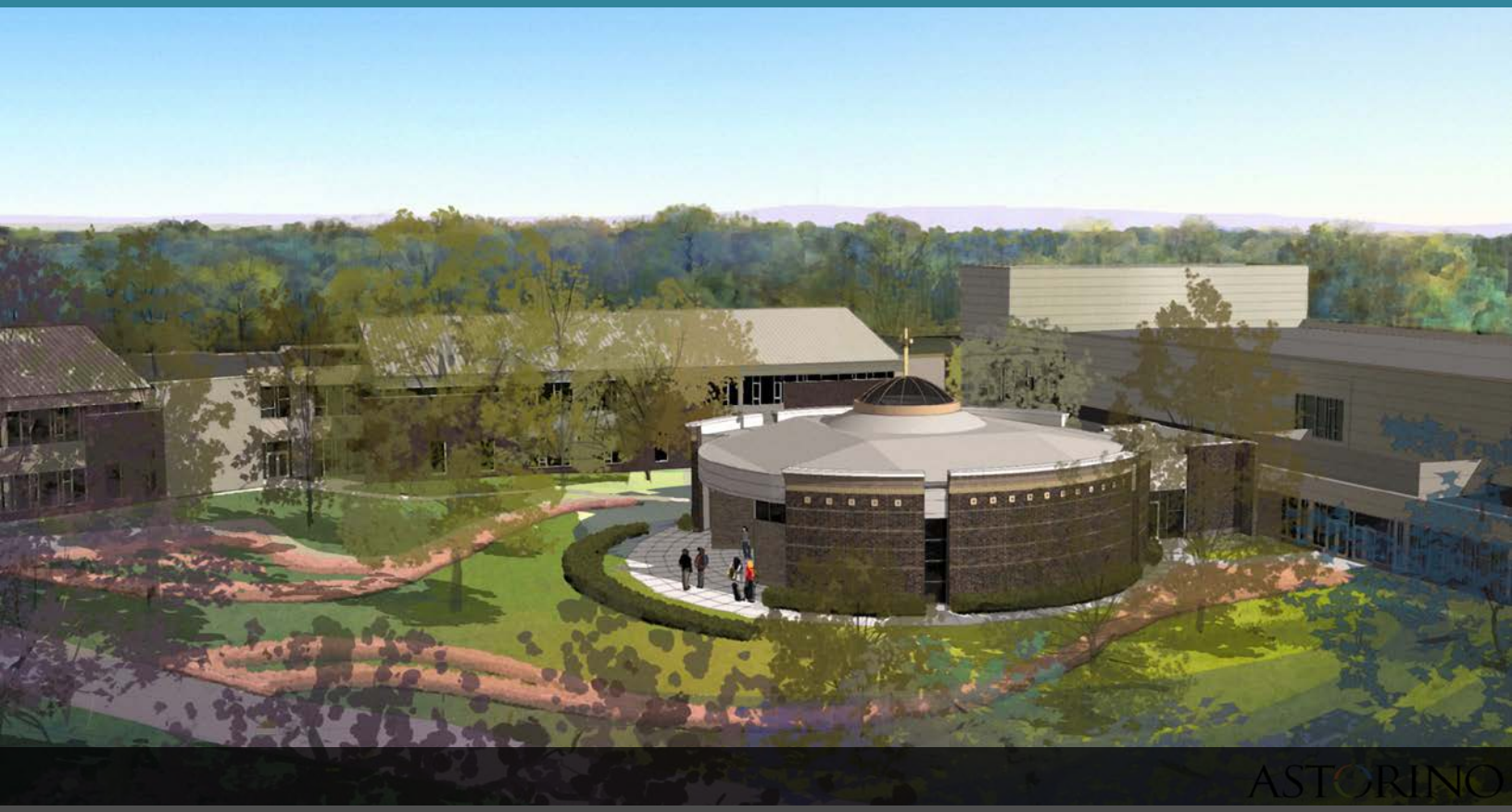

TECHNICAL REPORT II

Alec Hanley

Construction Management

Advisor – Ray Sowers

Cardinal Wuerl North Catholic High School

Cranberry Township, PA

Wednesday, October 16th, 2013

Executive Summary/Table of Contents

Design for Cardinal Wuerl North Catholic High School began in June 2011 after receiving the NTP from the Roman Catholic Diocese of Pittsburgh. CWNCHS includes extensive sitework & excavation, substructure, superstructure, exterior enclosure, complete MEP systems and all interior finishes. Due to a late start from the late acquisition of the building permit, work was taken onsite as it became available. An extensive schedule was developed with a critical path that aided in determining when work opened up. Other roadblocks were encountered with the addition of more grade beams and caissons on the north side of the building substructure. Despite these obstacles and getting behind by approximately one month, the initial finish date of January 31st, 2014 was regained by the beginning of summer 2013. The addition of a second phase (chapel) of CWNCHS pushed this date to the conclusion of May 2014, just in time for the next school year.

For the purpose of future research into alternative structural/MEP systems as well as GC cost impacts of schedule changes, a detailed structural systems estimate, MEP assemblies estimate and General Conditions estimate were compiled. The total cost of the structural system is estimated at $4,951,977.58 or $27.94/SF. This value is approximately $1 million lower than the Structural Systems estimate in Technical Report I. The lower value can be explained by the addition of the actual total project costs for Division 3, 4, & 5 (concrete, masonry, and metals) equaling the estimate total cost in Technical Report I. If brick veneer was taken out of these costs as well as the miscellaneous metals in Division 5, it would yield a value much closer to my detailed estimate. General Conditions costs at CWNCHS are a bit high and cost approximately $31,553.20/week including the heavy personnel load. This estimate will be critical in developing future scheduling techniques. MEP/FP costs were estimated at $9,125,341.15 (103% of real costs) or $51.52/SF through the use of an Assemblies estimate. These costs will help to develop a possible alternative system study.

Several constructability issues were encountered at CWNCHS. TPO roofing systems encountered a challenge when it was determined that TPO roofing could not be installed due to temperature restrictions in accordance with the low-VOC requirements for LEED, the project was ultimately delayed one month due to permitting issues with Cranberry Township, and the late design of the chapel led to some unique challenges. All of these issues will be outlined and analyzed for solutions.

BIM was vital to the success of CWNCHS. The GC and A/E used it to build virtual prototypes, utilize 3D coordination, engineering analyses, phase modeling (4D), record modeling, and other various applications. The owner's goals were to reduce change orders, assist in design visualization and develop a model for building operation & maintenance. LEED was also monitored heavily throughout this project and is on track to receive a Silver Certification. These practices will be further analyzed and criticized.

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Detailed Project Schedule

From the beginning of the design phase to the substantial completion of Phase II – Chapel, the construction of Cardinal Wuerl North Catholic High School will have encompassed a period of 3 years. Design began in June 2011 and the chapel will be completed at the end of May 2014. Many obstacles were encountered during this period that required the project team to adjust and make their best attempts to get the project back on schedule. Due to changes in substructure and the late arrival of the building permit, the schedule became a "take work as it is available" entity. This was the best possible option after the aforementioned events.

Originally, the schedule was slotted to conclude on January 31st, 2014 with the substantial completion of Phase I. The "late design" of the chapel was a consequence of a slow accrual of private funds on the project. Regardless, the GC (Mascaro Construction) was able to schedule the second phase to finish before the start of school in late August 2014. Once design development began, BIM clash-detection practices began, which occurred in simultaneous with procurement and fabrication. Site work began in June 2012 in order to prepare for a building pad turnover in early September 2012. Substructure began and looked as if it would follow a north-to-west flow of work, but the geotechnical addendum that added extra caissons & grade beams interrupted this flow of work. Structural steel erection ended in January 2013 and made way for the exterior skin and roofing systems. Once these were finished in September 2013, interior finishes began and are scheduled to conclude at the end of January 2014. Also, chapel activities commenced in August 2013 after receiving the building permit.

Area D became the epicenter of the critical path and all activities moved towards it (west-to-east & south-to-north). Regardless of this apparent pattern, the uniqueness of CWNCHS' shape rendered it without a transparent/logical flow of work. Instead, it became a living/breathing entity that needed to adapt and required constant maintenance to keep the date of completion intact. This required heavy coordination & cooperation by all subs, trades and primes.

The following table shows the critical milestones:

MILESTONES	
NTP - Site Earthwork	4-Jun-12
Building Pad Ready for Foundation Installation	1-Sep-12
Obtain Building Permit - Diocese	20-Sep-12
Structural Steel - Begin	12-Nov-12
Structural Steel - Complete	18-Jan-13
Building Exterior - Complete	26-Sep-13
Substantial Completion - Main Building	30-Jan-14
Substantial Completion - Chapel	30-May-14

Figure 1: Project Milestones

My Detailed Project Schedule is organized by milestones and each separate area of the building (A-G). I felt that this was the best way to show the breakdown of activities since the trades were often very

scattered. Not to mention, the main building areas were often divided up into further sections. This extended a lot of durations on the new detailed schedule. In order to consolidate the countless activities in each area into about 25-35 activities, a lot of activities had to be mixed together based on appropriateness of definable features of work. For example:

- *Structural Steel – Erect/Deck & Detail* – erection of primary members and detailing activities were grouped into one activity to save space.
- *TPO Roofing Installation & Termination* – often occurring in multiple sections of each building area and could not be terminated until wall blocking was completed, which often held up completion. Luckily it was not a problem due to float being available.
- *Exterior Framing/Sheathing/Spray-Applied Air Membrane* – these activities often followed one after another so it was appropriate to group them together for completion of the building envelope.
- *Brick Veneer* – scaffold set-up, bricking, curing, wash-down, removal of scaffolding
- *"O/H MEP Rough-In" & "In-Wall MEP Rough-In"* – a large surplus of activities occurred in these areas and needed to be shortened to these two designations in order to achieve ~200 activities.
- *Final MEP Connections* – GRDs, lights, and plumbing fixtures often all occurred around the same time because of predecessor activities (paint, in-wall/O/H rough-in, etc.) and had similar durations.
- *Frame/Insulation/Hang* – Drywall, etc. – often had very long durations when grouped, but made the most sense to group together based on DFW. These activities are necessary in the schedule since they are the predecessor to so many other activities such as wall finishes, floor finishes, MEP final connections, etc.

A more detailed version of the project schedule and definable features of work can be found in Appendix A. An error occurred with the scheduling of the critical path on the detailed schedule, which changed all start and end dates irreversibly, but all durations remain correct as well as all predecessor-successor relationships.

Detailed Structural Systems Estimate

Cardinal Wuerl North Catholic High School's varying story heights and building geometries lend to its overall unique shape. This unique shape involves many different structural elements of different shapes and sizes. These intricacies as well as the fact that structural systems are major components of building costs make it advantageous to perform a detailed cost estimate. To better understand the structural elements, the researcher compiled a quantity take-off of all structural steel, structural CMU walls, subgrade structure, slab-on-grade, etc. Overall costs of the structural system were $4,951,977.58 or $27.94/SF. This value is approximately $1 million lower than the Structural Systems estimate in Technical Report I. The lower value can be explained by the addition of the actual total project costs for Division 3, 4, & 5 (concrete, masonry, and metals). If brick veneer was taken out of these costs as well as the miscellaneous metals in division 6, it would yield a value much closer to my detailed estimate. Strict take-offs for each structural element were taken for every level of structure in Areas A-E since there isn't a typical bay in these areas to base a typical structure around. The first floor of Area F's steel skeleton was taken off and essentially multiplied by four since it is very similar to the 2nd floor of Area F and the 1st/2nd Floor of Area G. This is the only area where the "typical bay" concept was utilized.

The detailed estimate has been broken down into quantity take-offs and costs and can be found in Appendix B. All components listed above can be found here. Material costs were the primary contributor to structural systems costs, which makes sense based on the high price of steel. RS Means: Open Shop Building Construction Cost Data, 2014 Edition was used for all unit pricing in conjunction with appropriately matched quantities from structural system take-offs. All take-offs are under the categories of foundations – concrete/steel, slab-on-grade, slab-on-deck, steel columns/beams/joists, metal roof decking, shear studs or shear studs. All cost estimates are categorized as subgrade, columns, beams & joists, slab-on-deck or miscellaneous structural elements. The following table shows a breakdown of costs between these categories as well as material, labor, equipment & total costs. The location adjustment was also from RS Means and is localized for Pittsburgh, PA.

Structural Systems Estimate					
Category	Material	Labor	Equipment	Total	Total w/ O&P
SUBGRADE	$ 499,564.14	$ 325,748.65	$ 24.09	$ 825,336.88	**$ 1,056,919.50**
COLUMNS	$ 445,866.63	$ 24,478.97	$ 13,343.72	$ 483,689.32	**$ 545,869.84**
BEAMS & JOISTS	$ 1,691,243.65	$ 133,856.34	$ 58,104.46	$ 1,883,204.45	**$ 2,150,108.08**
SLAB-ON-DECK	$ 387,908.47	$ 280,165.11	$ 7,942.50	$ 676,016.08	**$ 877,453.00**
MISC.	$ 145,403.80	$ 36,017.45	$ 3,821.63	$ 185,242.88	**$ 224,529.56**
Sub-Total	$ 3,169,986.69	$ 800,266.52	$ 79,414.77	$ 4,049,667.98	**$ 4,854,879.98**
Location Factor (1.02)	$ 3,233,386.42	$ 816,271.85	$ 81,003.07	$ 4,130,661.34	**$ 4,951,977.58**
				Grand Total	**$ 4,951,977.58**

Figure 2: Structural System Grand Total & Estimate

Assemblies MEP Estimate

The combined costs of the MEP/FP systems at CWNCHS account for the largest cost component of the building. MEP/FP systems were estimated at $9,125,341.15 or $51.52/SF. Each system required a different quantification for each take-off to arrive at a reasonable cost. All systems were adjusted with a location modifier of 1.02 (Pittsburgh, PA) after developing a subtotal. The combined cost values came within 3% of the real project costs. This accuracy will be helpful in the future when researching alternative MEP systems for Cardinal Wuerl North Catholic High School. By determining accurate costs based on components it makes it much easier to determine what parts are expensive and what can possibly be value engineered out of the system. All take-offs & calculations to determine system costs can be found in Appendix C.

MEP/FP ESTIMATE COMBINED TOTAL	$	9,125,341.15
REAL MEP/FP COST	$	8,860,010.00
% Difference		97%

Figure 3: Assembly Estimate vs. Real Cost

The plumbing estimate required all fixtures to be accounted for in order to develop a cost. Fixtures included water closets, urinals, lavatories, kitchen sinks, lab sinks, service sinks, showers, cup sinks, electric water cooler & electric water heaters. A 75% multiplier was added to the fixture costs in order to account for distribution piping, drains, waste pipes, and vents. Also, an integrated approach with RS Means SF Cost 2013 allowed me to develop a lump sum for kitchen equipment which led me to the value of $1,442,325.90 total cost for the plumbing system or $8.14/SF.

The mechanical system estimate required calculating the quantity of SF (27,000) that the split system air conditioners serve compared the SF (153,000) that rooftop air-handling units serve. Applying these areas to the unit cost based on the building type and unit capacity (tons) determines a cost of $3,489,120.00. Adding auxiliary units, such as unit heaters (5) and fan coil units (2) equaled a total cost of $3,566,909.40 for the mechanical system or $20.14/SF.

The electrical system estimate required all lighting fixtures, receptacles, panel boards and light switches to be taken off as well as the underground electrical service, main switchboard and all branch wiring. These fairly straightforward, yet expensive take-offs provide the most expensive system in the building, settling in at $3,852,325.34 or $21.75/SF.

The fire protection system consists of a 4” wet pipe configuration, mostly on one floor. This situation provides a unit value based on SF from RS Means. A cost reduction was calculated in order to develop a more accurate systems cost (since the floor area is not 50,000 ft^2 as stated in Means), which can be found in Appendix C. After a location modifier of 1.02, the total FP cost came to $263,780.51 or $1.49/SF.

Site Layout Planning

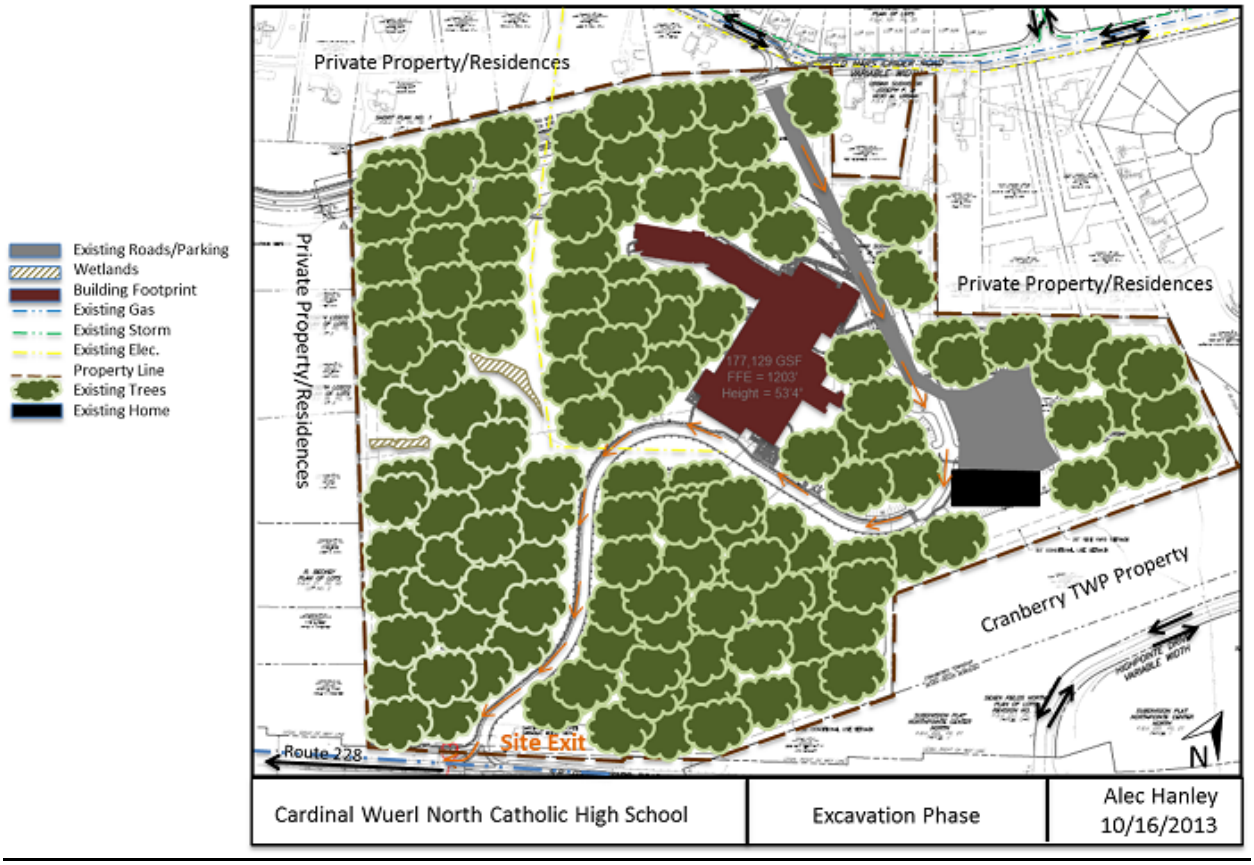


Figure 4: Excavation Phase (Astorino Property)

The primary concern during the beginning phase of the project was to clear all of the trees and overgrowth on the Cardinal Wuerl North Catholic High School property in order to grade the soil to the correct elevations. This is done in order to provide a clean building bad to the GC. Identification & removal of the existing overhead electrical wire during this time was critical. The existing house on the property must be demolished; shoring is required in “redbed” soil areas during excavation due to redbed’s tendency to slip; wetland mitigation/underground utilities/storm water management has not begun yet. Site access only from Old Mars Crider Road (North) and not Route 228 or Franklin Road yet.

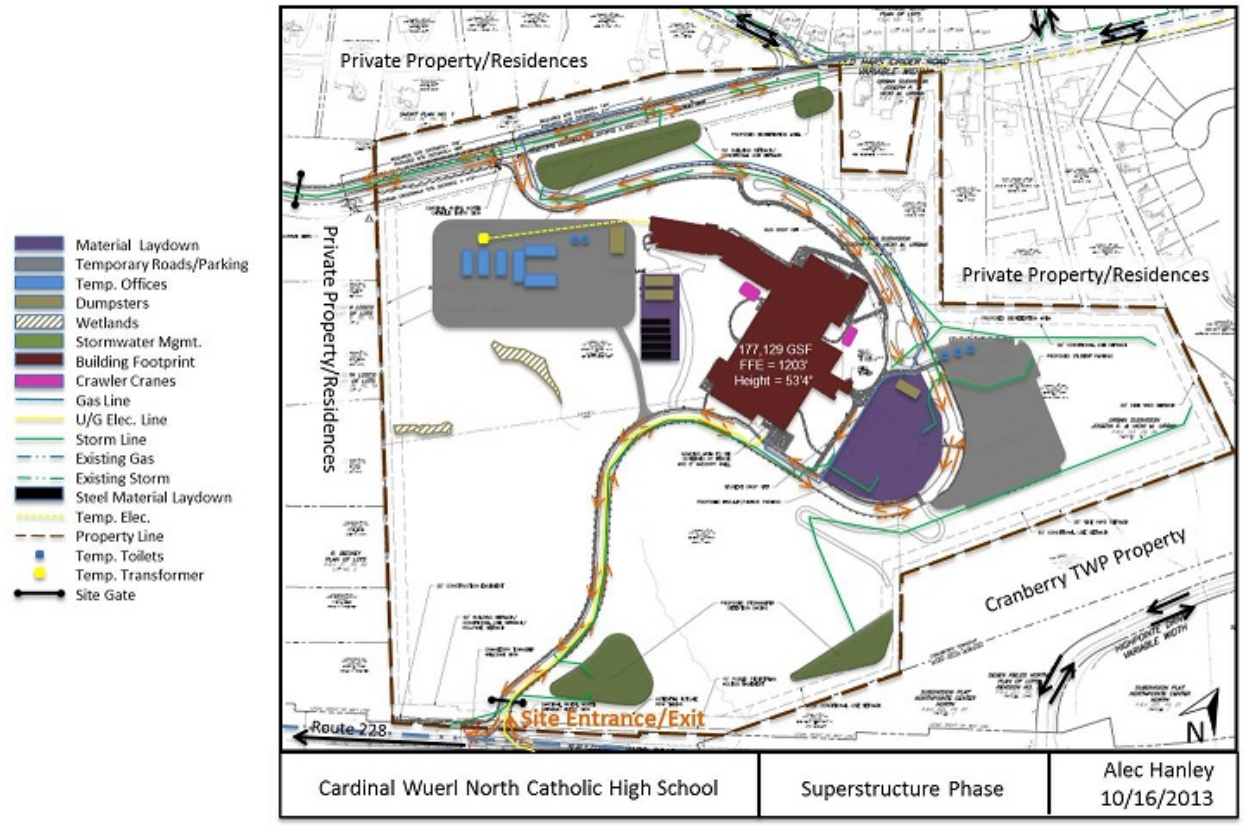


Figure 5: Superstructure Phase (Astorino Property)

The primary concern during this phase of the project is structural steel erection. All foundations have been installed and the site has been cleared & the building pad turned over from the site contractor. Material/laydown areas, dumpsters & temporary toilets have been moved closer to the temporary parking areas in order to not interfere with the two crawler cranes on site. By reducing foot traffic around the cranes, it reduces the risk of an accident. Rental cranes are very expensive to rent and it would not be beneficial to waste time because there are too many obstacles for the crane. Also, any areas in the cranes erection sequence for a given time period are considered “restricted access areas.” Other important logistics of the site during this time included gained access from Route 228, beginning of permanent underground utilities construction, site gates added at entrances and exits to protect developing assets, temporary transformer and electricity added for the site behind the temporary trailers on the NW side of the site, and storm water management reservoirs development begins. To protect them from breaking under the weight of the crawler cranes, underground storm piping and permanent water piping were not installed around the immediate building perimeter during this phase.

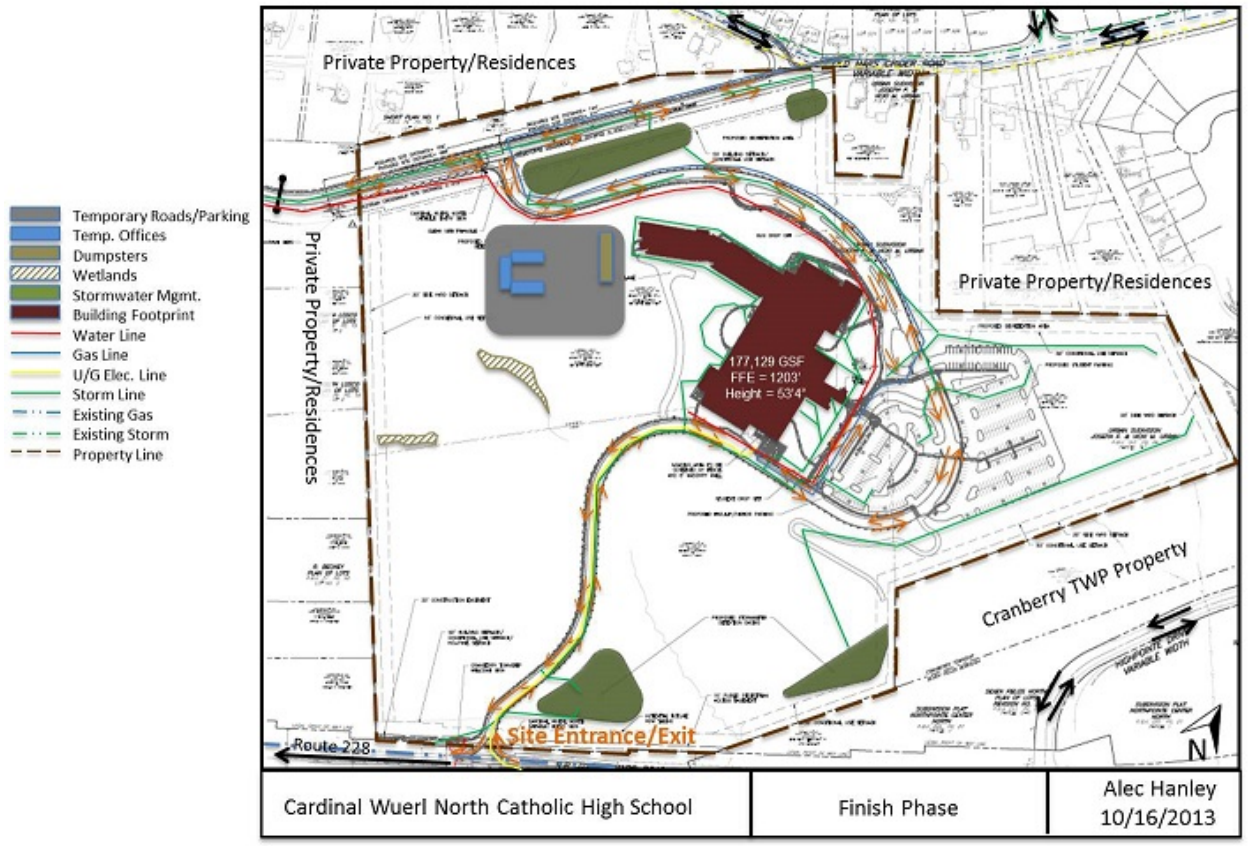


Figure 6: Finish Phase (Astorino Property)

The primary concern during this project phase is demobilization and opening up the site for owner occupation. In order to do this we want to reduce the number of dumpsters, material/laydown & parking area, temporary structures & toilets.At the end the project site team will consist of the GC and CM Agency. Primes with trailers should have demobilized. Active work during this phase primarily consists of interior finishes and chapel construction. Temporary parking has become permanent. Laborers are parking in the permanent lots on the southeast of CWNCHS. Temporary toilets should be reduced in place of utilizing indoor facilities. Many of the dumpsters have been removed due to demobilizing of work forces and the addition of permanent waste services. Finally, all permanent utilities are shown and installed.

General Conditions Estimate

The General Conditions cost for Cardinal Wuerl North Catholic High School was estimated to be $2,871,341 over the 21 month schedule. The period that General Conditions costs were counted was from September 2012 – June 2014 since the general contractor was on site during that time period. The site contractor's fees were not counted in this estimate (they began activity in June 2012). My estimate puts General Conditions at 6.67% of the actual building construction costs (~$43 million) and $136,730.52/month. GC costs were slightly high, which can be largely attributed to high temporary structure costs need for the large onsite staff. The project team reported an approximate value of $3,000,000 for their general conditions services. Therefore, most if not all of the actual resources, temporary structures and miscellaneous items have been accurately reported.

The Diocese of Pittsburgh was not overly concerned with the high staffing costs because their overall interest on this project was quality. Having a Project Manager, Superintendent, two full-time Project Engineers, as well as two interns allowed for increased site/safety management and quality assurance/control. To this point no recordable accidents have occurred and extensive programs in concrete, spray-applied air barrier membrane, TPO roofing, in-wall close-up, & above-ceiling close-up were implemented to ensure the quality of installed work. Therefore, the large management crew was critical when calculating GC costs. Several other critical items include high temporary service costs for housing the management team, daily clean up due to a high volume of publicity and visitors, extensive snow removal on the long site roads & building perimeter over two winters, and temporary access roads/parking/staging areas since the site itself is so large. Utilities were not a huge factor for the general contractor since temporary water was handled by the plumbing contractor and temporary lighting/electrical services were covered by the electrical contractor.

RS Means: Open Shop Building Construction Cost Data, 2013 Edition was the primary resource used for this estimate. Some known items were not available in the RS Means catalog so inferential knowledge was necessary for items such as closeout documents, project related travel, dumpsters, snow removal, computer software & equipment, drinking water and fire extinguishers. The table in Appendix D outlines all takeoffs and unit costs for the General Conditions Estimate.

Constructability Challenges

The project was essentially on hold for a month due to the permitting process in Cranberry Township. The project team started the job 31 days behind schedule and was able to work with all parties involved to bring the completion date back to January 31, 2014. This was attained by Mascaro Construction's efforts in critical path schedule weekly updating, perseverance and great work/efficiency by all tradesmen.

Due to the project starting late and haywire flow of work from that point, Mascaro Construction was required to install the roofing system during the winter season. Mascaro was not aware that the adhesive used for the TPO roof system was mandated by the Diocese of Pittsburgh to be compliant with low VOC thresholds. Due to the low VOC requirement, the temperature thresholds for applying the adhesive were more finite. Temperature restrictions delayed TPO roofing activity approximately 2-3 months. When the weather broke, Mascaro with the help of Florida Consulting (roofing consultant) increased crew sizes and worked on multiple areas concurrently in order to regain the lost time during the winter. Recent installation of the TPO roofing during warm weather can be seen below:

Figure 7: TPO Roof Finishing (Mascaro Property)

Figure 8: Phase I vs. Phase II (Mascaro Property)

Area C's (chapel) late design & round shape presented unique challenges to the building team. It delayed the substantial completion for the entire project an extra four months. All primes wanted to their crews on the CWNCHS site without interruption while transitioning between Areas A, B, D, E, F & G and Area C. This situation required special consideration when developing the chapel schedule. The circular shape of the chapel also presents challenges to the building trades. Materials such as exterior sheathing, masonry & interior GWB are composed of straight lines so tradesmen are more prone to making mistakes and not developing a consistent workflow. The picture shown below displays an almost complete building exterior for the main building and the completion of the chapel foundations. This picture helps to visualize the two phases occurring simultaneously.

LEED Practice Evaluation

Based on the funding situation for CWNCHS, I think it was important to achieve a LEED Certification at the very least. While it is difficult to achieve a LEED Certification in new construction of public high schools due to public funding and low-bid laws in Pennsylvania, private high schools are a bit easier to achieve this goal. The low bid did not have to be chosen, which gave the Diocese options when considering programs like LEED. Therefore, I believe it is the responsibility of the developer/owner in a situation such as this to make an attempt at sustainability. The most often chosen medium for sustainable practices is the Leadership in Energy & Environmental Design (LEED) program. LEED encompasses a wide variety of practices that promote an environmentally friendly design. In the interest of this specific building, I believe that the first goal to set is to attempt to determine what practices can be initiated without changing the design. These include points for open space (71 acre site provides this), joint use of facilities (churches/schools often share space with other programs), waste management (GC good practices), and utilizing local & recycled materials (minimal research necessary). Following this, attempts at sustainability can be developed by studying building system changes (TPO roofing for heat island), environment controls (thermal/lighting), sustainable sites (parking spots for efficient cars), and various other options. A lot of easily attainable practices can be achieved with minimal attention which will maximize the value of a building. My recommendation would be to attempt to achieve an appropriate level of certification based on the funding, current design, cost implications of change and the inevitable positive outcomes of building with sustainable practices. Overall, avoiding chasing LEED points that are not appropriate for CWNCHS is the best strategy to have.

The Roman Catholic Diocese of Pittsburgh simply wanted to incorporate the best practices possible with LEED options. The LEED Certification was important to the Diocese but overall goals of sustainability were more important than chasing LEED points. Anything that did not make sense for costs or the goals, needs and mission of Cardinal Wuerl North Catholic High School did not garner any interest. Environmental stewardship and energy costs were the focus. Weekly project meetings between the owner, CM, architect/engineers, GC, primes and subs were partially utilized to track progress of point development throughout construction. These methods have built confidence amongst the project team that they will fulfill LEED goals at substantial completion. The following is the breakdown of LEED Points for CWNCHS:

Figure 9: LEED Breakdown 1 (Astorino Property)

	Very Likely	Somewhat Likely	Not Likely	Not Attempting
Sustainable Sites	10	0	1	13
Water Efficiency	9	0	0	2
Energy & Atmosphere	9	0	0	24
Materials & Resources	7	0	0	6
Indoor Environmental Quality	11	0	1	7
Innovation & Design Process	4	2	0	0
Regional Priority	3	0	0	1
TOTALS	53	2	2	53

Figure 10: LEED Breakdown 2 (Astorino Property)

SUSTAINABLE SITES (*24 available points*)	**Points**	**Description**
Alternative Transportation/Fuel Efficient Vehicles	2	5% of parking is reserved for fuel efficient vehicles (19/375)
Alternative Transportation/Parking Capacity	2	Minimum parking requirements not exceeded.
Site Development - Maximize Open Space	1	LEED requires 20% - CWNCHS has 34.9%
Stormwater Design - Quantity Control	1	Susbstantial vegetation as well as wet detention basins.
Stormwater Design - Quality Control	1	90% of site can be infilfrated by vegetated portion of site.
Heat Island Effect - Roof	1	White TPO Roof meets requirements.
Light Pollution Reduction	1	Excessive lighting standards met. (<2% initial site lumens)
Joint Use of Facilities	1	Certain portions of the school are made available for sharing.
TOTAL	**10**	
WATER EFFICIENCY (11 available points)	**Points**	**Description**
Water Efficient Landscaping	4	Stormwater management basin water to be used for irrigation; no potable used.
Water Use Reduction	4	Rediced by 40%.
Process Water Use Reduction	1	Extensive list of water using appliances using water reduction.
TOTAL	**9**	
ENERGY & ATMOSPHERE (33 available points)	**Points**	**Desciption**
Optimize Energy Peformance	2	15.54% improvement from ASHRAE model.
Enhanced Commissioning	2	No Comment provided.
Enhanced Refrigerant Management	1	Architect MEP & food service consultant coordinated to choose approp. Equipment.
Measurement & Verification	2	Energy & Water Use Release form for USGBC provided & meters installed.
Green Power	2	Using Renewable Choice Energy for at least 2 years.
TOTAL	**7**	
MATERIALS & RESOURCES (13 available points)	**Points**	**Desciption**
Construction Waste Management	2	Utilizing 75% waste reduction plan. Mascaro reporting 0% waste to date.
Recycled Content	2	20% threshold. Should be achieved b/c of struct. Steel. Mascaro at 12.95% to date.
Regional Materials	2	20% threshold. Achievable b/c of concrete. Mascaro tracking 17.65% to date.
Certified Wood	1	FSC-certified products have been specified. Mascaro showing 60.59% thus far.
TOTAL	**7**	
INDOOR ENVIRONMENTAL QUALITY (19 available)	**Points**	**Desciption**
Outdoor Air Delivery Monitoring	1	Associated points in control board, CO2 monitoring, airflow monitoring in design.
Construction IAQ Management Plan (During Const.)	1	Included in Construction Documents
Construction IAQ Management Plan (Before occup.)	1	Client requested baseline IAQ test option. Ample time included in schedule.
Low-Emitting Materials - Adhesives & Sealants	1	VOC limits tracked by contractor throughout construction.
Low-Emitting Materials - Paints & Coatings	1	VOC limits tracked by contractor throughout construction.
Low-Emitting Materials - Composite Wood/Agrifiber	1	Compliant woods tracked by contractor.
Low-Emitting Materials - Ceiling & Wall Systems	1	VOC limits tracked by contractor throughout construction.
Indoor Chemical & Pollutant Source Control	1	Self-closing doors, deck-to-deck partitions, exhaust systems, MERV-13 filters.
Controllability of Systems - Lighting	1	Task lights in offices, minimum of one switch with two mode functions in classrooms
Controllability of Systems - Thermal Comfort	1	Thermostats in every office and all shared multi-occupant spaces.
Thermal Comfort - Design	1	Design meets credit requirements.
TOTAL	**11**	
INNOVATION & DESIGN PROCESS (6 available points)	**Points**	**Desciption**
Innovation in Design	1	Water reduced by 40%
Innovation in Design	1	Wetland mitigation integrated into Bio courses for Green Education credit.
Innovation in Design	1	Additional cost estimated by Renewable Choice Energy.
LEED Accredited Professional	1	Design Team included LEED APs.
TOTAL	**4**	
REGIONAL PRIORITY (5 available points)	**Points**	**Desciption**
Regional Priority: SS Credit 6.1	1	Achieved.
Regional Priority: SS Credit 6.2	1	Achieved.
Regional Priority: SS Credit 7.2	1	Achieved.
TOTAL	**3**	

*Note: All Prerequisites achieved; not outlined above.

As a critical evaluation of the LEED initiatives instituted on the project I would say that every point was executed well. Extensive studies by Astorino's LEED expert as well as many

conversations with the GC/CM & owner were held in preconstruction and throughout the project. Any further extensive pursual of more points that would greatly increase costs or go against the intial goals set by the project team would not be appropriate. That being said I believe that there are a few extra strides that could have been taken to increase the certification to a Gold level. The project will achieve a LEED Silver Certification with a minimum of 53 points or a maximum of 57 points in its current plan.

No comments were made for “Low-Emitting Materials – Flooring Systems/Furniture & Furnishings.” Simply choosing low VOC materials in these regards could have added another 2 points easily. Also, another point could have been added for “Optimize Energy Performance” with some ease. The currenty energy model is showing 15.54% improvement from the ASHRAE model, whereas adding another point would only entail another 0.46% increase in energy performance. It may have increased energy costs or initial system costs slightly but that would have been made up for with a better indoor atmosphere for the occupants. Better indoor air quality has been proven to improve the productivity and comfort of most building occupants.

BIM Practice Evaluation

I believe that building information modeling (BIM) can assist Cardinal Wuerl North Catholic High School in many ways. It has the capability to drastically save on costs with clash detection technology, produce high quality images to assist in design visualization, implement logistics/schedule management, assist in facilities management, as well as a multitude of other advantages. To use BIM effectively, one must consider the phrase that is used in the BIM Execution Plan developed by Penn State University, "begin with the end in mind." This phrase allows you to determine why you would use BIM and what you want to come out of the process with.

BIM should be used in CWNCHS for the purposes of cost savings, design visualization for earlier owner input, cost & schedule development, construction phase modeling, facilities/operations maintenance management, and marketing applications. Cost savings can be accrued by 3D coordination of all MEP, structural, and architectural elements to detect any physical interference between building systems. If this is detected early it only takes the click of a mouse to change the design rather than paying for an expensive change order. Cost estimations can be performed through the use of quantity takeoff programs. Schedule development in BIM helps to visualize the process in 3D over a certain time period and can work out inefficiencies in the schedule, such as heavy concentration of trades in one area. If site area is limited BIM can be used to plan out parking areas, site entrances & accessibility, material laydown areas, crane accessibility & swing radii, etc. during different phases of the project. Renderings of CWNCHS can be utilized by marketing professionals in an attempt to boost enrollment before the school officially opens in its new location. Also, a record model could assist the maintenance crew at the finished building by easily locating O&M manuals rather than searching through huge binders, determining what MEP/structural elements are behind each wall/ceiling, and informing them when maintenance on floors, mechanical units, fire protection systems, etc. is required.

The next step is determining when to perform each BIM activity through the schematic design, design development, construction and eventual operation of the building. The following table helped me outline how to reach the goals I stated above:

X	PLAN	X	DESIGN	X	CONSTRUCT	X	OPERATE
X	PROGRAMMING	X	DESIGN AUTHORING		SITE UTILIZATION PLANNING	X	BUILDING MAINTENANCE SCHEDULING
X	SITE ANALYSIS	X	DESIGN REVIEWS		CONSTRUCTION SYSTEM DESIGN	X	BUILDING SYSTEM ANALYSIS
		X	3D COORDINATION	X	3D COORDINATION		ASSET MANAGEMENT
		X	STRUCTURAL ANALYSIS		DIGITAL FABRICATION		SPACE MANAGEMENT / TRACKING
		X	LIGHTING ANALYSIS		3D CONTROL AND PLANNING	X	DISASTER PLANNING
		X	ENERGY ANALYSIS	X	RECORD MODELING	X	RECORD MODELING
		X	MECHANICAL ANALYSIS				
			OTHER ENG. ANALYSIS				
		X	SUSTAINABLITY (LEED) EVALUATION				
			CODE VALIDATION				
	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)	X	PHASE PLANNING (4D MODELING)		PHASE PLANNING (4D MODELING)
	COST ESTIMATION	X	COST ESTIMATION	X	COST ESTIMATION		COST ESTIMATION
	EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING		EXISTING CONDITIONS MODELING

Figure 11: Possible BIM Uses

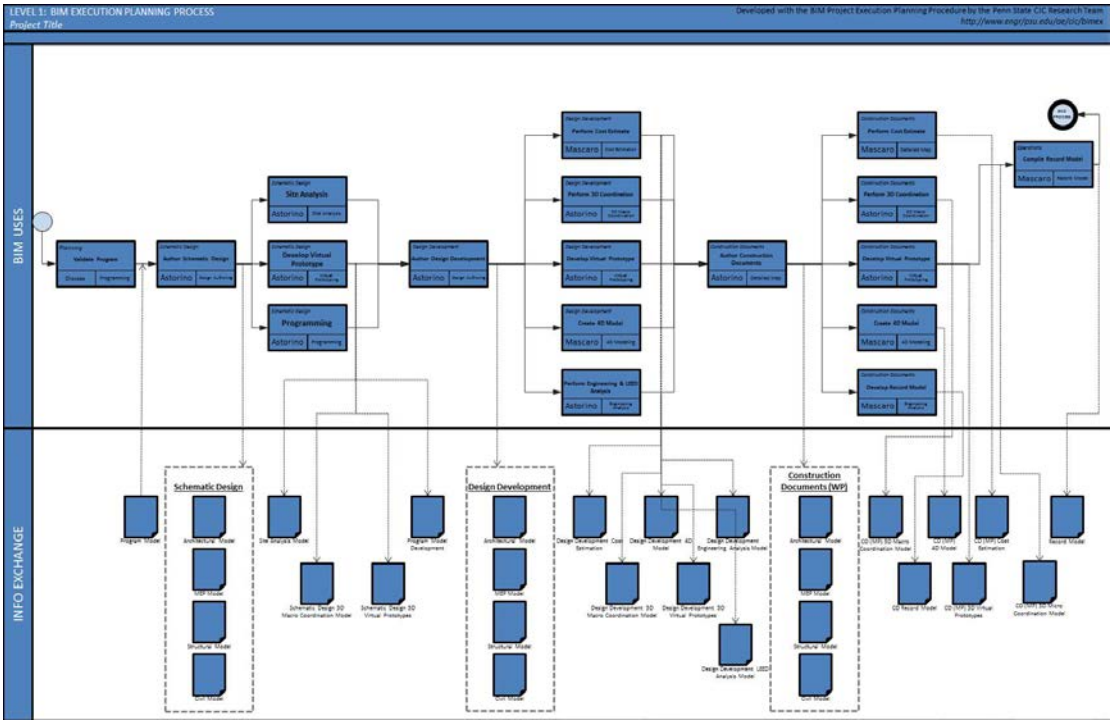


Figure 12: BIM Level 1 Process Map

The BIM goals that I outlined are very similar to the actual project goals. Major BIM goals for CWNCHS were, “reduce change orders due to poorly coordinated drawings, assist with visualization of design so that owner input could be obtained earlier in the process and so that marketing for the school could

begin earlier and logistics/schedule/asset management." All of the steps I have outlined in the above BIM Use Table are necessary to achieve these goals. The BIM Use List I developed is a bit more intensive than the actual project list.

Under the "Plan" category, I have added Programming and Site Analysis. I think programming in the design phase is necessary to help in determining a desirable size and shape and could have helped with building mass visualization. Since the site was virtually untouched prior to construction, a further site analysis during the planning stages using BIM could have given a few more options of where to place the building, sports fields, parking areas, etc.

For the "Design" category, I have added a Structural & Lighting Analysis. A structural analysis using BIM could have identified areas of weakness in the design and any possible flaws. A lighting analysis could have helped in developing a more efficient design as far as energy-saving luminaires/lamps, natural daylighting quantifications, and ensuring an even distribution of light in all areas. I don't think it makes complete sense to complete an energy analysis without factoring in lighting loads.

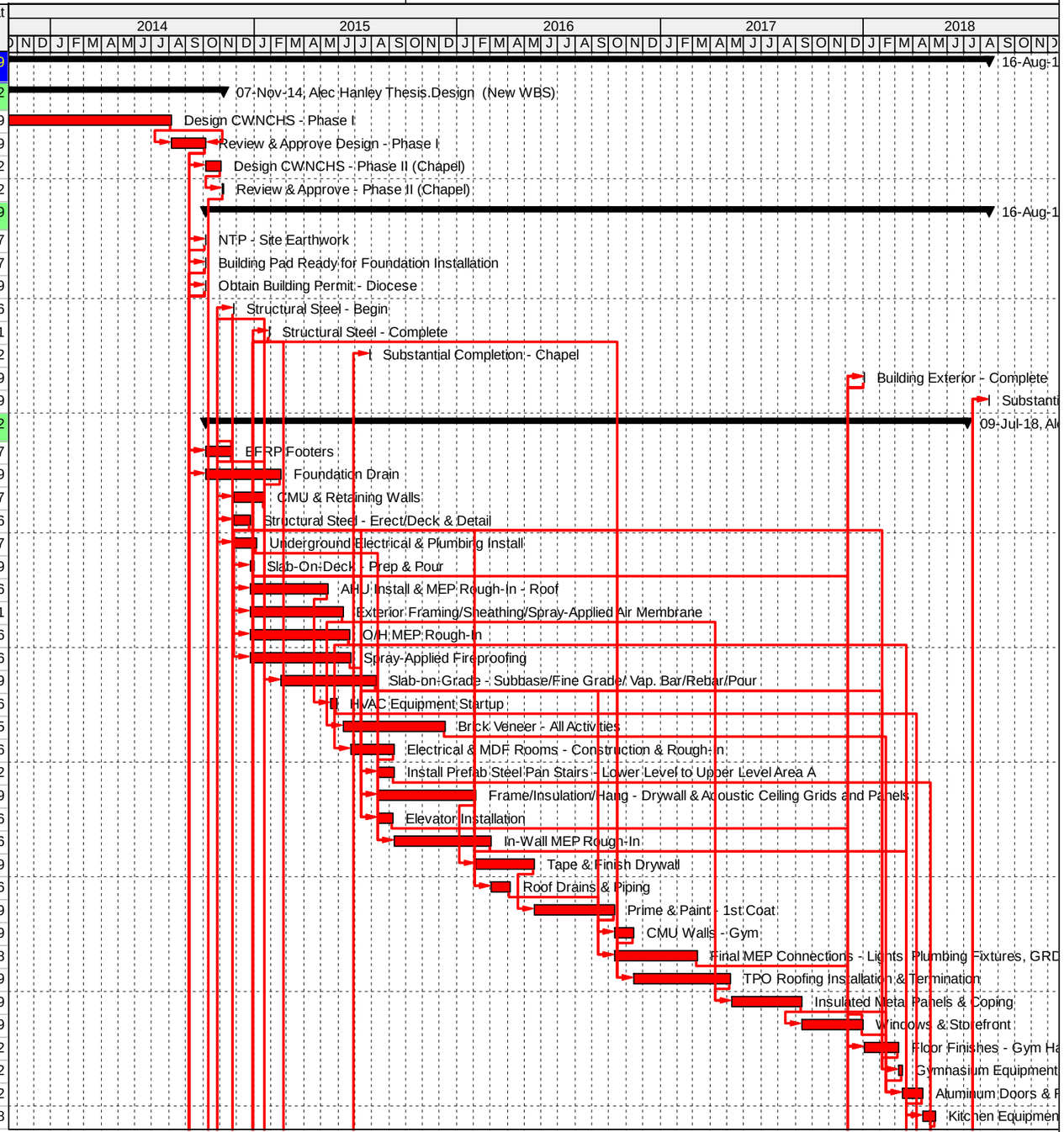
I did not change anything from the "Construct" category but I thought the "Operate" category could have used a big makeover. Site Utilization Planning was considered unnecessary due to the openness and accessibility of the 71 acre plot of land. CWNCHS's Execution Plan places "Produce a Federated Model that will aid in the Operation and Maintenance of the facility" with a high priority. Developing a Facilities Management Model has many more advantages than solely record modeling. I have added disaster planning in order to have more information on fire, tornado, flood, etc. plans available, asset management since it was an owner desired item, building system analysis to ensure that all systems are running to design specifications, and building maintenance scheduling to ensure that all systems are receiving maintenance when necessary and in assisting maintenance crews.

Models were transferred from design to construction in order to track any as-built changes and coordinate between the general contractor and all other primes. All models are continuously updated as needed and coordination meetings are held as necessary throughout construction between the owner, CM, GC, architect and primes. At the time of substantial completion, a Federated Model populated with As-Built information from the A/E, primes and subs will be delivered to the owner either as a .NWD or .DWF format.

APPENDIX A: Detailed CPM Schedule

Figure 13: Detailed Project Schedule

Activity Name	Original Duration	Start	Finish	Total Float
Alec Hanley Thesis CWNCHS	1261	14-Oct-13	16-Aug-18	-1099
Alec Hanley Thesis.Design (New WBS)	278	14-Oct-13	07-Nov-14	-302
Design CWNCHS - Phase I	210	14-Oct-13	05-Aug-14	-1099
Review & Approve Design - Phase I	44	06-Aug-14	06-Oct-14	-1099
Design CWNCHS - Phase II (Chapel)	20	07-Oct-14	03-Nov-14	-302
Review & Approve - Phase II (Chapel)	4	04-Nov-14	07-Nov-14	-302
Alec Hanley Thesis.8 Key Milestones	1007	07-Oct-14	16-Aug-18	-1099
NTP - Site Earthwork	0	07-Oct-14	07-Oct-14	-1077
Building Pad Ready for Foundation Installation	0	07-Oct-14	07-Oct-14	-1077
Obtain Building Permit - Diocese	0	07-Oct-14	07-Oct-14	-1099
Structural Steel - Begin	0	25-Nov-14	25-Nov-14	-1066
Structural Steel - Complete	0	29-Jan-15	29-Jan-15	-631
Substantial Completion - Chapel	0	28-Jul-15	28-Jul-15	-302
Building Exterior - Complete	0	03-Jan-18	03-Jan-18	-1099
Substantial Completion - Main Building	0	16-Aug-18	16-Aug-18	-1099
Alec Hanley Thesis.7 AREA A - 1st & 2nd Floor	980	07-Oct-14	09-Jul-18	-1072
EFRP Footers	35	07-Oct-14	24-Nov-14	-1077
Foundation Drain	97	07-Oct-14	18-Feb-15	-1099
CMU & Retaining Walls	40	25-Nov-14	19-Jan-15	-1077
Structural Steel - Erect/Deck & Detail	23	25-Nov-14	25-Dec-14	-1066
Underground Electrical & Plumbing Install	30	25-Nov-14	05-Jan-15	-1067
Slab-On-Deck - Prep & Pour	5	26-Dec-14	01-Jan-15	-309
AHU Install & MEP Rough-In - Roof	101	26-Dec-14	15-May-15	-306
Exterior Framing/Sheathing/Spray-Applied Air Membrane	119	26-Dec-14	10-Jun-15	-601
O/H MEP Rough-In	128	26-Dec-14	23-Jun-15	-726
Spray-Applied Fireproofing	129	26-Dec-14	24-Jun-15	-1066
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	123	19-Feb-15	10-Aug-15	-1099
HVAC Equipment Startup	10	18-May-15	29-May-15	-306
Brick Veneer - All Activities	131	11-Jun-15	10-Dec-15	-485
Electrical & MDF Rooms - Construction & Rough-In	57	24-Jun-15	10-Sep-15	-726
Install Prefab Steel Pan Stairs - Lower Level to Upper Level Area A	23	11-Aug-15	10-Sep-15	-362
Frame/Insulation/Hang - Drywall & Acoustic Ceiling Grids and Pan	127	11-Aug-15	03-Feb-16	-1099
Elevator Installation	20	11-Aug-15	07-Sep-15	-466
In-Wall MEP Rough-In	124	11-Sep-15	02-Mar-16	-726
Tape & Finish Drywall	76	04-Feb-16	19-May-16	-1099
Roof Drains & Piping	26	03-Mar-16	07-Apr-16	-726
Prime & Paint - 1st Coat	102	20-May-16	10-Oct-16	-1099
CMU Walls - Gym	25	11-Oct-16	14-Nov-16	-1099
Final MEP Connections - Lights, Plumbing Fixtures, GRDs	107	11-Oct-16	08-Mar-17	-858
TPO Roofing Installation & Termination	125	15-Nov-16	08-May-17	-1099
Insulated Metal Panels & Coping	91	09-May-17	12-Sep-17	-1099
Windows & Storefront	80	13-Sep-17	02-Jan-18	-1099
Floor Finishes - Gym Hardwood & Sealed/Polished Concrete	45	03-Jan-18	06-Mar-18	-1072
Gymnasium Equipment Installation	4	07-Mar-18	12-Mar-18	-1072
Aluminum Doors & Frames	27	13-Mar-18	18-Apr-18	-1072
Kitchen Equipment Installation	17	19-Apr-18	11-May-18	-1058



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

Activity Name	Original Duration	Start	Finish	Total Float
Casework	13	19-Apr-18	07-May-18	-1072
HVAC Balancing & Commissioning	18	08-May-18	31-May-18	-1072
Final Clean	27	01-Jun-18	09-Jul-18	-1072
Alec Hanley Thesis.6 AREA B - Mechanical/Ele	1007	07-Oct-14	15-Aug-18	-1099
EFRP Footers	12	07-Oct-14	22-Oct-14	-608
Foundation Drain	1	07-Oct-14	07-Oct-14	-517
Underground Electrical & Plumbing Install	26	07-Oct-14	11-Nov-14	-542
CMU & Retaining Walls	17	23-Oct-14	14-Nov-14	-545
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	17	17-Nov-14	09-Dec-14	-545
Structural Steel - Erect/Deck & Detail	47	25-Nov-14	28-Jan-15	-631
Mechanical Room - Construction & Rough-In	60	10-Dec-14	03-Mar-15	-545
Roof Drains & Piping	17	29-Jan-15	20-Feb-15	-388
TPO Roofing Installation & Termination	25	29-Jan-15	04-Mar-15	-422
AHU Install & MEP Rough-Ins - Roof	126	29-Jan-15	23-Jul-15	-432
Exterior Framing/Sheathing/Spray-Applied Air Membrane	31	29-Jan-15	12-Mar-15	-628
Spray-Applied Fireproofing	19	29-Jan-15	24-Feb-15	-488
Brick Veneer - All Activities	55	13-Mar-15	28-May-15	-483
O/H MEP Rough-In	76	13-Mar-15	26-Jun-15	-628
Insulated Metal Panels & Coping	27	29-May-15	06-Jul-15	-483
In-Wall MEP Rough-In	52	29-Jun-15	08-Sep-15	-628
Windows & Storefront	35	07-Jul-15	24-Aug-15	-483
HVAC Equipment Startup	10	24-Jul-15	06-Aug-15	-432
Frame/Insulation/Hang - Drywall & Acoustic Ceiling Grids and Pan	66	09-Sep-15	09-Dec-15	-628
Tape & Finish Drywall	21	10-Dec-15	07-Jan-16	-628
Prime & Paint - 1st Coat	11	08-Jan-16	22-Jan-16	-628
Ceramic Tile	11	08-Jan-16	22-Jan-16	-592
Final MEP Connections - Lights, Plumbing Fixtures, GRDs	60	25-Jan-16	15-Apr-16	-628
Aluminum Doors & Frames	15	18-Apr-16	06-May-16	-628
Floor Finishes - Carpet & Sealed/Polished Concrete	39	03-Jan-18	26-Feb-18	-1099
HVAC Balancing & Commissioning	57	27-Feb-18	16-May-18	-1099
Final Clean	65	17-May-18	15-Aug-18	-1099
Alec Hanley Thesis.5 AREA C - Chapel	186	10-Nov-14	27-Jul-15	-302
NTP - Chapel	0	10-Nov-14	10-Nov-14	-302
Building Permit	16	10-Nov-14	01-Dec-14	-302
EFRP Footers & Foundation Walls	15	02-Dec-14	22-Dec-14	-302
Foundation Drain	3	02-Dec-14	04-Dec-14	-276
Underground Electrical & Plumbing Install	5	02-Dec-14	08-Dec-14	-278
Electrical R-I - Electrical Room	10	09-Dec-14	22-Dec-14	-245
Structural Steel - Erect/Deck & Detail	18	23-Dec-14	15-Jan-15	-302
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	21	23-Dec-14	20-Jan-15	-288
TPO Roofing Installation & Termination	11	16-Jan-15	30-Jan-15	-302
Exterior Framing/Sheathing/Spray-Applied Air Membrane	19	16-Jan-15	11-Feb-15	-289
O/H MEP & Lighting	32	16-Jan-15	02-Mar-15	-263
Skylight Dome & Roof Cross Installation	6	02-Feb-15	09-Feb-15	-302
MEP Rough-Ins & Mech Start Up - Roof	21	02-Feb-15	02-Mar-15	-222
Frame & Hang Drywall	31	10-Feb-15	24-Mar-15	-302

Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

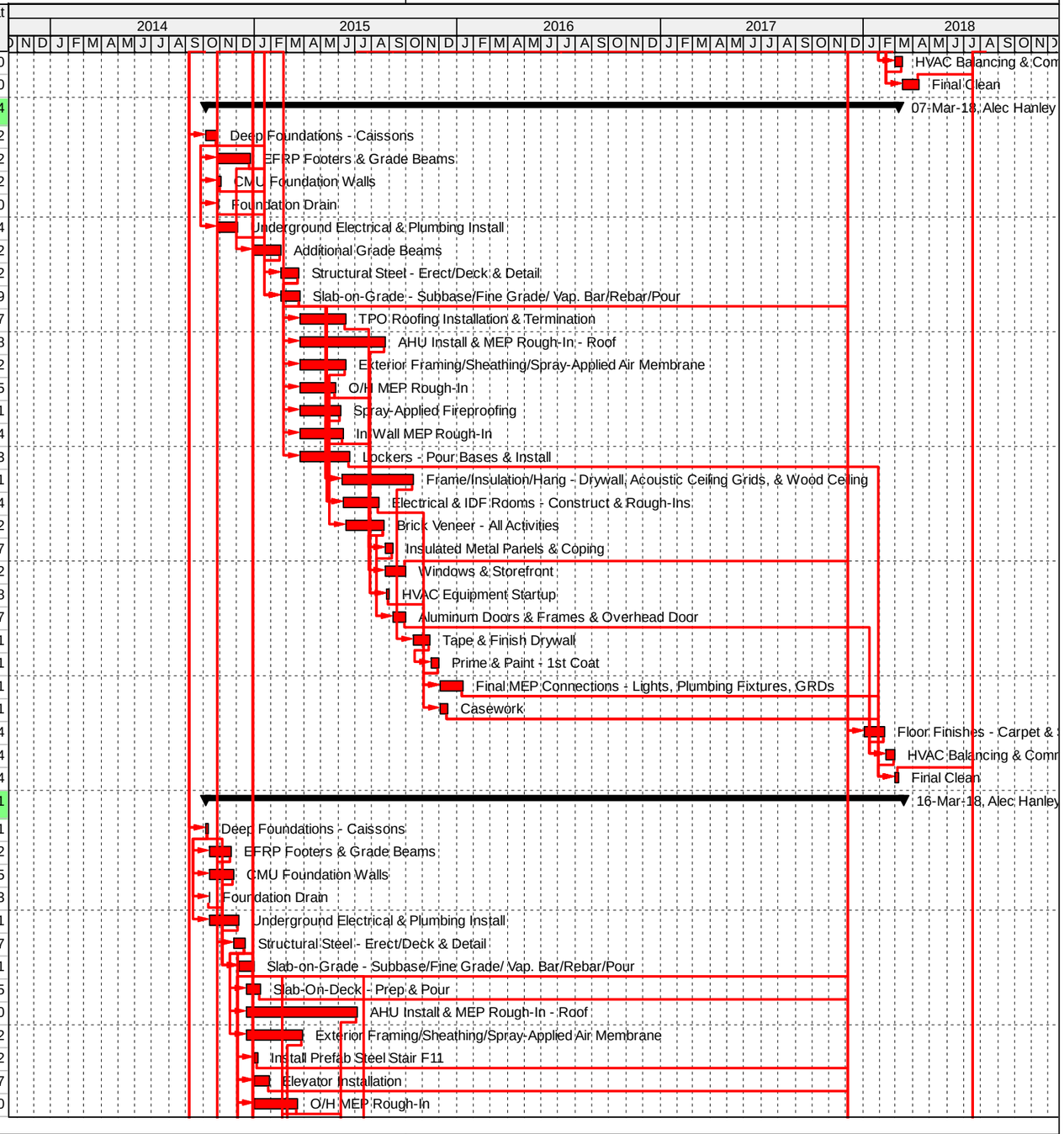
TASK filter: All Activities

Activity Name	Original Duration	Start	Finish	Total Float
Ext. CMU & Brick	33	12-Feb-15	30-Mar-15	-289
HVAC Equipment Startup	5	03-Mar-15	09-Mar-15	-222
Install Light Fixtures	10	25-Mar-15	07-Apr-15	-229
Tape & Finish	15	25-Mar-15	14-Apr-15	-302
Soffit/Fascia/Metal Panels	28	31-Mar-15	07-May-15	-289
Prime & Paint 1st Coat	5	15-Apr-15	21-Apr-15	-302
Electrical Trim Out	1	22-Apr-15	22-Apr-15	-239
Decorative Rose Petal - Ceiling	5	22-Apr-15	28-Apr-15	-259
Final Plumbing Fixtures & Connections	3	22-Apr-15	24-Apr-15	-302
Roof Plumbing & Accessory Installation	5	27-Apr-15	01-May-15	-302
Install Floor Finishes	25	04-May-15	05-Jun-15	-302
Windows & Storefront	24	08-May-15	10-Jun-15	-289
Pews & Casework - S/A/FD & Installation	15	08-Jun-15	26-Jun-15	-302
Aluminum Doors & Frames	1	29-Jun-15	29-Jun-15	-302
HVAC Balancing & Commissioning	15	30-Jun-15	20-Jul-15	-302
Final Clean	5	21-Jul-15	27-Jul-15	-302
Alec Hanley Thesis.4 AREA D - Auditorium, Sta	918	07-Oct-14	12-Apr-18	-1010
EFRP Footers	12	07-Oct-14	22-Oct-14	-582
Foundation Drain	1	07-Oct-14	07-Oct-14	-554
Underground Electrical & Plumbing Install	26	07-Oct-14	11-Nov-14	-579
CMU Foundation Walls	17	23-Oct-14	14-Nov-14	-582
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	87	17-Nov-14	17-Mar-15	-582
Structural Steel - Erect/Deck & Detail	31	25-Nov-14	06-Jan-15	-584
Roof Drains & Piping	35	07-Jan-15	24-Feb-15	-294
MEP Rough-Ins & Mech Start Up - Roof	144	07-Jan-15	27-Jul-15	-403
Exterior Framing/Sheathing/Spray-Applied Air Membrane	50	07-Jan-15	17-Mar-15	-424
O/H MEP Rough-In	82	07-Jan-15	30-Apr-15	-417
Spray-Applied Fireproofing	52	07-Jan-15	19-Mar-15	-584
TPO Roofing Installation & Termination	114	29-Jan-15	07-Jul-15	-406
CMU Walls - Auditorium	89	18-Mar-15	20-Jul-15	-454
Brick Veneer - All Activities	55	18-Mar-15	02-Jun-15	-424
Auditorium Seating - Installation, Field Measure, Fab & Deliver	80	18-Mar-15	07-Jul-15	-311
Frame/Insulate/Hang - Drywall, Acoustic Wall/Celing Panels, & Wc	129	20-Mar-15	16-Sep-15	-584
Insulated Metal Panels/Soffit & Fascia/Coping	68	03-Jun-15	04-Sep-15	-424
Smoke Vents - Stage Roof	10	08-Jul-15	21-Jul-15	-406
Deck & Pour Spot Platforms - Auditorium	2	21-Jul-15	22-Jul-15	-407
Install Prefab Spiral Stairs & Caged Ladders - Auditorium	2	21-Jul-15	22-Jul-15	-371
A/V Stage Equipment & Rigging	36	23-Jul-15	10-Sep-15	-407
Windows & Storefront	45	07-Sep-15	06-Nov-15	-424
In-Wall MEP Rough-In	68	17-Sep-15	21-Dec-15	-584
Aluminum & Overhead Doors & Frames	15	09-Nov-15	27-Nov-15	-424
Tape & Finish Drywall	20	22-Dec-15	18-Jan-16	-584
Prime, Paint & Block Filler - 1st Coat	56	19-Jan-16	05-Apr-16	-584
Final MEP Connections - Lights, Plumbing Fixtures, GRDs	68	06-Apr-16	08-Jul-16	-584
Casework & Architectural Woodwork	9	06-Apr-16	18-Apr-16	-564
Floor Finishes - Stage Hardwood, Carpet & Sealed/Polished Conc	39	03-Jan-18	26-Feb-18	-1010

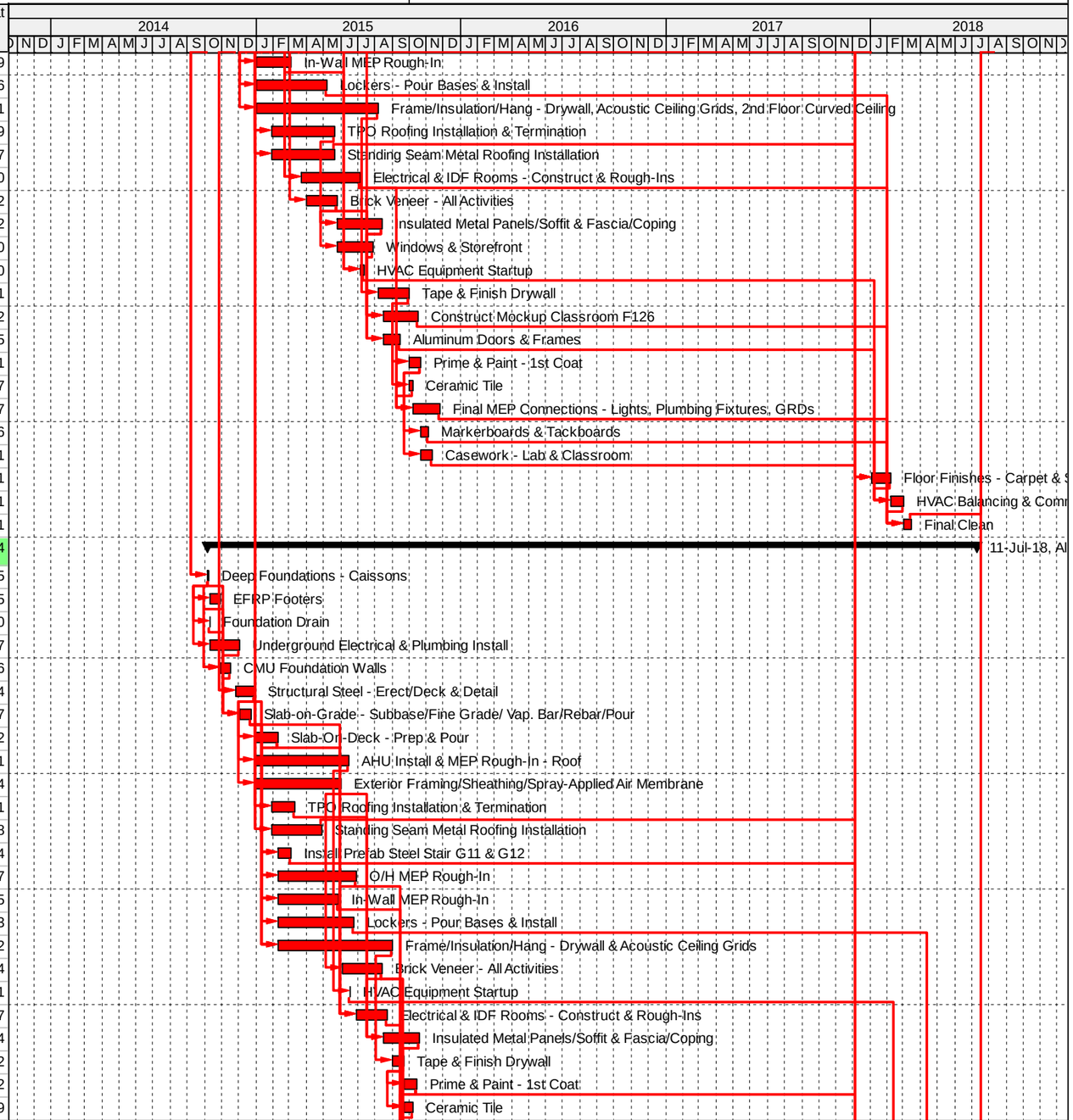
Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

Activity Name	Original Duration	Start	Finish	Total Float
HVAC Balancing & Commissioning	10	27-Feb-18	12-Mar-18	-1010
Final Clean	23	13-Mar-18	12-Apr-18	-1010
Alec Hanley Thesis.3 AREA E - Library & Arts E	892	07-Oct-14	07-Mar-18	-984
Deep Foundations - Caissons	15	07-Oct-14	27-Oct-14	-512
EFRP Footers & Grade Beams	44	28-Oct-14	26-Dec-14	-512
CMU Foundation Walls	5	28-Oct-14	03-Nov-14	-312
Foundation Drain	3	28-Oct-14	30-Oct-14	-310
Underground Electrical & Plumbing Install	27	28-Oct-14	03-Dec-14	-334
Additional Grade Beams	38	29-Dec-14	18-Feb-15	-512
Structural Steel - Erect/Deck & Detail	23	19-Feb-15	23-Mar-15	-512
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	25	19-Feb-15	25-Mar-15	-389
TPO Roofing Installation & Termination	60	24-Mar-15	15-Jun-15	-317
AHU Install & MEP Rough-In - Roof	112	24-Mar-15	26-Aug-15	-378
Exterior Framing/Sheathing/Spray-Applied Air Membrane	60	24-Mar-15	15-Jun-15	-512
O/H MEP Rough-In	48	24-Mar-15	28-May-15	-355
Spray-Applied Fireproofing	54	24-Mar-15	05-Jun-15	-441
In-Wall MEP Rough-In	55	26-Mar-15	10-Jun-15	-364
Lockers - Pour Bases & Install	63	26-Mar-15	22-Jun-15	-283
Frame/Insulation/Hang - Drywall, Acoustic Ceiling Grids, & Wood C	94	08-Jun-15	15-Oct-15	-441
Electrical & IDF Rooms - Construct & Rough-Ins	46	11-Jun-15	13-Aug-15	-364
Brick Veneer - All Activities	50	16-Jun-15	24-Aug-15	-512
Insulated Metal Panels & Coping	11	25-Aug-15	08-Sep-15	-367
Windows & Storefront	29	25-Aug-15	02-Oct-15	-512
HVAC Equipment Startup	5	27-Aug-15	02-Sep-15	-378
Aluminum Doors & Frames & Overhead Door	16	09-Sep-15	30-Sep-15	-367
Tape & Finish Drywall	21	16-Oct-15	13-Nov-15	-441
Prime & Paint - 1st Coat	11	16-Nov-15	30-Nov-15	-441
Final MEP Connections - Lights, Plumbing Fixtures, GRDs	31	01-Dec-15	12-Jan-16	-441
Casework	11	01-Dec-15	15-Dec-15	-421
Floor Finishes - Carpet & Sealed/Polished Concrete	28	03-Jan-18	09-Feb-18	-984
HVAC Balancing & Commissioning	12	12-Feb-18	27-Feb-18	-984
Final Clean	6	28-Feb-18	07-Mar-18	-984
Alec Hanley Thesis.2 AREA F - 1st & 2nd Floor	899	07-Oct-14	16-Mar-18	-991
Deep Foundations - Caissons	4	07-Oct-14	10-Oct-14	-431
EFRP Footers & Grade Beams	30	13-Oct-14	21-Nov-14	-422
CMU Foundation Walls	33	13-Oct-14	26-Nov-14	-425
Foundation Drain	1	13-Oct-14	13-Oct-14	-393
Underground Electrical & Plumbing Install	39	13-Oct-14	04-Dec-14	-431
Structural Steel - Erect/Deck & Detail	17	25-Nov-14	17-Dec-14	-387
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	19	05-Dec-14	31-Dec-14	-431
Slab-On-Deck - Prep & Pour	18	18-Dec-14	12-Jan-15	-215
AHU Install & MEP Rough-In - Roof	143	18-Dec-14	06-Jul-15	-320
Exterior Framing/Sheathing/Spray-Applied Air Membrane	73	18-Dec-14	30-Mar-15	-372
Install Prefab Steel Stair F11	5	01-Jan-15	07-Jan-15	-212
Elevator Installation	20	01-Jan-15	28-Jan-15	-227
O/H MEP Rough-In	57	01-Jan-15	20-Mar-15	-350



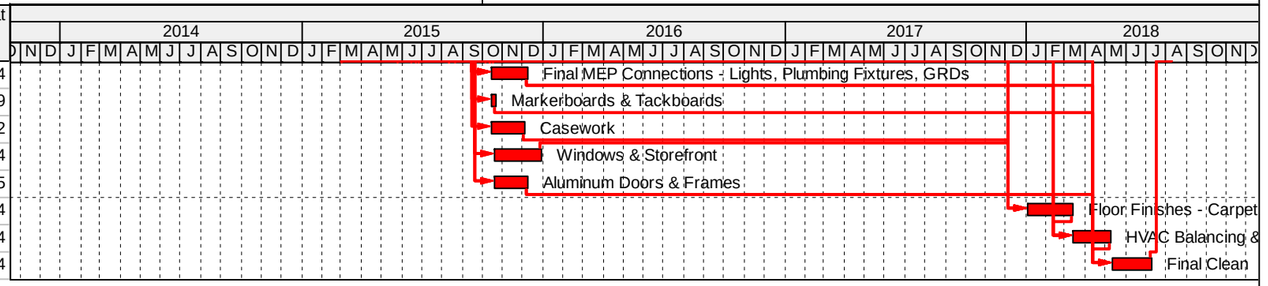
Activity Name	Original Duration	Start	Finish	Total Float
In-Wall MEP Rough-In	46	01-Jan-15	05-Mar-15	-339
Lockers - Pour Bases & Install	91	01-Jan-15	07-May-15	-256
Frame/Insulation/Hang - Drywall, Acoustic Ceiling Grids, 2nd Floor	156	01-Jan-15	06-Aug-15	-431
TPO Roofing Installation & Termination	80	29-Jan-15	20-May-15	-369
Standing Seam Metal Roofing Installation	82	29-Jan-15	22-May-15	-417
Electrical & IDF Rooms - Construct & Rough-Ins	76	23-Mar-15	06-Jul-15	-350
Brick Veneer - All Activities	40	31-Mar-15	25-May-15	-372
Insulated Metal Panels/Soffit & Fascia/Coping	59	26-May-15	14-Aug-15	-372
Windows & Storefront	47	26-May-15	29-Jul-15	-360
HVAC Equipment Startup	5	07-Jul-15	13-Jul-15	-320
Tape & Finish Drywall	39	07-Aug-15	30-Sep-15	-431
Construct Mockup Classroom F126	45	17-Aug-15	16-Oct-15	-372
Aluminum Doors & Frames	21	17-Aug-15	14-Sep-15	-365
Prime & Paint - 1st Coat	15	01-Oct-15	21-Oct-15	-431
Ceramic Tile	5	01-Oct-15	07-Oct-15	-417
Final MEP Connections - Lights, Plumbing Fixtures, GRDs	35	08-Oct-15	25-Nov-15	-417
Markerboards & Tackboards	11	22-Oct-15	05-Nov-15	-386
Casework - Lab & Classroom	14	22-Oct-15	10-Nov-15	-431
Floor Finishes - Carpet & Sealed/Polished Concrete	25	03-Jan-18	06-Feb-18	-991
HVAC Balancing & Commissioning	17	07-Feb-18	01-Mar-18	-991
Final Clean	11	02-Mar-18	16-Mar-18	-991
Alec Hanley Thesis.1 AREA G - 1st & 2nd Floor	982	07-Oct-14	11-Jul-18	-1074
Deep Foundations - Caissons	3	07-Oct-14	09-Oct-14	-555
EFRP Footers	13	10-Oct-14	28-Oct-14	-555
Foundation Drain	1	10-Oct-14	10-Oct-14	-460
Underground Electrical & Plumbing Install	38	10-Oct-14	02-Dec-14	-497
CMU Foundation Walls	14	29-Oct-14	17-Nov-14	-486
Structural Steel - Erect/Deck & Detail	25	25-Nov-14	29-Dec-14	-574
Slab-on-Grade - Subbase/Fine Grade/ Vap. Bar/Rebar/Pour	14	03-Dec-14	22-Dec-14	-497
Slab-On-Deck - Prep & Pour	30	30-Dec-14	09-Feb-15	-532
AHU Install & MEP Rough-In - Roof	121	30-Dec-14	16-Jun-15	-361
Exterior Framing/Sheathing/Spray-Applied Air Membrane	111	30-Dec-14	02-Jun-15	-574
TPO Roofing Installation & Termination	29	29-Jan-15	10-Mar-15	-461
Standing Seam Metal Roofing Installation	63	29-Jan-15	27-Apr-15	-398
Install Prefab Steel Stair G11 & G12	16	10-Feb-15	03-Mar-15	-334
O/H MEP Rough-In	100	10-Feb-15	29-Jun-15	-447
In-Wall MEP Rough-In	78	10-Feb-15	28-May-15	-425
Lockers - Pour Bases & Install	97	10-Feb-15	24-Jun-15	-323
Frame/Insulation/Hang - Drywall & Acoustic Ceiling Grids	145	10-Feb-15	31-Aug-15	-532
Brick Veneer - All Activities	53	03-Jun-15	14-Aug-15	-574
HVAC Equipment Startup	2	17-Jun-15	18-Jun-15	-361
Electrical & IDF Rooms - Construct & Rough-Ins	40	30-Jun-15	24-Aug-15	-447
Insulated Metal Panels/Soffit & Fascia/Coping	46	17-Aug-15	19-Oct-15	-574
Tape & Finish Drywall	16	01-Sep-15	22-Sep-15	-532
Prime & Paint - 1st Coat	16	23-Sep-15	14-Oct-15	-532
Ceramic Tile	11	23-Sep-15	07-Oct-15	-479



Actual Level of Effort | Remaining Work | Milestone
Actual Work | Critical Remaining Work | summary

TASK filter: All Activities

Activity Name	Original Duration	Start	Finish	Total Float
Final MEP Connections - Lights, Plumbing Fixtures, GRDs	39	15-Oct-15	08-Dec-15	-484
Markerboards & Tackboards	6	15-Oct-15	22-Oct-15	-409
Casework	37	15-Oct-15	04-Dec-15	-532
Windows & Storefront	51	20-Oct-15	29-Dec-15	-574
Aluminum Doors & Frames	37	20-Oct-15	09-Dec-15	-485
Floor Finishes - Carpet & Sealed/Polished Concrete	50	03-Jan-18	13-Mar-18	-1074
HVAC Balancing & Commissioning	42	14-Mar-18	10-May-18	-1074
Final Clean	44	11-May-18	11-Jul-18	-1074



APPENDIX B: Structural Takeoffs & Costs

FOUNDATIONS						
Type	**Size (FT)**			**Volume (CY)**	**Quantity**	**Volume Total (CY)**
Footings & Grade Beams (3000 psi)	**L**	**W**	**D**			
A	5	5	1.5	1.388888889	143	198.6111111
B	6	6	1.5	2	55	110
C	4	4	1.5	0.888888889	12	10.66666667
D	5	7	1.5	1.944444444	5	9.722222222
E	17.583	14.583	1	9.497170782	1	9.497170782
F	22	11	1	8.962962963	1	8.962962963
G	3	3	1	0.333333333	12	4
WF3 (varying width & length)	-	-	1	505.3787037	1	505.3787037
WF4 (varying length)	56.73	4	1.25	10.50555556	1	10.50555556
WF6 (varying length)	87.4	6	1.5	29.13333333	1	29.13333333
WF8.5 (varying length)	358.44	8.5	1.5	169.2633333	1	169.2633333
GB1 (varying length)	389.37	1.5	3	64.895	1	64.895
GB2 (varying length)	43.93	1.8333	3	8.948541	1	8.948541
GB3 (varying length)	749.35	1.25	1.5	52.03784722	1	52.03784722
Caissons	**Diameter**		**D**	**Volume (CY)**	**Quantity**	**Volume Total (CY)**
C1	3		25	6.55	48	314.4
TOTAL						**1502.022448**

*Assumed no formwork is necessary for footings, caissons & grade beams. All are poured into excavation.

Figure 14: Foundations - Concrete

FOUNDATIONS - REBAR						
Type						
Footings & Grade Beams (3000 psi)	**Reinforcement**	**Reinf. (LF)**	**Reinf. (lb/LF)**	**Quantity**	**Reinf. Total (lb)**	**Reinf. Total (tons)**
A	(6) #5 E.W.	60	1.043	143	8948.9400	4.47
B	(7) #5 E.W.	84	1.043	55	4818.6600	2.41
C	(5) #5 E.W.	40	1.043	12	500.6400	0.25
D	#5 @ 8" O.C. E.W.	101	1.043	5	526.7150	0.26
E	#5 @ 12" O.C., T & B, E.W.	540	1.043	1	563.2200	0.28
F	#5 @ 12" O.C., T & B, E.W.	484	1.043	1	504.8120	0.25
G	(4) #5 E.W.	24	1.043	12	300.3840	0.15
WF3 (varying width & length)	#5 x 2'-6" at 12" & (3) #5 CONT.	40948	1.043	1	42708.7640	21.35
WF4 (varying length)	#5 x 3'-6" at 12" T & B & (5) #5 CONT.	294	1.043	1	306.6420	0.15
WF6 (varying length)	#5 x 5'-6" at 12" T & B & (7) #5 CONT. T&B	1238	1.043	1	1291.2340	0.65
WF8.5 (varying length)	#5 x 8'-0" at 12" T & B & (10) #5 CONT. T&B	7189	1.043	1	7498.1270	3.75
GB1 (varying length)	(3) #5 CONT. T&B w/ #4 @ 12" O.C. Ties	2727	1.043; 0.668	-	29817.0180	14.91
#5	(3) #5 CONT. T&B	6	1.043	2727	17065.5660	8.53
#4	#4 @ 12" O.C. Ties	7	0.668	2727	12751.4520	6.38
GB2 (varying length)	(3) #6 CONT. T&B w/ #4 @ 12" O.C. Ties	309	1.502; 0.668	-	4367.2000	2.18
#6	(3) #6 CONT. T&B	6	1.502	309	2784.7080	1.39
#4	#4 @ 12" O.C. Ties	7.67	0.668	309	1582.4920	0.79
GB3 (varying length)	(4) #6 CONT. T&B w/ #4 @ 16" O.C. Ties	6558	1.502; 0.668	-	91943.1600	45.97
#6	(4) #6 CONT. T&B	8	1.502	6558	78800.9280	39.40
#4	#4 @ 16" O.C. Ties	3	0.668	6558	13142.2320	6.57
Caissons	**Reinforcement**	**Reinf. (LF)**	**Reinf. (lb/LF)**	**Quantity**	**Reinf. Total (lb)**	**Reinf. Total (tons)**
C1	(7) #8 w/ #3 @ 16" O.C. Ties & (4) #8 GB Ties	15799	2.67; 0.376	48	28348	14.17
#8	(7) 24.5' #8 + (4) 4' #8 GB Ties	203.5	2.67	48	26080.56	13.04
#3	#3 @ 16" O.C. Ties	125.65	0.376	48	2267.7312	1.13
TOTALS						
#3						1.13
#4						13.74
#5						42.52
#6						40.79
#8						13.04
TOTAL (tons)						**111**

Figure 15: Foundations - Steel

Slab-On-Grade			
Concrete	**Size (GSF)**	**Volume (CF)**	**Volume (CY)**
A - 5" Thick w/ One Layer WWF 6x6 - W2.1xW2.1	102819.38	42841.41	1586.7
B - 8" Thick w/ #5 @ 12" OC EW & One Layer WWF 6x6 - W2.1xW2.1	2409.01	1606.01	59.5
Reinforcement	**Size (GSF)**	**Unit Weight**	**Total Weight (tons)**
WWF 6x6 - W2.1xW2.1	105228.39	0.3 lb/SF	16
#5 Rebar	5095	1.043 lb/LF	2.657

Figure 16: Slab-On-Grade Takeoff

BEAMS				JOISTS			
Beam Name & Size	**LF**	**Weight (lbs)**	**Weight (tons)**	**Joist Name & Size**	**LF**	**Weight (lbs)**	**Weight (tons)**
W8x10	21.32	213.20	0.11	12K3	347.04	1839.31	0.92
W8x15	187.25	2808.75	1.40	14K3	563.00	3378.00	1.69
W12x16	92.88	1486.13	0.74	16K3	89.33	562.78	0.28
W12x22	1093.60	24059.20	12.03	16K4	949.08	6643.56	3.32
W12x26	1352.40	35162.40	17.58	16KCS4	196.00	2842.00	1.42
W12x30	277.22	8316.60	4.16	18K4	627.00	4514.40	2.26
W14x22	52.00	1144.00	0.57	18KCS4	201.25	3018.75	1.51
W14x26	1274.49	33136.74	16.57	18K5	2074.71	15975.24	7.99
W14x30	170.67	5120.10	2.56	18KCS5	562.67	10409.30	5.20
W16x26	2596.94	67520.44	33.76	20K4	178.50	1356.60	0.68
W16x31	2314.27	71742.52	35.87	20K5	2118.04	17367.90	8.68
W16x36	55.50	1998.00	1.00	20KCS5	278.30	5566.00	2.78
W18x35	4952.64	173342.51	86.67	20K6	557.00	4957.30	2.48
W18x40	1450.86	58034.40	29.02	22K5	404.67	3561.07	1.78
W21x44	3750.00	165000.00	82.50	22K6	235.69	2168.35	1.08
W24x55	2637.32	145052.60	72.53	24K8	399.66	4596.09	2.30
W24x62	938.37	58178.94	29.09	24K9	270.55	3246.60	1.62
W24x68	1228.08	83509.44	41.75	26K5	396.84	3769.98	1.88
W24x76	31.35	2382.60	1.19	26KCS5	264.56	5423.48	2.71
W24x84	284.56	23903.04	11.95	26K7	342.00	3727.80	1.86
W27x84	73.38	6163.92	3.08	26K8	219.45	2655.35	1.33
W30x99	111.35	11023.65	5.51	28K6	563.66	6425.72	3.21
W36x135	24.00	3240.00	1.62	30K10	441.00	6615.00	3.31
L3x3x1/4	143.00	699.27	0.35	32LH06	818.72	11462.08	5.73
L4x4x3/8	54.58	530.52	0.27	32LH08	904.00	15368.00	7.68
C12x20.7	85.35	1766.75	0.88	60DLH14	3729.00	149160.00	74.58
Hollow Structural Section							
HSS 16x8x3/8	362.13	21039.52	10.52				

Figure 17: Beams & Joists Takeoff

Structural Steel	
Columns	**Length (ft)**
W10x49	2135.81
W12x53	713.45
W12x65	1494.13
W14x90	228
HSS 6x6x3/8	226.23
HSS 8x4x1/2	94.5
HSS 8x8x3/8	29.6
HSS 10x10x3/8	802.3

Figure 18: Column Takeoff

Metal Deck - Roofing	Gross Square Feet
TOTAL	137,759.47

Figure 19: Metal Deck – Roofing Takeoff

SLAB-ON-DECK					
Concrete Topping	**Size (SF)**	**Volume (CF)**	**Volume (CY)**	**Unit Weight**	**Total Weight (tons)**
1st Flr. - Area A					
3 1/2" NWT Concrete	6569.87	1916.21	71	-	-
WWF 6x6 - W2.1xW2.1	6569.87	-	-	0.3 lb/SF	0.99
1st Flr. - Area B					
3 1/2" NWT Concrete	3557.67	1037.65	38	-	-
WWF 6x6 - W2.1xW2.1	3557.67	-	-	0.3 lb/SF	0.54
2nd Floor - Area F					
3 1/2" NWT Concrete	15462.15	4509.79	167	-	-
WWF 6x6 - W2.1xW2.1	15462.15	-	-	0.3 lb/SF	2.32
2nd Flr. - Area G					
3 1/2" NWT Concrete	12888.57	3759.17	139	-	-
WWF 6x6 - W2.1xW2.1	12888.57	-	-	0.3 lb/SF	1.94
TOTAL AREA	**38478.26**				
*Composite Slab A - 2" x 18 GA. Deck w/ one layer of WWF 6x6 - W2.1 x W2.1.					

Figure 20: Slab-On-Deck Takeoff

Shear Studs	
Area	Quantity
1st Flr. - A	1921
2nd Flr. - F	3136
2nd Flr. - G	2413
TOTAL	**7470**

Figure 21: Shear Studs Takeoff

CMU Walls								
Location	**Type**	**Perimeter**	**Height**	**Block Face Area**	**# of CMU**	**Reinforcement**	**LF/rebar**	**Weight (tons)**
Gym	12" Nominal	445.41	35	0.8888	17540	#5 @ 12" OC	15589	8.13
Auditorium	12" Nominal	500	35	0.8888	19689	#5 @ 12" OC	17500	9.13

Figure 22: CMU Walls Takeoff

SUBGRADE															
Category	CSI Division	Item	Unit	Unit Costs					Quantity	Total Costs				
				Material	Labor	Equipment	Total	Total Including O&P		Material	Labor	Equipment	Total	Total Including O&P
Footings & Grade Beams														
Reinforcing Bar	321110500	Footings, #4 to #7	TON	$ 1,000.00	$ 770.00	-	$1,770.00	$ 2,300.00	97.05	$ 97,050.00	$ 74,728.50	-	$171,778.50	$ 223,215.00
	321110550	Footings, #8 to #18	TON	$ 1,000.00	$ 450.00	-	$1,450.00	$ 1,800.00	13.04	$ 13,040.00	$ 5,868.00	-	$ 18,908.00	$ 23,472.00
Concrete Placement	330533945	Footings, strip (3000 psi), 24"x12" reinforced	CY	$ 136.00	$ 102.00	$ 0.68	$ 238.68	$ 310.00	1,188.00	$161,568.00	$121,176.00	-	$282,744.00	$ 368,280.00
Caissons	33113.35015	Heavyweight Concrete, Ready Mix (3000 psi)	CY	$ 99.00	$ 15.75	$ 4.85	$ 119.60	$ 138.50	315.00	$ 31,185.00	$ 4,961.25	-	$ 36,146.25	$ 43,627.50
Slab-On-Grade														
Reinforcing Bar	321110600	Slab on grade, #3 to #7	TON	$ 1,000.00	$ 705.00	-	$1,705.00	$ 2,200.00	2.66	$ 2,657.00	$ 1,873.19	-	$ 4,530.19	$ 5,845.40
	322110200	6x6 W2.1 x W2.1	CSF	$ 17.20	$ 26.00	-	$ 43.20	$ 60.00	1,052.30	$ 18,099.56	$ 27,359.80	-	$ 45,459.36	$ 63,138.00
Concrete Placement	330535005	5" Thick (4"/6" interpolation)	SF	$ 1.65	$ 0.85	$ 0.01	$ 2.51	$ 3.10	102,820.00	$169,653.00	$ 87,397.00		$257,050.00	$ 318,742.00
	330535010	8" Thick	SF	$ 2.62	$ 0.99	$ 0.01	$ 3.62	$ 4.40	2,409.00	$ 6,311.58	$ 2,384.91	$ 24.09	$ 8,696.49	$ 10,599.60
Subgrade Total										$ 499,564.14	$ 325,748.65	$ 24.09	$ 825,312.79	**$ 1,056,919.50**

Figure 23: Subgrade Estimate

COLUMNS														
Category	CSI Division	Item	Unit	Unit Costs					Quantity	Total Costs				
				Material	Labor	Equipment	Total	Total Including O&P		Material	Labor	Equipment	Total	Total Including O&P
Columns														
Structural Steel Members	521230900	W10x49, bolted connections	LF	$ 71.50	$ 5.10	$ 2.78	$ 79.38	$ 90.50	2,135.81	$ 152,710.42	$ 10,892.63	$ 5,937.55	$169,540.60	$ 193,290.81
	512231560	W12x53, bolted connections	LF	$ 73.00	$ 3.75	$ 2.04	$ 78.79	$ 88.50	713.45	$ 52,081.85	$ 2,675.44	$ 1,455.44	$ 56,212.73	$ 63,140.33
	512231580	W12x65, bolted connections	LF	$ 84.50	$ 3.75	$ 2.04	$ 90.29	$ 102.00	1,494.13	$ 126,253.99	$ 5,602.99	$ 3,048.03	$134,905.00	$ 152,401.26
	512232380	W14x90, bolted connections	LF	$ 131.00	$ 3.80	$ 2.07	$ 136.87	$ 153.00	228.00	$ 29,868.00	$ 866.40	$ 471.96	$ 31,206.36	$ 34,884.00
	512234550	HSS 6x6x3/8, structural tubing	12 LF	$ 360.00	$ 52.00	$ 28.50	$ 440.50	$ 515.00	18.85	$ 6,786.00	$ 980.20	$ 537.23	$ 8,303.43	$ 9,707.75
	512235600	HSS 8x4x1/2, structural tubing	12 LF	$ 485.00	$ 52.00	$ 28.50	$ 565.50	$ 650.00	7.88	$ 3,819.38	$ 409.50	$ 224.44	$ 4,453.31	$ 5,118.75
	512234600	HSS 8x8x3/8, structural tubing	14 LF	$ 775.00	$ 56.00	$ 30.50	$ 861.50	$ 985.00	2.11	$ 1,638.57	$ 118.40	$ 64.49	$ 1,821.46	$ 2,082.57
	512234650	HSS 10x10x3/8, structural tubing	16 LF	$ 1,450.00	$ 58.50	$ 32.00	$1,540.50	$ 1,700.00	50.14	$ 72,708.44	$ 2,933.41	$ 1,604.60	$ 77,246.45	$ 85,244.38
COLUMN TOTAL										$ 445,866.63	$ 24,478.97	$ 13,343.72	$483,689.32	**$ 545,869.84**

Figure 24: Column Estimate

BEAMS & JOISTS																
Category	CSI Division	Item	Unit	Unit Costs					Quantity	Total Costs						
				Material	Labor	Equipment	Total	Total Including O&P		Material	Labor	Equipment	Total	Total Including O&P		
Beams	512230300	W8x10	LF	$ 14.60	$ 4.68	$ 2.55	$ 21.83	$ 27.00	21.32	$ 311.27	$ 99.78	$ 54.37	$ 465.42	$ 575.64		
	512230320	W8x15	LF	$ 22.00	$ 4.68	$ 2.55	$ 29.23	$ 35.00	187.25	$ 4,119.50	$ 876.33	$ 477.49	$ 5,473.32	$ 6,553.75		
	512231100	W12x16	LF	$ 23.50	$ 3.19	$ 1.74	$ 28.43	$ 33.00	92.88	$ 2,182.75	$ 296.30	$ 161.62	$ 2,640.66	$ 3,065.14		
	512231300	W12x22	LF	$ 32.00	$ 3.19	$ 1.74	$ 36.93	$ 43.00	1093.60	$ 34,995.20	$ 3,488.58	$ 1,902.86	$ 40,386.65	$ 47,024.80		
	512231500	W12x26	LF	$ 38.00	$ 3.19	$ 1.74	$ 42.93	$ 49.00	1352.40	$ 51,391.20	$ 4,314.16	$ 2,353.18	$ 58,058.53	$ 66,267.60		
	512231510	W12x30 (W12x26/W12x35 interpolation)	LF	$ 44.50	$ 3.33	$ 1.82	$ 49.65	$ 56.50	277.22	$ 12,336.29	$ 923.14	$ 504.54	$ 13,763.97	$ 15,662.93		
	512231900	W14x22	LF	$ 38.00	$ 2.84	$ 1.54	$ 42.38	$ 48.00	52.00	$ 1,976.00	$ 147.68	$ 80.08	$ 2,203.76	$ 2,496.00		
	512231900	W14x26	LF	$ 38.00	$ 2.84	$ 1.54	$ 42.38	$ 48.00	1274.49	$ 48,430.62	$ 3,619.55	$ 1,962.71	$ 54,012.89	$ 61,175.52		
	512232100	W14x30	LF	$ 43.50	$ 3.12	$ 1.70	$ 48.32	$ 55.00	170.67	$ 7,424.15	$ 532.49	$ 290.14	$ 8,246.77	$ 9,386.85		
	512232700	W16x26	LF	$ 38.00	$ 2.81	$ 1.53	$ 42.34	$ 48.00	2596.94	$ 98,683.72	$ 7,297.40	$ 3,973.32	$ 109,954.44	$ 124,653.12		
	512232900	W16x31	LF	$ 45.00	$ 3.12	$ 1.70	$ 49.82	$ 56.50	2314.27	$ 104,142.36	$ 7,220.54	$ 3,934.27	$ 115,297.17	$ 130,756.52		
	512233000	W16x36	LF	$ 51.75	$ 3.32	$ 1.80	$ 56.87	$ 64.25	55.50	$ 2,872.13	$ 184.26	$ 99.90	$ 3,156.29	$ 3,565.88		
	512233300	W18x35	LF	$ 51.00	$ 4.22	$ 1.74	$ 56.96	$ 65.00	4952.64	$ 252,584.81	$ 20,900.15	$ 8,617.60	$ 282,102.56	$ 321,921.81		
	512233500	W18x40	LF	$ 58.50	$ 4.22	$ 1.74	$ 64.46	$ 73.00	1450.86	$ 84,875.31	$ 6,122.63	$ 2,524.50	$ 93,522.44	$ 105,912.78		
	512234100	W21x44	LF	$ 64.00	$ 3.81	$ 1.57	$ 69.38	$ 79.00	3750.00	$ 240,000.00	$ 14,287.50	$ 5,887.50	$ 260,175.00	$ 296,250.00		
	512234900	W24x55	LF	$ 80.00	$ 3.65	$ 1.51	$ 85.16	$ 96.00	2637.32	$ 210,985.60	$ 9,626.22	$ 3,982.35	$ 224,594.17	$ 253,182.72		
	512235100	W24x62	LF	$ 90.50	$ 3.65	$ 1.51	$ 95.66	$ 107.00	938.37	$ 84,922.49	$ 3,425.05	$ 1,416.94	$ 89,764.47	$ 100,405.59		
	512235300	W24x68	LF	$ 99.00	$ 3.65	$ 1.51	$ 104.16	$ 117.00	1228.08	$ 121,579.92	$ 4,482.49	$ 1,854.40	$ 127,916.81	$ 143,685.36		
	512235500	W24x76	LF	$ 111.00	$ 3.65	$ 1.51	$ 116.16	$ 130.00	31.35	$ 3,479.85	$ 114.43	$ 47.34	$ 3,641.62	$ 4,075.50		
	512235700	W24x84	LF	$ 122.00	$ 3.75	$ 1.55	$ 127.30	$ 143.00	284.56	$ 34,716.32	$ 1,067.10	$ 441.07	$ 36,224.49	$ 40,692.08		
	512235800	W27x84	LF	$ 122.00	$ 3.41	$ 1.40	$ 126.81	$ 142.00	73.38	$ 8,952.36	$ 250.23	$ 102.73	$ 9,305.32	$ 10,419.96		
	512236100	W30x99	LF	$ 144.00	$ 3.38	$ 1.39	$ 148.77	$ 166.00	111.35	$ 16,034.40	$ 376.36	$ 154.78	$ 16,565.54	$ 18,484.10		
	512237300	W36x135	LF	$ 197.00	$ 3.46	$ 1.43	$ 201.89	$ 224.00	24.00	$ 4,728.00	$ 83.04	$ 34.32	$ 4,845.36	$ 5,376.00		
	512230476	L3x3x1/4	LF	$ 5.70	$ 22.00	$ 2.49	$ 30.19	$ 47.50	143.00	$ 815.10	$ 3,146.00	$ 356.07	$ 4,317.17	$ 6,792.50		
	512230400	L4x4x3/8	LB	$ 0.77	$ 2.82	$ 0.32	$ 3.91	$ 6.20	530.52	$ 408.50	$ 1,496.07	$ 169.77	$ 2,074.33	$ 3,289.22		
	512230672	C12x20.7	LF	$ 9.15	$ 34.50	$ 3.95	$ 47.60	$ 75.50	85.35	$ 780.95	$ 2,944.58	$ 337.13	$ 4,062.66	$ 6,443.93		
Joists	521190160	12K3	LF	$ 4.72	$ 2.70	$ 1.21	$ 8.63	$ 11.15	347.04	$ 1,638.03	$ 937.01	$ 419.92	$ 2,994.96	$ 3,869.50		
	521190180	14K3	LF	$ 4.97	$ 2.70	$ 1.21	$ 8.88	$ 11.40	563.00	$ 2,798.11	$ 1,520.10	$ 681.23	$ 4,999.44	$ 6,418.20		
	521190200	16K3	LF	$ 5.20	$ 2.03	$ 1.01	$ 8.46	$ 10.75	89.33	$ 464.52	$ 180.89	$ 90.22	$ 755.73	$ 960.30		
	521190210	16K4 (16K4/16K6 interpolation)	LF	$ 5.70	$ 2.25	$ 1.01	$ 8.96	$ 11.30	949.08	$ 5,409.76	$ 2,135.43	$ 958.57	$ 8,503.76	$ 10,724.60		
	521191180	16KCS4	LF	$ 12.35	$ 2.25	$ 1.01	$ 15.61	$ 18.55	196.00	$ 2,420.60	$ 441.00	$ 197.96	$ 3,059.56	$ 3,635.80		
	521190240	18K4	LF	$ 6.40	$ 2.03	$ 0.91	$ 9.34	$ 11.50	627.00	$ 4,012.80	$ 1,272.81	$ 570.57	$ 5,856.18	$ 7,210.50		
	521191220	18KCS4	LF	$ 12.75	$ 2.03	$ 0.91	$ 15.69	$ 18.55	201.25	$ 2,565.94	$ 408.54	$ 183.14	$ 3,157.61	$ 3,733.19		
	521190240	18K5	LF	$ 6.40	$ 2.03	$ 0.91	$ 9.34	$ 11.50	2074.71	$ 13,278.12	$ 4,211.65	$ 1,887.98	$ 19,377.76	$ 23,859.13		
	521190245	18KCS5	LF	$ 6.40	$ 2.03	$ 0.91	$ 9.34	$ 11.50	562.67	$ 3,601.06	$ 1,142.21	$ 512.03	$ 5,255.29	$ 6,470.65		
	521190500	20K4	LF	$ 6.65	$ 2.03	$ 0.91	$ 9.59	$ 11.85	178.50	$ 1,187.03	$ 362.36	$ 162.44	$ 1,711.82	$ 2,115.23		
	521190500	20K5	LF	$ 6.65	$ 2.03	$ 0.91	$ 9.59	$ 11.85	2118.04	$ 14,084.94	$ 4,299.61	$ 1,927.41	$ 20,311.97	$ 25,098.73		
	521191260	20KCS5	LF	$ 14.05	$ 2.03	$ 0.91	$ 16.99	$ 19.95	278.30	$ 3,910.12	$ 564.95	$ 253.25	$ 4,728.32	$ 5,552.09		
	521190505	20K6 (20K5/20K9 interpolation)	LF	$ 7.19	$ 2.03	$ 0.91	$ 10.13	$ 12.43	557.00	$ 4,004.83	$ 1,130.71	$ 506.87	$ 5,642.41	$ 6,923.51		
	521190540	22K5	LF	$ 7.15	$ 2.03	$ 0.91	$ 10.09	$ 12.35	404.67	$ 2,893.37	$ 821.47	$ 368.25	$ 4,083.09	$ 4,997.63		
	521190545	22K6 (22K5/22K9 interpolation)	LF	$ 7.67	$ 2.03	$ 0.91	$ 10.61	$ 12.92	235.69	$ 1,807.74	$ 478.45	$ 214.48	$ 2,500.67	$ 3,045.11		
	521190590	24K8 (24K6/24K10 interpolation)	LF	$ 9.28	$ 1.84	$ 0.82	$ 11.94	$ 14.28	399.66	$ 3,708.84	$ 735.37	$ 327.72	$ 4,771.94	$ 5,707.14		
	521190600	24K9	LF	$ 10.65	$ 1.84	$ 0.82	$ 13.31	$ 15.80	270.55	$ 2,881.36	$ 497.81	$ 221.85	$ 3,601.02	$ 4,274.69		
	521190620	26K5	LF	$ 8.60	$ 1.84	$ 0.82	$ 11.26	$ 13.55	396.84	$ 3,412.82	$ 730.19	$ 325.41	$ 4,468.42	$ 5,377.18		
	521191380	26KCS5	LF	$ 14.05	$ 1.84	$ 0.82	$ 16.71	$ 19.55	264.56	$ 3,717.07	$ 486.79	$ 216.94	$ 4,420.80	$ 5,172.15		
	521190625	26K7 (26K6/26K10 interpolation)	LF	$ 9.25	$ 1.84	$ 0.82	$ 11.91	$ 14.28	342.00	$ 3,163.50	$ 629.28	$ 280.44	$ 4,073.22	$ 4,883.76		
	521190630	26K8 (26K6/26K10 interpolation)	LF	$ 9.90	$ 1.84	$ 0.82	$ 12.56	$ 15.00	219.45	$ 2,172.56	$ 403.79	$ 179.95	$ 2,756.29	$ 3,291.75		
	521190660	28K6	LF	$ 10.30	$ 1.69	$ 0.76	$ 12.75	$ 15.10	563.66	$ 5,805.70	$ 952.59	$ 428.38	$ 7,186.67	$ 8,511.27		
	521190710	30K10 (30K8/30K12 interpolation)	LF	$ 15.53	$ 1.69	$ 0.76	$ 17.98	$ 17.53	441.00	$ 6,848.73	$ 745.29	$ 335.16	$ 7,929.18	$ 7,730.73		
	521162355	32LH06	LF	$ 12.70	$ 2.25	$ 1.01	$ 15.96	$ 18.00	818.72	$ 10,397.74	$ 1,842.12	$ 826.91	$ 13,066.77	$ 14,736.96		
	521162360	32LH08	LF	$ 15.60	$ 2.25	$ 1.01	$ 18.86	$ 22.00	904.00	$ 14,102.40	$ 2,034.00	$ 913.04	$ 17,049.44	$ 19,888.00		
	521133290	60DLH14 (60DLH12/60DLH17 interpolat.)	LF	$ 36.80	$ 2.03	$ 0.91	$ 39.74	$ 45.00	3729.00	$ 137,227.20	$ 7,569.87	$ 3,393.39	$ 148,190.46	$ 167,805.00		
BEAMS & JOISTS TOTAL										$ 1,691,243.65	$133,856.34	$ 58,104.46	$ 1,883,224.56	**$ 2,150,108.08**		

Figure 25: Beams & Joists Estimate

Slab-On-Deck														
Category	CSI Division	Item	Unit	Unit Costs					Quantity	Total Costs				
				Material	Labor	Equipment	Total	Total Including O&P		Material	Labor	Equipment	Total	Total Including O&P
Slab On Deck	531135400	2" x 18 GA. Composite Steel Deck	SF	$ 2.62	$ 0.49	$ 0.04	$ 3.15	$ 3.79	38,478.26	$100,813.04	$18,854.35	$ 1,539.13	$121,206.52	$ 145,832.61
	331051400	Elevated Slab, less than 6" pumped	CY	$ 91.50	$ 17.25	$ 5.50	$ 122.75	$ 134.00	415.00	$ 37,972.50	$ 7,158.75	$ 2,282.50	$ 50,941.25	$ 55,610.00
	322110200	WWF 6x6 - W2.1 x W2.1	CSF	$ 17.20	$ 26.00	-	$ 43.20	$ 60.00	384.78	$ 6,618.26	$10,004.35	-	$ 16,622.61	$ 23,086.96
TOTAL SLAB ON DECK										$145,403.80	$ 36,017.45	$ 3,821.63	$188,770.38	**$ 224,529.56**

Figure 26: Slab-On-Deck Estimate

MISC														
Category	CSI Division	Item	Unit	Unit Costs					Quantity	Total Costs				
				Material	Labor	Equipment	Total	Total Including O&P		Material	Labor	Equipment	Total	Total Including O&P
Metal Deck - Roofing	531232650	1-1/2" deep, 20 GA	SF	$ 1.84	$ 0.40	$ 0.03	$ 2.27	$ 2.77	137760	$ 253,478.40	$ 55,104.00	$ 4,132.80	$ 312,715.20	$ 381,595.20
Shear Studs	505230300	3/4" Diameter, 4-3/16" long	EA	$ 0.63	$ 0.89	$ 0.51	$ 2.03	$ 2.82	7470	$ 4,706.10	$ 6,648.30	$ 3,809.70	$ 15,164.10	$ 21,065.40
CMU Walls	422101150	8"x16" units, Reinf., alt. courses, 12" thick	SF	$ 3.92	$ 6.60	-	$ 10.52	$ 14.35	33092.85	$ 129,723.97	$ 218,412.81	-	$ 348,136.78	$ 474,882.40
MISC. TOTAL										$ 387,908.47	$ 280,165.11	$ 7,942.50	$ 676,016.08	**$ 877,543.00**

Figure 27: MISC. Structure Estimate

GRAND TOTAL														
Category	CSI Division	Item	Unit	Unit Costs					Quantity	Total Costs				
				Material	Labor	Equipment	Total	Total w/ O&P		Material	Labor	Equipment	Total	Total w/ O&P
SUBGRADE										$ 499,564.14	$325,748.65	$ 24.09	$ 825,336.88	**$ 1,056,919.50**
COLUMNS										$ 445,866.63	$ 24,478.97	$13,343.72	$ 483,689.32	**$ 545,869.84**
BEAMS & JOISTS										$ 1,691,243.65	$133,856.34	$ 58,104.46	$ 1,883,204.45	**$ 2,150,108.08**
SLAB-ON-DECK										$ 387,908.47	$280,165.11	$ 7,942.50	$ 676,016.08	**$ 877,453.00**
MISC.										$ 145,403.80	$ 36,017.45	$ 3,821.63	$ 185,242.88	**$ 224,529.56**
Sub-Total										$ 3,169,986.69	$800,266.52	$ 83,236.40	$ 4,053,489.61	**$ 4,854,879.98**
Location Factor (1.02)										$ 3,233,386.42	$816,271.85	$ 84,901.13	$ 4,134,559.40	**$ 4,951,977.58**
Grand Total														**$4,951,977.58**

Figure 28: Grand Total – Structural Estimate

APPENDIX C: MEP Assemblies Estimate Takeoffs & Costs

PLUMBING ESTIMATE				
DESCRIPTION	**QUANTITY**	**UNIT**	**TOTAL $/UNIT**	**COST**
WATER CLOSET (vitreous china, bowl only with flush valve, wall hung)	88	EA	$ 2,760.00	$ 242,880.00
URINAL (vitreous china, wall hung)	18	EA	$ 765.00	$ 13,770.00
LAVRATORY (Wall hung, PE on CI, 18" x 15")	81	EA	$ 1,615.00	$ 130,815.00
KITCHEN SINK (w/ trim, countertop PE on CI, 24" x 21", single bowl)	10	EA	$ 1,615.00	$ 16,150.00
KITCHEN SINK (w/ trim, countertop PE on CI, 32" x 21", double bowl)	1	EA	$ 1,785.00	$ 1,785.00
LAB SINK (w/ trim, stainless steel, single bowl, single drainboard)	41	EA	$ 2,575.00	$ 105,575.00
SERVICE SINK (w/ trim, PE on CI, corner floor, 28" x 28", w/ rim guard)	5	EA	$ 3,775.00	$ 18,875.00
SHOWER (group w/ five heads, thermostatic mix valves & balancing valve)	6.6	EA	$ 5,375.00	$ 35,475.00
CUP SINK (polypropylene, oval, 10" x 4-1/2")	1	EA	$ 1,225.00	$ 1,225.00
ELECTRIC WATER COOLER (wall hung, dual height, 14.3 GPH)	19	EA	$ 2,120.00	$ 40,280.00
ELECTRIC WATER HEATER (commercial, 100F rise, 120 gal, 36 kW, 147 GPH)	1	EA	$ 12,050.00	$ 12,050.00
ELECTRIC WATER HEATER (commercial, 100F rise, 500 gal, 30 kW, 123 GPH)	2	EA	$ 40,400.00	$ 80,800.00
FIXTURE & EQUIPMENT SUBTOTAL	**$**			**699,680.00**
75% Multiplier for distribution piping, Drains, Waste, & Vents	$			524,760.00
Kitchen Equipment Addition Services & Accessories (RS Means SF Cost 2013)	$			189,605.00
Location Modifier (Pittsburgh)				1.02
TOTAL PLUMBING SYSTEM COST	**$**			**1,442,325.90**

Figure 29: Plumbing Assemblies Estimate

MECHANICAL ESTIMATE				
DESCRIPTION	**QUANTITY**	**UNIT**	**TOTAL $/UNIT**	**COST**
SPLIT SYSTEM AIR CONDITIONER (school, 3.83 ton)	27,000	SF	$ 9.66	$ 260,820.00
ROOFTOP MULTIZONE UNIT (schools, 15,000 SF, 575.5 ton)	153,000	SF	$ 21.10	$ 3,228,300.00
SUBTOTAL	**$**			**3,489,120.00**
ADDITIONAL EQUIPMENT				
UNIT HEATER (400 CFM, wall mounted, 34.1 Mbh)	5	EA	$ 950.00	$ 4,750.00
FAN COIL UNITS (15,000 BTUH cooling, 13,900 BTUH heating)	2	EA	$ 1,550.00	$ 3,100.00
Location Modifier (Pittsburgh)				1.02
TOTAL MECHANICAL SYSTEM COST	**$**			**3,566,909.40**
*Assumptions: chilled water circulation system & natural gas supply included with rooftop multizone units.				
*Electric baseboard heaters not listed in RS Means Assemblies Cost Data 2013, but assumed negligable since only 51 LF in CWNCHS.				

Figure 30: Mechanical Assemblies Estimate

ELECTRICAL ESTIMATE				
DESCRIPTION	**QUANTITY**	**UNIT**	**TOTAL $/UNIT**	**COST**
UNDERGROUND ELECTRIC SERVICE (3000A, including excavation, backfill & compaction)	1	EA	$ 90,800.00	$ 90,800.00
MAIN SWITCHBOARD (installation, breakers, panels, 277/480V, 3 phase, 3000A)	1	EA	$ 95,375.00	$ 95,375.00
RECEPTACLE (10 per 1,000 SF w/ transformer)	180	1000 SF	$ 3.48	$ 626.40
RECEPTACLE BRANCH WIRING (3/4" EMT conduit & wire, 120V grounded, 20A)	1800	EA	$ 263.00	$ 473,400.00
LIGHT SWITCHES (5 per 1000 SF)	180	1000 SF	$ 2.47	$ 444.60
LIGHT SWITCH BRANCH WIRING (3/4" EMT conduit & wire, 3 way switch, 20A)	900	EA	$ 275.00	$ 247,500.00
FLUORESCENT FIXTURES (23 fixtures per 1000 SF, avg. of strip, surface, recessed & pendant)	180,000	SF	$ 11.68	$ 2,102,400.00
LED (6" pendant downlights)	58	EA	$ 228.00	$ 13,224.00
FLUORESCENT HIGH BAY (1.5 watt/SF, 103 FC, 7 fixtures per 1000 SF)	12,765	SF	$ 5.97	$ 76,207.05
PANELBOARD (NQOD, 4 wire, 120/208V w/ conductor & conduit, 100A, avg. length)	29	EA	$ 4,900.00	$ 142,100.00
PANELBOARD (NEHB, 4 wire, 277/480V w/ conductor & conduit & safety switch, 100A, avg. length)	11	EA	$ 7,137.50	$ 78,512.50
PANELBOARD (NQOD, 4 wire, 120/208V w/ conductor & conduit, 225A, avg. length)	5	EA	$ 9,418.75	$ 47,093.75
PANELBOARD (NEHB, 4 wire, 277/480V w/ conductor & conduit & safety switch, 225A, avg. length)	9	EA	$ 12,006.25	$ 108,056.25
PANELBOARD (NQOD, 4 wire, 120/208V w/ conductor & conduit, 400A, avg. length)	8	EA	$ 10,650.00	$ 85,200.00
PANELBOARD (NEHB, 4 wire, 277/480V w/ conductor & conduit & safety switch, 400A, avg. length)	7	EA	$ 15,350.00	$ 107,450.00
PANELBOARD (NEHB, 4 wire, 277/480V w/ conductor & conduit & safety switch, 600A, avg. length)	2	EA	$ 21,700.00	$ 43,400.00
PANELBOARD (NQOD, 4 wire, 120/208V w/ conductor & conduit, 800A, avg. length)	1	EA	$ 65,000.00	$ 65,000.00
SUBTOTAL	**$**			**3,776,789.55**
Location Modifier (Pittsburgh)				1.02
TOTAL ELECTRICAL SYSTEM COST	**$**			**3,852,325.34**

Figure 31: Electrical Assemblies Estimate

FIRE PROTECTION ESTIMATE				
DESCRIPTION	**QUANTITY**	**UNIT**	**TOTAL $/UNIT**	**COST**
WET PIPE SPRINKLER SYSTEM (steel, black, sch. 40 pipe, light hazard, one floor, 50,000 SF)	177,129	SF	$ 2.10	$ 371,970.90
SUBTOTAL	**$**			**371,970.90**
Cost Reduction (~97,500 SF/floor avg.) (see calculations below)	177,129	SF	$ 0.64	$ 113,362.56
10,000 SF --> 50,000 SF = $2.64 - $2.10 = $0.54/40,000SF difference = $1.35 x 10^(-5) ((sq. ft.)^2) x (97,500 SF - 50,000 SF) = $0.64125/SF				
Cost Difference				$371,970.90 - $113,362.56
Location Modifier (Pittsburgh)				1.02
TOTAL FIRE PROTECTION SYSTEM COST	**$**			**263,780.51**

Figure 32: Fire Protection Assemblies Estimate

APPENDIX D → GC Takeoffs & Costs

GC Estimate	QTY.	UNIT	MAT. $/UNIT	MAT. TOTAL	LABOR $/UNIT	LABOR TOTAL	GRAND TOTAL
UTILITIES							$ 1,051,859.20
TEMP. HEAT (FUEL, OPERATION, 12 HR/DAY)	886 GSF*40 WK	CSF FLR/WK	$ 29.68	$ 1,051,859.20			$ 1,051,859.20
TEMPORARY STRUCTURES							$ 312,950.00
JOB OFFICE/TRAILER (50'x12')	2	EA	$ 31,600.00	$ 63,200.00			$ 63,200.00
TRAILER MOB/DEMOB	4	EA	$ 2,000.00	$ 8,000.00			$ 8,000.00
TRAILER SET-UP	2	EA	$ 10,000.00	$ 20,000.00			$ 20,000.00
TRAILER TEAR-DOWN	2	EA	$ 10,000.00	$ 20,000.00			$ 20,000.00
TEMPORARY PARKING & STAGING	1	LS	$ 50,000.00	$ 50,000.00			$ 50,000.00
TEMP. BUILDING ENCLOSURE (FRAMES + TARP)	25,000	SF	$ 2.63	$ 65,750.00			$ 65,750.00
TEMPORARY ACCESS ROADS	10,000	SY	$ 8.60	$ 86,000.00			$ 86,000.00
TEMPORARY SERVICES							$ 191,446.00
TOILETS/SANITARY SPACE	21	MO	$ 1,000.00	$ 21,000.00			$ 21,000.00
DRINKING WATER	21	MO	$ 100.00	$ 2,100.00			$ 2,100.00
CAMERAS, SITE PHOTOGRAPHY & OX BLUE	21	MO	$ 1,575.00	$ 33,075.00			$ 33,075.00
DUMPSTERS/TRASH REMOVAL	21	MO	$ 950.00	$ 19,950.00			$ 19,950.00
SNOW REMOVAL	12	MO	$ 500.00	$ 6,000.00			$ 500.00
DAILY CLEAN UP	455	DAY	$ 39.50	$ 17,972.50			$ 17,972.50
TRAILER CLEANING	455	MO	$ 39.50	$ 17,972.50			$ 17,972.50
TELE/DATA/LIGHTS	21	MO	$ 256.00	$ 5,376.00			$ 5,376.00
SECURITY	21	MO	$ 3,000.00	$ 63,000.00			$ 63,000.00
RADIOS/PHONES	21	MO	$ 500.00	$ 10,500.00			$ 10,500.00
PROJECT RELATED TRAVEL							$ 60,000.00
UTILITY VEHICLE PURCHASE & FUEL	1	LS	$ 50,000.00	$ 50,000.00			$ 50,000.00
AUTO ALLOWANCES	1	LS	$ 10,000.00	$ 10,000.00			$ 10,000.00
ADMINISTRATIVE SUPPLIES							$ 109,195.00
OFFICE SUPPLIES	21	MO	$ 75.00	$ 1,575.00			$ 1,575.00
OFFICE EQUIPMENT	21	MO	$ 220.00	$ 4,620.00			$ 4,620.00
OFFICE FURNITURE	1	LS	$ 8,000.00	$ 8,000.00			$ 8,000.00
COMPUTER SOFTWARE/EQUIPMENT	1	LS	$ 80,000.00	$ 80,000.00			$ 80,000.00
PRINTING - DRAWING & SPECS	1	LS	$ 15,000.00	$ 15,000.00			$ 15,000.00
STAFFING MONITOR & EBE							$ 1,151,900.00
SR. PROJECT MANAGER	23	WK			$ 4,000.00		$ 92,000.00
PROJECT MANAGER	91	WK			$ 3,200.00		$ 291,200.00
SUPERINTENDENT	91	WK			$ 2,950.00		$ 268,450.00
PROJECT ENGINEER	91	WK			$ 1,950.00		$ 177,450.00
PROJECT ENGINEER	91	WK			$ 1,950.00		$ 177,450.00
HOME OFFICE ADMINISTRATOR	23	WK			$ 1,100.00		$ 25,300.00
PROJECT ADMINISTRATOR	91	WK			$ 550.00		$ 50,050.00
BIM & MEP COORD	1	LS			$ 50,000.00		$ 50,000.00
PRECONSTRUCTION	1	LS			$ 20,000.00		$ 20,000.00
MISCELLANEOUS							$ 113,630.00
FIRE EXTINGUISHERS (20 LB)	10	EA	$ 163.00				$ 1,630.00
SURVEYING	180,000	SF	$ 0.50				$ 90,000.00
ELECTRICAL/DATA HOOK-UP	1	LS	$ 1,000.00				$ 1,000.00
MISC SAFETY EQUIPMENT	1	LS	$ 10,000.00				$ 10,000.00
SMALL TOOLS	1	LS	$ 2,000.00				$ 2,000.00
PROJECT CLOSEOUT DOCS	1	LS	$ 5,000.00				$ 5,000.00
FIRST AID	1	LS	$ 2,000.00				$ 2,000.00
						SUBTOTAL	$ 2,990,980.20
						LOCATION FACTOR (Butler, PA)	0.96
						TOTAL	**$ 2,871,340.99**

Figure 33: General Conditions Estimate