Twin Rivers Elementary/Intermediate School

McKeesport, PA

PENN STATE AE SENIOR CAPSTONE PROJECT

CHERRY Q. LU | CONSTRUCTION OPTION

ADVISOR: RAY SOWERS

PROJECT BACKGROUND

PRESENTATION OUTLINE:

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.

JC PIERCE llc

PJ DICK

LOFTUS ENGINEERING, INC.

Project Background

Location: 1600 Cornell St, McKeesport, PA

Occupancy: Educational

Total Levels: 3 stories

Size: 127,000 GSF

Dates of Construction: February 2013-January 2014

Building Cost: $28 million

Project Delivery Method: Design-Bid-Build

LEED Feature

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

SITE BEFORE CONSTRUCTION

SITE DURING CONSTRUCTION

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PROJECT BACKGROUND

PRESENTATION OUTLINE:

Electrical System

- **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

Structural System

- **Foundation:** 4" Spread footing shallow foundation
- **Superstructure:** Structural steel with concrete slab
- **Roofing System:** Composed structural steel system with metal decking.

Schedule

Schedule Breakdown			
Phase	Start Date	End Date	Duratio n
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

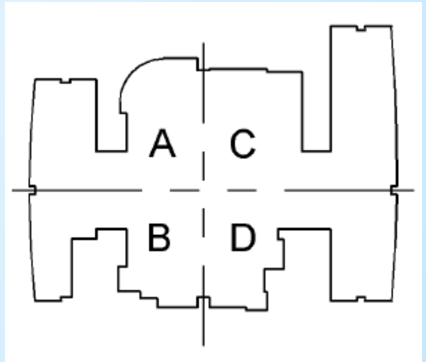
Cost

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

Project Feature

- Weather impact cause change orders
- Multiple LEED systems
- Long close out time
- Long interior fit-out time
- Long planning phase (hearings)
- Wide spread work sequence for MEP



CONSTRUCTION SEQUENCING DIAGRAM

Twin Rivers Elementary/ Intermediate School

McKeesport, PA

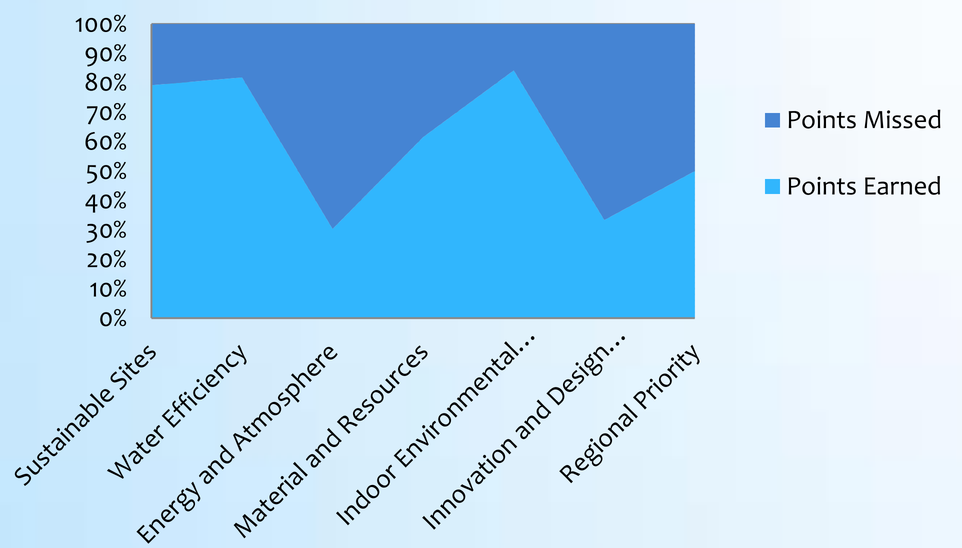
CHERRY Q. LU | CONSTRUCTION OPTION

Analysis I: LEED Implementation

PRESENTATION OUTLINE:

Goal of Analysis I

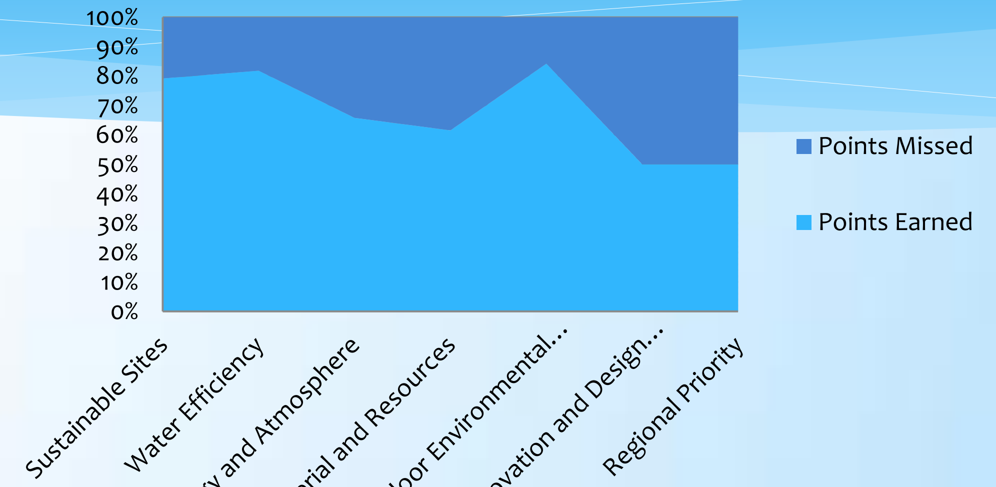
Current LEED Score Scatter



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	

- **Owner's Goal:**
  - District Scientific Education Center
  - State-of-the-Art Facility
- **Current Design**:
  - Renewable Energy Only for Showcase Purpose
- **Area of Study:**
  - Possibility of Renewable Energy Production for self-usage
  - LEED Improvement from the update
  - LEED in Public School

Potential LEED Score Scatter



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	

Twin Rivers Elementary/ Intermediate School
McKeesport, PA

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Analysis I: LEED Implementation

PRESENTATION OUTLINE:

Research Result I:

MAP OF CURRENT HOST SCHOOLS FOR WFS PROGRAM

- **Penn State University is Home to:**
  - Pennsylvania Wind for School Project(WFSP)
  - Wind Application Center (WAC) for Pennsylvania
- **Purpose**:
  - Help host schools seek funding.
  - Technical consults.
- **Goals:**
  - Work with selected schools to raise funding for and install small wind turbine (<2kw)
  - Students and Faculty assist in assessment, design and installation of wind system.
  - Provide teacher training and hands-on curricula for interactive and interschool wind-related activities.

Pennsylvania Wind for Schools Program

- **Supported by:**
  - The Wind Powering America Program
  - The National Renewable Energy Laboratory (NREL)
  - Department of Energy's (DOE's) Energy Efficiency and Renewable Energy Office
  - The National Wind for Schools program

Analysis I: LEED Implementation

Case Study I:
Boyce Middle School

Similarities:

- LEED Certified Public Middle School
- Located in Allegheny County
- Hearing and decision process for LEED

Uniqueness:

- School Board is the driving force of LEED
- Established a LEED study committee
- A vehicle for local business and professional leaders to lend their expertise toward school construction.

Lessons Learned:

- School Board initiative
- Financial benefit from industry donors
- Message sent to the students and the community about social responsibility, science and the benefits of quality learning environment.
- Role-Model for Twin Rivers Project

BOYCE MIDDLE SCHOOL

Analysis I: LEED Implementation

Case Study II: Mount Nittany Elementary/Intermediate School

Similarities:

- LEED Certified Public School
- Two schools in one campus
- Hearing and decision process for LEED

Uniqueness:

- Participant of Penn WFS Project
- Received funding of $ 16,000 (= $ 5,000 from West Penn Power Sustainable Energy Fund(WPPSEF) + $5,000 from Lowes Educational Toolbox + $5,000 from Citizen Power + $ 1,000 from the Superintendent's Fund for Instruction Innovation)
- Education program with support from Penn State University

Lessons Learned:

- Early planning
- Financial assistance from WFS Project
- Education curricula from both schools

INSTALLATION OF ROOF-TOP TURBINES

Twin Rivers Elementary/
Intermediate School
McKeesport, PA

CHERRY Q. LU | CONSTRUCTION OPTION

Analysis I: LEED Implementation

PRESENTATION OUTLINE:

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

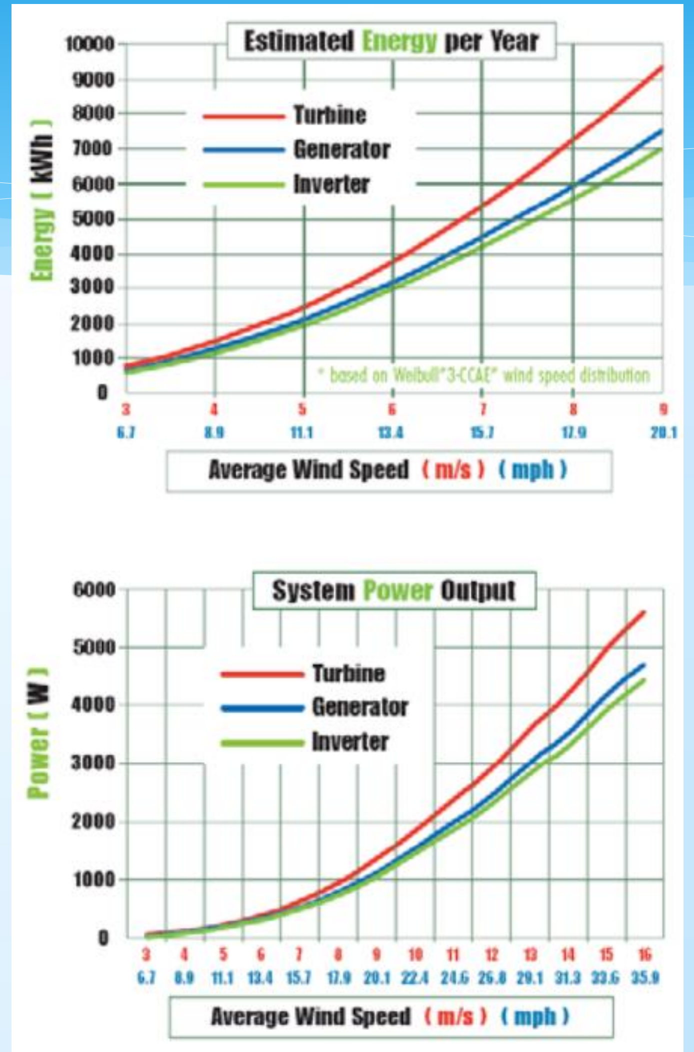
Roof-Top Wind Turbine for Energy Production is Recommended.

Current Turbine:

- Showcase purpose only
- Vertical axis turbines from Clean Field Energy

Propose Turbine:

- Small unit vertical axis turbines from Clean Field Energy
- Energy production purpose



ENERGY & POWER OUTPUT

Analysis I: LEED Implementation

Cost Analysis without Funding

Assumptions

- One unit every 4 square feet
- The impact of the installation to the structural system will be analyzed as the structural breadth.
- The capacity of a unit from Clean Field is = 23% of its maximum output.
- Electricity prices = 0.05 $/Kwh (based on conservative estimate)
- Crane cost = $750 per day + $200 per hour

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

Thus, 18* 800w * 8766hr * 23% = **29033 Kwh**

$ 0.05 * 29033 = **$ 1452**

Cost saving of $1452/year from the installation of rooftop wind turbine units.

Analysis I: LEED Implementation

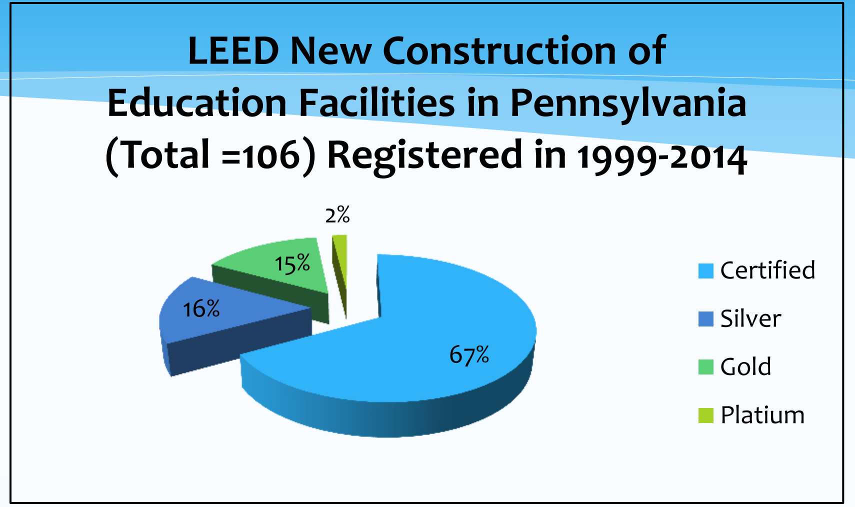
LEED in Public School

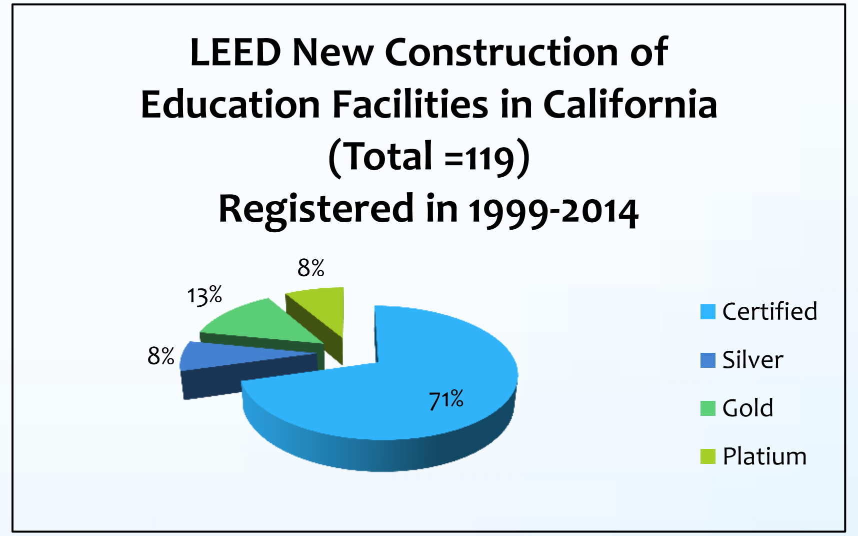
Factors considered for LEED incentives:

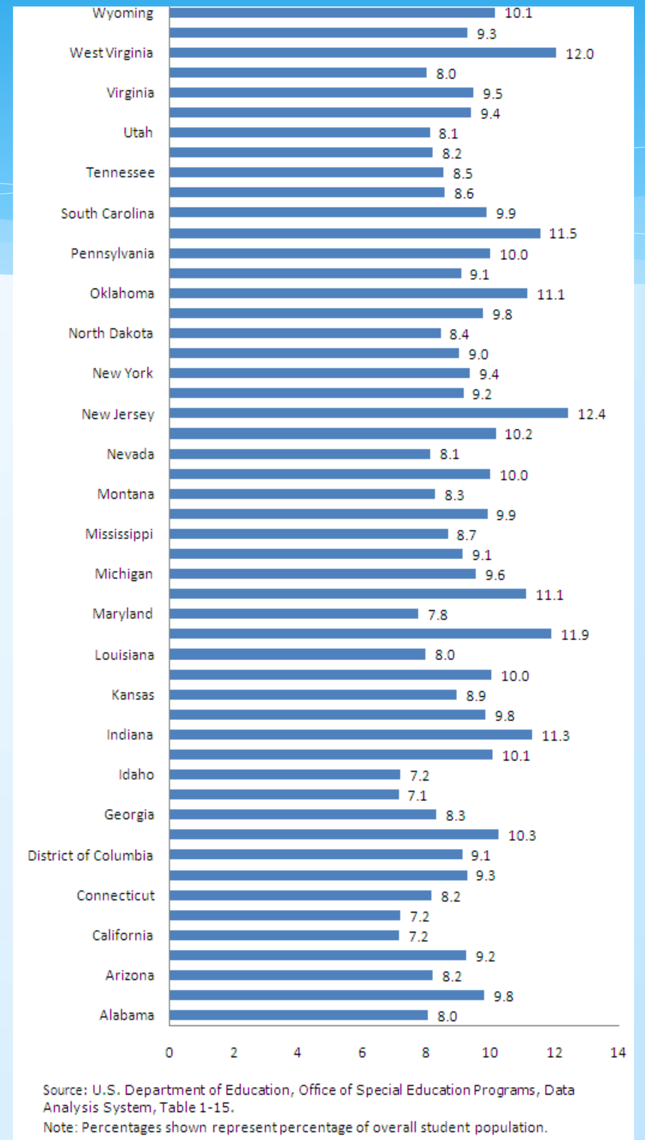
- Aged 6-21 population of each state
- GDP of each state

Responsibilities of Construction Management Team:

- Support LEED projects for long term saving on operation and maintenance cost; short payback period.
- Raise the awareness of the benefits of LEED implementation to public schools
- Help engage industry donor to assistant with the development of LEED







AGED 6-21 POPULATION PERCENTAGE IN EA. STATE

Analysis II: Value Engineering

PRESENTATION OUTLINE:

Goal of Analysis II

Increase project value by:

- Possibility of upsizing electrical distribution system
- Implementation of Wind energy production

Cost Analysis without Funding

Assumptions

- One unit every 4 square feet
- The impact of the installation to the structural system will be analyzed as the structural breadth.
- The capacity of a unit from Clean Field is = 23% of its maximum output.
- Electricity prices = 0.05 $/Kwh (based on conservative estimate)
- Crane cost = $750 per day + $200 per hour

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

- Total cost from the calculation in table above = **$17490**
- Total cost / cost saving per year = the payback period of the system = 12 years.
- 12 yrs / 20 yrs = 60%
- This is 60% of the system's designed lifetime.

PRESENTATION OUTLINE:

R-T Turbine Cost Analysis with Funding

Assumptions

- One unit every 4 square feet
- The impact of the installation to the structural system will be analyzed as the structural breadth.
- The capacity of a unit from Clean Field is = 23% of its maximum output.
- Electricity prices = 0.05 $/Kwh (based on conservative estimate)
- Crane cost = $750 per day + $200 per hour

Conservative Estimate of Funding/Grants:

- Estimate funding of $ 15,000 = $ 5,000 from West Penn Power Sustainable Energy Fund(WPPSEF) + $5,000 from Lowes Educational Toolbox + $5,000 from Citizen Power
- Total cost = $17490 - $ 15000 = **$ 2, 490**

The addition of roof-top wind turbine system is cost effective and Serves the goal of value engineering by improving system value with reasonable cost addition.

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

- Total cost / cost saving per year = the payback period of the system = 12 years.
- 2 yrs / 20 yrs = 10%
- This is 10% of the system's designed lifetime.

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Structural Breadth

PRESENTATION OUTLINE:

Project Team

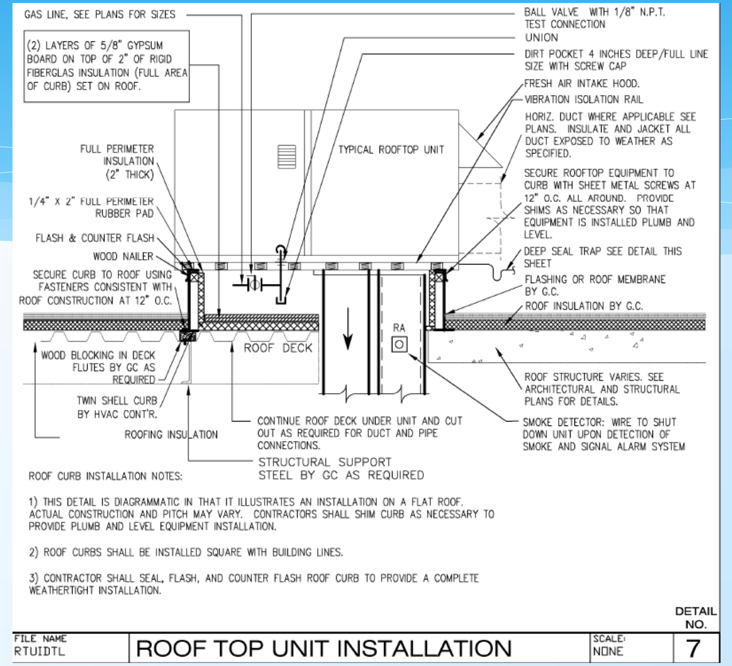
Assumptions

- One unit every 4 square feet
- Each unit = 40 lbs
- Wind turbines will be sitting on the existing design of roof curb.
- Same installation method as roof top mechanical units.

- 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

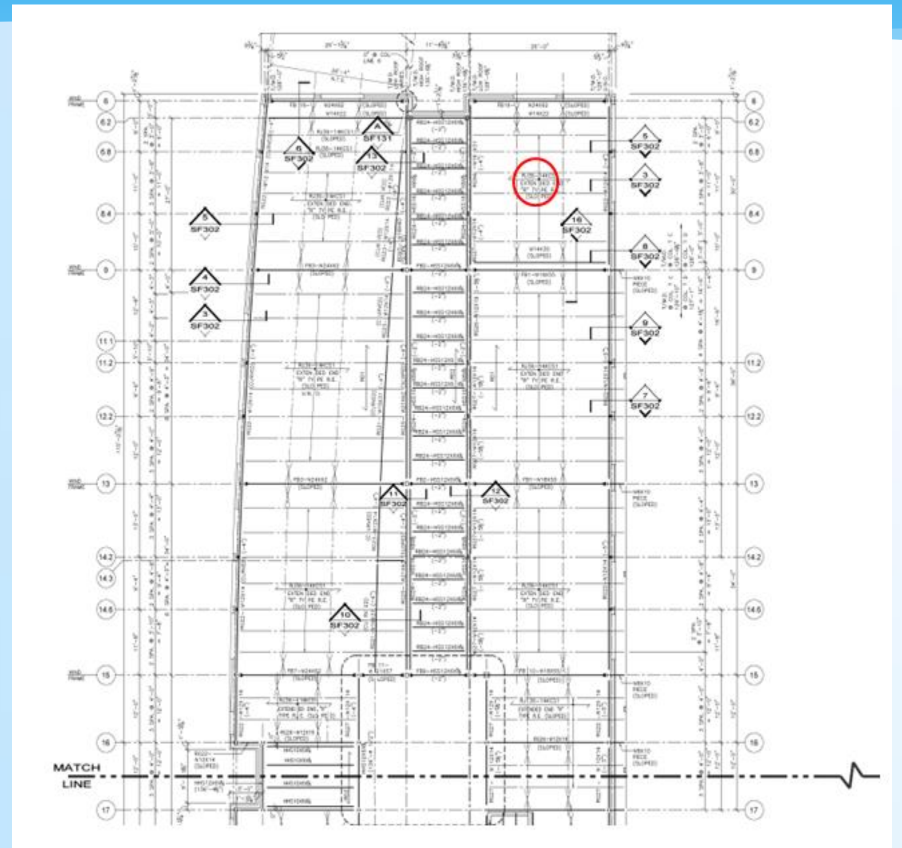
20 + 3 = 23 PSF

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



CURRENT DESIGN OF ROOF TOP MECHANICAL UNIT INSTALLATION

Structural Breadth



Assumed Typical Bay Calculated in Zone A

- **Factored Distributed Load**: W = (1.2)(DL) + (1.6)(LR)
  - Wu = (1.2)(139 PSF) + (1.6)(20 PSF) = 198.8 PSF
  - Deflection (ACI 318-11): Ln/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**
  - Vu = (312 PSF)(18.60' x 18.09') = 64,603 lbs.
- **Critical Shear** Vc = 4λ bod c f '
  - bo = 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**
  - Vu < ϕ Vc
  - 64,603 lbs. < (0.75) x (250,174.38 lbs.)
  - 64,603 lbs. < 187,630.78 lbs

Current design meets design criteria.

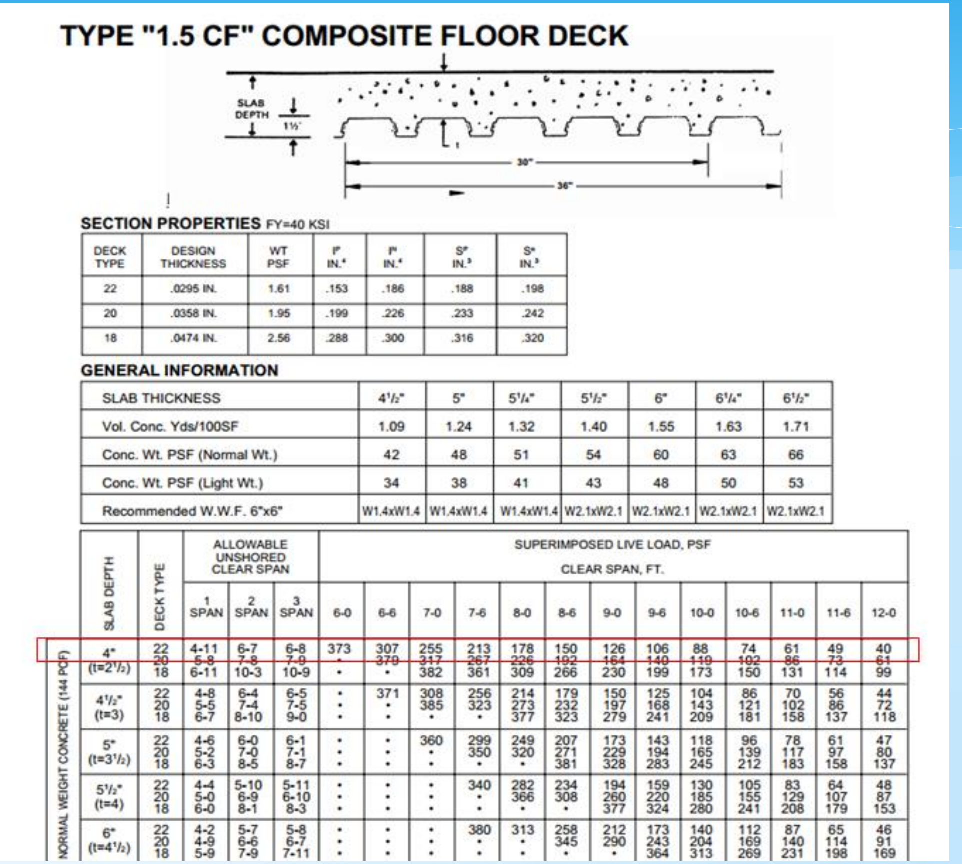


TABLE 9.5(c)—MINIMUM THICKNESS OF SLABS WITHOUT INTERIOR BEAMS*

f_y, psi†	Without drop panels‡: Exterior panels: Without edge beams	Without drop panels‡: Exterior panels: With edge beams§	Without drop panels‡: Interior panels	With drop panels‡: Exterior panels: Without edge beams	With drop panels‡: Exterior panels: With edge beams§	With drop panels‡: Interior panels
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.

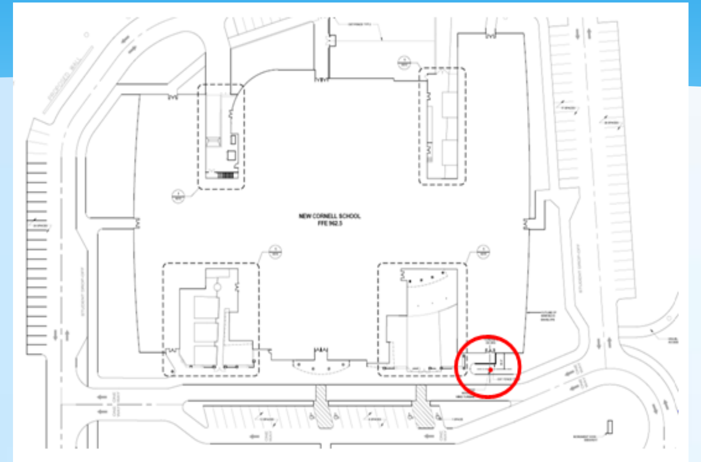
9.5.3.2 — For slabs without interior beams spanning between the supports and having a ratio of long to short span not greater than 2, the minimum thickness shall be in accordance with the provisions of Table 9.5(c) and shall not be less than the following values:

(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.

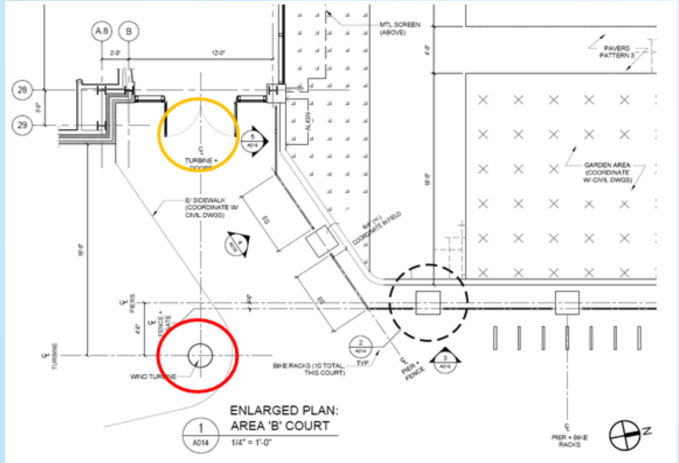
Structural Concrete Building Code (ACI 318-11)

Electrical Breadth

PRESENTATION OUTLINE:



Pole-Mounted Wind Turbine Location



Pole-Mounted Turbine/Electrical Room

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

UPSIZED THE DISTRIBUTION SYSTEM

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

Size (AWG or kcmil)	Ampacity 60°C 140°F	Ampacity 75°C 167°F	Ampacity 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

DESIGN PRINCIPLE

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	OF,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	HUMD – 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	

CURRENT SWITCHBOARD SCHEDULE

Analysis III: Schedule Acceleration

PRESENTATION OUTLINE:

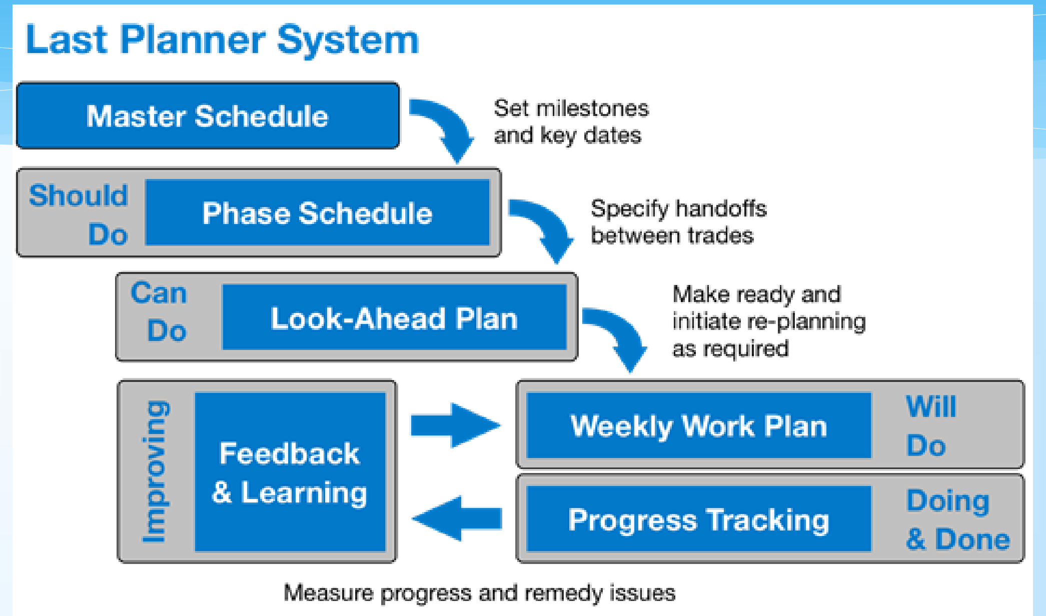
Goal of Analysis III

Improve project schedule by:

- Methods to control unexpected weather impact
- Possibility of implementing SIPS method
- Possibility of implementing Last Planner System

Project Features

- Tight schedule time frame of 21 months construction for high-performance facility with LEED implementations
- Addition of project value per the order of Penn Department of Environmental Protection of $ 156,275 from insufficient sedimentation and erosion control on site
- 3 weeks of addition of scope
- Symmetric building structure provides possibility of implementing SIPS
- LEAN construction method might help to recover project schedule



Analysis III: Schedule Acceleration

Scenario I:Precautionary and Reaction Plan

Project Features

- Urban surrounding
- Relative high elevation
- Site takes up an entire block
- Clear material delivery routes

Proposed System

- Slope stakes: interval of 4'
- Normal silt fence for high elevation than surrounding

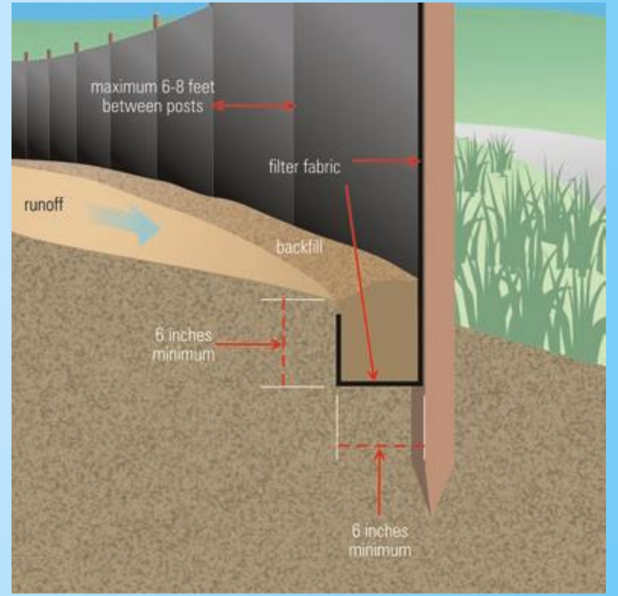
Analysis Components

- Cost impact for the proposed system
- Schedule impact for the proposed system
- Cost and schedule compared with the original system per EPA's order

Estimate Based on

- RS Means Green Building Cost Data 2014 (31 25 14.16)

SOIL RUN-OFF TO NEIGHBORING ROAD



EPA SILT FENCING DETAIL

Twin Rivers Elementary/ Intermediate School

McKeesport, PA

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Analysis III: Schedule Acceleration

PRESENTATION OUTLINE:

Cost Analysis

Scenario I:Precautionary and Reaction Plan

Cost Benefits

- Cost saving of **98.37%** compared with $156,275
- **87.49%** of the cost saving is from the material and labor

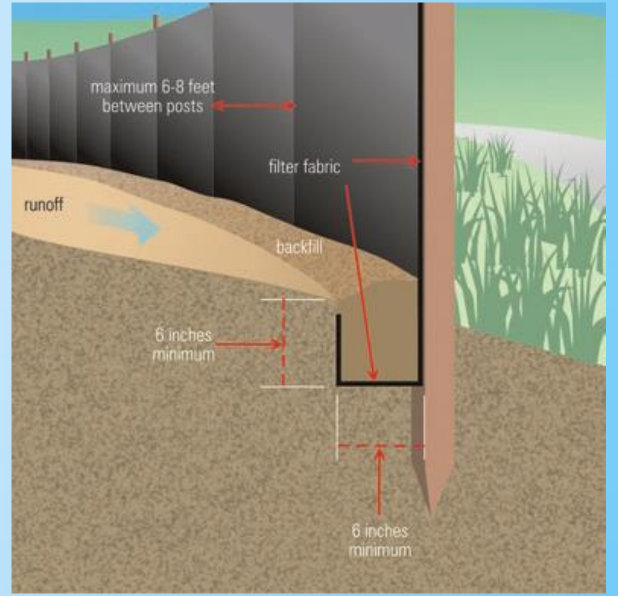
Schedule Benefits

- 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
- **95%** saving on schedule

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

SOIL RUN-OFF TO NEIGHBORING ROAD



EPA SILT FENCING DETAIL

Analysis III: Schedule Acceleration

PRESENTATION OUTLINE:

Scenario II: SIPS Method

SIPS

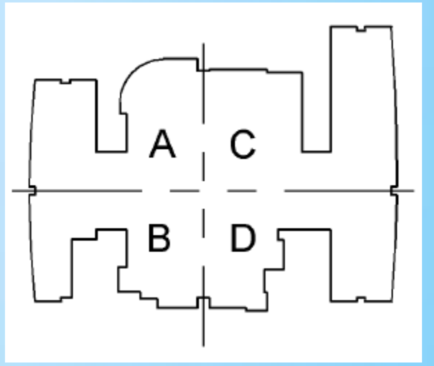
- A short interval production schedule (SIPS) is based upon repeatable construction activities that can be detailed by tasks and work days and then scheduled sequentially.
- Due to the equivalent durations of each activity, a matrix can clearly reflect a direct flow of work from one activity to the next in a typical area.
- Fast-tracked projects.

Project Features

- Symmetry of building structure
- Similar design of two wings
- Two-stories above ground
- Lack of proactive planning
- Rescheduling activities due to weather impacts
- Multiple change orders for value engineering or other purposes after start of construction
- Delay of project start date due to the extension of decision process and the demolish project prior to the start of construction
- Limited learning curve due to weather impact
- Extra material staging, equipment moving time due to weather impact

Benefit of SIPS implementation is limited.

SOIL RUN-OFF TO NEIGHBORING ROAD



CONSTRUCTION SEQUENCING DIAGRAM

Analysis III: Schedule Acceleration

Scenario III: Last Planner System

Last Planner System

- A very collaborative planning process developed by the Lean Construction Institute.
- 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.
- Requires very high commitment and promises from the project team, especially the management team.

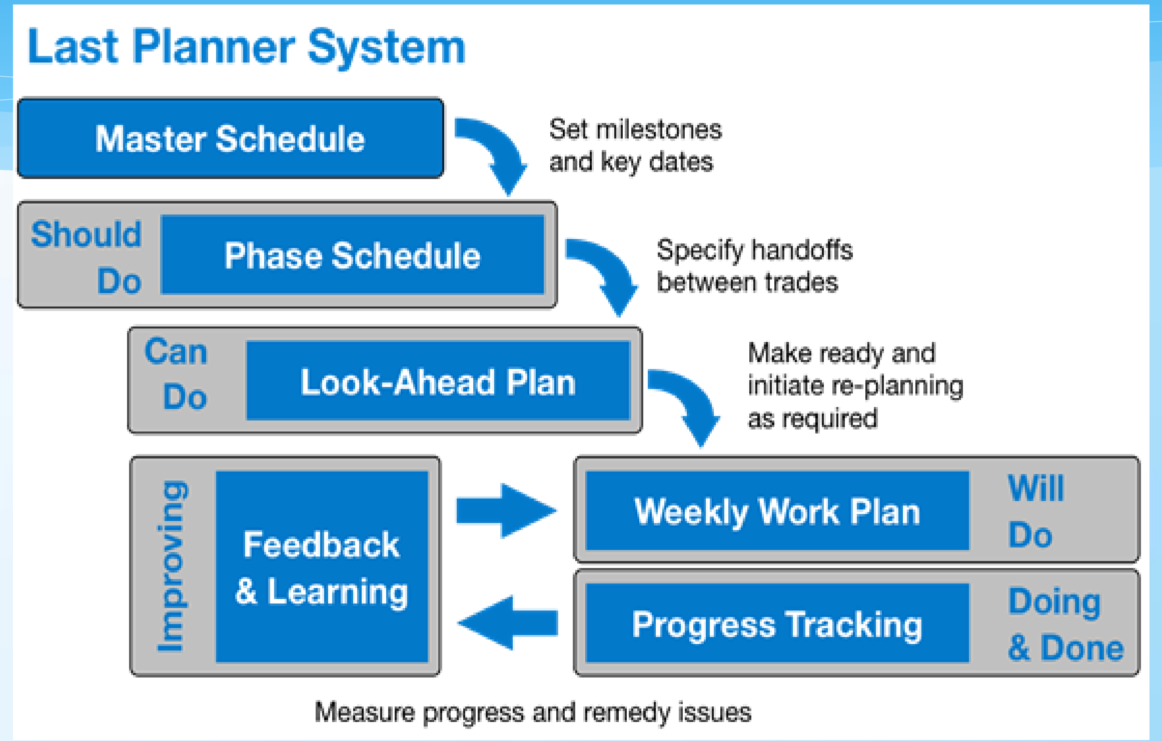
Project Features

- Need of a recovery plan from the weather impact
- High commitment from the project team after the impact
- Weekly meeting on schedule catch up
- Adoption of extra crews and extra working time

Method Implementation

- New backward inducted project schedule can be developed with updated schedules of each trade.
- Phase schedule, look-ahead plans, and weekly work plans can be developed and followed-up.

Implementation of Last Planner Method is highly recommended.



Twin Rivers Elementary/ Intermediate School
McKeesport, PA

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Analysis III: Schedule Acceleration

PRESENTATION OUTLINE:

Summary of Analysis III

Precautionary Plan

- Huge cost and schedule saving
- Highly recommended

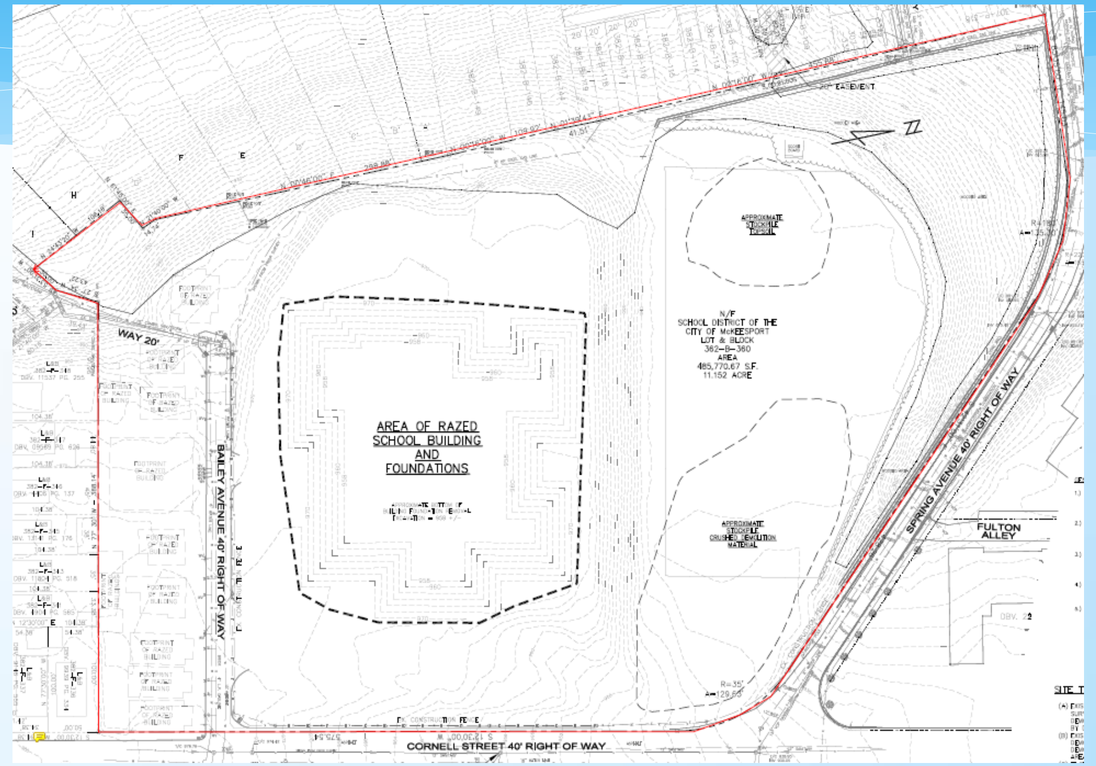
SIPS

- 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.
- Not recommended

Last Planner System

- Recover the lost schedule
- Highly recommended

	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 Extra commitment
Implementation on Twin Rivers	Huge Cost and Schedule Saving	Unforeseen Project Delay Change Orders Lack of Planning	Proactive Collaboration of Management Team Recover Lost Schedule
Implementation on Public Educational Facility	Risks Control of Unexpected Impact on Project	Pre-fabrication Repetitive tasks Collaboration Sufficient Planning	Integration with Critical Path Method



Installation of normal silt fencing is highly recommended.

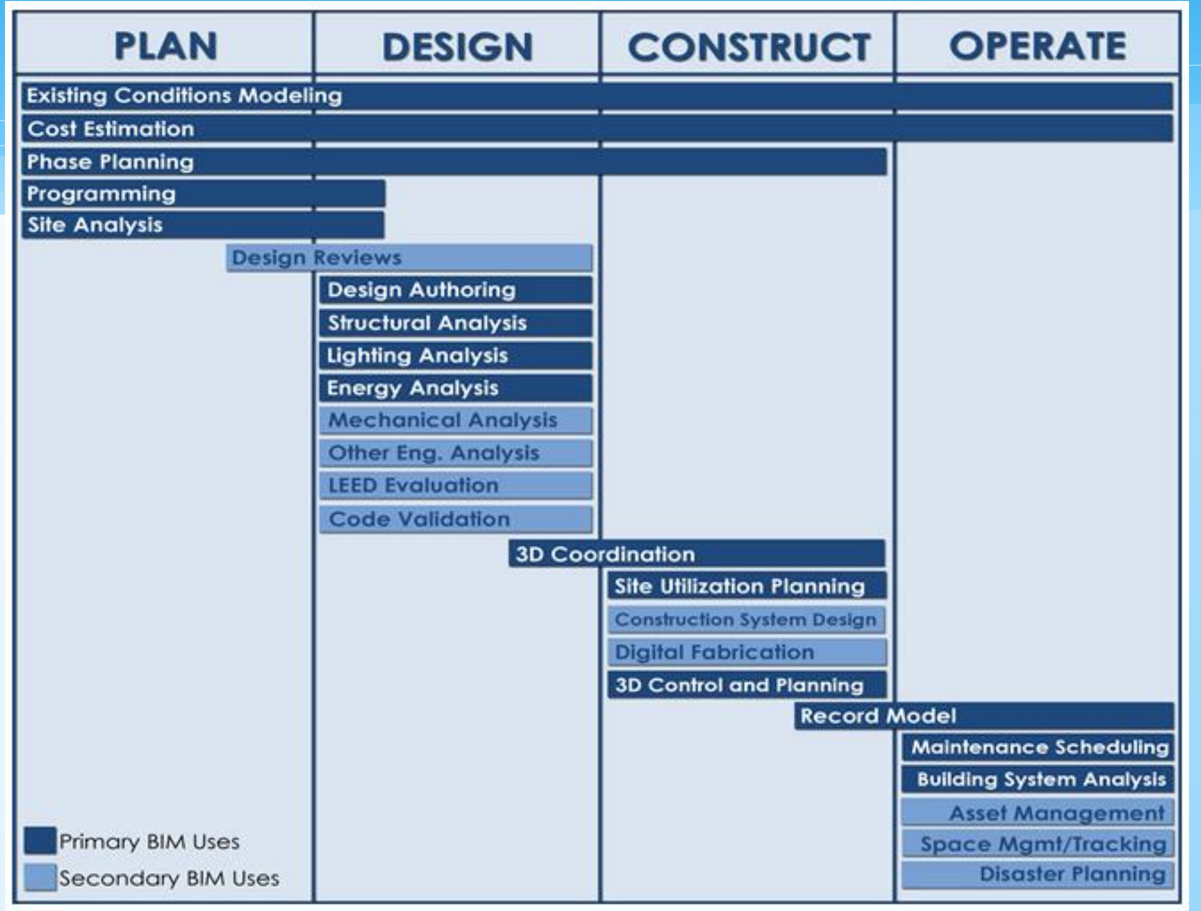
Analysis IV: BIM Implementation

Goal of Analysis IV

- Potential benefit to operation and maintenance from BIM
- Improve construction schedule
- Minimize unexpected impact (weather)
- Improve project delivery efficiency

Project Features

- IPD Project per contract
- Minimal integration effort in practice until severe weather impact
- Lack of initial collaboration between trades
- Multiple design changes and change of orders for value engineering and other purposes
- Hearings and decision approval process from the District
- Multiple LEED Systems



The Pennsylvania State University BIM Execution Planning Guide

Analysis IV: BIM Implementation

PRESENTATION OUTLINE:

Case Study I: American Canyon High School

Similarities:

- LEED Certified Public Middle School
- Geothermal HVAC system
- Hearing and decision process
- Renewable energy (solar)
- Fast-tracked (2 year of construction time)

Uniqueness:

- Project value of $ 160 million
- 7 two-stories buildings
- 260,000 square feet

Lessons Learned:

- BIM was used for conceptual design; clash detection and building performance testing.
- BIM also used for daylighting design.
- BIM aided in the erection of steel member for the project

American Canyon High School, CA

Analysis IV: BIM Implementation

PRESENTATION OUTLINE:

Case Study II:
Whatcom Middle School

Similarities:

- Re-construction of previously existed school
- Symmetry structural
- Aggressive schedule

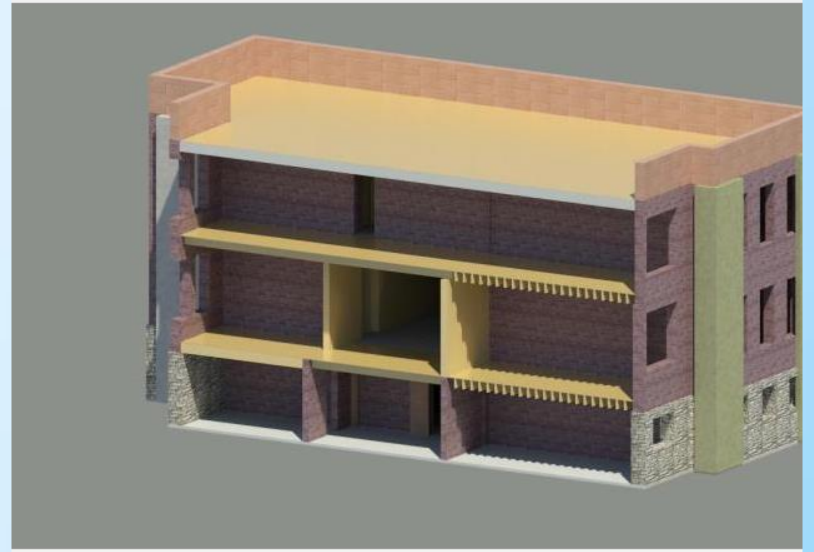
Uniqueness:

- Complex amalgam of the building
- Established a LEED study committee
- A vehicle for local business and professional leaders to lend their expertise toward school construction.

Lessons Learned:

- Major use is during the construction phase
- Colored-coded material
- Improvement of project team coordination to resolve the problem of design updates

Color-coded material assignments



Building section

WHATCOM MIDDLE SCHOOL, WA

Twin Rivers Elementary/ Intermediate School
McKeesport, PA
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Analysis IV: BIM Implementation

PRESENTATION OUTLINE:

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, Assets Management

BIM and IPD

	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

Analysis IV: BIM Implementation

PRESENTATION OUTLINE:

A BIM plan tailed to the construction of Twin Rivers School shows benefits to both the construction, planning and the operation phase.

BIM implementation is highly recommended.

BIM USE Selection

BIM Uses per Phase	Desire to Implement (Y/N/Maybe)	Responsible Parties: Lead Team Member	Responsible Parties: 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/

Acknowledgement

PRESENTATION OUTLINE:

Academic:
Penn State Architectural Engineering Faculty
Dr. Ray Sowers
Dr. Robert Leicht
Dr. Craig Dubler

Industrials:
JC Pierce LLC
PJ Dick INC
Loftus Engineers INC
Gurtner Construction LLC

Special Thanks:
David Nitchkey
Ryan Mangan
The Twin Rivers Elementary/Intermediate School Project Team
PACE Industry Members
My Family and Friends

THANK YOU!

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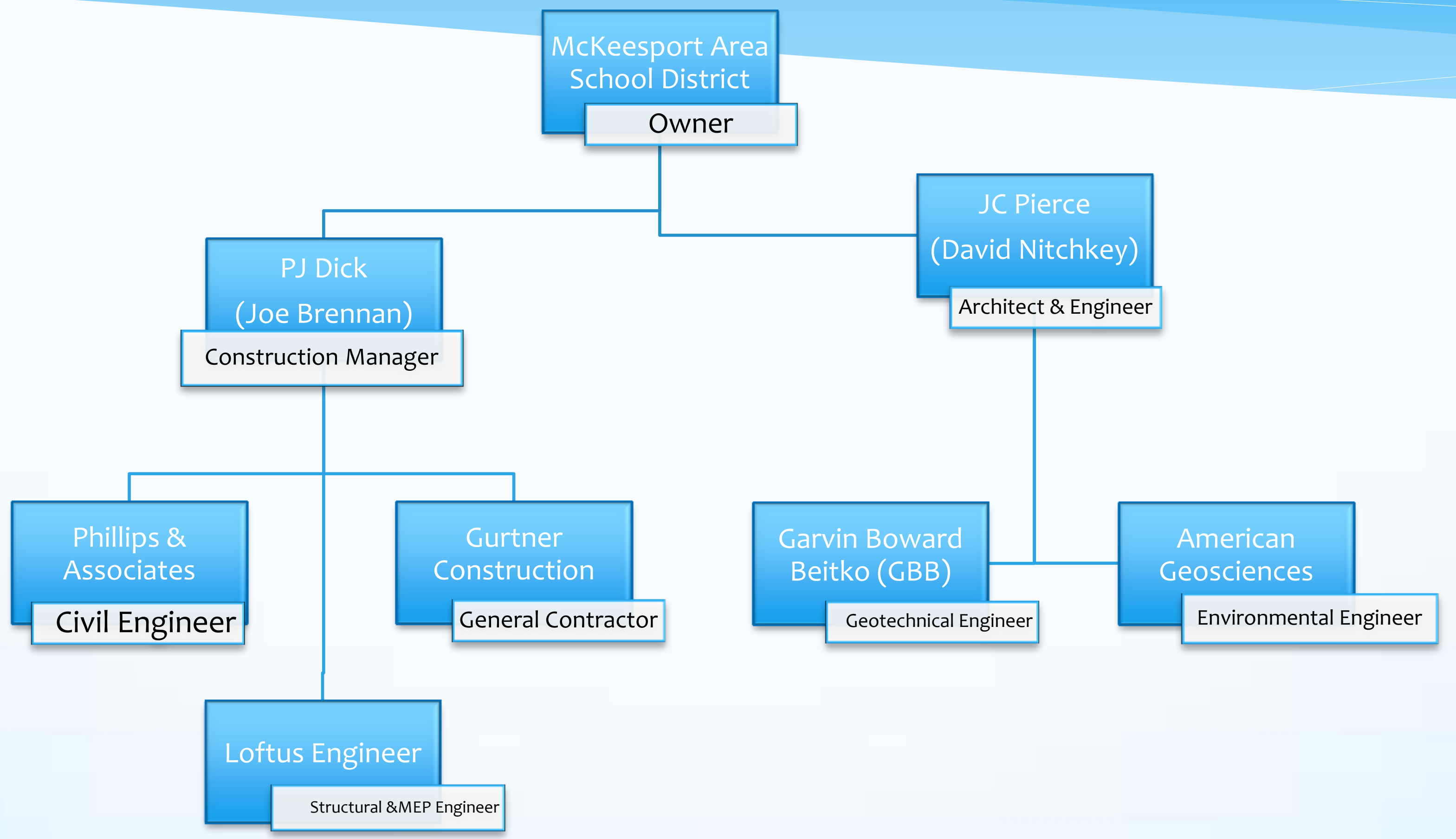
Appendices

Project Organization Chart



Twin Rivers Elementary/ Intermediate School
McKeesport, PA
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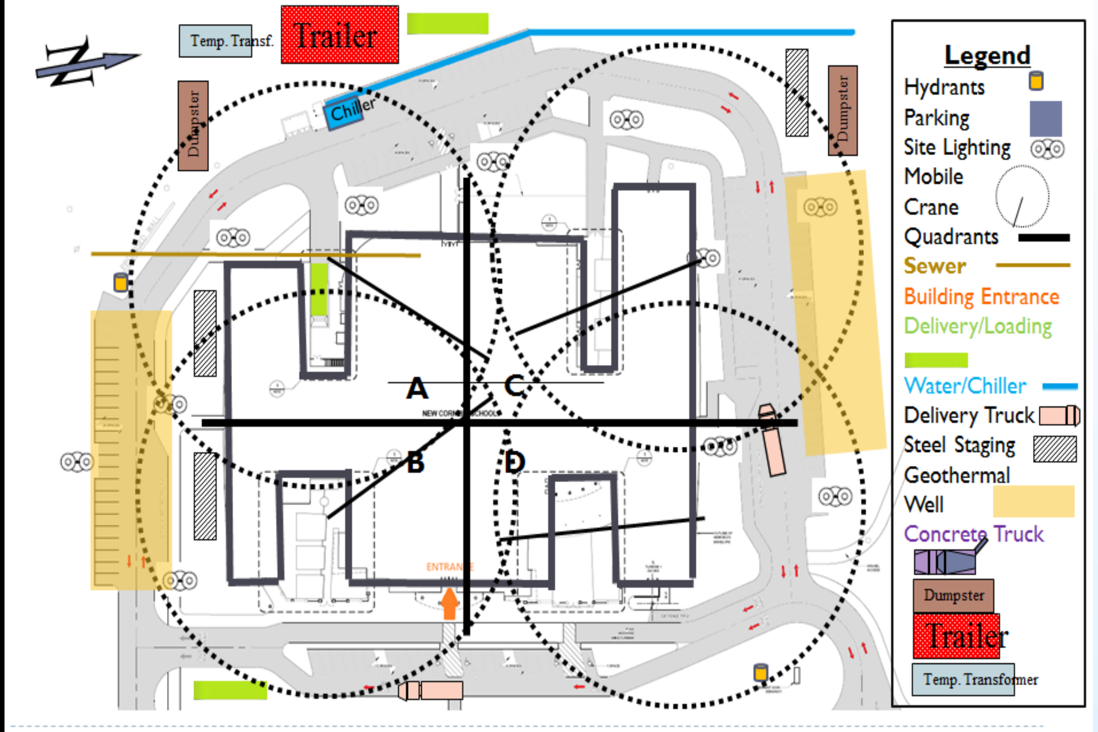
Appendices

PRESENTATION OUTLINE:

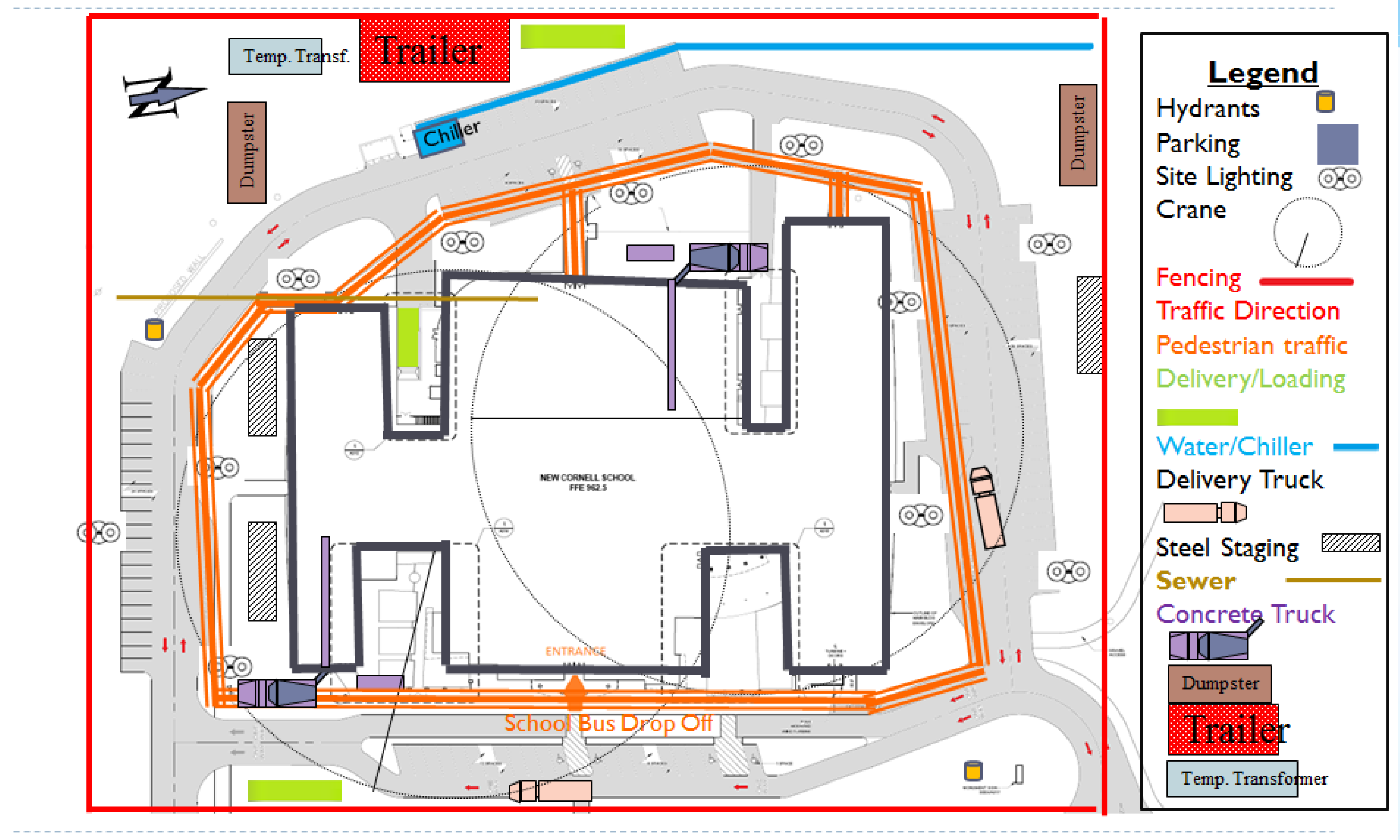
I. Project Introduction
II. Analysis 1: LEED Implementation
  I. Problem Identification
  II. Case Studies
  III. Results
III. Analysis 2: Value Engineering
  I. Problem Identification
  II. Case Studies
  III. Results: Cost Analysis
  IV. Electrical Breadth
  V. Structural Breadth
IV. Analysis 3: Schedule Acceleration
  I. Problem Identifications
  II. Results
V. Analysis 4: BIM Implementation
  I. Problem Identification
  II. Case Studies
  III. Results
VI. Conclusion
VII. Acknowledgements
VIII. Appendices

Site Logistics and Layout Plan

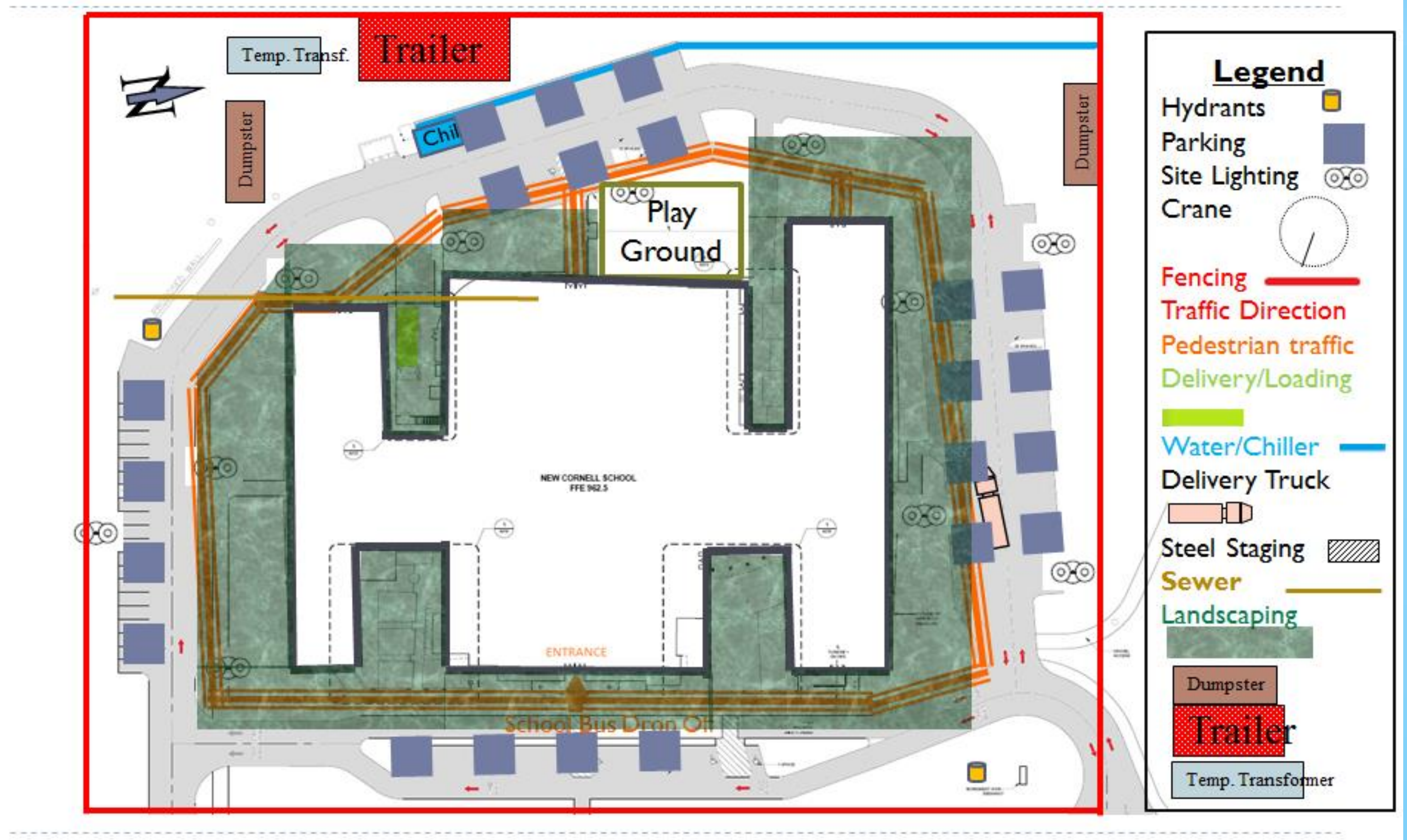
Steel Erection Plan



Site Traffic Plan



Finish Phase Site Plan



Appendices

LEED Score Cared

LEED 2009 for Schools New Construction and Major Renovations
McKeesport Elementary/Intermediate School Project
McKeesport, PA

Y	?	N		Sustainable Sites	Possible Points: 24
19	2				
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

Y	?	N		Water Efficiency	Possible Points: 11
9	1				
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

Y	?	N		Energy and Atmosphere	Possible Points: 33
10	6				
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

Y	?	N		Materials and Resources, Continued	
		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

Y	?	N		Indoor Environmental Quality	Possible Points: 19
16	1				
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

Y	?	N		Innovation and Design Process	Possible Points: 6
2	4				
	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

Y	?	N		Regional Priority Credits	Possible Points: 4
2					
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

Y	?	N	Total	Possible Points: 110
66	14			

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