Adam Finley

Construction Management Option

Thesis Report

The Pennsylvania State University
Health and Counseling Services Building
University Park, Pennsylvania

ADAM MICHAEL FINLEY

Construction Management Option

Project Team

Owner: The Pennsylvania State University
CM: The Whiting- Turner Contracting Company
Architect: Hillier Architecture
Landscape Architect: Lager Raabe Skafte Landscape Architects, Inc
Structural Engineering: Groenman- Pederson, Inc
Civil Engineering: Gannett Fleming
MEP Engineering: B R + A/ Bard, Rao Engineering

Architecture

- Traffic flow away from patients
- Brick veneer and glass curtain wall exterior
- Pharmacy and garage located on 1st floor
- Green roof around mechanical penthouse
- LEED certification goal

Project Information

Building Size: 63,318 S.F.
Number of Stories: 5
Overall Construction Cost: $24 Million
Project Schedule: May 06- May 08
Location: University Park, Pennsylvania
Project Delivery Method: Traditional Design-Build

Structural System

- Micro pile footings with grade beams
- Typical steel moment frames
- Glass curtain wall on South face
- Non load bearing brick shelf

MEP System

- High pressure steam system- supplied from university
- 2 rooftop air handling units
- 1 indoor air handling unit supplying server room
- Variable and constant volume boxes
- Wet sprinkler system supplying majority of building
- Dry sprinkler system supplying server room

Electrical System

- Typical fluorescent and incandescent fixtures
- Main switchgear 277/480V,3 phase,4 wire
- Main circuit breaker 1600A Frame and 1200A Trip
- Main utility work under seperate contract
- Emergency power can supply 1/2 floor full power
- Optional ADD for emergency power to full floor

PENNSTATE

Penn State Health and Counseling Services Building

CPEP Website: www.arche.psu.edu/thesis/eportfolio/2007/portfolios/AMF232/

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Appendix

Executive Summary

The first technical analysis deals with the emergency electrical system of Health and Counseling Services. The existing system is fed from the campus standby power system. This system operates from the East Power Plant at 4160/480-277V. This power supplies life safety and emergency lighting to the East side of the University Park campus. A standby generator system was designed in lieu of the campus standby power system. The designed change costs $219,000.00 and would have a minimal impact on the existing construction schedule if the change was incorporated in the design phase. It is the recommendation of this paper that this addition does not add enough value to warrant a change to the existing design.

The second technical analysis is part of a Penn State commissioning depth study. The depth study looks at Penn State commissioning problems associated with recent base building and major renovation projects. The purpose of this study was to determine where problem areas were located through contact with 3rd party Cx agents and the Office of Physical Plant's in-house commissioning team. After compiling the results from this analysis they were made into a document of problems and proposed solutions to be given to the Office of Physical Plant for their review and possible implementation into a new standard commissioning policy. In order to improve the commissioning process the addition of UVGI (Ultra Violet Germ Irradiation) devices to improve the indoor air quality of Health and Counseling Services were analyzed. 112 locations were identified within the building. After review, UVGI's are a recommended addition to Health Services at a cost of $295,363.00. Each device takes approximately 3 hours to install totaling 336 hours man hours.

The last analysis is a construction management research depth study looking at items that cause cost and schedule increases on LEED projects. Members of a typical project team were contacted to express their opinions on what causes the cost and schedule to increase as well as how to minimize their impacts. After analyzing the results, the decision to build a LEED project before the design begins eliminates most increases. Other items that improve LEED construction include LEED education, proper commissioning, experience through lessons learned documents, and mandating LEED or a similar green building methodology at the federal level.

Project Background

Client Information

The owner is The Pennsylvania State University. The new Health and Counseling Services Building is being constructed for multiple reasons. The existing facility, Ritenour Building, is undersized for the growing demands of an ever increasing student community. Ritenour Building was built in 1929 to accommodate a population of approximately 4,000 students. Multiple additions and renovations have been completed to the structure, but as of 2006 the facility is incapable of supporting the 40,000 strong student population at the same level of care that it once was able to.

The new structure, that is almost 64,000 square feet and capable of holding 614 people will be able to support the community for generations to come. Other factors that have encouraged the development of this building include not having enough space for each clinician, a counseling service that is one of the largest in the country having only one group room and utilizing a hallway as part of its space, overcrowded waiting services that spread disease, a pharmacy that is too small, and privacy issues with spaces being used for applications that were never intended.

As an experienced owner O.P.P., Penn State's representing division known as the Office of Physical Plant; has expectations for a high quality project that is on time and within budget are. O.P.P. knows that safety is an important factor in any project from marketing, ethical, and litigation standpoints. O.P.P. will not compromise safety for any expectations they may have about the construction, and therefore have incorporated guidelines above and beyond OSHA requirements for all projects on Penn State campuses.

Chad Spackman, Penn State's project manager, is concerned about the overall project schedule and it's affect on the health services at the university. The need to keep Ritenour Building operational while moving the facility into the new structure will be an difficult challenge. Another concern are the bids that will be received for portions of the work that have been value engineered. Due to a tight budget, a large amount of value engineering was incorporated into the design process. The estimated value of the buildings systems needs to remain constant due to this situation. Bids that come in above

these estimates will be negotiated with the contractor to fit within this price or extra value engineering may need to be added into the design. The last of Mr. Spackman's concerns is the timing of the steel order. Some pieces of steel that are in the project are an odd size and will need to be coordinated with the steel mill. Many steel mills have been contacted about these structural elements, and at this time the mills would not be able to accommodate a steel order for these sizes for on schedule delivery. Over sizing the steel has occurred so that they can be purchased from a regional distribution warehouse.

There are a small number of scheduling concerns for this project. The concrete work will be placed during the winter in State College. Quality control will need to be performed to ensure that all concrete has cured to the designed strength. The curtain wall, on the South face, is another important issue that may need to be addressed. The manufacturer has informed Penn State and Whiting- Turner that the lead-time for this curtain wall system may impact the current schedule.

The success of this construction in Penn State's eyes will be dependent on multiple factors. As a rule, all owners consider a high quality project that is on schedule and on budget with no safety incidents a successful project. Penn State challenges its general contractors and construction managers to take safety more seriously than other owners they have worked with previously. Specifically, fall protection and the covering of open holes from pedestrians, especially students, are of high importance to the university and O.P.P.

Another issue is the need for a properly constructed and commissioned mechanical system that will pass air balancing in a timely manner. Many recent projects at the campus had issues with the mechanical systems not passing the commissioning process after multiple attempts have been made. Mr. Spackman has made it known that this is not acceptable on the Health and Counseling Services Building.

The university has also recently adopted a policy of only constructing green buildings on its campuses. Health and Counseling Services will have a LEED certification. Credits for this include waste management plans, materials with recycled content, regionally manufactured materials, air quality, data collection systems for energy use, and VOC content guidelines among other items.

Project Delivery System

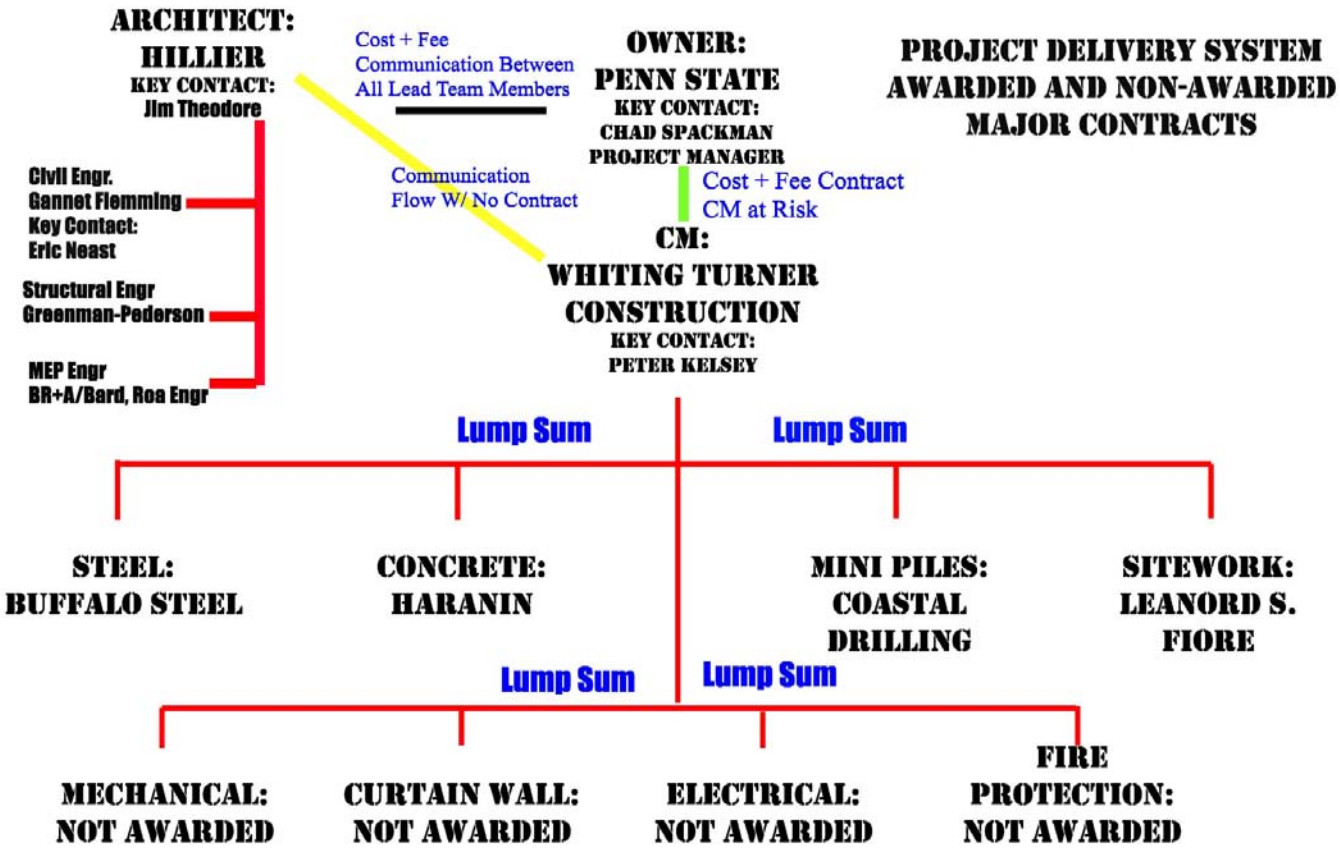


Fig 3.1 Organizational Chart of Health Services Project.

The main utility work was performed outside of the scope of this project, due to time constraints. Sweetland Engineering made the document and Stove Valley Construction performed the utility sub-grade work. This was done so that the building construction side of the project could remain on a scheduled completion date of July 2008.

Hillier Architecture holds a cost plus fee contract with Penn State to design the structure and the building systems. The project construction is being coordinated by Whiting- Turner and constructed by its prime contractors. Whiting-Turner holds a CM at Risk contract with Penn State. That is to say the construction manager, Whiting-Turner,

holds all contracts with the prime contractors that are actually constructing the building and therefore holds all the risk on the project. A chart showing how this delivery system is set up can be seen on page 8.

The contract between Penn State and Whiting-Turner includes specific requirements for insurance, local and national laws that govern construction, the submittal process, the request for information processes, the change order processes, scope, coordination and communication between all parties, scheduling and completion dates, and miscellaneous owner requirements. Penn State has items in the document that are site and location specific. For example, these items include plant, land protection and LEED goals. One interesting item is that Penn State and their respective project management team have the right to take control of the project and the prime contactors if at any point Whiting-Turner are found to be incapable or unwilling to fill their contract. Whiting-Turner and their sub-contractors have similar contractual agreements. Less detail is provided in these areas, but more specific scope packages are defined between the CM and the respective specialty trades.

All sub-contractors that were sent invitations to bid are on a pre-qualified bidders list that Penn State requires all contractors that work on their campuses to apply for and be accepted into. Penn State requires this because the forms that must be filled out about insurance, bonding and surety agencies, previous projects, etc. help to eliminate the submission of bids from unqualified contractors. All bids received have been chosen by the lowest bid method. Although Penn State reserves the right to choose any bid it wishes for any reason, it has decided to work with the lowest bid and then make sure a full scope of work was included in the lump sum price.

Bid bonds at five percent are required of all bidders. This bond will be forfeited to the owner any time an awarded contractor cannot fulfill their obligation to the project. Performance and payment bonds are also required. These bonds are also added on the bidding form as an alternative to deduct from the price supplied by the contractor.

Staffing Plan

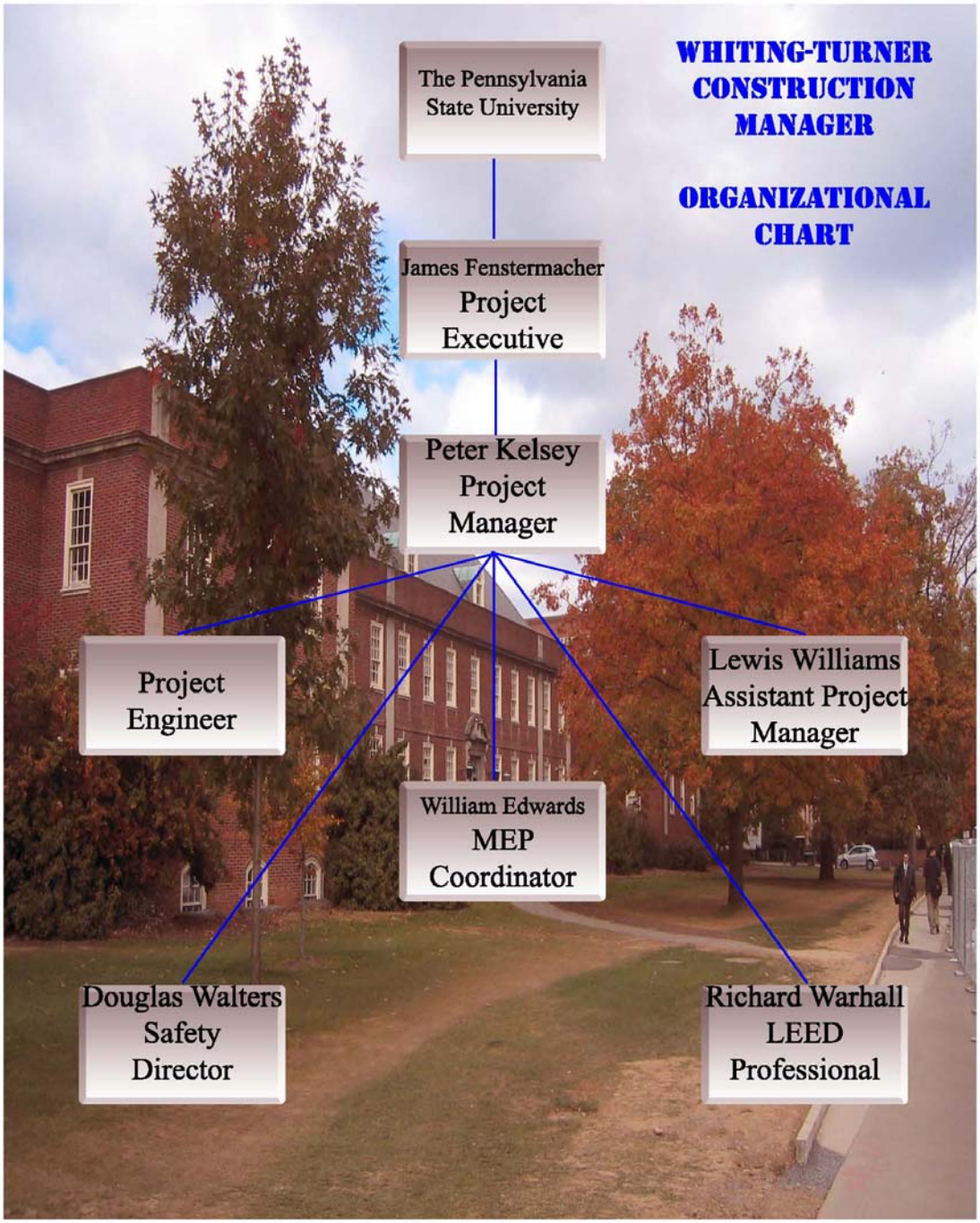


Fig 3.2 Organizational Chart of Whiting-Turner Staffing Plan

During the estimating and preconstruction phases, James Martini, a vice president of Whiting- Turner was the project executive on Health Services. James Fenstermacher

holds senior project manager status and oversees the MEP coordinator, LEED accredited professional, senior scheduling manager, director of safety, and two project managers working on the University Park campus. These two project managers are Keith Jarvis who will be the project manager on the Life Sciences 2 building and Peter Kelsey who is the project manager on the new Health and Counseling Services building.

Upon mobilization at the construction site, the organizational structure changed to the diagram shown on page 10. The Vice President, James Martini, has left his role as the project executive and James Fenstermacher has taken on that role. All of the technical support such as MEP coordinator, Director of safety, etc. has been given to Peter Kelsey to oversee and coordinate during the construction process.

Local Conditions

The preferred method of construction on the University Park campus is steel frames with masonry brick veneer and glass curtain wall exteriors. Floor construction is mostly metal decking with welded wire mesh or rebar. Micro piles and grade beams are typical of foundations in the area. This is due to the existing subsurface ground conditions, which will be explained in the following paragraph.

The subsurface of the proposed site and surrounding properties is primarily bedrock formations, classified as the Nittany Formation. This bedrock is composed of fine and coarse crystalline dolomite, with areas of cherty dolomite. The region has an overabundant amount of clay that is found above this bedrock formation. Usable soil for building construction is usually not found within construction sites. The formation of sinkholes is common in the area due to this bedrock formation. The bedrock, quite frequently, has caverns below what is found in initial surveys. When the bedrock is loaded with the structure it can give way into the cavern causing the sinkhole formation.

Local recycling centers are found in Lewistown, Pleasant Gap, Snowshoe, and Bellefonte, Pennsylvania. These centers mostly take scrap iron, aluminum, brass, copper, and steel. Only one local recycler accepts cardboard and paper products. All other materials that will need to be recycled on this project will have to be transported out of the local area. To maintain the LEED certification goal on this project the construction manager will need to make arrangements to move past this obstacle.

Parking on-site by tradesmen and most of the construction manager's staff is not permitted. This is due to the limited number of parking lots and parking spaces for the students, staff, and faculty of the university. Construction parking is provided at Lot 44, which is located south of Beaver Stadium. Transportation to and from the site for the construction manager and prime contractors is not provided under the contract and is the responsibility of the individual contractor to make proper arrangements.

Building Systems Summary

Yes	No	Work Scope
	X	Demolition Required
X		Structural Steel Frame
X		Cast In Place Concrete
	X	Precast Concrete
X		Mechanical System
X		Electrical System
X		Masonry
X		Curtain Wall
X		Support of Excavation

Demolition

A small amount of demolition will be required on the project. A stone retaining wall to the south of MBNA building will need to be removed to accommodate the building. A few sidewalks that pass through the area and multiple trees and bushes will need to be relocated, removed, or protected at the discretion of the university. Also, large amount of unsuitable soil will be removed to make way for the new structural fill that the foundation systems will be placed on.

Structural Steel Frame

The structure will utilize a structural steel frame with typical moment connections, non-load bearing masonry, and glass curtain walls. Beams and girder sizes

range from a minimum of W12 X 14 to W27 X 84 of ASTM A992 steel. The most common size is W16 X 26. Columns utilize a variety of wide flange and hollow structural steel sections.

There will be bracing required on the project and it is left to the steel contractor to determine which type they will use. Some pieces of steel are of an abnormal size and need to be upsized for the project to stay on schedule. This is due to the steel mills in the area not starting new runs during the time that steel fabrication needs to begin. Due to the limited space available on the site, the crane will be limited to three locations to pick from the staging area and place the steel.

Cast in Place Concrete

Due to multiple addendums to the drawing sets and the schedule for construction, only certain portions of the entire C.I.P. bid package were released and awarded prior to construction. Typically, the concrete used on site will have design strength of 3000 psi. Concrete placement methods include both pump and crane with bucket. There is the potential for a concrete chute to be used for the elevated slabs later in the project, when the steel contractor has a crane on site.

Precast Concrete

No precast concrete will be used on this project.

Mechanical System

Penn State's campus chilled water and steam loop will feed the Health Services Building. The mechanical system consists of two rooftop air handling units supplying 37,500 CFM each to the entire building. A server room, located on the third floor is maintained by an indoor air handler that supplies that room alone. The supply air is distributed via a network of variable air volume boxes. Fan coil units and constant volume boxes help to supply some areas of the building. The South face of the structure uses radiant heat located in ceiling panels. This was done to eliminate the unpleasant aesthetic of baseboard heating against the glass curtain wall. The fire alarm suppression

system is primarily wet with a dry system currently designed for the server room. An add alternate is being reviewed to place a preaction system in the server room.

Electrical System

The electrical system is supplied from the utility at 277/480V at 1200 Amps. The voltage is stepped down through a series of transformers to supply fluorescent and incandescent light fixtures, outlets and other various devices as needed. The building has emergency power, supplied by the campuses emergency/ standby system, with an automatic transfer switch located adjacent to the main electrical room.

Light fixtures throughout the building are typical, incandescent and fluorescent, but in most rooms tied into an occupancy sensor that will turn off lights if there is no movement within the room for a predetermined amount of time. This sensor saves energy and money over the life of the building, and also is a credit towards the projects LEED certification.

An interesting feature of this system is its capability to have full backup power for half of one floor if the power was to go out. This was incorporated into the design so that the clinicians would still have the ability to treat patients in emergency situations. Penn State also looked at two add alternates, to have the capability to manually turn on another floor's power and the operation of the entire building in an emergency where the utilities service was interrupted.

Masonry

The skin of the building is a combination of brick veneer and a glass curtain wall. Generally speaking, a mechanical fastener between the structural system and brick veneer is required where masonry elements are adjacent to structural framing. Anchors are not to exceed 16" O.C. and should be able to support a horizontal load of no less than 500 lbs.

Curtain Wall

The curtain wall, glass, metal panels, and glazing will all be awarded under one prime contract. The basis of the curtain wall design is a Vistawall CW-250 system. The

system can adjust its interior mullion depths for aesthetic and loading requirements. That is to say, if the owner does not like the visual depths of the mullions between the glass panels they can be easily adjusted. Also if the owner required a glass curtain wall that could hold a large load it would also be possible. Heavy-duty vertical mullions can be implemented for larger structural loads depending on the size and requirements of the system. This system is not load bearing and will not require this option to be implemented.

Construction of the system will use the butt-glazed method. The system uses few parts allowing for less confusion on the job site leading to quicker and cheaper installation. Vistawall also uses pre-punched pressure plates to allow for easier installation.

Support of Excavation

Dewatering of the site will be required, but only temporarily during the construction. The North end of the building has a drainage system incorporated into the design because the 1st floor of the structure will be partially below grade. During the excavation and the foundation work phases, shotcrete will be applied to the unearthed walls. This system was chosen because it is relatively cheap and it has the ability to be placed quickly. While an unconventional approach, Whiting- Turner's project manager has experience with this method of supporting excavated walls

Project Schedule Summary

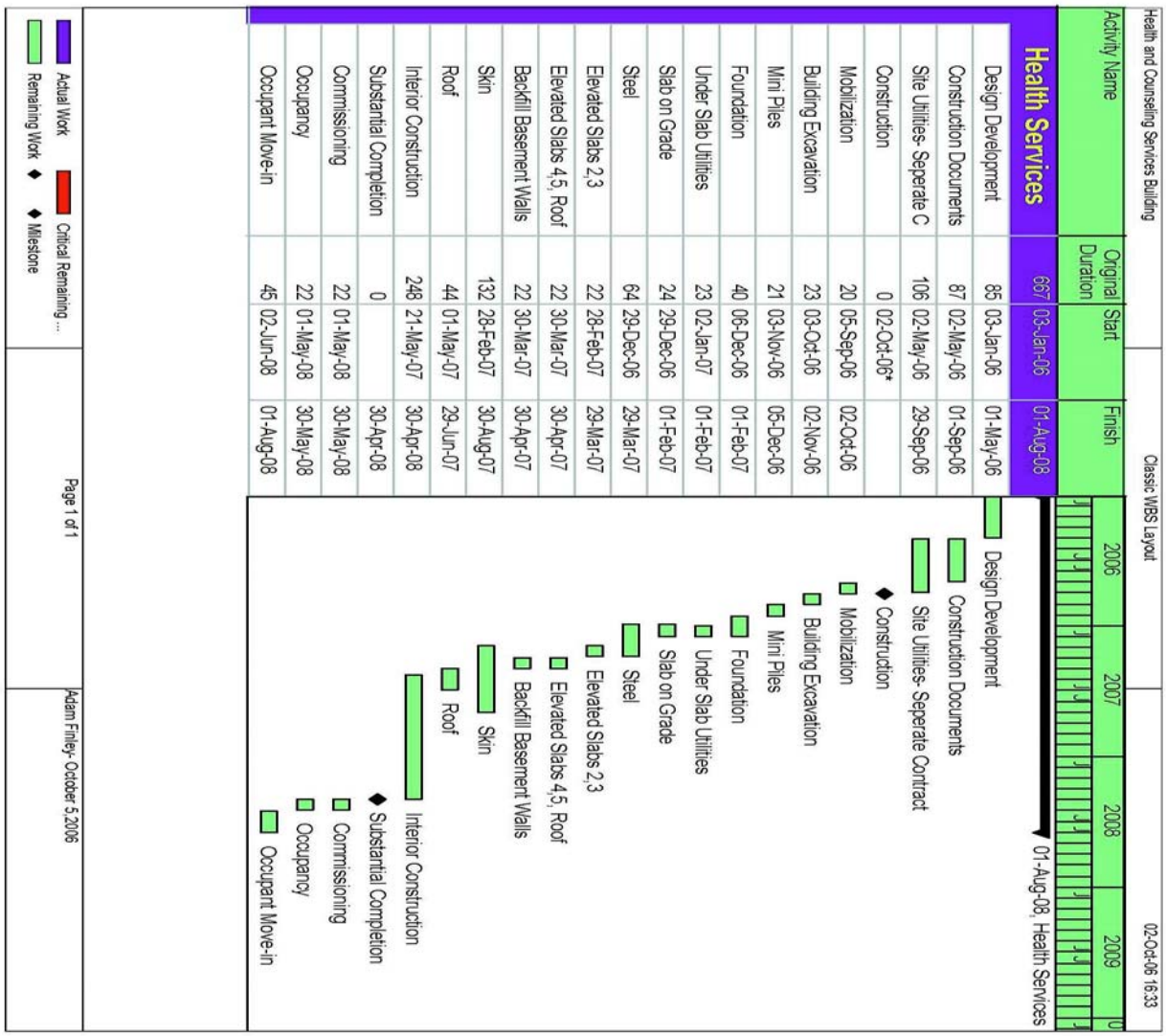


Fig 3.3 Health Services Milestone Construction Schedule

A preliminary schedule was created to show the basic elements of design and construction. The site work and foundation will be completed during the first winter of 2006 to 2007. Steel erection will continue through the spring of 2007 with elevated slab construction lagging a few weeks behind. The exterior skin and roof will be completed through the summer of the same year. Interior construction will be the last portion of the work, starting in July 2007 and ending May 2008. A detailed schedule is in Appendix E.

Project Cost Evaluation

The overall project cost is $24 million dollars. The approximate cost of construction is $17.1 million dollars. Almost all contracts have been awarded at this time, but some of the finishes contractors are still awaiting contracts.

Construction and Project Costs

Type	Cost	Cost/ S.F.
Construction Cost	$17,100,000.00	$270.00
Project Cost	$24,000,000.00	$379.00

Contract Costs

Contract	Cost	Cost/ S.F.
Arch Woodwork	$410,000.00	$6.41
Site work/ Excavation	$678,000.00	$10.71
Minipiles	$446,355.00	$7.05
Foundation Concrete	$480,000.00	$7.58
Structural Steel	$1,703,220.00	$26.90
Masonry	$642,000.00	$10.03
Landscaping	$132,943.00	$2.08
Telecommunications	$132,000.00	$2.06

A D4 cost estimate, construction-estimating software, showed a roughly 7 million dollar shortfall between actual and estimated construction costs. The data that was available at the time of the estimate from awarded contracts was substituted into the D4 estimate. The building used as a comparison was the five-story Sylvester Comprehensive Cancer Center that is located in Miami, Florida. This building was constructed in 1990

over a period of three years and has the same basic major structural and building envelope systems as the new Health Services Building.

The cost difference between these two buildings can be attributed to multiple factors. The inflation between 1990 and 2006 is the first obvious factor. The new health services building is LEED rated and its construction cost will be slightly higher due to the requirements required of that goal. The cancer center does not employ a glass curtain wall. While the schedule of values is not yet available for comparison, the curtain wall/ brick veneer combination should be more expensive to install than a conventional brick veneer system.

The Costworks estimate used a 2-4-story office building with a glass curtain wall and structural steel frame, obtained from the program Costworks (copyright 1996-2004 Costworks CD R.S. Means Co., Inc.). This model type was chosen because it most closely resembled the design of the new Health Services and Counseling Building. The Costworks estimate gave a construction cost of $6,666,350.00 and is well below the $17,100,000.00 price tag of the actual construction. This can be attributed to multiple factors. The Costworks estimate was for a three-story structure that had a much smaller square footage. Also, the office building estimate does not include the major amounts of equipment that a medical and teaching building need, such as x-ray machines, lab equipment, and seating areas.

Thesis Research

Breadth #1- Emergency Electrical System

Proposal

Health and Counseling Services will be unique, in the fact that it will have power supplied to areas beyond emergency lighting and life safety. BR + A has designed the emergency power system to supply emergency lighting, life safety, and full power to half of a single floor. The intent of this design is to allow for partial operation of the building in the event of a city, state, or national emergency where power supply would be interrupted for a significant amount of time. Initially the university wanted to be able to supply the entire building with power in the event of an emergency. The campus standby power supply cannot handle the entire building power requirements as well as life safety and emergency systems for other buildings on East campus.

After reviewing the situation with the university's electrical engineer, it was decided to add a standby generator to the building to supply the full power backup. Utilization of the designed emergency electrical room for the new equipment will help with keeping the cost increase of the change low.

Future analysis will require study in the following areas:

1. Constructability to determine if there will be enough space in the areas that have been designated for electrical use.
2. The cost and schedule impact of adding the redundant system. Extra electrical equipment and wiring will be needed within the structure. Outside of the structure, enclosures for the standby equipment and the addition of exhaust piping will require a cost estimate

In order to accomplish this analysis, the electrical engineers from Penn State and outside engineers will be contacted. Information regarding Penn State's policy on outdoor standby generators will be needed. Any special requirements they require will have to be

incorporated. NFPA 110 will be utilized to determine code requirements for the standby system.

Once the information has been gathered, R.S. means and appropriate material/equipment suppliers will be used, as a base for pricing, to make a detailed cost estimate of the design change. The analysis should show a large cost impact to the project, but the added benefit may outweigh the cost from the university's perspective. The redesign of the electrical system should not require a large amount of calculations. Where calculations are required, computer programs will be used as much as possible. Electrical faculty and Penn State's electrical engineers will be contracted and asked to assist in the process of adding the system.

Research

The main electrical system is fed from the main campus supply at 4160/480-277V and is then stepped down through a transformer to 480/270 V. In turn this main power supply is stepped down accordingly to 208/120 V where needed depending on what an electrical panel is feeding. The emergency electrical system is fed from the campus standby power supply. This standby power is spread across the entire campus and thus only life safety and emergency lighting can be fed to Health and Counseling Services while still being able to supply the same emergency supply to the other campus buildings. After some study within the Office of Physical Plant, Dick Harris (University Electrical Engineer) determined that one half of one floor could be fully supplied with power from the campus standby system while still being able to maintain power to other buildings in the case of an emergency. The Office of Physical Plant is Penn State's design, construction, and maintenance body for all of the commonwealth campuses as well as the main campus, University Park. This change in the design was bought into the electrical contractor's contract; therefore no change order was needed.

After speaking with Chad Spackman, Office of Physical Plant Project Manager, Penn State originally wanted to have full service to the entire building during the event of a power disruption to the normal supply. After reviewing multiple options, a standby generator feeding to the emergency electric room with an automatic transfer switch was found to be the most feasible option. Inside the emergency electrical room, all equipment

associated with the designed standby emergency backup will be removed and the remaining area will be used for the new emergency electrical equipment.

The next step was to locate the standby generator. Ideally, the generator would be located within the building near the transfer switch. This is not an option for Health and Counseling Services. All available spaces within the basement/ first floor of the structure are occupied. Therefore the generator must be located outside of the building. Criteria for locating the generator were established first. The criteria included aesthetics, available space, distance from transfer switch, and noise. Only one location will work. On the North face of the building at the Western end of the structure. Here the generator will not greatly diminish any desired aesthetic, there is available space, the distance from the generator and transfer switch will be less than 50 feet, which will make it within code requirements, but noise could become an issue with students passing through that area on a regular basis. To offset this noise issue, the generator selected has sound isolation equipment installed as well as a sound and weather enclosure. The enclosure will also be surrounded by a brick enclosure extending past the generator by three feet on both sides. A brick enclosure was chosen to keep the outer aesthetic of the building intact.

Exhaust from the generator is required to be ventilated away from any public space or opening, such as a window, on the exterior of the building. 5” Stainless steel piping will run up the exterior of the building from within the brick enclosure and vent the exhaust at the penthouse level. While it would have been ideal to run the exhaust piping inside a mechanical chase within the building, there was not enough room left to implement that method.

The Kohler Company was chosen for the generator, automatic transfer switch, sub base tank, and paralleling switch gear. The demand load for the building is approximately 300,000 KW. The load requirement was increased by 30% for safety and a 400KW EPA certified generator was chosen, model 400REOZDD. The automatic transfer switch for the generator is required by code to be the same size as the main circuit breaker’s over current protection, which is 1200A. After speaking with a Kohler supplier, they recommended that a dual breaker paralleling switchgear be used in lieu of an automatic transfer switch to save money. The dual breaker acts as an automatic transfer switch. The sub base tank comes optional with the generator. The tank holds 898 gallons of diesel

fuel and is 13.25'X4.35'X3'. Finally, the paralleling switchgear is a model PD-100C-SH1-M6NN-1212 rated at 1200A. All calculations and drawings for the equipment chosen are located in Appendix A.

A diesel generator was chosen instead of bio-diesel, natural gas, or a bi-fuel mixture. Natural gas and bi-fuel were not used because of the price of natural gas and because PSU does not have the systems in place for the use of natural gas. Bio-diesel was not used due to its limited shelf life and the 5-7% efficiency drop for generators that supplement bio-diesel instead of straight diesel. Other green fuels such as hydrogen are not yet viable for use in the industry.

The paralleling switchgear will be located in the emergency electrical room. A 30-inch clearance around all sides of the switchgear will remain free for maintenance personal, according to NFPA 110 Section 5-2.5. From this room, all of the designed panels will have backup wiring sent to them from the paralleling switchgear. All of the existing electrical panels used for the normal service inside the building will be used for the standby system. Power will be run separately from the paralleling switchgear to each panel. The panels will be switched from both sides so that when the main power is off and the standby generator is activated they will still remain with power. By reusing the electrical panels that are already in place, a large amount of money is saved with this redesign. All of the designed electrical equipment from the emergency electrical room forward in the system will be reused.

Finally, a location for the fuel storage tank was decided upon. It is to be located directly below the standby generator and within the brick enclosure. The storage tank is made by Kohler and holds 898 gallons. The tank can supply the generator at 100% loaded capacity for slightly more than one day. At 75% capacity the tank will run the generator for almost a day and a half. Leak detection monitoring equipment as well as fuel level monitoring sensors that feed to central services at Physical Plant has been added to the tanks standard package.

Standby generators require routine maintenance to make sure that the system will be ready when a power outage occurs. According to NFPA, National Fire Protection Association, 110 Section 6-4.2.2, the standby generator must be tested once a month at 25% rated capacity for 30 minutes, 50% rated capacity for 30 minutes, and 75% rated

capacity for 60 minutes. The generator must be tested from a cold start with the normal loads that it would encounter during a loss of normal service. Also, once every 1.5 years the diesel fuel in the storage tank must be replaced because diesel fuel has a shelf life of approximately 1.5 to 2 years. It is recommended that the fuel is used for other immediate purposes and replaced.

In conclusion, the total estimated cost impact of this addition is $219,000.00 and would have a minimal schedule impact on the construction of Health Services. With the elimination of the original standby system and the addition of the new system the overall schedule impact is expected to be minimal. The system is expected to take 30 days to install over the course of the electrical construction. It is the recommendation of this paper to not add the generator to the site. The addition of the new standby generator system would not add enough value to the structure to warrant the change. The addition of the exhaust piping up the length of the North side of the building would be a blemish on the overall building aesthetic. The designed system is adequate to meet the needs of the building as long as the campus standby power system is not affected by a catastrophic event.

Depth Topic #1- Commissioning

Proposal

All Penn State buildings undergo a process known as commissioning. Commissioning is the process where at the start-up of a building testing and adjusting HVAC, electrical, plumbing, and other systems is done to assure proper functioning and adherence to design criteria. Commissioning also includes the instruction of building representatives in the use of the building systems. Through the owner's representative, completing commissioning in a timely manner has been identified as a critical problem that Penn State has faced on all new construction. New base buildings have not passed the tests set by their commissioning agent within the schedule time allotted. Examples of problematic buildings on the University Park campus include the Chemistry Building, Life Sciences Building, and the Sala Building. Some buildings have been occupied for use while commissioning was still being completed due to associated delays within the

process. It is the hope of this analysis that the problems that have been prevalent on prior projects will not be subject to occurring again on Health and Counseling Services.

One method that will be implemented to improve the indoor air quality is to add UVGI (Ultraviolet Germ Irradiation) devices to the return air ducts in disease sensitive areas. Examples of these rooms include waiting rooms and exam rooms. The purpose of these devices is to instantly kill viruses and bacteria that medication and antibiotics are unable to destroy. The number and locations of each UVGI will be calculated for the most efficient placement at the lowest cost.

The areas that will be analyzed in this section include:

1. The process set into place for commissioning by the owner's agent in comparison to previous projects on University Park campus.
2. The constructability of the building in relation to this process. Specifically, when certain steps are supposed to take place in relation to the construction.
3. The schedule of this process and improvements that can be made to it through construction methods.
4. The addition of UVGI's throughout the space to eradicate viruses.

To accomplish this goal, the owners commissioning agent will be contacted. The commissioning agent will be asked to supply the process by which they will certify the building. They will also be asked to lay out the logic for the steps and sequence they have chosen. Next, the Office of Physical Plant will be asked to supply detailed information about previous projects that have passed and not passed commissioning with the scheduled time for completion. Once the buildings have been identified, the commissioning agents that have been involved with those projects will be contacted to gather information about where and why the problems happened. Problems that are found will be organized and patterns will be identified. A document will be made and submitted to Penn State for their use on future projects.

To accomplish the addition of UVGI's to the space, the construction documents will be analyzed to identify critical infection areas. Once this has been completed, calculations to determine the size and number required for each space will be completed.

Finally a cost and schedule analysis will be conducted to determine the overall benefit of the UVGI addition to Health Services.

The results will be compiled and a list of necessary adjustments to the commissioning process of Health and Counseling Services will be formalized as well as a list of general rules for commissioning of future projects. Proposed solutions to each problem will be incorporated. Also, the results of the UVGI addition will be summarized with importance placed on showing the benefits and consequences of this addition.

Research

Commissioning of Penn State buildings has been a steady challenge in recent years. The time allotted to the commissioning process has been adequate or better on the project schedule, yet final commissioning reports on a multitude of buildings have yet to be turned in to the university. The purpose of this analysis is to determine where during the process or development of the drawings that commissioning has fallen behind or been overlooked. A multitude of commissioning agents have been contacted and asked to supply information about the processes used on buildings they have been involved with. The parties contacted include Aramark, Sebesta Bloomberg, Facility Dynamics, and the Office of Physical Plant in-house commissioning personnel. Once this information was gathered, it was compared to the process set into place for Health and Counseling Services. As a part of this analysis, a list of recommendations for commissioning on the University Park campus is located in Appendix B. This list has been given to the Office of Physical Plant for their review and implementation.

Common Commissioning Problems

The most common reasons for a delay in the commissioning process on the Penn State University Park campus are listed in this section.

Start of Cx Process

The largest reason for commissioning problems is the view of when commissioning starts. In the Office of Physical Plant, there are varying mindsets on when this process begins. Some believe that commissioning should begin before 60% construction documents while others think that it begins at the start of construction. The

earlier a commissioning agent is brought into the design stage, the smaller the cost impact that will be incurred from unidentified design flaws. While there is a larger fee from the commissioning agent, if they are brought in earlier typically that money will be saved by design flaws being caught before purchasing of materials and the start of construction.

The recommendation for this problem is to bring the commissioning agent into the project team at the same time as the architect and A/E. The benefit of bringing the Cx consultant onboard at this time will most likely save the project money. When a design-build approach is used the Cx agent should be brought into the team at the same time as the A/E professional. The Cx agent should be involved during the design meetings to add input into the systems. While this may cause problems with the design professional, a strong project manager should oversee this process so that any disagreements can be remedied as the review progresses.

Normally, PSU does not hold contracts with their Cx agents. A project manager receives a scope of work from the Cx agent and accepts it. The recommendation is to pay the Cx as a consultant during the design phase and then hold a contract with the Cx during the construction of the project. With the addition of a contract, the owner can stipulate what requirements the university will be holding the Cx agent too. This addition will most likely alleviate any confusion during construction regarding responsibility and/or scope if the contract document is constructed properly and in the right level of detail. If a contract is not used, the project manager must make sure that the scope of work to be performed by the Cx agent is very detailed and lays out the plan that will be put into place correctly to the best of their ability.

Time

The project schedule including design and construction is usually very compact with little room for error. Multiple items are rushed through so that an occupancy date can be achieved. During design, the amount of time for review of drawing and specifications is a challenge to all Cx agents. This can lead to problems with multiple systems during the construction phase. The solution to this problem is to allow more time for design if at all possible. Time may not be available to extend the design phase, but every effort should be made to make more time available so that systems can be reviewed in more detail.

During construction, time is always a problem for the Cx agent as well as every contractor on a construction site. The milestones on the construction schedule should be maintained as much as possible. The commissioning schedule is based upon the construction schedule. Any time that there is a problem with the construction schedule it will cause delays to the commissioning schedule. Functional testing of the buildings systems is supposed to be completed after the contractors have completed the building systems. Often, the commissioning is not as good as it should be due to construction overflowing into the time allocated for the Cx agent to finish their functional testing. Since the time allowed for the building construction is always tied to an occupancy date, the functional testing is sometimes done while the building is occupied. When the building is occupied, a true functional test of the system can never be verified 100% accurate. This can be due to occupants changing system or equipment setting during the testing period.

Construction Schedule

Frequent and accurate schedule updates to the master construction schedule are critical to commissioning. If this is not done the Cx agent can not update their commissioning schedule and may not know when they are ready to commission a piece of equipment or a system. This can lead to backlogs of functional tests which will cause the Cx agent and specialty contractors to be on site much later than expected.

Commissioning Training

Commissioning is a somewhat new way of making sure that a building is working properly. Many A/E professionals, architects, construction managers, general contractors, and specialty contractors have not been involved with a lot of projects that have undergone a detailed commissioning process. The level of involvement from each member of the team is often not understood and can cause issues with commissioning finishing in a timely manner. This problem can be solved through the Cx agent having a strong kick-off meeting when construction starts. .If a Cx agent is selected during the design phase, having them present at pre-bid meetings to discuss some of the things that subcontractors should expect on the project can decrease the amount of money a contractor allows for in a bid for commissioning. Contractors that do not usually bid on

commissioned projects may have large allowances to offset an unknown cost like commissioning.

In- House Training of Building Systems

Training of maintenance personnel is another large problem that the University must deal with. When a training program is set in place for a system, sometimes the training is not held onsite with the system. All training programs should be held in the building that the program is for and the system itself should be incorporated for a hands on training program. The maintenance and support personnel that will be using the buildings system should be present for the training. Many times there are people at these mandatory training programs that are not in the appropriate field and are not going to be involved with the buildings maintenance. Due to these issues, commissioning agents are frequently being called back for malfunctioning systems. Another less common issue with maintenance is familiarity with new systems on gold and platinum LEED buildings. Typically these systems are not common to other buildings on campus and maintenance personnel have trouble adjusting to these new systems.

Building Turnover- Warranty Issues

Another issue commissioning agents have with PSU construction is the question of when is a building supposed to be turned over for the owners occupancy. With workers still in the building and commissioning not yet completed maintenance personnel and building staffs are already within the building on most recent projects. With this occurring, it becomes increasingly more difficult to complete the commissioning process and submit a final report to the university. Typically the problem here is that finishing the commissioning on the mechanical system, specifically the air balance, becomes more of a challenge for the commissioning agent and the mechanical contractor. Another problem with having building occupancy before commissioning of the systems is the warranty. When does the warranty of systems and equipment happen? Do warranties go into effect when it becomes occupied by Penn State or is it at the submission of the final report? A great deal of time is spent on determining this on each project.

Communication

Communication is paramount in order for a building to be commissioned properly and within the schedule. Contractors and commissioning agents must be on the same page in order for this process to work. A contractor reporting that a system is completed or a piece of equipment is installed to the commissioning agent when it is not finished or installed properly causes major delays to this process. While this issue is not a problem that Penn State faces alone, it is still a prevalent cause for the delay in commissioning.

Cx agents often allow for the fact that specialty contractors are not going to communicate their true completion of a system or piece of equipment accurately. They allow money in their budget for multiple functional tests. Often, they allow for themselves to be called onto site two or three times when they will not be able to perform a test. Usually, contractors have penalties in their contracts for system or equipment re-tests if a Cx agent is unable to perform their work on their first attempt. Written documentation of pre-functional test completion from a specialty contractor to the Cx agent is another method to maintain that the specialty contractor remains on schedule and truthful about their level of completion. This documentation can be used to prove that a specialty contractor owes money for penalties if multiple re-tests are required.

In order to fix this problem, the owner and construction manager must make it known that the commissioning process is something that will be completed and completed properly. Only mentioning a commissioning plan to a contractor that thinks commissioning will go away will accomplish nothing. New language should be added to contractor's contracts so that the owner or construction manager can point out exactly where their responsibilities are located. Also, attaching Cx milestones to the schedule of values could help the enforcement of the Cx plan.

Another problem with communication is a lack of information being readily available to the entire project team. Programs such as Timberline and Prolog have integrated all of the different aspects of a project into one location. Real time status of submittals, RFI's, change orders, etc. can be reviewed by the project team instantly. Since these types of programs are being used more frequently in the industry, integrating this into the Penn State system would not be extremely difficult

Design Review

The design review team makes suggestions to the A/E professional from the specifications, construction documents, and addendum. The Cx agent has no power to force an item to be changed, but makes suggestions. Issues that are brought up by the Cx agent and other members of the team sometimes are not resolved. Cx agents need closure to these issues on whether they are being implemented or why they are not. This may be difficult to maintain during a design-build project, but all attempts should be made for closure of issues.

Submittal Review

Submittal review is another problem that frequently delays commissioning and project completion. Usually the process is for a contractor to submit for review materials, fixtures, equipment, and basically anything that goes into the building for review to the construction manager or general contractor. Then the contractor reviews it and sends it along to either the architect or engineer depending on who specified it to be in the building. Usually, a specification slips through that is wrong. This may be the contractor's error or an error with the drawings. When these items are not caught in this process a major delay can happen. If this is a long lead time item, especially mechanical or electrical equipment, schedule delays and added costs become prevalent. The Cx agent needs to be in the loop for the submittal review. If they receive submittals late their input may be left out. Ideally, the Cx agent should be doing all reviews in parallel with the designer.

Process Map/ Document in House

Up until this point most of the problems that have been discussed have dealt with the third party agent and their associated challenges. Inside the Office of Physical Plant, the project team needs to be on the same page for every project that is started. Commissioning of buildings may be a somewhat new trend in the construction industry, but with Penn State's commitment to optimizing its energy use and their dedication to LEED construction commissioning is something that OPP will have to become accustomed to. A process/ plan for commissioning was created in 2002. This process was not fully integrated or accepted into the normal construction process due to personnel

turnover and a non-commitment to commissioning. A review of this process has been started recently and appropriate updates will be forthcoming in the upcoming months.

Making a document into standard policy can be a difficult task as Penn State has already seen. To offset this problem, upper management needs to buy into this document. Meetings to discuss the process need to be held with all personnel that are involved with construction projects. Appropriate amounts of review for projects need to be conducted to confirm that a project is following this process and if it is not then the reasoning behind the decision to not follow it needs to be evaluated. Essentially, the Office of Physical Plant needs to take a team approach to commissioning for it to become a fully integrated aspect of any construction project.

Mechanical Designs

Poor mechanical designs are another lingering issue that has troubled recent projects including the Smeal College of Business and the Forestry building. Mechanical designs that are vague and left for interpretation of the contractor putting them in place cause major issues for the commissioning schedule. After the system is set up and the system is turned on the finger pointing begins. That is to say the design professional, contractor, construction manager, and commissioning agent all deny their fault with the improper design. Proper design review from the beginning of the process by the commissioning agent, as well as other members of the team, should identify faulty designs and save the project from future delays.

Building Control Designs and Sequences

The A/E professional often designs poor control systems and their associated sequences. This is largely due to a lack of experience with these systems. This problem is faced by the entire construction industry. When the designer submits the control sequences they are often vague and left up to the interpretation of the controls contractor. Often this leads to the controls contractor installing them incorrectly. Also, this makes the Cx agents responsibility of making a functional testing plan extremely difficult. Penn State should incorporate a standard policy or a list of standard criteria for the A/E professional of what they require to be listed in the construction drawings and specifications.

Building Turnover and Cx System Testing

Contractors are using the time allotted for the systems testing after the construction end date to finish punch lists and minor items that are still outstanding. While this was typical and accepted for construction projects before commissioning became prevalent, now with the additional amount of time to test the system that is allotted into the CPM schedule the time is not available for contractors to play catch up. Any work that is not completed on a system will end up delaying it's associated commissioning. Contractors need to be told and reminded that once they are bought into a schedule, they are responsible for completion by the construction ending milestone date. Barring a change order to their contract, ideally the contractor has made the necessary arrangements to finish in the time the CPM schedule has made for them. Penalties to contractors that are not finished on time would be a deterrent and would encourage a timely completion. If penalties are not an option, the construction manager or general contractor must enforce this date to leave time for the commissioning agent. Also, the construction manager or general contractor needs to make realistic construction schedules so that specialty contractors are able to finish within their schedule.

Design Intent Document D.I.D.

At the start of any project a design intent document is made. This document specifies exactly what the occupant and owner want in the building or the building to do. Often this document does not specify, in enough detail, what exactly the designer should be including. When this is left to interpretation by the design professional, multiple issues of the design documents are usually needed to fix mistakes. Reviewing multiple sets of construction documents can lead to confusion of which set contains the up to date drawing. Items that may have needed to be changed are overlooked and sometimes become approved for construction. When this happens the amount of money needed to fix an item costs significantly more than if it were caught during the design phase. If the item is not caught until the end and is a critical system or piece of a system commissioning may be delayed. Cookie cutter design intent documents with minimal changes have to be replaced with in-depth reviewed design intent documents so that OPP and the building occupants receive what they want.

The D.I.D. is supposed to be reviewed and updated throughout the design and construction process. Any changes from the initial D.I.D must be approved by the owner. This aids the Cx agent in the requirements they must incorporate into their commissioning plan.

Staffing- In house

In house commissioning is typically limited to small to large renovation projects. While there are few large renovation projects occurring at this time, many small projects happen every month. The groups that review the drawings and specifications are called engineering services and commissioning services. Engineering services looks for specific items to be included in the specifications such as a generator. Commissioning services looks at the drawings and specifications in a broader sense looking for design flaws or omissions. Two people encompass the entirety of the commissioning services group. A proper review of construction documents is difficult with a large volume of work. While every attempt is made to catch every problem, the shear fact that there are not enough people to do a good job is apparent. A staffing review should be done to determine how many people are needed to do the job properly at this time and how many people will be needed during the upcoming renovation phase of the University Park campus. If hiring new employees is not an option, outsourcing commissioning to a third party should be evaluated on a project by project basis.

Health Services Commissioning

At this time, the commissioning plan for Health and Counseling services is finished. No items on this process have needed to be commissioned at this point due to where the project is at on the schedule. After speaking with John Elder, Aramark Inc., he is aware of all of these issues and will be monitoring them very carefully. John has been involved with multiple buildings that have recently been constructed including SALA, Food Sciences, Life Sciences, Outreach Innovation, and Forestry building. John was brought onto the project team early in the design and has already found and corrected many errors within the design and construction documents.

The commissioning plan is very detailed. The plan lays out every aspect of the scope of work from systems to be commissioned, pre-functional and functional testing

procedures, to systems training. Every member of the commissioning team is identified and expected to be at every meeting. The responsibilities of every team member is listed for what they are expected to do and be involved with. How the commissioning of the buildings equipment and systems is listed with what documentation will be required of each member of the team. Finally, sample reports of deficiency reports and performance deficiency reports are shown as examples of what the team should expect to see.

After reviewing the commissioning process for Health and Counseling Services building, the following recommendations will be made to Chad Spackman, OPP Project Manager, and to John Elder, Aramark Inc., so that this project will not encounter the previously discussed typical problems on PSU construction projects.

Health Services Recommendations

Since Health and Counseling Services is past the design phase of the project, many of the problems identified in the previous section do not apply during the construction phase. Recommendations that can be made specific to Health and Counseling Services will be discussed in greater detail than more general rules. Please refer to the appropriate recommendation in the previous section for extra information.

Communication

Aramark and Penn State need to make commissioning a priority from the commissioning kick-off meeting until the final report is made. All subcontractos must be made aware of the importance of reporting when a system or piece of equipment is finished being installed and ready for the Cx agent.

Submittal Review

All members of the submittal review team should make the time to do a complete review of each specification. To avoid problems in the past, any questions regarding sizes of equipment should be forwarded to the appropriate design professional before approving the specification.

Time

The construction schedule milestones are the key to maintaining the timely completion of the commissioning process. The commissioning plan relies on the

milestones so that there will be enough time to do proper functional testing of the equipment and systems at the end of the project. A detailed commissioning schedule that specifies each piece of equipment to be commissioning should be made as well. This will enforce the importance of the contractor finishing installation on time.

Building Turnover- Cx System Testing

The construction schedule must be held to the construction end date. Any time after that date should be left for punch list items and system testing by the Cx agent. During the bi-weekly construction meeting, the PSU project manager, Cx agent, and construction manager need to maintain this idea. Contractors need to be held accountable to the construction end date and not be allowed to believe they can finish normal construction during the Cx system testing period. While this is an ideal construction schedule and may not be possible depending on construction circumstances, delays, and change orders, every effort should be made to maintain the end date.

Building Turnover- Warranty

A definitive date for maintenance personal and building staff move in should be set and held to unless there are special circumstances. This will avoid questions of when the warranty should take effect for building equipment and systems. The appropriate testing will have taken place and there will be no questions of whether the building occupants or the construction personal are responsible for any problems that are identified.

Construction Schedule

Whiting-Turner should update their master construction schedule frequently and accurately. The schedule needs to incorporate Aramark's commissioning schedule with the correct predecessors and successors added. This schedule needs to be forwarded to Aramark after each schedule update.

Commissioning Training

Aramark should have a strong kick off meeting for the commissioning team. Time should be spent to make sure that each member of the team understands their roles and responsibilities during the construction process. If the commissioning training is done well during construction, the contractors will become more accustomed to how the

process is completed. Since all of these contractors are on the Penn State pre-qualified bidders list it will be beneficial to the university on future projects if they are trained properly.

Training of Building Systems

Appropriate personal should be attending equipment and systems training. The training session should be videotaped and copies should be kept at the Physical Plant Building and at the Health and Counseling Services Building.

Breadth Topic #2-UVGI Devices

Improving the indoor air quality of Health and Counseling Services Building was chosen because it would add the most value for the university and the building occupants that will often come to the building with a sickness that could be transported through the buildings ventilation systems. UVGI (Ultraviolet Germ Irradiation) devices will be analyzed for use in the building. These devices have been proven to destroy viruses and bacteria that HEPA filters have not been able to contain. Steritubes are proven to

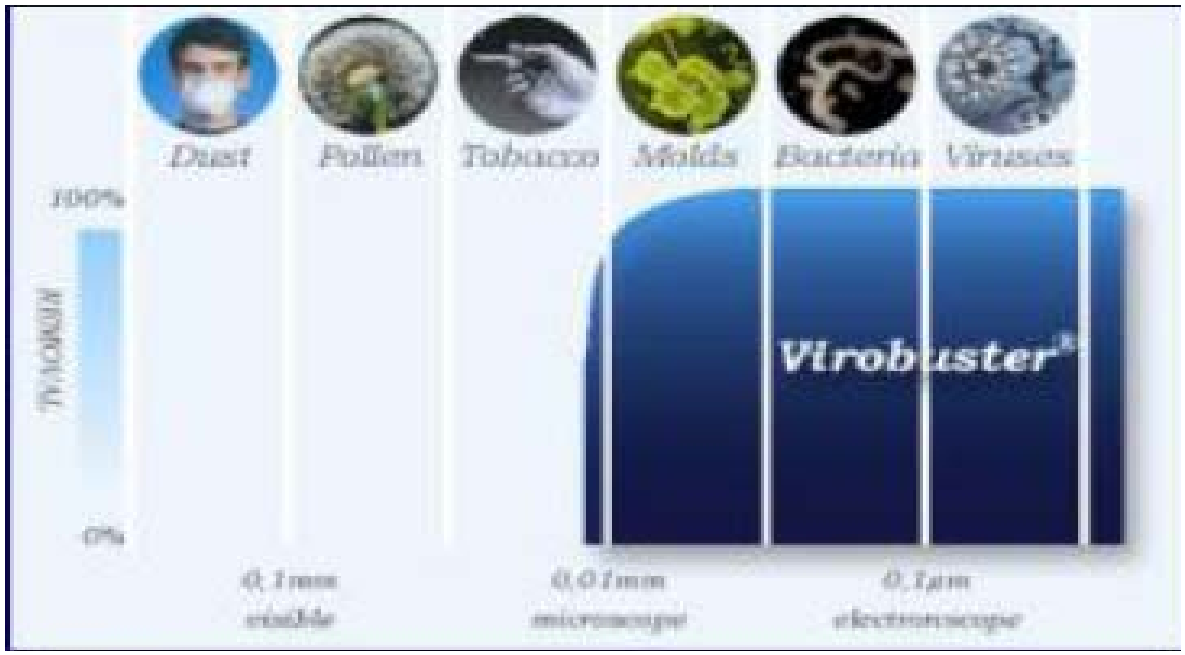


Fig 4.1 Graphic of Virobuster Effectiveness

eliminate 100% of airborne bacteria, viruses, and molds. Some diseases that it has been proven to contain include bird flu, SARS, TBS, influenza, and anthrax. With the use of UVGI devices the spread of disease will be greatly reduced. Virobuster Steritubes were chosen as the UVGI devices to be installed in Health and Counseling Services. While

there are other options for UVGI devices than Virobuster, most of the companies are located in Europe and were not able to be contacted for information.

This section will discuss some of the technical data involved with the Virobuster Steritube. Each Steritube weighs eleven pounds with dimensions of 7.89”X7.89”X59”. It requires 60 Watts of power at 208/110 Volts. The power required is easily accessible in the ducts since the building utilizes VAV boxes in each space. The Steritubes will be located close to the VAV boxes so that a minimal amount of extra wiring is required. A pressure drop of +/- 5 Pa occurs while 176 CFM of air pass through it during each air change. The Steritubes run very quiet and will not impact the acoustics in any space. It is also important to note that each steritube array is easily monitored through a microchip in the design. This microchip is linked to monitoring equipment either within the building or adaptable to the Office of Physical Plants central services. If at any time there is a malfunction in a device, it will report itself for maintenance. Service is required after every 9000 hours on a steritube and each array requires maintenance on a ten year basis. CE, UL, Kema, and TuV are the accredited research laboratories that have approved the Steritube technology.

Since the building uses return ducts and not a plenum system for ventilation of spaces, UVGI devices will work perfectly in this mechanical design type. Steritubes are placed in the designed plenum duct system. They are adaptable to fit into any size duct, therefore no redesign of the ducts were needed. Depending on the space and the number of Steritubes required, the mounting system can accommodate up to twelve at a time. With each steritube able to clean up to 175 CFM at a time, no more than three will be required for any space in Health and Counseling Services.

Identifying the locations that these devices should be located was the next step. Primarily the second, third, and fourth floors required their use in the most spaces. This was to be expected because those floors have all of the exam and procedural rooms as

Fig 4.2 Installation of Virobuster Steritubes in Plenum Ductwork

well as waiting and reception areas for health services. The first floor is mainly departmental offices with only a few treatment rooms. The fifth floor is used for counseling services, therefore only group therapy rooms where there would be a high level of occupancy were identified as needing UVGI's. In total 123 locations were identified in the building. Offices, exam rooms, treatment rooms, receptions and waiting rooms, procedural rooms, and hallways make up most of the spaces that will require the devices to be installed.

The Virobuster website has a Steritube calculator to determine the exact number required for each room. This calculator also gives the expected cost impact and saving over an annual period. In total 112 Steritubes are required to completely cover the entire building. A detailed listing of each room with the number of Steritubes required is available in Appendix B.

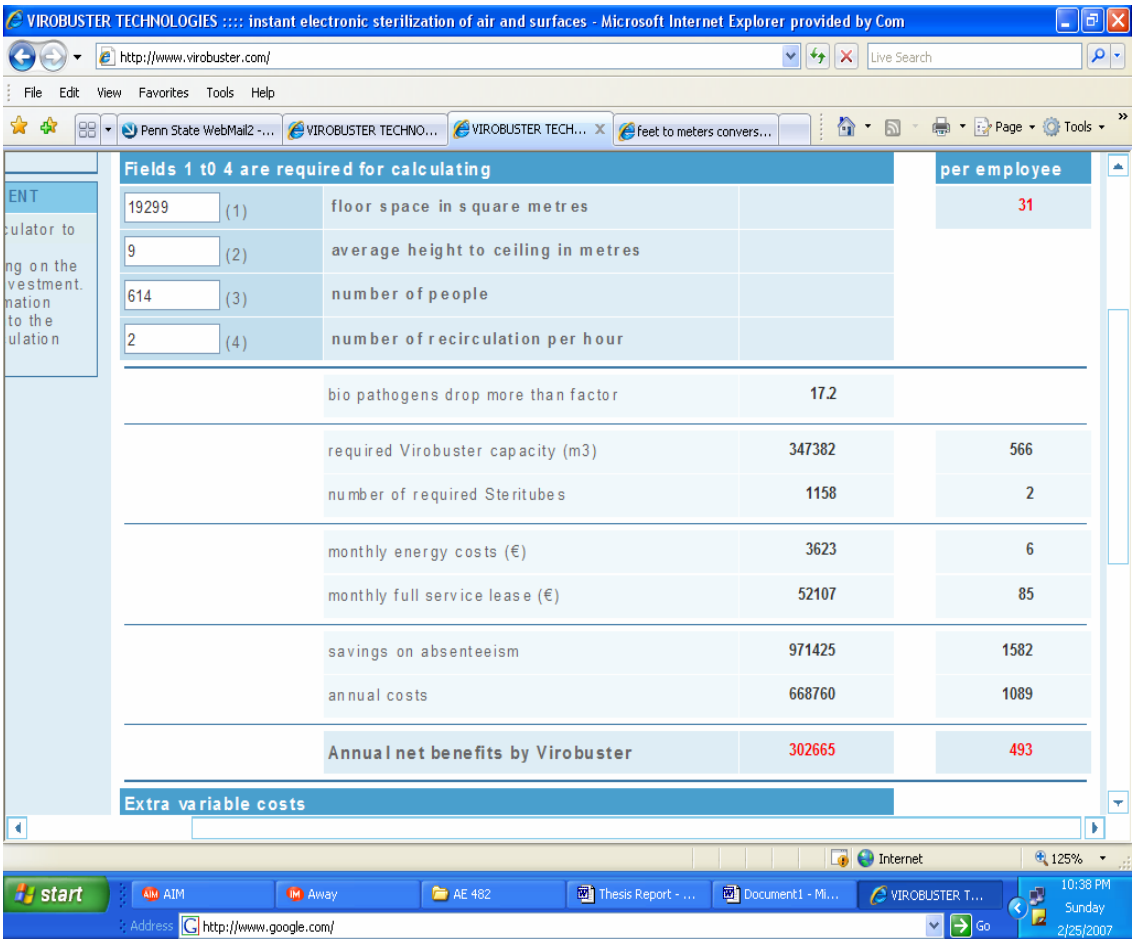


Fig 4.3 Virobuster Steritube Calculator (www.virobuster.com)

The total cost impact to the design is $295,363.00. Each steritube costs $2,954.00. Pennsylvania prevailing wage rates for the Health and Counseling Services project, dated 12/17/07, were used to calculate the cost for installation by an electrician. At three hours to install per steritube, the total installation cost is $15,923.00. The total time to install is 336 hours or 42 days by a single electrician. Since there will be dozens of electricians on site the time to install would be significantly less.

It is the recommendation of this analysis that the addition of the Virobuster Steritube or another comparable UVGI device would be beneficial and add great value to Health and Counseling Services. The indoor air quality would greatly improve the buildings occupants comfort level. The amount of money saved from students and employees of Penn State not contracting a disease would offset the cost of the addition over the life cycle of the building. The monthly operating costs of each steritube would only amount to roughly $1.33 each totaling $150.00. Installing each Steritube in the

plenum ductwork would not require very much additional work since the building already utilizes VAV boxes throughout the spaces. Finally, the schedule would not be impacted large enough to delay the set occupancy date of August 2008.

Depth Topic #2- Leed Cost and Schedule Increases

Proposal

This research topic that has been identified through contact with industry representatives at the PACE Roundtable and from various general contractors in green design and construction. Specifically, the cost and schedule increases that subcontractors have been applying to LEED rated projects. After speaking to Mr. James Bognet, owner of Bognet Construction Associates which is a general contractor in the D.C. metropolitan area, it was made clear that he sees a ten percent increase in cost and schedule on most projects that are LEED rated in comparison to non LEED rated projects. This was verified as a trend after speaking to faculty within the architectural engineering department. It was suggested that this increase may be due to architects and engineers including a larger amount of materials and systems in LEED buildings than ever before. This increase and the unfamiliarity of subcontractors with LEED and these new materials may be a large underlying cause of the problem.

The proposed solution to this cost and schedule increase is to make a quantitative spreadsheet of the problem areas. Through this spreadsheet, areas that subs are having problems with could be solved through green building education. Another solution will be to show how certain materials, building systems, and construction methods impact a subcontractor's cost on a LEED rated project. Through this cost analysis, architects and engineers may think more about the systems, equipment, and materials they are specifying in their construction documents.

This research will benefit all parties involved in the construction process. Contractors, construction managers, architects, and engineers will see exactly where the industry is having problems with their methods for obtaining LEED certifications. The materials, systems, and methods that architects and engineers have been designing and placing in specifications will be seen with their associated drawbacks from the subcontractor view. While owners will benefit from this research, they will primarily be

concerned with the cost and schedule savings. It is the purpose of this research to show how green building construction does not imply a drastic cost or schedule increase.

In order to accomplish these solutions the following steps will be taken:

1. Contact subcontractors from multiple trades. The contractors will be from the Health and Counseling Services project as well as from outside sources.
2. Depending on location of subcontractor, conduct a phone interview, in person interview, or send survey from Appendix A.
3. Collect information.
4. Create spreadsheet with all information gathered from questionnaires. Make recommendations for Health and Counseling Services to make construction run on schedule and within the original budget.

Research

Background of Research

LEED design and construction have been identified through industry representatives as having potential cost and schedule impacts associated with each project that incorporates this approach. After conversations with general contractors, construction managers, and specialty contractors that are known through the PACE seminar and internships, there are varying opinions on this subject. Some believe that there are no cost and schedule impacts while others have percentages associated with each level from certification through platinum. The purpose of this analysis was to gain a complete perspective of LEED projects through surveys and conversations from every member of a typical project team. Team members contacted include architects, engineers, construction managers, general contractors, specialty contractors, and consultants. The following questions were asked of the previously mentioned team members.

Questions:

1. How many LEED or green buildings have you or your company been involved with?
2. Is there a cost increase associated with LEED rated projects?

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects?
4. Of the additional Cost how much are hard costs and how much are soft costs?
5. What are the long term and the short term cost to your firm to build a LEED Project?
6. Is there a schedule increase associated with LEED rated projects?
7. If yes, what are the most common causes?
8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?
9. If yes, how has this affected the cost and schedule on LEED projects?
10. What materials, systems, and construction methods do you find the most problematic to LEED construction?
11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?
12. What LEED credits do you or your company find the most difficult and expensive to comply with?
13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?
14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?
15. Have your or your company received training on how to build LEED rated buildings?
16. If yes, what additional training was required?

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?
18. How is your productivity during construction impacted on Leed Projects?
19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

The results and analysis of these questions is available in the Survey Results section.

The intent of this research is to compile a list of areas that cause increases in cost and schedule. This will allow all members of a project team to identify where potential cost and schedule impacts are located. Recommendations for offsetting these costs and/or eliminating these problems will then be given. This will allow for LEED construction projects to be run smoother and remove any misconceptions regarding LEED projects.

Background of Leed on Health and Counseling Services

Health and Counseling Services is attempting to obtain a LEED certification. Using LEED-NC Version 2.2 Registered Project Checklist, Whiting-Turner and PSU are planning on obtaining 29 to 49 of the possible 69 points available. The team that decided what LEED points were to be obtained included the Office of Physical Plant, Hillier Architecture, BR+A Engineers, and Whiting-Turner Contracting. Penn State's Office of Physical Plant used members from many different areas such as engineering services, architecture, landscape, storm water management, transportation/parking, purchasing, project management, maintenance, janitorial, and health and safety. Penn State does this review so that there is a broad representation from the University's operational groups. From PSU's Leed Policy, the criteria for establishing the points that a project will obtain is based upon energy conservation, natural resources conservation, prevention of environmental degradation, people's health, and financial payback.

PSU's Leed Policy looks at each individual credit and determines which ones will be mandatory, should have significant effort put into, and minimal effort put into. To

view this policy, please contact Dave Zehngut at O.P.P.. Comparisons between PSU's Leed Policy and the LEED project checklist for Health Services, Appendix C, show that this building followed the policy with only a few exceptions. These exceptions include not making the following credits mandatory. Sustainable Sites credit 6.1 storm water design and quality control, Energy and Atmosphere credit 1.6 optimize energy performance of 28%, Materials and Resources credit 7 certified wood, and indoor environmental quality credit 4.4 low emitting materials for composite wood and agrifiber products are all not credits that will likely be achieved. The reasons for not obtaining these credits are due to the timing of PSU's LEED Policy in relation to when the LEED Project Checklist for Health and Counseling Services was made. The Leed Policy was finished in January of 2007 while the project checklist was made in April of 2006. At this time the only credits that have an increased cost associated with their implementation are EA credit 5 for $20,000 and EQ credit 3.2 for $15,000. These two prices were based off of the newly built SALA architecture building that gained these credits obtained.

Survey Results

The following information summarizes the results from these surveys. To view each individual survey as well as a list of all people contacted, refer to Appendix C.

This section will analyze the results per each question or questions and then discuss the questionnaire as a whole and the implications of the results.

Is there a cost increase associated with LEED rated projects? If yes, why and what is the % Cost increase associated with LEED Certified Projects?

Almost every person contacted responded yes. Projects that are designed with LEED in mind show almost no cost increase compared with projects that decide to apply for a LEED rating after or at the end of design. It is also thought that the life cycle costs of the buildings will outweigh any negative effect that cost would add to the design of a LEED rated building. On the construction side there is an added cost with administrative work that affects the general conditions of a project. Documentation of weights/volumes of materials in dumpsters is an example of this that was brought up often. The additional amount of dumpsters that a general contractor or construction manager will need can add a considerable amount of money to the price of construction.

Subcontractors deal with the increased prices for materials. Some materials have to be certified as not containing certain harmful substances. For example, paints can not have PVC's or VOC's. The construction documents often specify mechanical equipment that is non-typical. This leads to higher prices for the equipment and generally larger installation fees associated with them.

Some companies have detailed percentages through studies conducted within their company of LEED rated projects to help with the bidding of such projects. These companies show a wide range of percentages that can be found in Appendix C. Most of the companies showed a range from 0%-15%, but one estimated it to be as high as 40%.

Of the additional Cost how much are hard costs and how much are soft costs?

The majority of costs are soft costs. While exact amount are specific to any single project and what certification level the project is trying to obtain. One general contractor listed the soft costs as typically 10% and included paperwork, inspections, and equipment start up as the highest costs.

What are the long term and the short term cost to your firm to build a LEED Project?

Long term costs are the training of employees on LEED. While this is usually a relatively small cost for the initial training there may be a need to continue training as LEED develops new points and regulations for certification.

Short term costs include construction costs and the administration of paperwork. These costs though are reimbursable over the course of a project.

Is there a schedule increase associated with LEED rated projects? If yes, what are the most common causes?

There is not an increase in the schedule associated with LEED projects as long as the decision is made during the design phase to get a level of certification. If the decision is made to attempt a certification during construction multiple problems can occur that would cause the scheduled completion to increase. Some of these problems are

procurement of new materials and/or equipment, tearing out of installed work, and the learning curve.

LEED credit EQ3.2 may need extra time if it is not scheduled properly. Credit EQ3.2 states reduce indoor air quality problems resulting from construction/renovation process in order to help sustain the comfort and well being of construction workers and building occupants, according to LEED-NC Version 2.2. For this credit, if Option 1 is chosen for a building flush out prior to occupancy, a down time for the building would have to be incorporated into the schedule.

Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings? If yes, how has this affected the cost and schedule on LEED projects?

Most respondents said that there was an increase in the above areas. While there are more materials, systems, etc. there appears to be little to no cost or schedule impact associated with them. The only items that may cause a cost impact are LEED rated finish products such as carpets and wall coverings, and some mechanical and electrical equipment. There is however a greater level of coordination required due to there typically being more systems involved in a LEED rated building.

What materials, systems, and construction methods do you find the most problematic to LEED construction?

Each respondent had different opinions of which materials, systems, and construction methods caused the most problems in construction of a LEED rated project. One item that was brought up more than once was the sourcing of FSC wood. Porous paving systems can be problematic since excavators typically are not aware that their trucks can over compact the soil and ruin the system. Low VOC adhesives and sealants can cause problems because some subcontractors will attempt to use left over materials from other projects that are not LEED rated and contain the VOC's.

If a project contains an on-site waste water treatment facility multiple issues come up. There are not many, if any contractors, that can do a commercial installation turnkey, plumbing and electrical work associated with the system need to be performed by a

tradesman licensed in your state/area, and troubleshooting problems with the system is difficult due to lack of experience with the installation.

Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

Lack of experience/education of the project team and suppliers charging more money for LEED rated products for no other reason than its LEED rated are the most common responses. Schedules are affected by the lengthy permitting and decision making times.

What LEED credits do you or your company find the most difficult and expensive to comply with?

The WE or water efficiency credits are very difficult to obtain especially on healthcare projects.

MR credit 2.1 and 2.2 state that 50-75% of construction waste should be diverted from the landfill. Difficulties in diverting drywall gypsum board are common.

MR credit 3 is meant for the reuse of building materials and products in order to reduce demand for virgin materials and to reduce waste, thereby reducing impacts associated with the extraction and processing of virgin resources. MR credit 3 looks for a 5-10% reuse in materials. The problem with this credit is that there is typically a high cost premium for the materials with no return on the investment for the owner.

MR credit 6 was created to reduce the use and depletion of finite raw materials and long-cycle renewable materials by replacing them with rapidly renewable materials. Examples of these rapidly renewable materials include bamboo, wool, and cotton. Once again, there are high cost premiums with these materials.

MR credit 7 uses certified wood to encourage environmentally friendly forest management. Certified wood is usually a lot more expensive than other woods and shows no return to the investment for an owner.

EQ credits 4.1-4.3 are meant to reduce the quantity of indoor air contaminants that are odorous, irritating and/or harmful to the comfort and well-being of installers and

occupants. These credits cover everything from adhesives and sealants, paints and coatings, and carpet systems. It is difficult to properly track all of these materials for the LEED documentation of these credits.

EQ credit 4.4, low emitting materials- composite woods and agrifiber products, is meant to do the same things as EQ credits 4.1-4.3. One qualification of this credit is that there can be no urea-formaldehyde resins. This is difficult to document and the materials typically have a 5% premium.

EA credits 1.1-1.10 are meant to achieve increasing levels of energy performance above the baseline in the prerequisite standards to reduce environmental and economic impacts associated with excessive energy use. Systems and equipment, specifically the ones that are mechanical, can be extremely challenging and add 20-30% to the mechanical contract.

For all credits, the training that usually needs to be given to subcontractors is extremely challenging. Since LEED is still a fairly new method of designing and constructing buildings, many subcontractors have little to no experience with the documentation procedures that they are required to do. Specifically, tracking levels of pre and post consumer contents in materials cause the most problems.

Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

All general contractors, construction managers, and consultants contacted replied that an analysis of each LEED point and its typical up front cost to a project as well as life cycle savings would benefit their company. Some responded that their company had already taken steps toward having an in-house document for that purpose.

On the subcontracting level, the response was typically that they did not require the up front and life cycle savings information. Since they bid projects per the drawings and specifications they believe that there is little to no benefit in the analysis for them.

How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

This question allowed each person to use their own experience and make any suggestion that they could think of. Not surprisingly, almost every response was unique.

- Spend the time to train and give the knowledge of LEED to every employee
- Mandate LEED at the governmental level
- Do nothing and allow the costs and premiums to reduce over time
- Make LEED guidelines for building types that can't meet the requirements of LEED as they are due to their function- Example: Healthcare projects
- Continually ask project managers, superintendents, foreman, etc. on LEED projects how to improve the LEED process and then make recommendations to the USGBC.
- Always make the decision on whether a project will attempt a LEED certification before the design process begins
- Reduce the amount of documentation for reporting of LEED credits
- Streamline the commissioning process so that it is more efficient and easier to complete
- Owners who decide to do more credits will drive the cost of LEED down. If only a few are done then usually the cost will be more.

Have your or your company received training on how to build LEED rated buildings? If yes, what additional training was required?

A variety of answers were given to this question. Some companies have received in-house training conducted multiple times over a yearly span. Other companies are just in the process of employees studying the USGBC LEED accreditation. On the subcontracting level, most companies replied that they had not received training and it was not important for them to. One subcontractor has implemented awareness seminars in an effort to make their employees more knowledgeable of the process.

Beyond the LEED accreditation some contractors have taken the Green Building Advantage Exam. This exam is specific to contractors, subcontractors, and specialty contractors.

Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

Less call back issues are typical of a LEED project.

How is your productivity during construction impacted on Leed Projects?

Most people responded that their productivity has actually increased on projects. This has been due to less material waste being on-site from the recycling methods. This in turn has lead to specialty contractors being able to work more efficiently.

On LEED projects, typically materials and equipment are sourced from a large multitude of suppliers. This has lead to problems with materials showing up on time in conjunction with other materials. This causes subcontractors to wait to start an activity and leads to wasted valuable schedule time.

Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

Most companies have initiated some green initiatives to incorporate LEED goals. Examples of this include car pools, skiing to work, walking to work, reducing the amount of paper use, turning off electrical equipment such as computers when they are not being used, and attempting to implement LEED ideas to non-LEED rated projects.

Comparison to Health Services

Health and Counseling Services was designed for a LEED certification from the beginning of the project. Since the decision to build a LEED certified structure was done at the beginning, very little cost and schedule impacts have occurred. At this time, the only two credits have shown any cost impact. EA credit 5, measurement and verification, has a cost impact of approximately $20,000. It is currently being bid as an add alternate to the construction documents. The estimated price is based on the SALA architecture building that was recently constructed and is similar in size. The other credit that has a cost impact is EQ credit 3.2, construction IAQ management before occupancy, and it will cost roughly $15,000.

Comparing Health and Counseling Services to the industry's opinions of cost and schedule impacts shows how a proper plan can offset any misconceptions of LEED. The water efficiency credits that Health Services is applying for show no potential cost impact and since the building was designed for this purpose this was to be expected.

MR Credits 2.1 and 2.2, Construction waste management 50 and 75% diverted from landfill, have caused no problems for Whiting-Turner at this point. The extra amounts of dumpsters were bought into the general conditions for the project. In the state college area, multiple LEED projects have been completed at this point with these credits and the local recycling plants are easily capable of handling the drywall gypsum board as well as most other materials.

MR Credit 3, materials reuse, causes no problems for Health and Counseling Services because it is a new base building project and not a major renovation. The PSU LEED Policy suggests that minimal effort should be put towards achieving this credit. They document cites that the potential benefit may not justify the level of effort.

MR Credit 6, rapidly renewable materials, is a credit that Health Services is unlikely to achieve. At this time, PSU does not construct building types that would allow the use of most of these materials.

MR Credit 7, certified wood, is a possible credit for Health Services. The university has mandated this a required credit. They believe that the types of buildings they construct can easily incorporate this credit. It is being bid as an add alternate to the construction documents. This credit will most likely come with an increased cost.

EA Credits 1.1-1.10 optimize energy performance; have been incorporated into the design. The university strives for a minimum 30% energy savings in new buildings and Health Services is currently modeled to have a 32% energy savings. In the future, PSU will strive to heighten its level of commitment to energy savings on new construction.

EQ Credits 4.1-4.3, use of low emitting materials, is mandatory for all new university buildings. This is done for the health and well being of the buildings occupants. Health Services will apply all three at no additional cost.

EQ Credit 4.4, low emitting materials composite woods and agrifiber products, is also a credit PSU makes mandatory. Currently, this credit is listed as possible on Health

Services. They are attempting to find a manufacturer that can make a similar or the same door as the design that will meet this requirement. There will most likely be a cost impact with this if a change is made.

Recommendations

The decision to build a LEED certified building should be decided on before the design has started. Almost all of the problems that cause increases in cost and/or schedule are related to the fact that LEED was not made a priority from the beginning. If the decision is made to obtain a LEED certification during the design phase, many areas that cause price increases can still be headed off. If the decision is made during construction, cost increases and schedule delays will most likely happen. The learning curve associated with implementing LEED during construction will cause many delays. Installed work may have to be removed to obtain a certification. Every effort should be made to incorporate LEED into the design and budget from the conceptual stage of project development.

LEED training is essential to a project running smoothly. Multiple in-house personnel should be trained through a USBGC, United State Green Building Council, course or through a similar program. Once construction has begun, sub-contractors should go through a training program set into place by a construction manager or general contractor. Included in this program should be specifics on what documentation is required and what level of tracking is needed to gain credits.

In-house data of cost and schedule impacts of each credit would benefit a project. General contractors and construction managers would benefit the most from this approach. Document how much each point costs to obtain for each level of LEED certification. More accurate overhead costs would help to keep the cost of a LEED project down. Architects and engineers would more easily realize the cost impact of a system implemented from a LEED credit.

The commissioning agent should be hired at the same time as the design professionals. Advice given from the Cx agent should be evaluated thoroughly. The Cx agent should address the issues laid out in the previous section’s commissioning research.

A lessons learned document should be created for each project. This document should address anything that was good or bad about the LEED process. An effort should be made to determine the causes for everything that went well and went wrong. These results should be compiled and given to the employees of the company that directly work with LEED projects so that they may gain an insight into how to make their next LEED project keep costs down while keeping the project running smoothly.

The general contractor or construction manager should question any premiums they are paying for LEED certified products. Often these products are marked up only because they are typically used on LEED projects. Given time the prices will drop, but every effort should be made to verify prices and if needed find different suppliers.

Schedule delays are not typical of a LEED project unless LEED was brought into the construction plan after design or if improper scheduling was done. Special consideration must be given to special equipment so that their lead time does not adversely affect when a section of the project can begin. Commissioning issues such as building flush out must be coordinated properly so that the building is not occupied during that phase.

The most effective means to reduce costs on LEED projects is to mandate it at state or national level. ADA was implemented at a national level over 15 years ago. While this was difficult at first, the construction industry adapted and now there are no second thoughts about how to meet ADA requirements. If LEED or a similar green construction program was mandated slowly the market would change allowing for the price of many materials to come down. Contractors would become used to the idea of LEED and how to install the new materials and systems. Documentation of credits would become easier as the learning curve disappeared from the initial few projects.

Summary and Conclusions

The addition of a standby generator system that can supply power to the entire building in lieu of the campus's typical standby power supply was found to not be a feasible alternative. The cost increase of the addition as well as the overall disruptive aesthetic of having the generator outside of the building do not warrant the change.

Penn State's problematic commissioning process can be solved through a better understanding of the process and a stronger commitment to commissioning. The areas identified in this paper should be reviewed and the proposed solutions implemented. When the next edition of the PSU commissioning process is updated, attention should be paid to the items listed herein to determine if they have been covered within the document.

The addition of UVGI devices shows a fairly high initial cost, but the overall benefit over the life cycle of the building should warrant the change. At this time, UVGI devices are fairly new in their use in the United States. Once the life cycle benefits are better known through the implementation in other buildings, they will become more prevalent in the United States.

LEED projects often show price and schedule increases due to ignorance of the process and construction practices. The areas identified in the LEED Cost and Schedule section can greatly reduce the impact of LEED if done properly and planned appropriately. Typically, most consequences of LEED are seen through poor training of the process and an owner deciding to pursue LEED certification late in the design or during the construction phases.

Acknowledgements

I would like to thank the following people for their help with my research. Without the assistance of everyone listed here I would not have been able to finish thesis and finally graduate from the Architectural Engineering program. (Names are listed alphabetically.)

- **John Bechtel- The Pennsylvania State University, Assistant Vice President of Operations**
- **Mike Coyle- Bognet Construction Associates, Project Manager**
- **John Elder- Aramark**
- **Phil Engers- Facility Dynamics**
- **Tom Ertsgard- The Pennsylvania State University, Commissioning Services**
- **Jim Freihaut- The Pennsylvania State University, Mechanical Faculty**
- **Stephen Halsted- Sebesta Bloomburg**
- **Terry Hansel- The Pennsylvania State University, Project Coordinator**
- **Dick Harris- The Pennsylvania State University, University Electrical Engineer**
- **Wouter Hofmeijer- Blygold America**
- **Michael Horman- The Pennsylvania State University, Construction Management Faculty**
- **Bob Muhollen- The Pennsylvania State University, Commissioning Services**
- **Ian Solada- The Pennsylvania State University, Engineering Services**
- **Chad Spackman- The Pennsylvania State University, Project Manager of Health and Counseling Services**

References

NFPA Codes and Standards Volume 5 (2001).

Green Building Rating System for New Construction and Major Renovations Version 2.2 (October 2005).

Home page. Virobuster Technologies. 20 Feb 2007.
<http://www.virobuster.com>

Home page. Office of Physical Plant. 1 Mar 2007.
<http://www.opp.psu.edu>

Home page. United States Green Building Council. 1 Mar 2007.
<http://www.usgbc.org>

Home page. Kohler Global Power Group. 20 Feb 2007.
< http://www.kohler.com/hub/powersystem.html>

PSU LEED Policy (2007) The Pennsylvania State University (Please contact Mr. Dave Zehngut at PSU's Office of Physical Plant for a copy of this document)

Costworks. CD-ROM. Ver. 8.0 R.S. Means, 1996

Harris, Richard. Personal Interview. 12 Feb 2007

Elder, John. Personal Interview. 16 Feb 2007

Ertsgard, Tom. Personal Interview. 2 Mar 2007

Bechtel, John. Personal Interview. 9 Mar 2007

Solada, Ian. Personal Interview. 9 Mar 2007

Muhollen, Bob. Personal Interview. 9 Mar 2007

Zehngut, Dave. Personal Interview. 13 Feb 2007

Engers, Phil. Phone Interview. 20 Mar 2007

Halsted, Stephen. Phone Interview. 23 Mar 2007

Appendix A

Emergency Generator Equipment Sizing

Emergency Generator CAD Drawings

Emergency Generator Equipment Sizing

Building Power Requirements		
Level		Watts
First Floor:		80,360
Second Floor:		44,856
Third Floor:		52,550
Fourth Floor:		86,807
Fifth Floor:		34,305
	Total:	298,878

Automatic Transfer Switch			
Brand	Model	Amperage	Cost
Kohler	MPAC1000	1200	$11,500.00
Note: ATS required to be same size as main circuit breaker			

Emergency Generator Sizing		
Building Power:		300,000
Over sizing (30%)		90,000
	Total	390,000
Brand	Model	Wattage
Kohler	400REOZDD	400 KW

Paralleling Switchgear			
Brand	Model	Amperage	Cost
Kohler	PD-100C	1200	
Note: Dual Breaker; Sized the same as main switchgear			

Optional Accessories
Sub base tank
Sound Enclosure
Weather Enclosure
Block Heater
Fuel Pressure Gauge
Battery
Battery Heater

Electrical Installation			
Days	$/Elec	# of Elec	Total Cost
30	$47.40	6	$68,256.00

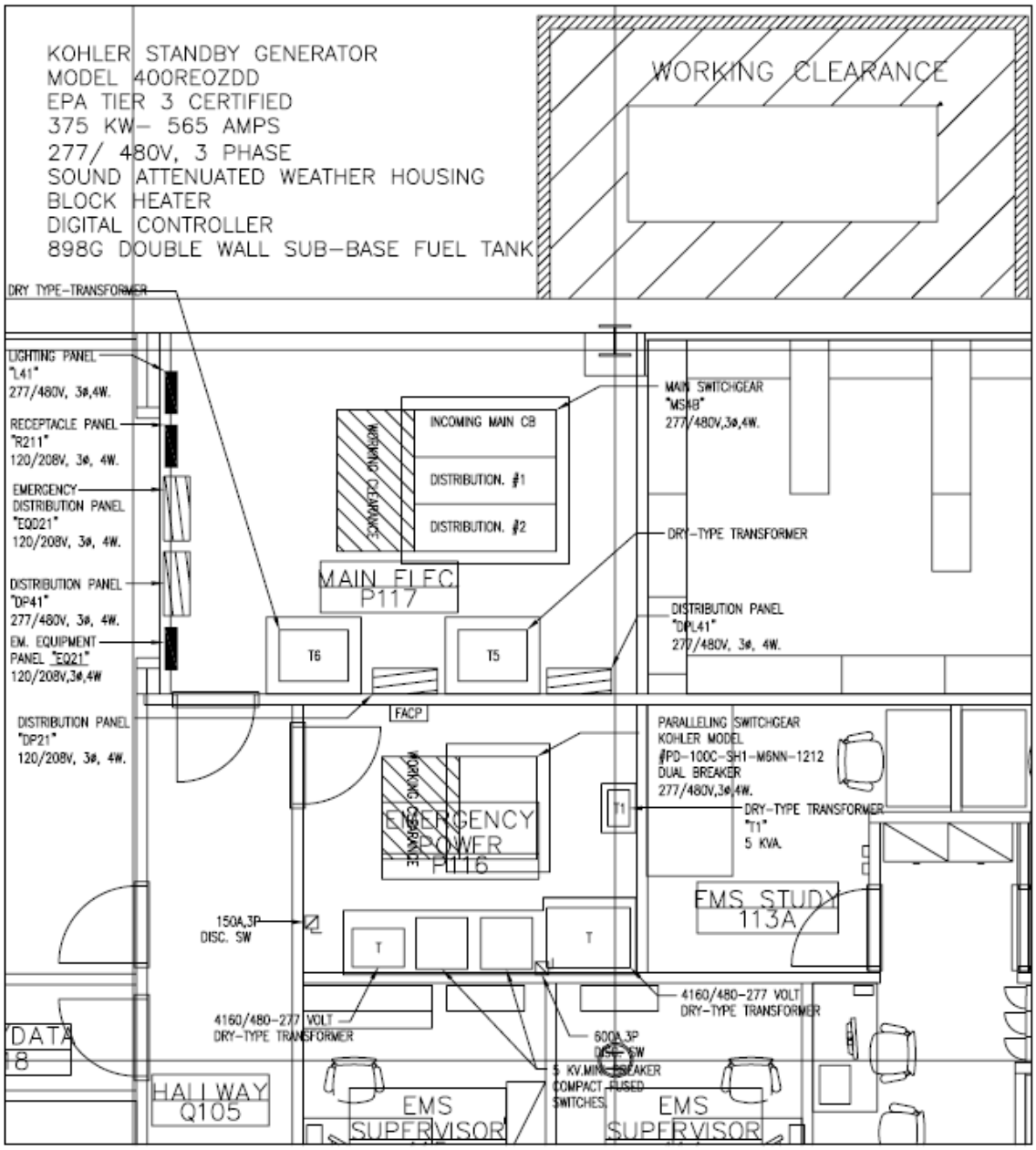
Brick Enclosure					
Description			S.F.	Cost/S.F.	Total
Standard Brick w/4" Masonry Backup			335	$26.20	$8,777.00
Note: Estimate made from R.S. Means Costworks 2005; Total includes material and labor					

Exhaust Piping			
Description	L.F.	Cost/L.F.	Total
5" Stainless Steel	80	$81.00	$6,480.00
Note: Estimate made from R.S. Means Costworks 2005; Total includes material and labor			

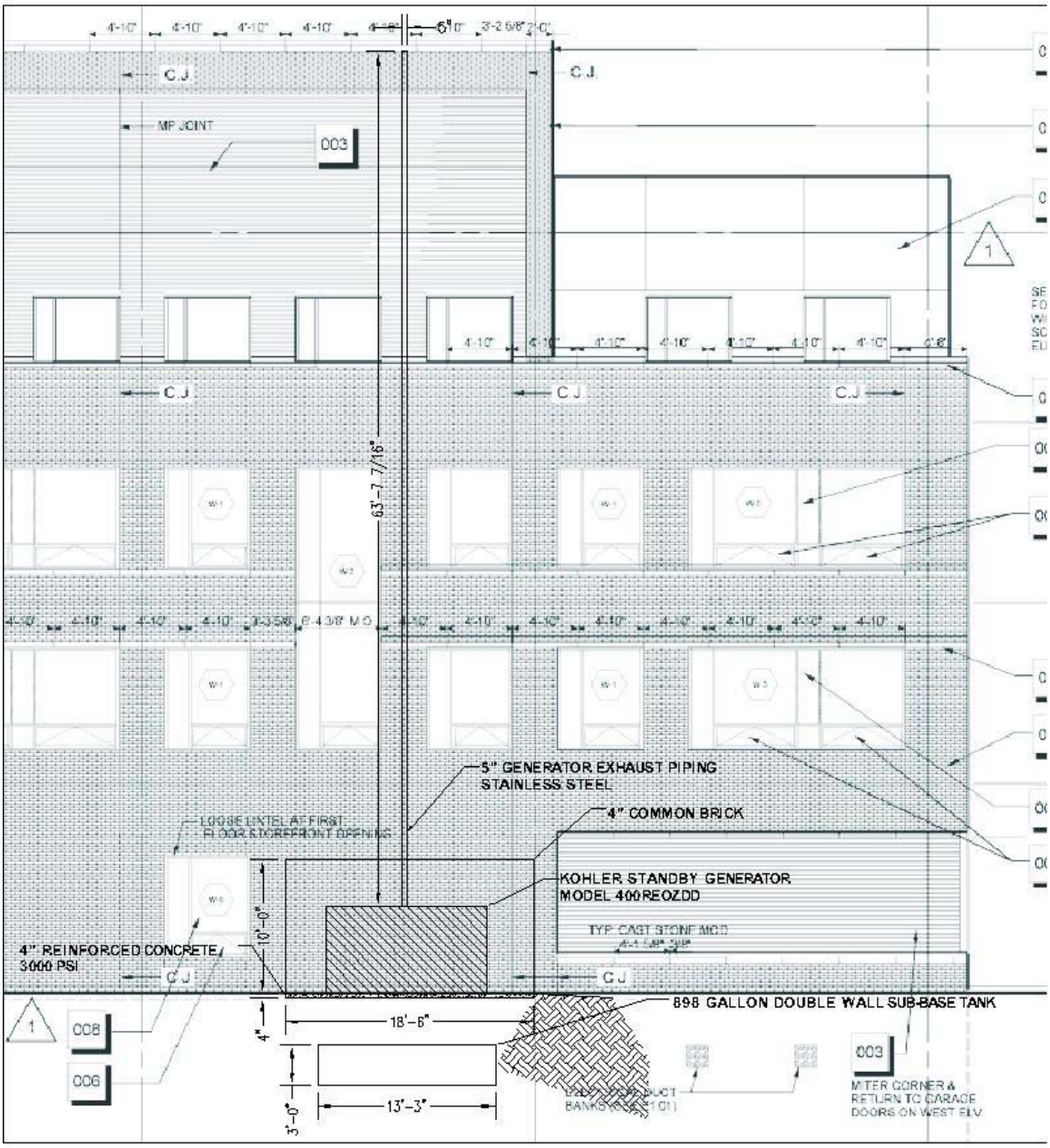
Concrete Pad (Inside Brick Enclosure)			
Description	S.F.	Cost/S.F.	Total
4" S.O.G. Light Industrial Reinforced	194.25	$4.80	$932.40

Note: Estimate made from R.S. Means Costworks 2005; Total includes material and labor

Total Cost Of Design Change:	**$218,095.40**



PART PLAN – MAIN NORMAL AND EMERGENCY ELECTRICAL ROOMS



PART NORTH ELEVATION – STANDBY GENERATOR LOCATION

Appendix B

UVGI Calculations

PSU Cx Document

UVGI Calculations

Name	Room #	Sq Ft	Sq Meter	Virobuster Capacity (M^3)	Required # Steritubes	Monthly Energy Cost(Euro)	Monthly Energy Cost	Annual Cost (Euro)	Annual Cost	Initial Cost	Total Cost/Rm
1st Floor											
Treatment	102	416	38.61	235	1	2	$2.63	452	$593.88	$2,495	$2,495
	102A	108	10.03	61	1	1	$1.31	117	$153.73	$2,495	$2,495
	102B	108	10.03	61	1	1	$1.31	117	$153.73	$2,495	$2,495
Autoclave	107A	154	14.31	87	1	1	$1.31	167	$219.42	$2,495	$2,495
Staff Lounge	124	720	66.89	407	1	4	$5.26	783	$1,028.78	$2,495	$2,495
2nd Floor											
Reception	203	264	24.53	224	1	2	$2.63	431	$566.29	$2,495	$2,495
Pharmacy Storage	202F	480	44.59	271	1	3	$3.94	522	$685.86	$2,495	$2,495
Pharmacy	202B	70	6.5	40	0	0	$0.00	0	$0.00	$2,495	$0
	202C	550	51.1	311	1	3	$3.94	598	$785.71	$2,495	$2,495
	202D	90	8.36	51	0	0	$0.00	0	$0.00	$2,495	$0
Pharmacy Waiting	202A	392	36.4	221	1	2	$2.63	426	$559.72	$2,495	$2,495
Office	201B	130	12.07	73	0	0	$0.00	0	$0.00	$2,495	$0
	201C	72	6.69	41	0	0	$0.00	0	$0.00	$2,495	$0
	201D	130	12.07	73	0	0	$0.00	0	$0.00	$2,495	$0
	201E	72	6.69	41	0	0	$0.00	0	$0.00	$2,495	$0
	201F	80	7.43	45	0	0	$0.00	0	$0.00	$2,495	$0
	201G	90	8.36	51	0	0	$0.00	0	$0.00	$2,495	$0
	201H	130	12.07	73	0	0	$0.00	0	$0.00	$2,495	$0
	201J	130	12.07	73	0	0	$0.00	0	$0.00	$2,495	$0
	201K	130	12.07	73	0	0	$0.00	0	$0.00	$2,495	$0
Hallway	Q201	275	25.53	156	1	2	$2.63	299	$392.86	$2,495	$2,495
	Q202	113	10.49	64	0	0	$0.00	0	$0.00	$2,495	$0
	Q203	288	26.74	163	1	2	$2.63	313	$411.25	$2,495	$2,495
	Q204	120	12.26	75	0	0	$0.00	0	$0.00	$2,495	$0
	Q205	132	11.14	68	0	0	$0.00	0	$0.00	$2,495	$0
3rd Floor											
Exam	315	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	316	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	317	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	324	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	325	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	333	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	334	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	336	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495

	338	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	339	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	341	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	342	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	347	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	348	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	352	90	8.36	152	1	2	$2.63	294	$386.29	$2,495	$2,495
	353	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	354	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	360	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	361	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	363	99	9.19	168	1	2	$2.63	323	$424.39	$2,495	$2,495
	367	104	9.66	176	1	2	$2.63	339	$445.41	$2,495	$2,495
	368	117	10.86	198	1	2	$2.63	381	$500.60	$2,495	$2,495
	369	117	10.86	198	1	2	$2.63	381	$500.60	$2,495	$2,495
Patient Toilet	322						$0.00		$0.00	$2,495	$0
	326A	66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
	335	48	4.46	54	0	0	$0.00	0	$0.00	$2,495	$0
	349	54	5.01	61	0	0	$0.00	0	$0.00	$2,495	$0
	362	66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
		66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
Procedure	350	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
Immunization	351	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
Observation	323	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
	340	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
Ultrasound Exam	327	132	12.26	149	1	2	$2.63	287	$377.09	$2,495	$2,495
Colposcopy Proc	326	121	11.23	137	1	1	$1.31	263	$345.56	$2,495	$2,495
Specimen Procc.	321	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
S/I-B/O Waiting	302A	160	14.86	181	1	2	$2.63	348	$457.24	$2,495	$2,495
Student Ins.	302	187	17.36	211	1	2	$2.63	406	$533.44	$2,495	$2,495
Hallway	Q301	385	35.75	435	1	5	$6.57	837	$1,099.73	$2,495	$2,495
.	Q302	942	84.47	1027	3	11	$14.45	1977	$2,597.58	$2,495	$7,485
	Q303	150	13.93	169	1	2	$2.63	326	$428.33	$2,495	$2,495
	Q304	276	25.63	312	1	3	$3.94	600	$788.34	$2,495	$2,495
	Q305	276	25.63	312	1	3	$3.94	600	$788.34	$2,495	$2,495
	Q306	276	25.63	312	1	3	$3.94	600	$788.34	$2,495	$2,495
	Q307	276	25.63	312	1	3	$3.94	600	$788.34	$2,495	$2,495
Waiting	301A	462	42.9	522	2	5	$6.57	1004	$1,319.16	$2,495	$4,990
	370	756	70.19	854	3	9	$11.83	1643	$2,158.74	$2,495	$7,485
Lobby	F301	324	30.08	366	1	4	$5.26	704	$924.99	$2,495	$2,495

4th Floor

Exam	413	90	8.36	102	1	1	$1.31	196	$257.52	$2,495	$2,495
	414	90	8.36	102	1	1	$1.31	196	$257.52	$2,495	$2,495
	415	90	8.36	102	1	1	$1.31	196	$257.52	$2,495	$2,495

	416	90	8.36	102	1	1	$1.31	196	$257.52	$2,495	$2,495
	417	90	8.36	102	1	1	$1.31	196	$257.52	$2,495	$2,495
	418	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	419	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	420	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	431	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	432	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	433	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
	434	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
	441	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	442	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	443	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	444	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	445	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	453	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	454	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	456	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	457	99	9.19	112	1	1	$1.31	215	$282.49	$2,495	$2,495
	461	104	9.66	117	1	1	$1.31	226	$296.94	$2,495	$2,495
	462	104	9.66	117	1	1	$1.31	226	$296.94	$2,495	$2,495
	463	104	9.66	117	1	1	$1.31	226	$296.94	$2,495	$2,495
Procedure	424	132	12.26	149	1	2	$2.63	287	$377.09	$2,495	$2,495
	447	121	11.23	137	1	1	$1.31	263	$345.56	$2,495	$2,495
Alter. Med.	448	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
Paitent Toilet	421	66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
	435	66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
	446	66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
	455	66	6.13	75	0	0	$0.00	0	$0.00	$2,495	$0
Observation	436	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
Changing	404A	42	3.9	47	0	0	$0.00	0	$0.00	$2,495	$0
X-Ray	404	228	21.17	257	1	3	$3.94	496	$651.69	$2,495	$2,495
Waiting	401A	564	52.37	632	2	7	$9.20	1226	$1,610.84	$2,495	$4,990
	402A	170	15.78	192	1	2	$2.63	369	$484.83	$2,495	$2,495
	405	88	8.17	99	1	1	$1.31	191	$250.95	$2,495	$2,495
Phlebotomy	408	110	10.21	124	1	1	$1.31	239	$314.02	$2,495	$2,495
Conference	402	289	26.83	326	1	3	$3.94	628	$825.13	$2,495	$2,495
Lobby F401	138	12.81		156	1	2	$2.63	300	$394.17	$2,495	$2,495
Hallway	Q401	220	20.43	248	1	3	$3.94	478	$628.04	$2,495	$2,495
	Q402	822	76.32	928	3	10	$13.14	1787	$2,347.94	$2,495	$7,485
	Q403	235	21.82	265	1	3	$3.94	511	$671.40	$2,495	$2,495
	Q404	235	21.82	265	1	3	$3.94	511	$671.40	$2,495	$2,495
	Q405	235	21.82	265	1	3	$3.94	511	$671.40	$2,495	$2,495
	Q406	235	21.82	265	1	3	$3.94	511	$671.40	$2,495	$2,495
	Q407	456	42.34	515	2	5	$6.57	991	$1,302.07	$2,495	$4,990
Clinical Lab	407	731	67.87	825	3	9	$11.83	1589	$2,087.79	$2,495	$7,485

5th Floor

Group Therapy	512	144	13.37	163	1	2	$2.63	313	$411.25	$2,495	$2,495
	515	144	13.37	163	1	2	$2.63	313	$411.25	$2,495	$2,495
	520	216	20.06	244	1	3	$3.94	470	$617.53	$2,495	$2,495
Conference	540	180	16.71	203	1	2	$2.63	391	$513.73	$2,495	$2,495
Waiting	503	77	7.15	87	1	1	$1.31	167	$219.42	$2,495	$2,495
				TOTALS	112		$296.94		$54,281.15		$279,440

Schedule Impact			
Number of UVGI's	Estimated Man Hours	Total Hours	Total Days
112	3	336	42
Note: Schedule Estimate is using 1 Electrician. With 12 electricians working on the installation the time is significantly reduced to 3.5 Days			

PSU Cx Document
Common Cx Problems & Solutions

A. In-House Specific

a. Start of Cx Process

The Cx agent is often not brought into the project team until late in the design phase and sometimes not until construction begins. This decision is left up to the project leader at Penn State to determine. A decision should be made in the budgeting phase that commissioning is going to be a part of the process. The PSU project leaders need to know the benefits of the Cx process. This will allow the project leader to budget accordingly so that commissioning can be accomplished. The Cx agent should be brought into the team at the same time as the design professional so that their services can be fully utilized during design review. This will head off design problems that cannot be changed easily in the late part of the design phase.

b. Training for Systems

Proper personnel need to be present for the training of each system within the building. A determination must be made of the exact number of personnel that will be attending and how the training should be documented. Documentation could be videotaped if done properly.

c. Building Turnover

Building staff and maintenance personnel are occupying the building fairly early. The warranty of the building and the individual systems within the building are sometimes at question. This is due to building staff and maintenance personnel using the building prior to these systems being completed. If systems are being used during functional testing, settings for systems may be changed by these personnel. When this happens the functional testing results may be flawed and cause the Cx agent and contractors to be on site after occupancy. The proper amount of time for move in needs to be built into every construction schedule to avoid these issues.

d. Process Map and Commissioning Document

The commissioning plan that was made in 2002 was not fully integrated into the construction or renovation of buildings. This led to varying levels of confusion regarding how buildings were supposed to be commissioned and what level of design review was expected of projects. When the revised document is produced and distributed to the project management and engineering services divisions, upper management needs to enforce the document through meetings and appropriate levels of review for compliance.

e. Design Intent Document (D.I.D.)

The D.I.D. that is made for every project is usually lacking in the amount of detail that is required to design a building properly for what the university and the soon to be building occupants require. In turn, this causes multiple issues in the design documents that should not be required. These issues include building control systems and mechanical system sizing among many others. More time needs to be spent making the document building specific. A review of this document needs to be made during each phase of the design to make sure that the design documents and specifications are up to the standards required.

f. In-House Cx Staffing

In-house commissioning of renovation projects has become more common in the past few years. Major renovations and smaller renovation projects require a large level of detail and time to be spent reviewing documents and specifications. The commissioning services division has become overextended with the volume of work handed to their department. As the renovation phase across the University Park campus expands and base building construction comes to an end this problem will most likely grow. A yearly review of the number of personnel required to do this job properly needs to be made. If there are not enough staff to properly do commissioning properly then outsourcing to a 3rd party Cx agent should be done.

g. Cx Contract

Typically, the Cx agent makes a proposal that includes their scope of work and the PSU project leader signs off on this document. Then the Cx agent constructs a commissioning plan for a project. This often leads to confusion over responsibilities in the scope of work between PSU and the Cx agent. PSU should use a contract between the Cx agent and the university. This will help to eliminate confusion and will bind the Cx agent to complete exactly what the university requires. Typically, a contract is not used between an owner and Cx agent. A study of what should be included in this contract should be done in-house to make sure that all items needed are included.

B. 3rd Party and In-House

a. Communication

Contractors often report that systems are completed before they really are finished. The Cx agent then shows up on the site and finds that they are almost done or that it was done wrong to begin with. Contractors often think that commissioning is something that will be forgotten about or just disappears as a project continues. The OPP project leader, construction manager/general contractor, and Cx agent need to make it clear from the beginning of the construction phase that commissioning will be completed

and completed properly. Pre-functional checklists should be completed and signed off on for a system or piece of equipment before the Cx agent is called upon to commission it. The release of payment and/or retainage could be tied to proper completion of functional testing of systems that fall within the scope of a specific contractor. Another method to insure compliance is to add new language to the contract documents.

b. Submittal Review

Sometimes, an item designated for submittal review is sent through all of the proper design review channels and is never found to be incorrect. The submittal is either completely wrong or is the wrong size for the buildings purpose. This can lead to major delays in commissioning and the projects completion if it is a long lead item. More time needs to be spent reviewing submittals and questioning discrepancies during this phase when items and systems can still be altered. This will lead to significant savings in money.

c. Mechanical Designs

Improperly designed mechanical systems have caused major problems with commissioning in the past few years. During design review, the team needs to spend more time reviewing the designs calculations and making sure the design documents are not vague. When vague designs are left up to the mechanical contractor to implement, there will usually be differences between the design professional's intent and what is put into place. Vague designs are anything that does not clearly lay out the intent of how the system or equipment is supposed to be installed.

d. Cx System Testing -Schedule Item

On every project schedule a specific amount of time is usually left for the commissioning agent to finish building system testing. This time is usually after the construction end date. Often specialty contractors are still present in the building at this point doing punch list items and/or finishing items with systems that need to be tested. Enforcement of the construction end date is essential to allowing the Cx agent to remain on schedule and for the project to be completed on time. A greater commitment from the O.P.P. project leader and the construction manager to insure that the construction end date is upheld will allow for a more timely completion of the project and the final commissioning report. A commitment from the construction manger to create a realistic construction schedule is required in order to maintain a functional testing date.

e. Time

Often the amount of time allowed for design and construction on a PSU project is limited due to funding decisions and occupancy dates. When a Cx agent or the rest of the review team does not allow enough time for proper design review, construction may progress with flawed documents.

During construction, scheduling milestones that are not adhered to cause backups in the prefunctional and functional testing of equipment and systems.

f. Construction Schedule Updates

The master construction schedule must incorporate the commissioning schedule into it with the appropriate predecessors and successors required for each item. The master construction schedule should be updated frequently and accurately. The Cx agent should receive each schedule update so they can plan their commissioning testing appropriately.

g. Commissioning Training

Every project should make a significant effort to train the commissioning team properly. The commissioning kick off meeting should lay out every member's roles and responsibilities clearly to alleviate confusion. The more time spent on training contractors, the better they will be at the process on the next project at Penn State.

h. Design Review

Cx agent suggestions made during design review should be clarified on whether they are implemented in the design or if they are not. Reasons for not implementing a suggestion should be explained by the A/E professional. This will help to eliminate confusion and allow the commissioning agent to plan accordingly.

i. Building Control Designs and Sequences

Control systems designs and sequences are often vague and left up to the interpretation of the controls contractor and the commissioning agent. A standard set of requirements for the design and sequence should be given to the A/E professional so that their can be no confusion and so that the installation is done correctly.

Appendix C

LEED Survey Contacts

LEED Questionnaires

LEED SURVEY CONTACTS

CONSTRUCTION MANAGERS

Type	Name	Company	Phone #	email	Sent	Returned
CM	Jennifer Macks	Barton Malow	(248) 436-5744	Jennifer.Macks@BartonMalow.com	Yes	Yes
CM	Teresa Miller	Barton Malow	734-998-0855	Teresa.Miller@BartonMalow.Com	Yes	Yes
CM	Jim Fenstemach.	Whiting Turner		Jim.Fenstermacher@Whiting-Turner.com	Yes	Yes

GENERAL CONTRACTORS

Type	Name	Company	Phone #	email	Sent	Returned
GC	Kimberly Pexton	Hitt	703.846.9000	kpexton@hitt-gc.com	Yes	Yes
GC	Mike Coyle	Bognet	202.369.0212	mcoyle@bognetconstruction.com	Yes	Yes

SPECIALTY CONTRACTORS

Type	Name	Company	Phone #	email	Sent	Returned
Sub	Michael Deer	Truland	N/A	MDeer@truland.com	Yes	Yes
Sub	Brad Bolino	JJ Kirlin	240.882.7758	bbolino@jjkllc.com	Yes	Yes
Sub	Mr. Shapiro	Shapiro & Duncan	301-315-6260	jshapiro@shapiroandduncan.com	Yes	Yes

CONSULTANTS

Type	Name	Company	Phone #	email	Sent	Returned
Consultant	Michael Pulaski	Foreman Sol.	207.347.5066	mike@fore-solutions.com	Yes	Yes
Consultant	**John Elder**	**Aramark Cx**	814.404.7546	elder-john@aramark.com	**Yes**	**No**

ARCHIITECTS

Type	Name	Company	Phone #	email	Sent	Returned
Architect	Kevin Sneed	OTJ Arch	202-238-4064	sneed@otj.com	Yes	No
Architect	**Greg Kirley**	**Inscape Studio**	202-416-0334		**Yes**	**No**
Architect	**J. Theodore**	**Hillier**		JTheodore@hillier.com,	**Yes**	**No**

LEED Questionnaire

LEED Construction Survey

Name: Jennifer Macks, PE, LEED AP

Company: Barton Malow Company

Job Title: Project Director

Years of Experience: 13

1. How many LEED or green buildings have you or your company been involved with?

I have been involved with 1. Our company has been involved with 4.

2. Is there a cost increase associated with LEED rated projects?

It depends on what your starting point is. There is an additional cost for the actual registration and compiling process. The actual building cost can be more, but may be less if you take into consideration life cycle costing.

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects?

See #2. There are expenses associated with the development of the energy model for the energy requirements. Also, some of the materials are more expensive such as non-PVC and VOC free paints

4. Of the additional Cost how much are hard costs and how much are soft costs?

I don't know how to split up for an exact comparison

5. What are the long term and the short term cost to your firm to build a LEED Project?

Short term cost – additional engineering time for administration of paperwork;

Long term cost – paying for training and registration for employees to become LEED Accredited

6. Is there a schedule increase associated with LEED rated projects?

Not if the decision is made from day 1. If it is decided mid-process, it can be disruptive and cause decisions to be re-thought

7. If yes, what are the most common causes?

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?

Yes – there are many more options available

9. If yes, how has this affected the cost and schedule on LEED projects?

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

12. What LEED credits do you or your company find the most difficult and expensive to comply with?

Water efficiency in health care projects

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

Absolutely

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

Transferring more knowledge of the process to employees. There is an extreme learning curve for those who haven't worked on these type of projects before which causes escalation in costs

15. Have your or your company received training on how to build LEED rated buildings?

No

16. If yes, what additional training was required?

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

18. How is your productivity during construction impacted on Leed Projects?

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

No

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: **Kimberly A. Pexton**

Company: **HITT Contracting, Inc.**

Job Title: **Director, Sustainable Construction**

Years of Experience: 12

1. How many LEED or green buildings have you or your company been involved with?

   HITT has been involved with 15 LEED projects in the last year and a half. I personally have been involved with 30+ LEED projects in the last 6 years.

2. Is there a cost increase associated with LEED rated projects?

   This is a question that is loaded. There are many different factors that shape the cost of a project and, yes, LEED requirements end up as a factor.

3. If yes, why and what is the % Cost increase associated with LEED Certified

   Projects?

   Depends on the certification level that is being pursued and the type of project. Approximations would be as follows (based on my experience):

   Certified/Silver – 0% to 3%
   Gold – 4% to 8%
   Platinum – 10%+

4. Of the additional Cost how much are hard costs and how much are soft costs?

   Above figures are for first cost of construction only. I am not familiar with the design side/soft cost percentages.

5. What are the long term and the short term cost to your firm to build a LEED Project?

   No out of pocket costs to a general contractor. Long term intangibles would be increased opportunity for added "green" work.

6. Is there a schedule increase associated with LEED rated projects?

   Not on the construction end, unless commissioning completion is tied to the occupancy of the building.

7. If yes, what are the most common causes?

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?

   For the most part construction means and methods (pouring concrete, setting steel, etc.) are the same. If a project is utilizing renewable energy and/or on site waste water treatment, than there is definitely an "increase" in the number of systems.

9. If yes, how has this affected the cost and schedule on LEED projects?

   Obviously, the more "systems" the higher the costs; more stuff. Construction schedule wise, there is just that much more coordination of trades to do in the same amount of slated construction time.

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

    Post fire treated wood substrates pose problems for the millwork trade. On-site waste water treatment has a few issues: 1) there are not many, if any, that can do a commercial installation turnkey, 2) plumbing and electrical work associated with the system need to be performed by a tradesman licensed in your state/area, 3) troubleshooting problems with the system is difficult due to lack of experience with the installation. Commissioning can be a big challenge if all parties are not

in agreement of what is contract document work and "desired/intended" operations. All issues which will shake out over time.

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

    Lack of experience or knowledge of green building or LEED.

12. What LEED credits do you or your company find the most difficult and expensive to comply with?

    Rapidly renewable materials and certified wood represent straight adds to the project making them very expensive for no return on investment. The most difficult is tracking adhesives, sealants, and paints, other low-emitting materials on the ob site.

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

    I am sure it would be helpful to a lot of companies. We do have our own in-house data.

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

    Mandate it. That will change the baseline/conventional construction definition that everyone wants to compare their LEED premiums.

15. Have your or your company received training on how to build LEED rated buildings?

    In house training is conducted on a quarterly basis.

16. If yes, what additional training was required?

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

    Less

18. How is your productivity during construction impacted on Leed Projects?

    In isolated incidents productivity has gone up.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

    Yes, HITT has begun to implement certain Green Initiatives.

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: Michael Deer

Company: Truland Systems

Job Title: Project Manager

Years of Experience: 5

1. How many LEED or green buildings have you or your company been involved with? Two, personally. One data center, one office building core and shell.

2. Is there a cost increase associated with LEED rated projects? Yes. Typically, material is purchased through select vendors, and their prices tend to not be the lowest.

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects? Percent extra is usually between 0% and 15%. Why is above.

4. Of the additional Cost how much are hard costs and how much are soft costs? I do not know, but would assume that the hard costs are minor, and the increase is mostly soft costs associated with dealing with a particular vendor and manufacturer. Basically, a premium to deal with certain supplies that others do not represent (sell), or cannot represent.

5. What are the long term and the short term cost to your firm to build a LEED Project? If the job is bid as a LEED project, then no impact is felt at the

subcontracting level, because price quotations are issued based on the requirements.

6. Is there a schedule increase associated with LEED rated projects?

   Again, typically, the material is of a longer lead time nature. This is not full proof, but most cases there is an addition of around 25% to the lead times of the material manufacturing.

7. If yes, what are the most common causes?

   See #6.

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?

   Not really. The amount of LEED jobs is not sufficient enough at this time to increase the demand that would facilitate additional sources.

9. If yes, how has this affected the cost and schedule on LEED projects?

   See above answers.

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

    On the electrical portion of work, the material typically has more control components to it. This "low voltage" side of the business is typically not a large chunk of a building contract. LEED requirements change this need on a job.

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

    Current market state affects schedules do to manpower needs more so than material, in my opinion. Supply and Demand, really.

12. What LEED credits do you or your company find the most difficult and expensive to comply with?

    Since we only deal with electrical work, the backup power systems (Generators and UPS systems) tend to be on the higher side when adding specialty exhaust systems (Urea systems) to generators. These can be very high cost, along with the added install costs too for such a system.

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

    Not on the subcontracting level. We bid these items out, and as long as the manufacturers follow the specification requirements, their components are priced to us as LEED approved.

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

    I would not change the system, personally. There has to be a cost associated with getting these accreditations and the individual credits themselves. The costs associated will come down in time like any other technology when the demand increases, and more options are present.

15. Have your or your company received training on how to build LEED rated buildings?

    No. Again, on the subcontracting level, this is not imperative.

16. If yes, what additional training was required?

    N/A

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

    I have not noticed any difference in warranty and call back.

18. How is your productivity during construction impacted on Leed Projects?

    The biggest problem on the productivity standpoint is if the material does not come in like it would on a normal material job. When you are waiting on one thing from supplier A, but have the rest from supplier B, due to either a longer lead-time, etc, then you find yourself wasting valuable schedule time on

something that could have already been started had it all been from a single source.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

    This one is new to me, and have never dealt with these types of things, so I cannot comment here.

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: Teresa Miller

Company: Barton Malow Co.

Job Title: Project Manager (of Health Facilities building types)

Years of Experience: 10

1. How many LEED or green buildings have you or your company been involved with?
    a. Me: 0 completed; currently kicking off and bidding a project that will be LEED Certified
    b. Co.: only a handful – 2 or 3 maybe. I can verify

2. Is there a cost increase associated with LEED rated projects?
    My perception and feeling is yes. I do not personally have any data to support this. Though any extra costs could be mostly mitigated if LEED requirements are incorporated and designed for from the onset of the project. But, per the typical LEED argument, it is assumed most of these costs will be off-set with lower maintenance and operating costs.

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects?
    c. much of the cost is borne and absorbed on the design side with specification and research into LEED methods
    d. as a construction manager there is an additional cost associated with debris removal (if it is sorted on the site, this takes longer, thus more man hours; if it is sorted at a facility, we are paying a premium to hire the contractor to sort our trash)
    e. There is additional staffing time associated with the documentation to substantiate the LEED Certification: to verify all recycling content is documented, to track the dumpster weight/volume tickets, for additional commissioning time (even though some projects already will have a commissioning program, the LEED required program could be excessive), to document (photograph) temporary filters, etc.
    f. There is the cost to the subcontractor for installations that are not typical but may be specified to achieve LEED: installing non-typical MEP equipment, installing / maintaining a green roof, installing temporary HEPA filters on return ductwork, etc.
    g. All of these costs are extremely hard to quantify, and since our company has not been prolific in completing LEED projects, we do not have the data to officially back up any additional costs. However, we have increased our project budget by 2.5% (of direct project costs) to cover LEED costs.

4. Of the additional Cost how much are hard costs and how much are soft costs?
   Based on the notes above, the majority and biggest costs are soft (staffing time)

5. What are the long term and the short term cost to your firm to build a LEED Project?
   Being a CM and not involved with maintenance of a building, our costs are essentially reimbursable, therefore short term. This sounds more like a question for a user / owner perspective. We do bear a cost to have employees take the LEED exam (a relatively small cost) since we believe it is necessary to have LEED AP people work on LEED Certified projects.

6. Is there a schedule increase associated with LEED rated projects?
   If the project is designed and built always having been a LEED project, then there should not be a significant schedule difference than other similar project types. If the owner decides to pursue LEED after the design is complete and/or after construction has begun, then, yes, there will be a schedule impact to switch gears (for the learning curve, procurement, and tear out of installed work, etc.).

7. If yes, what are the most common causes?
   See above

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?
   Yes.

9. If yes, how has this affected the cost and schedule on LEED projects?
   Not significantly. LEED rated finish products (carpets, wall covering, etc.) tends to be more expensive, however, these are products that are of the lowest relative cost to a project. Since mechanical and electrical systems, structural and exterior wall elements tend to be the largest costs, these all are affected by LEED, but not drastically.
   I also do not believe these will have a significant impact on the schedule. An exterior wall takes just as long to procure and install if the glass is more or less transmitting.

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?
    Again, a LEED building goes together the same way as any other building – just because you are using recycled cork flooring doesn't make the installation

any different than a non-LEED compliant flooring material. The methods of construction do not change.
From a construction perspective, the things that affect us are the additional paperwork and sorting / recycling of trash.

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?
    Products marketed for LEED compliance do cost more because they are a marketed as such.

12. What LEED credits do you or your company find the most difficult and expensive to comply with?
    h. Recycling / diverting from landfills of drywall gypsum materials are problematic.
    i. Training our subcontractors to comply with the documentation (pre/post-consumer content %s, etc.) to support the LEED process is difficult.
    j. I'm sure there are many more challenging aspects from an A/E designer and owner perspective.

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?
    Yes.

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?
    My work is for and of hospitals. I know the USGBC is supposed to be developing a guideline for healthcare – this is essential. There is a Green Guide for Healthcare, which is a good start, but this does not count toward gaining a Certification for a healthcare facility. Most of the typical LEED credits are contradictory to healthcare needs and codes, therefore many of the credits, specifically the energy credits, are unattainable for clinical space. It is extremely difficult right not to have a healthcare building achieve a silver status or above.
    But, then again, some of the requirements to meet certain LEED credits are already a part of how a healthcare project is executed. For instance, all ductwork is sealed when arriving on the jobsite and all loose ends are always sealed and filtered to keep the system clean.

15. Have your or your company received training on how to build LEED rated buildings?
    Yes, but only through being LEED Accredited.

16. If yes, what additional training was required?
    We do not have any other training programs specific to our company or industry.

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?
    I have not yet completed a LEED project, so cannot answer this.

18. How is your productivity during construction impacted on Leed Projects?
    See comments above on schedule.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.
    It has affected how we procure and bid out work and some of our administrative processes, but has not affected how we physically execute a project.

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: Michael Pulaski

Company: Fore Solutions (Consultants for High Performance Buildings)

Job Title: Project Manager

Years of Experience: 4

1. How many LEED or green buildings have you or your company been involved with?

Me (8)
Company (30+)

2. Is there a cost increase associated with LEED rated projects?

It depends. If it's integrated into the project at the start, then there doesn't have to be, but there are clearly several credits that do simply cost more to achieve than standard construction. It also depends highly on what you are comparing it to. If you use a $/Sf range, for a certified or silver building it will typically fall between the average $/SF cost range for that building type.

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects?

Based on several reports 0-2% for certified and silver projects.

4. Of the additional Cost how much are hard costs and how much are soft costs?

Again it depends on the project size, scale and owner. We typically charge ~30K for LEED consulting services on your standard 50,000Sf office building. 10-15K for energy modeling. I think it would be reasonable to assume that contractors would

expect to 1-2% increase for coordination for the first 1 or 2 LEED projects they do, and then it becomes integrated into their standard operating procedures, and becomes negligible.

5. What are the long term and the short term cost to your firm to build a LEED Project? *Not Applicable. This is our core business.*

6. Is there a schedule increase associated with LEED rated projects?

Absolutely not. Only if you opt for LEED Credit EQ3.2 and have to schedule in down time in the schedule to do a building flush, but there are lots of ways around this. Some extra lead time may be required for some materials.

7. If yes, what are the most common causes?

See response above

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?

Absolutely yes. Green Building involves using new materials and sometimes different construction methods.

9. If yes, how has this affected the cost and schedule on LEED projects?

I believe this is negligible. I have never heard a contractor complain that the installation of a particular green product had a big enough schedule impact to affect cost.

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

No Added Urea Formaldehyde composite wood because there is a zero tolerance rule on it.

Low VOC adhesives and sealants, because contractors will often substitute products from another job at the last minute.

(Note I would not use the term "LEED Construction". I think what you mean to say is what materials etc. are most problematic during construction on LEED projects.)

Sourcing FSC wood can be problematic and challenging

Installation of porous pavement systems can be tricky, as many excavators are not aware of the impact their trucks have on the area under construction and can easily compact the soil too much so that it renders the porous paving system inoperable, although I have personally never installed one.

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

Educating the team. If a project team has never done a LEED project before there is a significant amount of education and training required to get them up to speed on what is required.

12. What LEED credits do you or your company find the most difficult and expensive to comply with?

EQ4.4 No added Urea Formaldehyde. - Difficult, not expensive. Possible 5% premium for these materials.

MR6 Rapidly renewable materials – cost premium typically very high.

MR 3 Resource Reuse. Challenging on large projects, but very achievable on small projects and it often results in lower costs when you can purchase used/ salvaged materials which are readily available in some markets, especially New England.

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

Yes, especially MR6. A good question would be given a typically project budget (office or school), what would be the most cost effective way to achieve this credit. There's a lot of great products out there, but this credit is often no pursued because it's very challenging to purchase 5% of all the products from rapidly renewable sources. Typical products include linoleum, bamboo floors, wheat board or strawboard.

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

Have a look at my thesis. Integrating Sustainability and Constructability: A Continuous Value Enhancement Process. Or any papers that I wrote. This was always the underlying theme. I believe the key is to actively engage project team members who get excited about

this stuff and typically don't get the opportunity to provide new ideas or research new products. Just simply asking those (field level workers and project engineers and manager) how they can make the process better is a great first step. CMs will naturally find ways to make this faster and cheaper, that's their job…. Providing them with some guidance and tools and asking them the right questions you can lead them to finding win – win solutions that improve the green project attributes, achieve a higher LEED Rating and reduce costs all at the same time. It's not easy, but it's possible.

15. Have your or your company received training on how to build LEED rated buildings?

YES. We do the training. On a project there are typically several stages of them, Initial LEED workshop to get everyone on the same page and talking the same language. There is almost always a contractor training workshop and sometimes more specific ones with the subs as required.

16. If yes, what additional training was required?

I recently took the Green Building Advantage Exam, specifically designed for contractors.

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

Contractor specific question. Not applicable to me but good question,.

18. How is your productivity during construction impacted on Leed Projects?

Contractor specific question. Can't answer, but it shouldn't have a big impact, in fact I've heard from some people that it makes you more efficient, especially with respect to construction recycling.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

Good question. I hope that you get some good responses to this one because it gets at the heart of what LEED is trying to do, raise awareness and transform the market place. Working on LEED projects is a continuous reminder for me to try and live a more sustainable life. I choose to live in a place, Portland Maine, where I can walk to work, live in an urban setting with all the amenities around me so I don't have to drive, only have 1 care between my wife and I and just the other day I cross-country skied into work). These are quality of life choices that I have made which are grounded in sustainability principles and exactly the type of thinking LEED is trying to promote and encourage.

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: Michael Coyle

Company: Bognet Construction Associates

Job Title: Senior Project Manager

Years of Experience: 17 years

1. How many LEED or green buildings have you or your company been involved with?

8 projects

2. Is there a cost increase associated with LEED rated projects?

Yes

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects?

It will depend on the degree of certification, but it could range from a 10% to 40% cost increase.

4. Of the additional Cost how much are hard costs and how much are soft costs?

There is about a 10% soft cost increase for the associated paperwork, inspections and equipment start up. The remainder is the hard coast for the equipment materials etc used on the project.

5. What are the long term and the short term cost to your firm to build a LEED Project?

Long term will be the training for our employees and identifying the different business practices associated with a LEED project. The short term are the construction costs, schedule adjustments and the administrative work associated with a LEED project.

6. Is there a schedule increase associated with LEED rated projects?

Yes.

7. If yes, what are the most common causes?

Some materials have a lead time, FSC wood, Recycled materials some come from over seas. The commissioning process. With a LEED project there is a required time frame for off gassing of materials and furniture which occurs at the end of the project and is not associated with a typical project

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?

Yes

9. If yes, how has this affected the cost and schedule on LEED projects?

There have been some improvements with the availability of materials and some manufacturers have been granted LEED certification for their products so it improves the managing of the commissioning process. Some materials have more competitive pricing and continue to improve. Also more materials are becoming more main stream thus reducing the schedule impact.

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

Millwork products, paint products, adhesives,

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

In some cases the lack of understanding or knowledge on a contractor's part will increase the cost. Some material suppliers feel that because it is a LEED product they can charge more. With knowledge and understanding most of these issues can be eliminated.

12. What LEED credits do you or your company find the most difficult and expensive to comply with?

The most expensive are the mechanical equipment and mechanical systems. These points can quickly add another 20% - 30% in cost to the project.

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

Yes

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

Make the decision to use LEED BEFORE the design process starts. Reduce the reporting process and stream line the commissioning process.

15. Have your or your company received training on how to build LEED rated buildings?

We are in the process

16. If yes, what additional training was required?

We have several people reviewing the manuals preparing for the examination.

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

No

18. How is your productivity during construction impacted on Leed Projects?

Minimal amount. The separation of trash makes a cleaner project and thus more can get accomplished with an organized site.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

Efforts are made to reduce the amount of paper, turning off computers, reviewing areas on NON-LEED projects to interject Green ideas.

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: **Brad Bolino**

Company: **John J. Kirlin, LLC**

Job Title: **Division President**

Years of Experience: **31**

1. How many LEED or green buildings have you or your company been involved with?
   A few, more are being built every day. The list of completed projects is pretty short – the pipeline is pretty full though

2. Is there a cost increase associated with LEED rated projects?

   Depends on the rating and the building size and design. LEED Platinum can be a pretty big premium, as much as 30-40%. Lower ratings are 5-7% typically; initial levels can sometimes be done for no premium

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects?

   Compliance reporting and analysis, different means and methods, different products

4. Of the additional Cost how much are hard costs and how much are soft costs?

   Ours are predominantly hard costs, but we consider field labor a hard cost.

5. What are the long term and the short term cost to your firm to build a LEED Project? I don't understand this question – seems to duplicate the previous 2?

6. Is there a schedule increase associated with LEED rated projects?

   Not usually but that is partially product driven

7. If yes, what are the most common causes?

   Longer lead times from high efficiency products

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings?

   Hard to answer because there are so many influences on these items that from our viewpoint it is hard to determine.

9. If yes, how has this affected the cost and schedule on LEED projects?

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

    Other than high efficiency products, it has less of an effect on Mechanical contractors than other trades

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

    All products and projects have been affected by a large run up in commodity costs. Schedules are affected by the lengthy permitting and decision making times.

12. What LEED credits do you or your company find the most difficult and expensive to comply with?

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company?

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

    Only more of them will drive the cost down. As long as only a few are done they will always cost more

15. Have your or your company received training on how to build LEED rated buildings?

    Yes

16. If yes, what additional training was required?

    We have done some awareness seminars

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

    No

18. How is your productivity during construction impacted on Leed Projects?

    Not by LEED requirements.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

    No that we have seen

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

LEED Construction Survey

Name: Jim Fenstermacher

Company: Whiting-Turner

Job Title: Sr. PM

Years of Experience: 21

1. How many LEED or green buildings have you or your company been involved with? Me two – PSU SALA and HCS. WT – 41 and growing everyday.

2. Is there a cost increase associated with LEED rated projects? Yes

3. If yes, why and what is the % Cost increase associated with LEED Certified Projects? It depends…! It depends on everything from the standards of the facility, the points you select to go after the project conditions themselves. If you really need to choose a figure, you can start with 0 to 2%.

4. Of the additional Cost how much are hard costs and how much are soft costs? This is hard cost. The soft cost info needs to come from someone like Chad.

5. What are the long term and the short term cost to your firm to build a LEED Project?

Long term we are invested in educating our personnel, participating in continuing education, coordinating company wide effort. Storage of the info will be a long term expense to consider.

Short term we have the manpower to push, track and document the pursuit on each project,

6. Is there a schedule increase associated with LEED rated projects?

Yes

7. If yes, what are the most common causes?

Two week Building flush is the biggest. Other causes depend on the points chosen and their effect on the building design.

8. Have you seen an increase in the number of materials, systems, and construction methods associated with LEED and Green buildings? Yes

9. If yes, how has this affected the cost and schedule on LEED projects? I think it is diminishing as familiarity increase.

10. What materials, systems, and construction methods do you find the most problematic to LEED construction?

11. Have you or your company noticed any other reasons for the increases in cost and schedule on these projects?

12. What LEED credits do you or your company find the most difficult and expensive to comply with? The LEED format has in it the successful percentages by each point. That is a pretty good indication.

13. Would a detailed analysis of these points and the initial construction costs associated with them be beneficial to you or your company? We do that.

14. How would you make LEED or green projects less expensive, i.e. changing the system set in place, changing the rules to gain credits, etc.?

15. Have your or your company received training on how to build LEED rated buildings? Yes

16. If yes, what additional training was required?

It had mostly come from motivated individuals within our own company taking up the charge.

17. Do you experience more or less 'Call Back' warranty type issues, after occupancy, on a LEED Project?

18. How is your productivity during construction impacted on Leed Projects? Very minor impact.

19. Has LEED conformance impacted any of your corporate processes, either directly or indirectly, as a result of your association with LEED Projects? I.e. such as traveling via public transportation to construction sites.

Indirectly I think we all are changing the way we do business and things (like recycling) that are son easy to do are becoming common practice for good reason.

Thank you for helping with this research. Please return to amf232@psu.edu when completed.

Appendix D

Weight Matrix

Weight Matrix

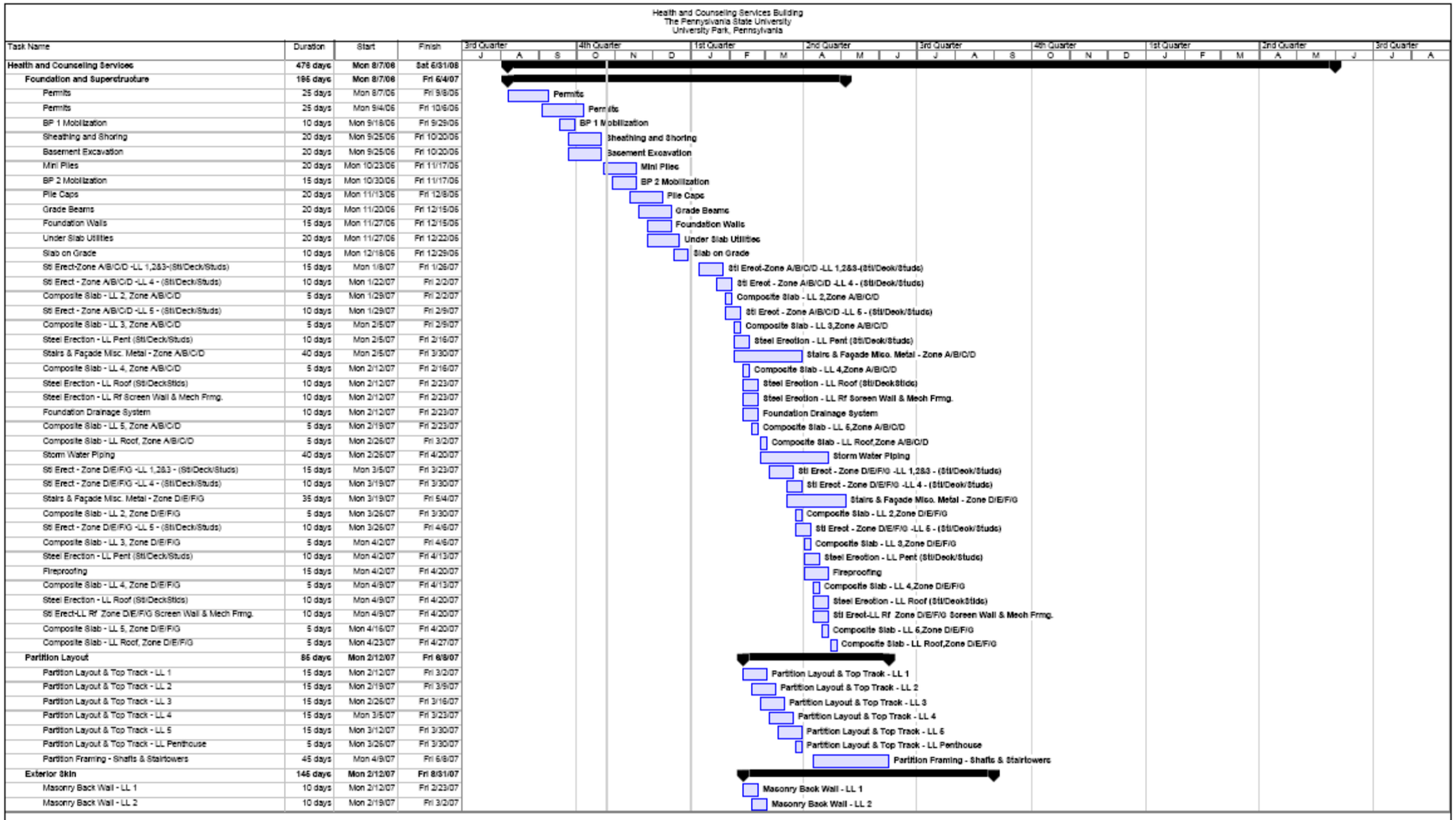
Weight Matrix					
Description	**Research**	**Value Eng.**	**Const. Rev.**	**Sched. Red.**	**Total**
Commissioning	20%	10%	10%	10%	50%
Emerg. Power	0%	10%	10%	0%	20%
LEED Design	30%	0%	0%	0%	30%
Total	50%	20%	20%	10%	100%

Appendix E

Project Schedule

Health and Counseling Services Building
The Pennsylvania State University
University Park, Pennsylvania

Task Name	Duration	Start	Finish
Health and Counseling Services	**478 days**	**Mon 8/7/06**	**Sat 6/31/08**
Foundation and Superstructure	**195 days**	**Mon 8/7/06**	**Fri 6/4/07**
Permits	25 days	Mon 8/7/06	Fri 9/8/06
Permits	25 days	Mon 9/4/06	Fri 10/6/06
BP 1 Mobilization	10 days	Mon 9/18/06	Fri 9/29/06
Sheathing and Shoring	20 days	Mon 9/25/06	Fri 10/20/06
Basement Excavation	20 days	Mon 9/25/06	Fri 10/20/06
Mini Piles	20 days	Mon 10/23/06	Fri 11/17/06
BP 2 Mobilization	15 days	Mon 10/30/06	Fri 11/17/06
Pile Caps	20 days	Mon 11/13/06	Fri 12/8/06
Grade Beams	20 days	Mon 11/20/06	Fri 12/15/06
Foundation Walls	15 days	Mon 11/27/06	Fri 12/15/06
Under Slab Utilities	20 days	Mon 11/27/06	Fri 12/22/06
Slab on Grade	10 days	Mon 12/18/06	Fri 12/29/06
Stl Erect-Zone A/B/C/D -LL 1,2&3-(Stl/Deck/Studs)	15 days	Mon 1/8/07	Fri 1/26/07
Stl Erect - Zone A/B/C/D -LL 4 - (Stl/Deck/Studs)	10 days	Mon 1/22/07	Fri 2/2/07
Composite Slab - LL 2, Zone A/B/C/D	5 days	Mon 1/29/07	Fri 2/2/07
Stl Erect - Zone A/B/C/D -LL 5 - (Stl/Deck/Studs)	10 days	Mon 1/29/07	Fri 2/9/07
Composite Slab - LL 3, Zone A/B/C/D	5 days	Mon 2/5/07	Fri 2/9/07
Steel Erection - LL Pent (Stl/Deck/Studs)	10 days	Mon 2/5/07	Fri 2/16/07
Stairs & Façade Misc. Metal - Zone A/B/C/D	40 days	Mon 2/5/07	Fri 3/30/07
Composite Slab - LL 4, Zone A/B/C/D	5 days	Mon 2/12/07	Fri 2/16/07
Steel Erection - LL Roof (Stl/DeckStids)	10 days	Mon 2/12/07	Fri 2/23/07
Steel Erection - LL Rf Screen Wall & Mech Frmg.	10 days	Mon 2/12/07	Fri 2/23/07
Foundation Drainage System	10 days	Mon 2/12/07	Fri 2/23/07
Composite Slab - LL 5, Zone A/B/C/D	5 days	Mon 2/19/07	Fri 2/23/07
Composite Slab - LL Roof, Zone A/B/C/D	5 days	Mon 2/26/07	Fri 3/2/07
Storm Water Piping	40 days	Mon 2/26/07	Fri 4/20/07
Stl Erect - Zone D/E/F/G -LL 1,2&3 - (Stl/Deck/Studs)	15 days	Mon 3/5/07	Fri 3/23/07
Stl Erect - Zone D/E/F/G -LL 4 - (Stl/Deck/Studs)	10 days	Mon 3/19/07	Fri 3/30/07
Stairs & Façade Misc. Metal - Zone D/E/F/G	35 days	Mon 3/19/07	Fri 5/4/07
Composite Slab - LL 2, Zone D/E/F/G	5 days	Mon 3/26/07	Fri 3/30/07
Stl Erect - Zone D/E/F/G -LL 5 - (Stl/Deck/Studs)	10 days	Mon 3/26/07	Fri 4/6/07
Composite Slab - LL 3, Zone D/E/F/G	5 days	Mon 4/2/07	Fri 4/6/07
Steel Erection - LL Pent (Stl/Deck/Studs)	10 days	Mon 4/2/07	Fri 4/13/07
Fireproofing	15 days	Mon 4/2/07	Fri 4/20/07
Composite Slab - LL 4, Zone D/E/F/G	5 days	Mon 4/9/07	Fri 4/13/07
Steel Erection - LL Roof (Stl/DeckStids)	10 days	Mon 4/9/07	Fri 4/20/07
Stl Erect-LL Rf Zone D/E/F/G Screen Wall & Mech Frmg.	10 days	Mon 4/9/07	Fri 4/20/07
Composite Slab - LL 5, Zone D/E/F/G	5 days	Mon 4/16/07	Fri 4/20/07
Composite Slab - LL Roof, Zone D/E/F/G	5 days	Mon 4/23/07	Fri 4/27/07
Partition Layout	**86 days**	**Mon 2/12/07**	**Fri 6/8/07**
Partition Layout & Top Track - LL 1	15 days	Mon 2/12/07	Fri 3/2/07
Partition Layout & Top Track - LL 2	15 days	Mon 2/19/07	Fri 3/9/07
Partition Layout & Top Track - LL 3	15 days	Mon 2/26/07	Fri 3/16/07
Partition Layout & Top Track - LL 4	15 days	Mon 3/5/07	Fri 3/23/07
Partition Layout & Top Track - LL 5	15 days	Mon 3/12/07	Fri 3/30/07
Partition Layout & Top Track - LL Penthouse	5 days	Mon 3/26/07	Fri 3/30/07
Partition Framing - Shafts & Stairtowers	45 days	Mon 4/9/07	Fri 6/8/07
Exterior Skin	**145 days**	**Mon 2/12/07**	**Fri 8/31/07**
Masonry Back Wall - LL 1	10 days	Mon 2/12/07	Fri 2/23/07
Masonry Back Wall - LL 2	10 days	Mon 2/19/07	Fri 3/2/07



Health and Counseling Services Building
The Pennsylvania State University
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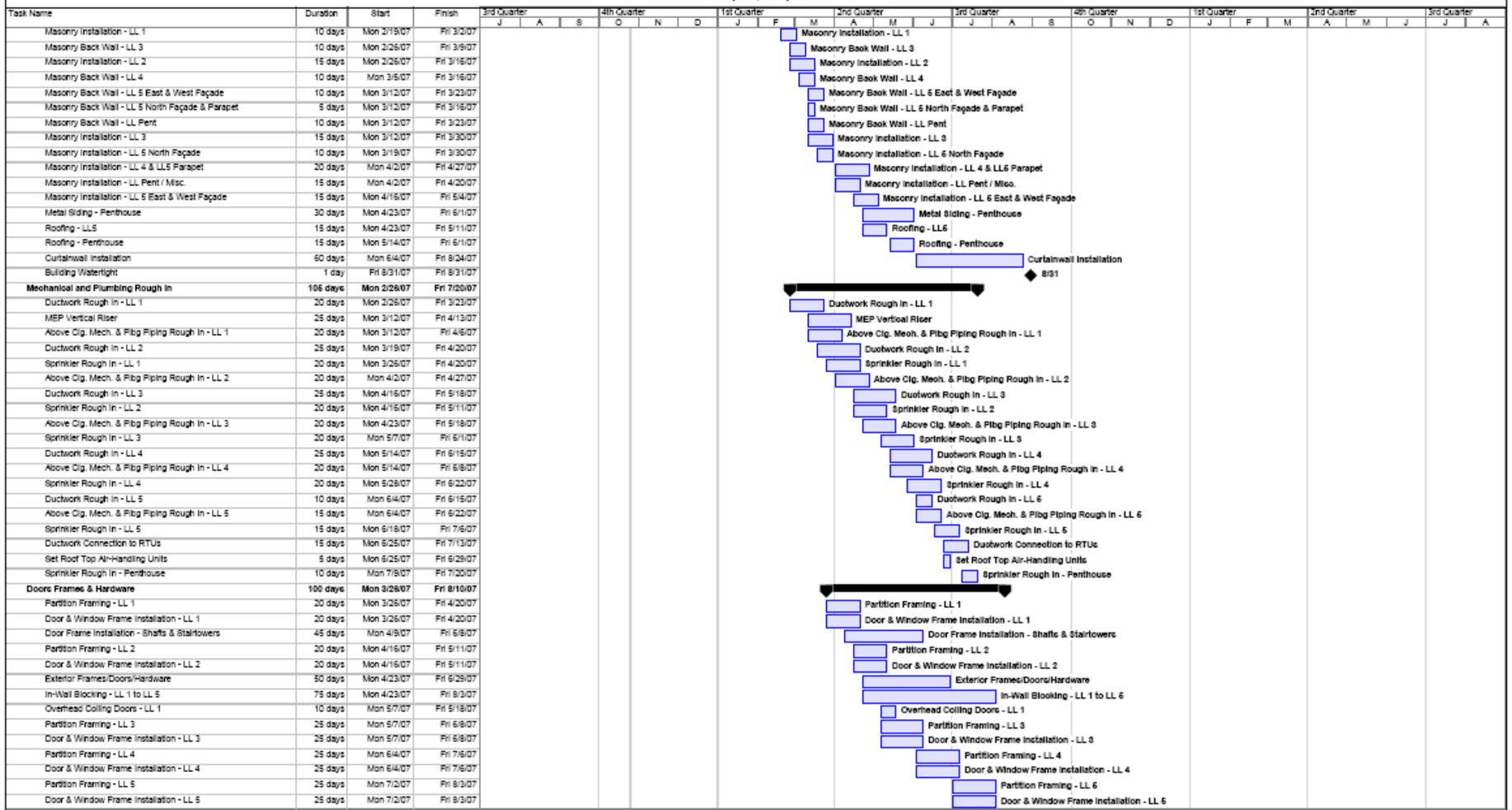
Task Name	Duration	Start	Finish
Masonry Installation - LL 1	10 days	Mon 2/19/07	Fri 3/2/07
Masonry Back Wall - LL 3	10 days	Mon 2/26/07	Fri 3/9/07
Masonry Installation - LL 2	15 days	Mon 2/26/07	Fri 3/16/07
Masonry Back Wall - LL 4	10 days	Mon 3/5/07	Fri 3/16/07
Masonry Back Wall - LL 5 East & West Façade	10 days	Mon 3/12/07	Fri 3/23/07
Masonry Back Wall - LL 5 North Façade & Parapet	5 days	Mon 3/12/07	Fri 3/16/07
Masonry Back Wall - LL Pent	10 days	Mon 3/12/07	Fri 3/23/07
Masonry Installation - LL 3	15 days	Mon 3/12/07	Fri 3/30/07
Masonry Installation - LL 5 North Façade	10 days	Mon 3/19/07	Fri 3/30/07
Masonry Installation - LL 4 & LL5 Parapet	20 days	Mon 4/2/07	Fri 4/27/07
Masonry Installation - LL Pent / Misc.	15 days	Mon 4/2/07	Fri 4/20/07
Masonry Installation - LL 5 East & West Façade	15 days	Mon 4/16/07	Fri 5/4/07
Metal Siding - Penthouse	30 days	Mon 4/23/07	Fri 6/1/07
Roofing - LL5	15 days	Mon 4/23/07	Fri 5/11/07
Roofing - Penthouse	15 days	Mon 5/14/07	Fri 6/1/07
Curtainwall Installation	60 days	Mon 6/4/07	Fri 8/24/07
Building Watertight	1 day	Fri 8/31/07	Fri 8/31/07
Mechanical and Plumbing Rough In	**105 days**	**Mon 2/26/07**	**Fri 7/20/07**
Ductwork Rough In - LL 1	20 days	Mon 2/26/07	Fri 3/23/07
MEP Vertical Riser	25 days	Mon 3/12/07	Fri 4/13/07
Above Clg. Mech. & Plbg Piping Rough In - LL 1	20 days	Mon 3/12/07	Fri 4/6/07
Ductwork Rough In - LL 2	25 days	Mon 3/19/07	Fri 4/20/07
Sprinkler Rough In - LL 1	20 days	Mon 3/26/07	Fri 4/20/07
Above Clg. Mech. & Plbg Piping Rough In - LL 2	20 days	Mon 4/2/07	Fri 4/27/07
Ductwork Rough In - LL 3	25 days	Mon 4/16/07	Fri 5/18/07
Sprinkler Rough In - LL 2	20 days	Mon 4/16/07	Fri 5/11/07
Above Clg. Mech. & Plbg Piping Rough In - LL 3	20 days	Mon 4/23/07	Fri 5/18/07
Sprinkler Rough In - LL 3	20 days	Mon 5/7/07	Fri 6/1/07
Ductwork Rough In - LL 4	25 days	Mon 5/14/07	Fri 6/15/07
Above Clg. Mech. & Plbg Piping Rough In - LL 4	20 days	Mon 5/14/07	Fri 6/8/07
Sprinkler Rough In - LL 4	20 days	Mon 5/28/07	Fri 6/22/07
Ductwork Rough In - LL 5	10 days	Mon 6/4/07	Fri 6/15/07
Above Clg. Mech. & Plbg Piping Rough In - LL 5	15 days	Mon 6/4/07	Fri 6/22/07
Sprinkler Rough In - LL 5	15 days	Mon 6/18/07	Fri 7/6/07
Ductwork Connection to RTUs	15 days	Mon 6/25/07	Fri 7/13/07
Set Roof Top Air-Handling Units	5 days	Mon 6/25/07	Fri 6/29/07
Sprinkler Rough In - Penthouse	10 days	Mon 7/9/07	Fri 7/20/07
Doors Frames & Hardware	**100 days**	**Mon 3/26/07**	**Fri 8/10/07**
Partition Framing - LL 1	20 days	Mon 3/26/07	Fri 4/20/07
Door & Window Frame Installation - LL 1	20 days	Mon 3/26/07	Fri 4/20/07
Door Frame Installation - Shafts & Stairtowers	45 days	Mon 4/9/07	Fri 6/8/07
Partition Framing - LL 2	20 days	Mon 4/16/07	Fri 5/11/07
Door & Window Frame Installation - LL 2	20 days	Mon 4/16/07	Fri 5/11/07
Exterior Frames/Doors/Hardware	50 days	Mon 4/23/07	Fri 6/29/07
In-Wall Blocking - LL 1 to LL 5	75 days	Mon 4/23/07	Fri 8/3/07
Overhead Coiling Doors - LL 1	10 days	Mon 5/7/07	Fri 5/18/07
Partition Framing - LL 3	25 days	Mon 5/7/07	Fri 6/8/07
Door & Window Frame Installation - LL 3	25 days	Mon 5/7/07	Fri 6/8/07
Partition Framing - LL 4	25 days	Mon 6/4/07	Fri 7/6/07
Door & Window Frame Installation - LL 4	25 days	Mon 6/4/07	Fri 7/6/07
Partition Framing - LL 5	25 days	Mon 7/2/07	Fri 8/3/07
Door & Window Frame Installation - LL 5	25 days	Mon 7/2/07	Fri 8/3/07



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Task Progress Summary External Tasks Deadline
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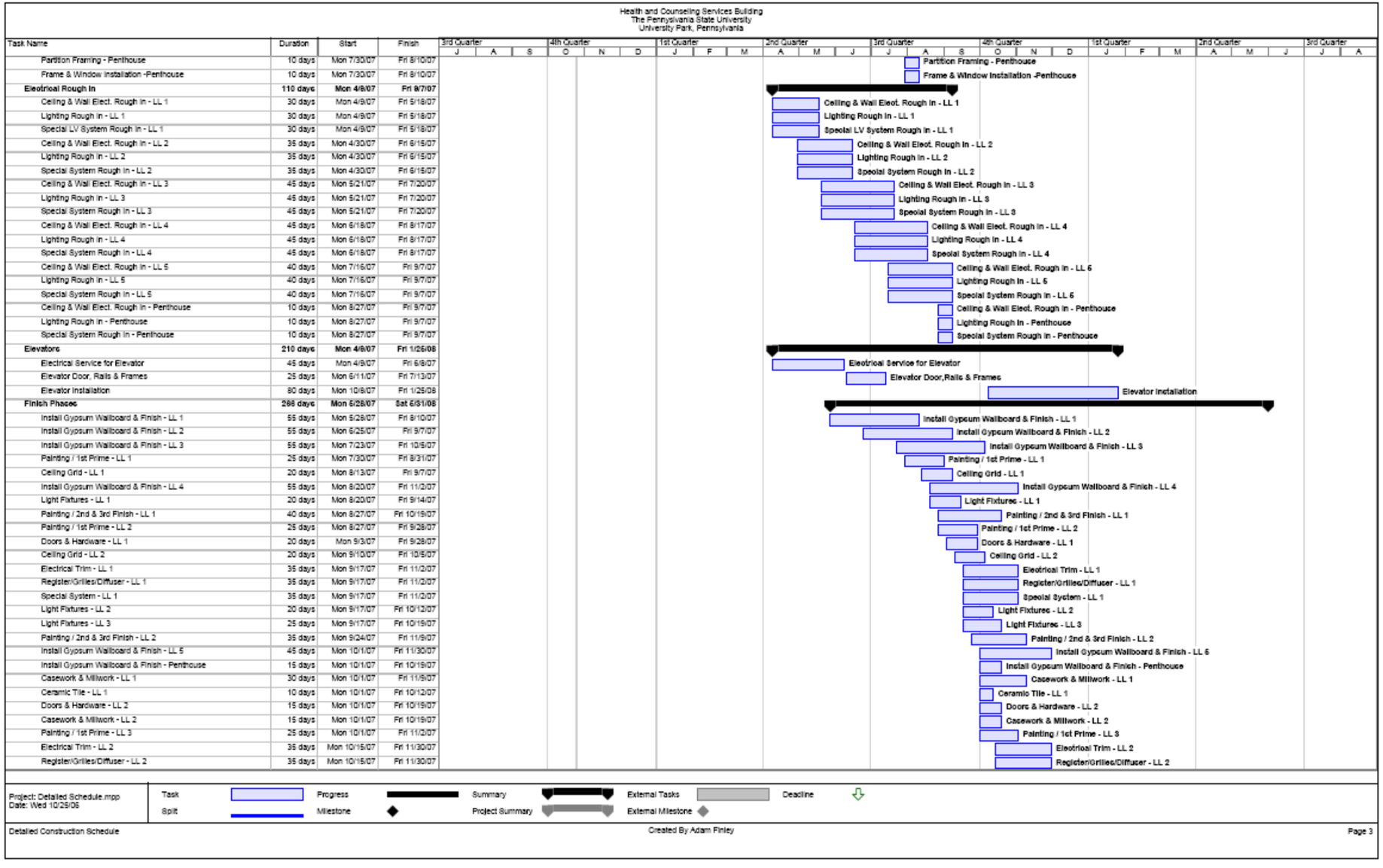
Detailed Construction Schedule Created By Adam Finley Page 2

Health and Counseling Services Building
The Pennsylvania State University
University Park, Pennsylvania

Task Name	Duration	Start	Finish
Partition Framing - Penthouse	10 days	Mon 7/30/07	Fri 8/10/07
Frame & Window Installation -Penthouse	10 days	Mon 7/30/07	Fri 8/10/07
Electrical Rough In	**110 days**	**Mon 4/9/07**	**Fri 9/7/07**
Ceiling & Wall Elect. Rough In - LL 1	30 days	Mon 4/9/07	Fri 5/18/07
Lighting Rough In - LL 1	30 days	Mon 4/9/07	Fri 5/18/07
Special LV System Rough In - LL 1	30 days	Mon 4/9/07	Fri 5/18/07
Ceiling & Wall Elect. Rough In - LL 2	35 days	Mon 4/30/07	Fri 6/15/07
Lighting Rough In - LL 2	35 days	Mon 4/30/07	Fri 6/15/07
Special System Rough In - LL 2	35 days	Mon 4/30/07	Fri 6/15/07
Ceiling & Wall Elect. Rough In - LL 3	45 days	Mon 5/21/07	Fri 7/20/07
Lighting Rough In - LL 3	45 days	Mon 5/21/07	Fri 7/20/07
Special System Rough In - LL 3	45 days	Mon 5/21/07	Fri 7/20/07
Ceiling & Wall Elect. Rough In - LL 4	45 days	Mon 6/18/07	Fri 8/17/07
Lighting Rough In - LL 4	45 days	Mon 6/18/07	Fri 8/17/07
Special System Rough In - LL 4	45 days	Mon 6/18/07	Fri 8/17/07
Ceiling & Wall Elect. Rough In - LL 5	40 days	Mon 7/16/07	Fri 9/7/07
Lighting Rough In - LL 5	40 days	Mon 7/16/07	Fri 9/7/07
Special System Rough In - LL 5	40 days	Mon 7/16/07	Fri 9/7/07
Ceiling & Wall Elect. Rough In - Penthouse	10 days	Mon 8/27/07	Fri 9/7/07
Lighting Rough In - Penthouse	10 days	Mon 8/27/07	Fri 9/7/07
Special System Rough In - Penthouse	10 days	Mon 8/27/07	Fri 9/7/07
Elevators	**210 days**	**Mon 4/9/07**	**Fri 1/25/08**
Electrical Service for Elevator	45 days	Mon 4/9/07	Fri 6/8/07
Elevator Door, Rails & Frames	25 days	Mon 6/11/07	Fri 7/13/07
Elevator Installation	80 days	Mon 10/8/07	Fri 1/25/08
Finish Phases	**288 days**	**Mon 5/28/07**	**Sat 6/31/08**
Install Gypsum Wallboard & Finish - LL 1	55 days	Mon 5/28/07	Fri 8/10/07
Install Gypsum Wallboard & Finish - LL 2	55 days	Mon 6/25/07	Fri 9/7/07
Install Gypsum Wallboard & Finish - LL 3	55 days	Mon 7/23/07	Fri 10/5/07
Painting / 1st Prime - LL 1	25 days	Mon 7/30/07	Fri 8/31/07
Ceiling Grid - LL 1	20 days	Mon 8/13/07	Fri 9/7/07
Install Gypsum Wallboard & Finish - LL 4	55 days	Mon 8/20/07	Fri 11/2/07
Light Fixtures - LL 1	20 days	Mon 8/20/07	Fri 9/14/07
Painting / 2nd & 3rd Finish - LL 1	40 days	Mon 8/27/07	Fri 10/19/07
Painting / 1st Prime - LL 2	25 days	Mon 8/27/07	Fri 9/28/07
Doors & Hardware - LL 1	20 days	Mon 9/3/07	Fri 9/28/07
Ceiling Grid - LL 2	20 days	Mon 9/10/07	Fri 10/5/07
Electrical Trim - LL 1	35 days	Mon 9/17/07	Fri 11/2/07
Register/Grilles/Diffuser - LL 1	35 days	Mon 9/17/07	Fri 11/2/07
Special System - LL 1	35 days	Mon 9/17/07	Fri 11/2/07
Light Fixtures - LL 2	20 days	Mon 9/17/07	Fri 10/12/07
Light Fixtures - LL 3	25 days	Mon 9/17/07	Fri 10/19/07
Painting / 2nd & 3rd Finish - LL 2	35 days	Mon 9/24/07	Fri 11/9/07
Install Gypsum Wallboard & Finish - LL 5	45 days	Mon 10/1/07	Fri 11/30/07
Install Gypsum Wallboard & Finish - Penthouse	15 days	Mon 10/1/07	Fri 10/19/07
Casework & Millwork - LL 1	30 days	Mon 10/1/07	Fri 11/9/07
Ceramic Tile - LL 1	10 days	Mon 10/1/07	Fri 10/12/07
Doors & Hardware - LL 2	15 days	Mon 10/1/07	Fri 10/19/07
Casework & Millwork - LL 2	15 days	Mon 10/1/07	Fri 10/19/07
Painting / 1st Prime - LL 3	25 days	Mon 10/1/07	Fri 11/2/07
Electrical Trim - LL 2	35 days	Mon 10/15/07	Fri 11/30/07
Register/Grilles/Diffuser - LL 2	35 days	Mon 10/15/07	Fri 11/30/07



Health and Counseling Services Building
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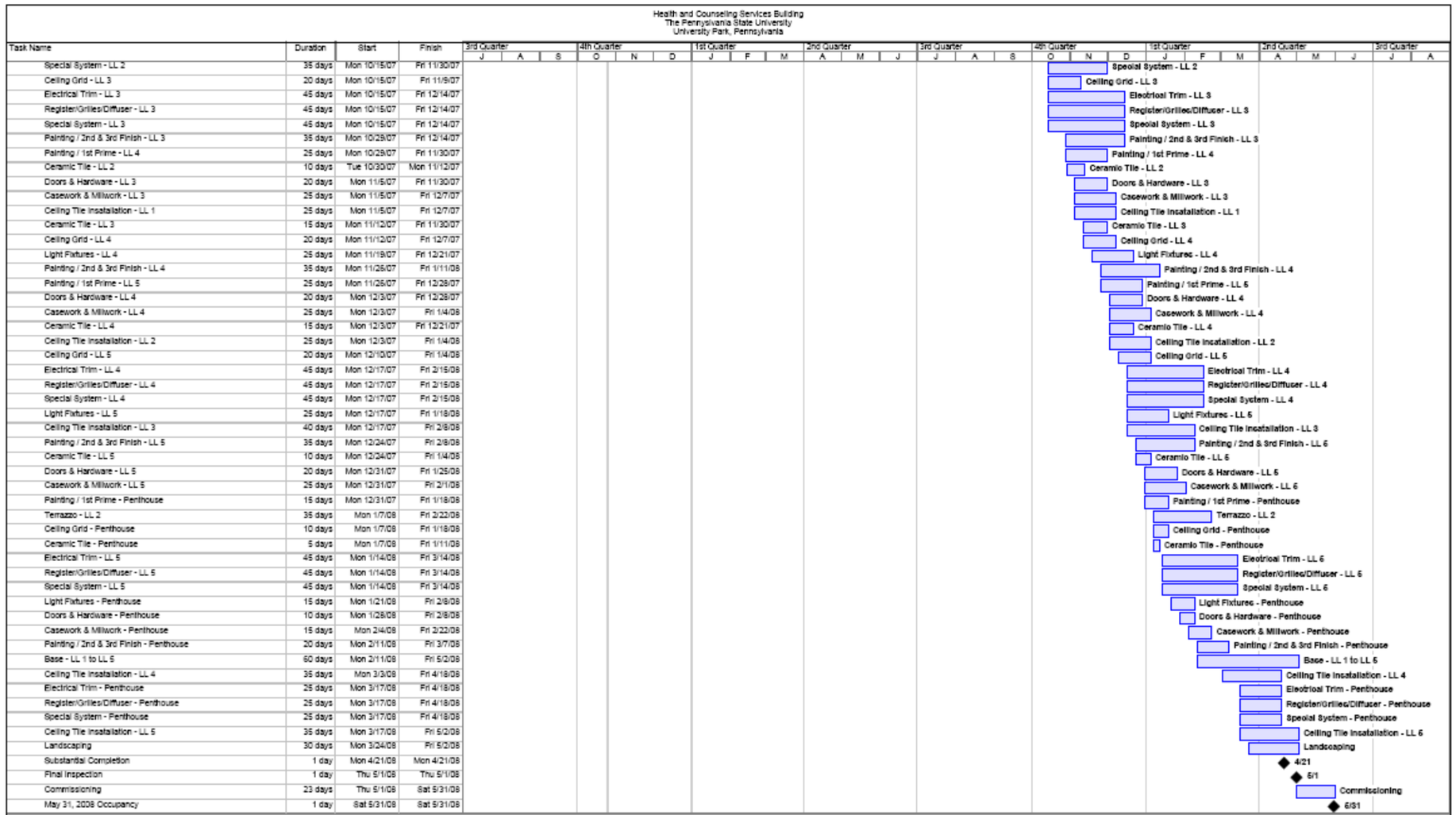
Task Name	Duration	Start	Finish
Special System - LL 2	35 days	Mon 10/15/07	Fri 11/30/07
Ceiling Grid - LL 3	20 days	Mon 10/15/07	Fri 11/9/07
Electrical Trim - LL 3	45 days	Mon 10/15/07	Fri 12/14/07
Register/Grilles/Diffuser - LL 3	45 days	Mon 10/15/07	Fri 12/14/07
Special System - LL 3	45 days	Mon 10/15/07	Fri 12/14/07
Painting / 2nd & 3rd Finish - LL 3	35 days	Mon 10/29/07	Fri 12/14/07
Painting / 1st Prime - LL 4	25 days	Mon 10/29/07	Fri 11/30/07
Ceramic Tile - LL 2	10 days	Tue 10/30/07	Mon 11/12/07
Doors & Hardware - LL 3	20 days	Mon 11/5/07	Fri 11/30/07
Casework & Millwork - LL 3	25 days	Mon 11/5/07	Fri 12/7/07
Ceiling Tile Installation - LL 1	25 days	Mon 11/5/07	Fri 12/7/07
Ceramic Tile - LL 3	15 days	Mon 11/12/07	Fri 11/30/07
Ceiling Grid - LL 4	20 days	Mon 11/12/07	Fri 12/7/07
Light Fixtures - LL 4	25 days	Mon 11/19/07	Fri 12/21/07
Painting / 2nd & 3rd Finish - LL 4	35 days	Mon 11/26/07	Fri 1/11/08
Painting / 1st Prime - LL 5	25 days	Mon 11/26/07	Fri 12/28/07
Doors & Hardware - LL 4	20 days	Mon 12/3/07	Fri 12/28/07
Casework & Millwork - LL 4	25 days	Mon 12/3/07	Fri 1/4/08
Ceramic Tile - LL 4	15 days	Mon 12/3/07	Fri 12/21/07
Ceiling Tile Installation - LL 2	25 days	Mon 12/3/07	Fri 1/4/08
Ceiling Grid - LL 5	20 days	Mon 12/10/07	Fri 1/4/08
Electrical Trim - LL 4	45 days	Mon 12/17/07	Fri 2/15/08
Register/Grilles/Diffuser - LL 4	45 days	Mon 12/17/07	Fri 2/15/08
Special System - LL 4	45 days	Mon 12/17/07	Fri 2/15/08
Light Fixtures - LL 5	25 days	Mon 12/17/07	Fri 1/18/08
Ceiling Tile Installation - LL 3	40 days	Mon 12/17/07	Fri 2/8/08
Painting / 2nd & 3rd Finish - LL 5	35 days	Mon 12/24/07	Fri 2/8/08
Ceramic Tile - LL 5	10 days	Mon 12/24/07	Fri 1/4/08
Doors & Hardware - LL 5	20 days	Mon 12/31/07	Fri 1/25/08
Casework & Millwork - LL 5	25 days	Mon 12/31/07	Fri 2/1/08
Painting / 1st Prime - Penthouse	15 days	Mon 12/31/07	Fri 1/18/08
Terrazzo - LL 2	35 days	Mon 1/7/08	Fri 2/22/08
Ceiling Grid - Penthouse	10 days	Mon 1/7/08	Fri 1/18/08
Ceramic Tile - Penthouse	5 days	Mon 1/7/08	Fri 1/11/08
Electrical Trim - LL 6	45 days	Mon 1/14/08	Fri 3/14/08
Register/Grilles/Diffuser - LL 6	45 days	Mon 1/14/08	Fri 3/14/08
Special System - LL 6	45 days	Mon 1/14/08	Fri 3/14/08
Light Fixtures - Penthouse	15 days	Mon 1/21/08	Fri 2/8/08
Doors & Hardware - Penthouse	10 days	Mon 1/28/08	Fri 2/8/08
Casework & Millwork - Penthouse	15 days	Mon 2/4/08	Fri 2/22/08
Painting / 2nd & 3rd Finish - Penthouse	20 days	Mon 2/11/08	Fri 3/7/08
Base - LL 1 to LL 6	60 days	Mon 2/11/08	Fri 5/2/08
Ceiling Tile Installation - LL 4	35 days	Mon 3/3/08	Fri 4/18/08
Electrical Trim - Penthouse	25 days	Mon 3/17/08	Fri 4/18/08
Register/Grilles/Diffuser - Penthouse	25 days	Mon 3/17/08	Fri 4/18/08
Special System - Penthouse	25 days	Mon 3/17/08	Fri 4/18/08
Ceiling Tile Installation - LL 6	35 days	Mon 3/17/08	Fri 5/2/08
Landscaping	30 days	Mon 3/24/08	Fri 5/2/08
Substantial Completion	1 day	Mon 4/21/08	Mon 4/21/08
Final Inspection	1 day	Thu 5/1/08	Thu 5/1/08
Commissioning	23 days	Thu 5/1/08	Sat 5/31/08
May 31, 2008 Occupancy	1 day	Sat 5/31/08	Sat 5/31/08



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