	170
2/0	145	175	195
3/0	165	200	225
4/0	195	230	260
250	215	255	290
300	240	285	320
350	260	310	350
400	280	335	380
500	320	380	430

Appendix L: Re-Design of Feeder Sizing

SECT NO	CKT NO	GMO HEIGHT	DEVICE/FRAME RATING	TRIP AMP	FUSE/ TRIP	#P	DESIGNATION	Proposed Size Phase Legs	ORIGNINAL Design			
									QTY	PHASE WIRE RANGE	QTY	NEUT. WIRE RANGE
1	UCT	–	3000A	–	–	–	DUQUESNE LIGHT	-	9	–	9	–
2	M1	–	NW 3000A Plug A	3000A	A-LSIG	3P	Main Breaker	2/0	–	3/0 - 750 kcmil	–	3/0 - 750 kcmil
3	1	4.5 in	JJ	200A	–	3P	Elevator B	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	2	4.5 in	JJ	200A	–	3P	Elevator A	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	3	4.5 in	JJ	225A	–	3P	Panel M1B	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	4	4.5 in	JJ	225A	–	3P	Panel M2A	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	5	4.5 in	JJ	225A	–	3P	Panel M2B	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	6	7.5 in	LC	600A	–	3P	Motor Control	2/0	2	4/0 – 500kcmil	2	4/0 - 500kcmil
3	7	7.5 in	LC	350A	–	3P	CH – 1	2/0	2	4/0 – 500kcmil	1	#4 – 600 kcmil
3	8	4.5 in	JJ	225A	–	3P	Panel M1A	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	9	4.5 in	JJ	225A	–	3P	Panel M1C	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	10	4.5 in	JJ	225A	–	3P	DOAS-2	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil
3	11	4.5 in	JJ	225A	–	3P	ATS-LS	1/0	1	3/0 – 350 kcmil	1	#6 – 350 kcmil

Appendix M: BIM Execution Plan

Owner Involvement Breakdown for Project Phases			
Phase	**Start Date**	**End Date**	**Owner Involvement**
Project Planning Phase	3/24/2009	12/9/2009	Y
Schematic Design Phase	12/9/2009	6/1/2010	Y
Design Development Phase	3/1/2010	9/6/2010	Y
Construction Documents Phase	4/23/2010	5/5/2011	Y
Bidding Phase	5/25/2010	8/225/11	Y
Construction Administration Phase	7/8/2010	3/24/2014	Y
Construction Phase	5/3/2012	12/13/2013	Y
Substantial Completion	12/13/2013	12/13/2013	Y
Project Close-out	13/13/2013	3/24/2014	Y

BIM Goals

Priority (1-5) 1 - Very Important	Goal Description/ Value added objectives	Potential BIM Uses
1	Accurate 3D Record Model for Project Team	Record Model, 3D Design/MEP Coordination
1	Increase Effectiveness of Design	Design Authoring, Design Reviews
2	Increase Field Productivity	Design Reviews, 3D /MEP Coordination
3	Increase effectiveness of Sustainable Goals	Engineering Analysis, LEED Evaluation
4	Lay Out Precautionary Reaction Plan for Unexpected Impacts	Design Reviews, Constructability Analysis
5	Preparation for Operation and Maintainance	Record Model, Assest Management

BIM USE Selection						
		Responsible Parties				
BIM Uses per Phase	Desire to Implement (Y/N/Maybe)	Lead Team Member	Addt'l Team Members	Experience Level (1-5) 5=High	Process Map Available?	Comments
Operations Phase						
Record Model	Y	Contractor		2	N	
			MEP Subs	1	N	Responsible for As-Built Model / Info
			A/E	2	N	Provide input on information required
Building System Analysis	Maybe	Contractor		3	N	
Building Maintenance Scheduling	Y	Owner		4		
Construction Phase						
Site Utilization Planning	Maybe	Contractor		3	N	Staging, Temp Utilities, Crane Info
			MEP Subs	2	N	Underground Modeling / Information
3D Control and Planning	N					
3D Design / MEP Coordination	Maybe	Contractor	MEP Subs	4	Y	See Project Map
Design Phase						
Design Authoring	Y	Arch		4	N	Level of Detail Needs Defined
Engineering Analysis	Maybe	Contractor		2		

Planning Phase						
Programming	Maybe	Arch		2	N	Software Requirement
			Owner			Initial Input Required
Site Analysis	Y	Arch	Owner	3		Schedule and Software - see Map
Multi-Phase						
Phase Planning (4D Modeling)	N					
Cost Estimation	Y	Contractor		3	N	Scope Needs Defined
			Arch	3	N	Level of Detail Needs Defined
Existing Conditions Modeling	N					
For detaild regarding each BIM use, reference Appendix C or the BIM Wiki site at : http://bimex.wikispaces.com/						

Appendix N: References

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