The Pennsylvania State University
5th Year Senior Thesis

Thesis Proposal

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Unknown Data Center
Somewhere, USA
December 10, 2010

Executive Summary:

The senior thesis final proposal is intended to explain the research and analysis proposed for the spring semester portion of senior thesis. The topics that were chosen have been identified based on cutting costs, energy consumption, accelerating the schedule, value engineering, constructability, jobsite efficiency, and critical industry issues. Additionally, breadth topics were determined relating to the analysis in order to fulfill the requirements as an Architectural engineer.

Analysis #1 - *Green Roof Analysis:*

This analysis is to change the structure of the roof system of the building from concrete, EPDM to a green roof. The goal of this analysis is to minimize the cost of the original roofs material and labor. In addition, calculations on energy savings will be performed to look more appealing to the client. An acoustical breadth analysis will be assessed to determine if the sound isolation is adequate for the proposed solution. More information on this topic can be found in Appendix A of this report.

Analysis #2 - *Implement 3D coordination:*

The proposed solution to this problem would be implementing 3D coordination in the design and preconstruction phases to this project. The goal of this analysis is to decrease the amount of RFI's and change orders, also accelerate the coordination portion of the schedule, which can be found in Appendix C of this report. In addition, the use of 3D models and clash detection can give insight to subcontractors on what will be needed onsite, which in term could decrease site congestion. Also, a good 3D model could essentially benefit the prefabrication/procurement process.

Analysis #3 - *Façade alterations:*

The proposed solution to this is to add windows into the architectural precast panels. The goal of this analysis is to add more natural light and make the building more appealing. An architectural analysis will need to be conducted to determine optimal window placement. This will apply for an architectural breadth. More information on this specific breadth can be viewed in Appendix A of this report.

Analysis #4 - *Critical Industry Analysis – Implement Latista:*

The proposed solution for this analysis is to implement the Latista technology during the construction process. The goal of this analysis is to increase to productivity of construction, decrease site congestion, accelerate the schedule (procurement). Latista is a great tool for organization of materials onsite and procurement. Using this will decrease the congestion of materials onsite. This technology was discussed during the 2010 PACE roundtable. Latista can directly help with the procurement process by having the information of what materials are onsite. More information can be viewed in technical assignment two.

Table of Contents:

Project Background:

NOTE: Due to the sensitivity of this project the name, location, and some cost will not be given.

The Data Center is one story expansion/renovation project consisting of roughly 17,500 square feet of a new addition to roughly an existing 114,500 square feet. This building is the second of three expansions. The project is designed for another a third expansion allowing for an additional 30,000 square feet. The addition will include more computer, electrical and mechanical rooms. As well as more storage and advanced data network distribution. Figure A.1 shows an image on the new addition and the existing buildings that surround it.

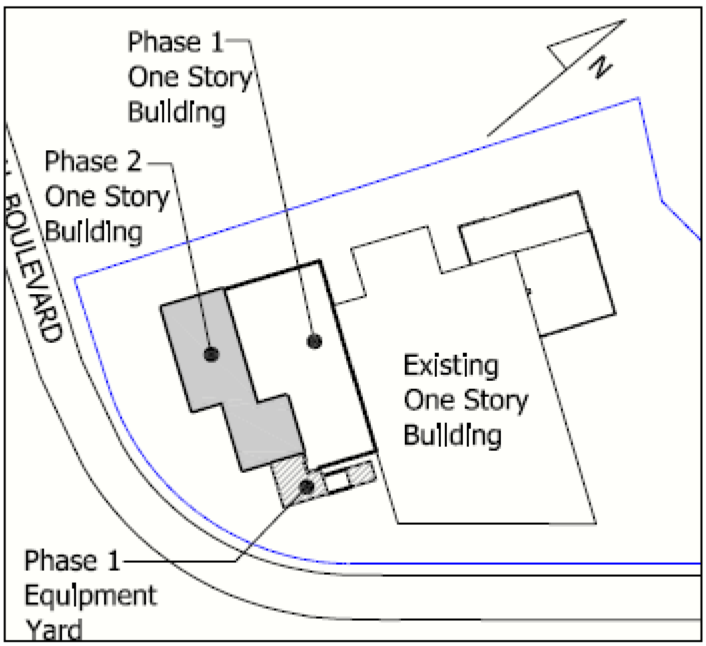


Figure A.1 Building Layout

The Data Center's shell is primarily made up of architectural precast concrete and is designed to withstand wind up to 200 miles per hour. A liquid membrane is used between the precast and flashing for maximum water protection. The precast is erected to bearing surfaces that must bear 2 ½ inches on steel and/or 3 inches on concrete block or masonry brick. Shims or jacks are used to align and level the precast panel.

The mechanical rooms and penthouse is enclosed with EIFS with 3 inch insulation with intake louvers on some areas of the rooms. The rooms are also equipped with acoustical silencer and dampers on a stand to account for any undesirable sound.

For the project's schedule, the design for the Data Center was completed in December of 2008. However the preconstruction did not start until August of 2009 with the completion of the conceptual documents and the soils report. As previously mentioned, this is the second of three

expansions. The first and second expansions are done. The second phase was competed on August 30, 2010.

The largest challenge associated with the projects schedule is the complexity of the mechanical and electrical systems. Coordination was the main focal point for this project. The mechanical system includes: Chilled water systems, glygol water systems. The chilled water system is 350 ton and the GPM ranges from 1,100 – 1,300. The dry cooling is a 190 ton system. The glygol water system is located on the roof and pumps out 110,040 CFM. In addition, the electrical system includes a 2N electrical infrastructure with concurrent maintenance.

For more information, please refer to the following website: http://www.engr.psu.edu/ae/thesis/portfolios/2011/djs5162/index.html, click on any of the following links:

- Building Statistics
- Technical Assignments

Analysis #1- *Green Roof Analysis:*

Problem Identification:

The Data Center's roof construction primarily constructed with EPDM fully adhered to concrete slab on deck. On top of the EPDM is interlocking insulation board covered with UV protection fabric and is topped off with interlocking concrete pavers. This type of roof was selected for sound isolation purposes. This type of roof selected includes various amounts of materials and two different trades to construct this roof type.

Proposed Solution:

The proposed solution to this problem would be to replace the current roof with a green roof. This type of roofing system may reduce the cost of labor and material for the Data Center. A cost comparison would need to be done to determine whether this analysis is beneficial. Also, this proposed change in the roof brings various amounts of benefits that will be explained in the next section of this analysis. Since sound isolation is a main concern for this analysis, an acoustical breadth may apply. More information on this specific breadth may be viewed on Appendix A on this report.

Benefits:

- Economic Benefits:
  - If constructed correctly, this type of roofing system may last longer than the original design resulting in savings on replacement/maintenance costs.
  - Potential savings on heating and cooling costs.
  - Reduces storm water runoff.
- Sound Isolation Benefits:
  - Soil and plants can insulate sounds from the mechanical systems located on the roof.
  - Green roofing systems with a substrate layer up to 20 cm can reduce sound by 46-50 decibels.*
- Financial Benefits:
  - Increases the buildings value.

Drawbacks:

- More costs up front
- Depending on the type of green roof, a maintenance cost may occur.
- The weight increase may affect the structure of the building.

Research:

The research components of the analysis will primary estimate the cost and schedule comparisons. Additionally, client research will be performed to determine any additional cost savings using a green roof in an effort to make this analysis more appealing. As mentioned above, the sound isolation will be researched to determine if green roof is an adequate solution to this problem.

Methodology:

- Calculate the cost and schedule impacts to the proposed solution.
- Calculate any energy savings cost that may appeal to the owner.
- Evaluate the constructability issues associated with this proposed solution.
- Summarize findings.

Resources and Tools to be used:

- Industry Professionals
- AE Faculty – Acoustical
- Turner Construction
- Sigma 7 – Architect
- Microsoft Excel
- Project owner

Expected Outcome:

The expected outcomes from this analysis would include having positive effects on the cost, schedule and potential energy consumption of the building. To successfully complete this analysis, client research cannot be taken likely.

Analysis #2 – *Implement 3D coordination:*

Problem Identification:

The use of BIM and 3D coordination was not pursued for the Data Center. This is a problematic feature because the Data Center could have benefited by implementing BIM and 3D coordination. The schedule shows a portion of the coordination meetings for the whole project between Sigma 7 and Turner. This portion of the detailed schedule can be viewed in Appendix C of this report.

3D coordination could have been implemented shaving time and money for this project. The use of this coordination technique could have lowered the amount of time spent in coordination meetings.

Proposed Solution:

The proposed solution to this problem would be implementing 3D coordination in the design and preconstruction phases to this project. The goal of this analysis is to decrease the amount of RFI's and change orders, also accelerate the coordination portion of the schedule, which can be found in Appendix C of this report. The use of 3D models and clash detection can give insight to subcontractors on what will be needed onsite, which in term could decrease site congestion. Also, a good 3D model could essentially benefit the prefabrication/procurement process.

Benefits:

- Possibly cut the scheduled coordination meetings.
- Benefit the preconstruction/procurement of the project.
- Minimize the RFI's and change orders early on.
- Essentially minimize site congestion.
- Extensive system coordination.
- An increased interaction between trades.

Drawbacks:

- More cost upfront.
- Lack of experience with 3D coordination with subcontractors.

Research:

This analysis will need several items to research. The cost will need to be research for the BIM/3D coordination team and any RFI and change orders that could have been resolved using 3D coordination. The feasibility of the 3D coordination will need to be research to determine if all trades have or lacked experience to complete actual 3D coordination clash detection. The schedule will need to be researched to determine if this analysis will decrease the duration of the coordination meetings.

Methodology:

- Determine the effect of the cost for a 3D coordination team.
- Determine the effect of the schedule for coordination meetings.
- Develop a 3D model for areas where RFI's/change orders occurred.
- Perform clash detections.
- Summarize results.

Resources and Tools to be used:

- Industry Professionals
- 3D coordination Professionals
- Professors and Colleagues
- Revit and Navisworks
- Turner Construction – Project Manager
- Sigma 7 – Architect and Engineers
- Subcontractors

Expected Outcome:

The expected outcomes from this analysis would include having positive effects on the cost, schedule, prefabrication, and procurement for the Data Center. To successfully complete this analysis, research for how many RFI's/Change orders will be assessed and a 3D model/clash detection would be performed for this analysis.

Analysis #3- *Façade alterations:*

Problem Identification:

The architectural precast poses a problem for the fact that there are no windows for this new expansion, the owner is losing opportunity to light his building with natural sunlight. This intern will reduce cost of the artificial lights needed inside the building as well as decrease the mechanical heat load in the building.

Proposed Solution:

The proposed solution to this is to add windows into the architectural precast panels. The goal of this analysis is to add more natural light and make the building more appealing. An architectural analysis will need to be conducted to determine optimal window placement. This will apply for an architectural breadth. More information on this specific breadth can be viewed in Appendix A of this report.

Benefits:

- Decrease the energy consumption from artificial lights.
- Decrease the mechanical/electrical heat load.

Drawbacks:

- Costs upfront
- Extends the schedule

Research:

Cost research will need to be conducted for upfront cost, future energy consumption savings, artificial light cost and heat savings. Client research will also need to be conducted to determine the reason for the lack of windows. A construction analysis will need to be conducted to determine the effect of the schedule for the windows to be installed.

Methodology:

- Collaborate with professor for AE faculty for optimal window placement.
- Determine cost of windows
- Determine the effect of the schedule/prefabrication.
- Collaborate with the owner.
- Summarize results.

Resources and Tools to be used:

- AE faculty – Architectural
- Window manufactures.
- Sigma 7 – Architect
- Revit

- Client
- Colleagues

Expected Outcome:

The expected outcomes from this analysis would include having positive on the energy consumption for the Data Center. This analysis will extend the schedule and increase the costs for material/labor for the windows and installation. This analysis will compare the buyback costs by comparing the initial upfront cost to future savings in electrical consumption.

Analysis #4- *Critical Industry Analysis – Implement Latista:*

Problem Identification:

The schedule is set up for multiple trades to be onsite at once. The site plan used for the Data Center may be problematic for this scenario. There is not sufficient lay out space for the steel, concrete, precast, and MEP trades. The usage of the crane may be problematic during the architectural precast erection. The MEP trades will need to use the crane to hoist the mechanical equipment to the roof and the precast trades will need the crane for erection of the architectural precast panels.

Proposed Solution:

The proposed solution for this analysis is to implement the Latista technology during the construction process. Latista is a great tool for organization of materials onsite and procurement. Using this will decrease the congestion of materials onsite. This technology was discussed during the 2010 PACE roundtable. Latista can directly help with the procurement process by having the information of what materials are onsite. More information can be viewed in technical assignment two.

Benefits:

- Decrease site congestion.
- Increase efficiency.
- Benefit the preconstruction/procurement of the project.
- Material organization onsite.
- Save costs on drawing documentation.
- Track down material deliveries for all trades.

Drawbacks:

- Increase in cost upfront
- May be a lack of knowledge from all the trades.

Research:

A research study on the knowledge/experience of this tool would need to be conducted to figure out if preliminary classes would need to be held for the project team to learn this tool. Additionally, the upfront costs for the equipment will need to be determined.

Methodology:

- Research Latista
- Determine the upfront cost from manufacture.
- Interview Turner and subcontractors on experience with Latista.
- Develop plan to integrate Latista
- Calculate the cost savings

- Calculate the schedule impact (Construction/prefabrication/procurement)
- Summarize results.

Resources and Tools to be used:

- PACE seminar contacts
- AE faculty – Construction
- Colleagues
- Equipment Manufactures
- Turner Construction
- Subcontractors

Expected Outcome:

The expected outcomes from this analysis have additional costs upfront and possible training seminars to learn the technology. Using Latista during the construction processes will possibly increase the production and minimize site congestion. Lastly, using this technology may increase the schedule.

Analysis Weight Matrix:

Shown below in Table 1 is the weight matrix. This table represents how each analysis for all four focal points of investigation. The percentages illustrate the time and effort for each analysis.

Analysis Description:	Research	Value Engr.	Const. Rev.	Sched. Red.	Total
Green Roof Analysis	10%	10%	10%	5%	35%
Implement 3D coordination	10%	5%	-	10%	25%
Façade alterations	5%	10%	5%	5%	25%
Critical Industry Analysis	5%	-	5%	5%	15%
Total:	**30%**	**25%**	**20%**	**25%**	**100%**

Table 1 Weight Matrix

Timetable:

For the purpose to stay on schedule and meet thesis milestones, a preliminary spring semester timetable has been developed to represent the work progression for each technical analysis. For more information, refer to Appendix B of this report.

Conclusion:

The proposed technical analysis will provide a detailed review of improving the construction cost, schedule acceleration, future energy consumption savings, and increase the efficiency onsite. It is irrelevant that some of the analysis will cost more upfront, but researching each analysis will benefit the project and essentially buyback the original proposed solution. This proposal is a working submission and is expects feedback from thesis advisors for revisions.

Appendix A – Breadth Studies:

Breadth Topics:

The following topics involve a more detailed analysis from the disciplines within the Architectural engineering major. Each topic mentioned in this section relates to an analysis mentioned in the previous analysis, which are identified accordingly.

Acoustical Analysis (Analysis #4):

In an attempt to change the current concrete, EPDM roof to a green roof system, an acoustical analysis would need to be conducted for both systems to determine if the proposed analysis is adequate for the Data Center. If the calculations results in an undesirable sound leaking into the building, more research will be needed to determine a solution so the sound transmission are at acceptable levels.

Structural Analysis (Analysis #4): *- Alternate Breadth*

In an attempt to change the current concrete, EPDM roof to a green roof system, a structural analysis will need to be performed to determine if the structural system can carry the load of a green roof. Different size beams, columns, and steel deck may arise through the structural calculations that will be performed.

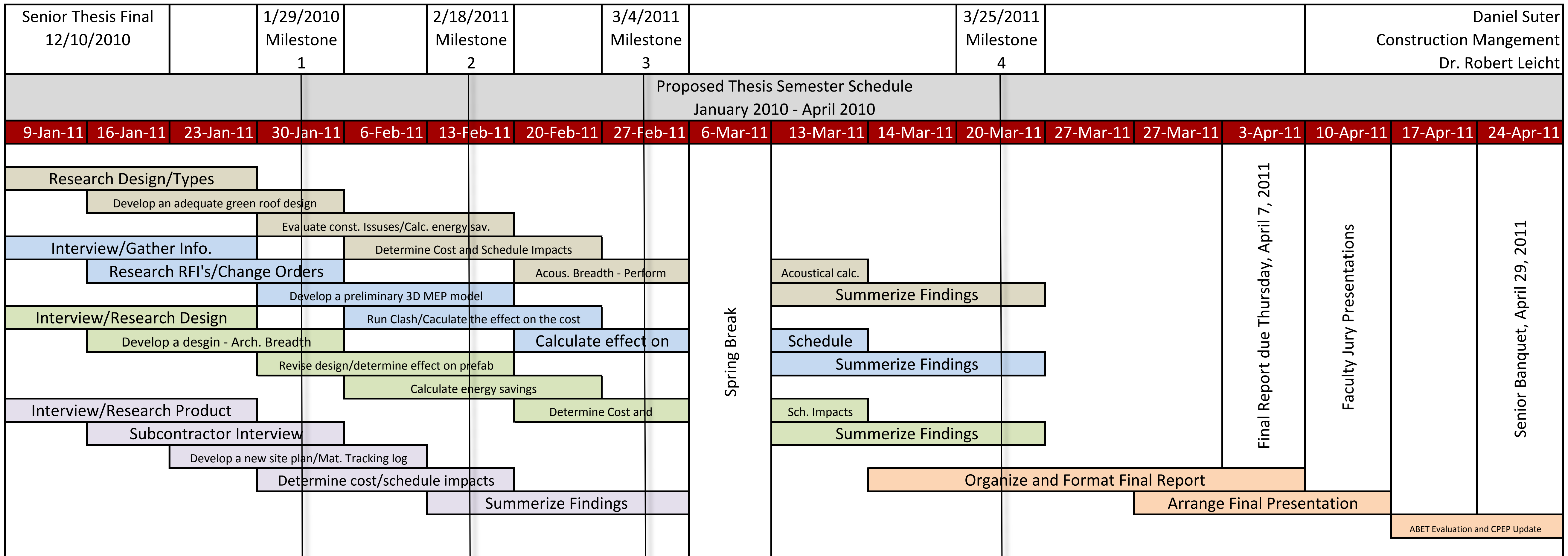
Architectural Analysis (Analysis #3):

Due to the proposed solution of changing the façade to having windows, an architectural analysis will be needed to determine optimal window placement for natural lighting in the building as well explore different types of windows for efficient construction.

Electrical/Lighting Analysis (Analysis #3): *- Alternate Breadth*

Since the Data Center did not include any windows in the new addition, a lighting/electrical analysis will need to be conducted to determine the amount of natural and artificial light needed to luminate the building. In addition, the lighting fixtures will need to be researched for any unnecessary energy output to luminate the Data Center.

Appendix B – Spring Semester Schedule:

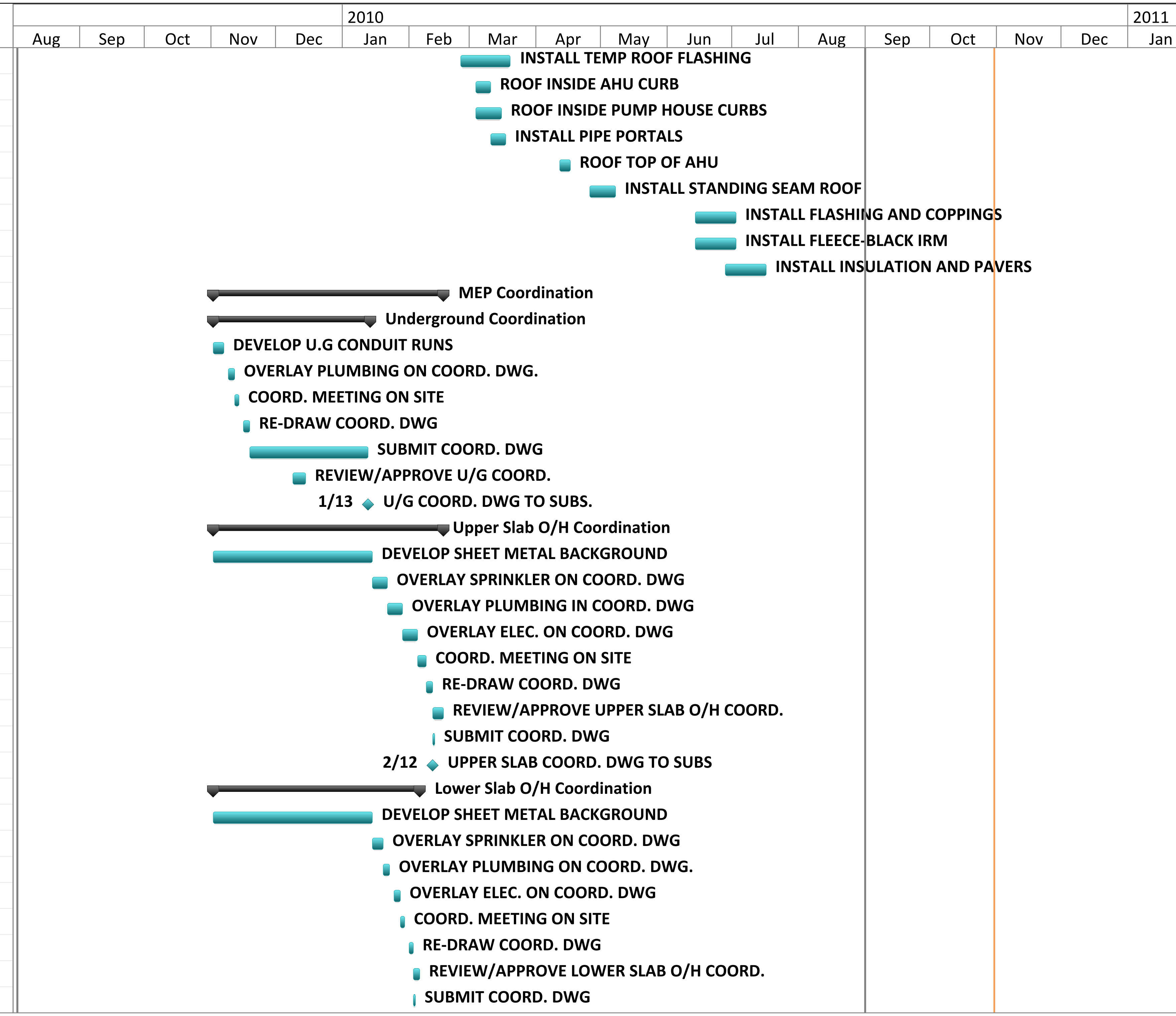


Milestones	
1	Gather the necessary information for analysis.
2	Preliminary designs for green roof and façade complete
3	Analysis 4 complete.
4	Start the final report and have all the analysis substantially complete

Analysis 1 - Green Roof Analysis
Analysis 2 - Implement 3D Coordination
Analysis 3 - Façade Alterations
Analysis 4 - Critical Industry Analysis - Implement Latista

Appendix C – Detailed Schedule of Coordination Meetings:

ID	Task Name	Duration	Start	Finish
38	INSTALL TEMP ROOF FLASHING	17 days	Thu 2/25/10	Fri 3/19/10
39	ROOF INSIDE AHU CURB	5 days	Thu 3/4/10	Wed 3/10/10
40	ROOF INSIDE PUMP HOUSE CURBS	8 days	Thu 3/4/10	Mon 3/15/10
41	INSTALL PIPE PORTALS	5 days	Thu 3/11/10	Wed 3/17/10
42	ROOF TOP OF AHU	5 days	Mon 4/12/10	Fri 4/16/10
43	INSTALL STANDING SEAM ROOF	10 days	Mon 4/26/10	Fri 5/7/10
44	INSTALL FLASHING AND COPPINGS	15 days	Mon 6/14/10	Fri 7/2/10
45	INSTALL FLEECE-BLACK IRM	15 days	Mon 6/14/10	Fri 7/2/10
46	INSTALL INSULATION AND PAVERS	15 days	Mon 6/28/10	Fri 7/16/10
47	**MEP Coordination**	**77 days**	**Mon 11/2/09**	**Tue 2/16/10**
48	**Underground Coordination**	**53 days**	**Mon 11/2/09**	**Wed 1/13/10**
49	DEVELOP U.G CONDUIT RUNS	5 days	Mon 11/2/09	Fri 11/6/09
50	OVERLAY PLUMBING ON COORD. DWG.	3 days	Mon 11/9/09	Wed 11/11/09
51	COORD. MEETING ON SITE	2 days	Thu 11/12/09	Fri 11/13/09
52	RE-DRAW COORD. DWG	3 days	Mon 11/16/09	Wed 11/18/09
53	SUBMIT COORD. DWG	39 days	Thu 11/19/09	Tue 1/12/10
54	REVIEW/APPROVE U/G COORD.	4 days	Wed 12/9/09	Mon 12/14/09
55	U/G COORD. DWG TO SUBS.	0 days	Wed 1/13/10	Wed 1/13/10
56	**Upper Slab O/H Coordination**	**77 days**	**Mon 11/2/09**	**Tue 2/16/10**
57	DEVELOP SHEET METAL BACKGROUND	54 days	Mon 11/2/09	Thu 1/14/10
58	OVERLAY SPRINKLER ON COORD. DWG	5 days	Fri 1/15/10	Thu 1/21/10
59	OVERLAY PLUMBING IN COORD. DWG	5 days	Fri 1/22/10	Thu 1/28/10
60	OVERLAY ELEC. ON COORD. DWG	5 days	Fri 1/29/10	Thu 2/4/10
61	COORD. MEETING ON SITE	2 days	Fri 2/5/10	Mon 2/8/10
62	RE-DRAW COORD. DWG	3 days	Tue 2/9/10	Thu 2/11/10
63	REVIEW/APPROVE UPPER SLAB O/H COORD.	3 days	Fri 2/12/10	Tue 2/16/10
64	SUBMIT COORD. DWG	1 day	Fri 2/12/10	Fri 2/12/10
65	UPPER SLAB COORD. DWG TO SUBS	0 days	Fri 2/12/10	Fri 2/12/10
66	**Lower Slab O/H Coordination**	**70 days**	**Mon 11/2/09**	**Fri 2/5/10**
67	DEVELOP SHEET METAL BACKGROUND	54 days	Mon 11/2/09	Thu 1/14/10
68	OVERLAY SPRINKLER ON COORD. DWG	3 days	Fri 1/15/10	Tue 1/19/10
69	OVERLAY PLUMBING ON COORD. DWG.	3 days	Wed 1/20/10	Fri 1/22/10
70	OVERLAY ELEC. ON COORD. DWG	3 days	Mon 1/25/10	Wed 1/27/10
71	COORD. MEETING ON SITE	2 days	Thu 1/28/10	Fri 1/29/10
72	RE-DRAW COORD. DWG	2 days	Mon 2/1/10	Tue 2/2/10
73	REVIEW/APPROVE LOWER SLAB O/H COORD.	3 days	Wed 2/3/10	Fri 2/5/10
74	SUBMIT COORD. DWG	1 day	Wed 2/3/10	Wed 2/3/10



Project: Detailed project schedule
Date: Sun 10/31/10

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

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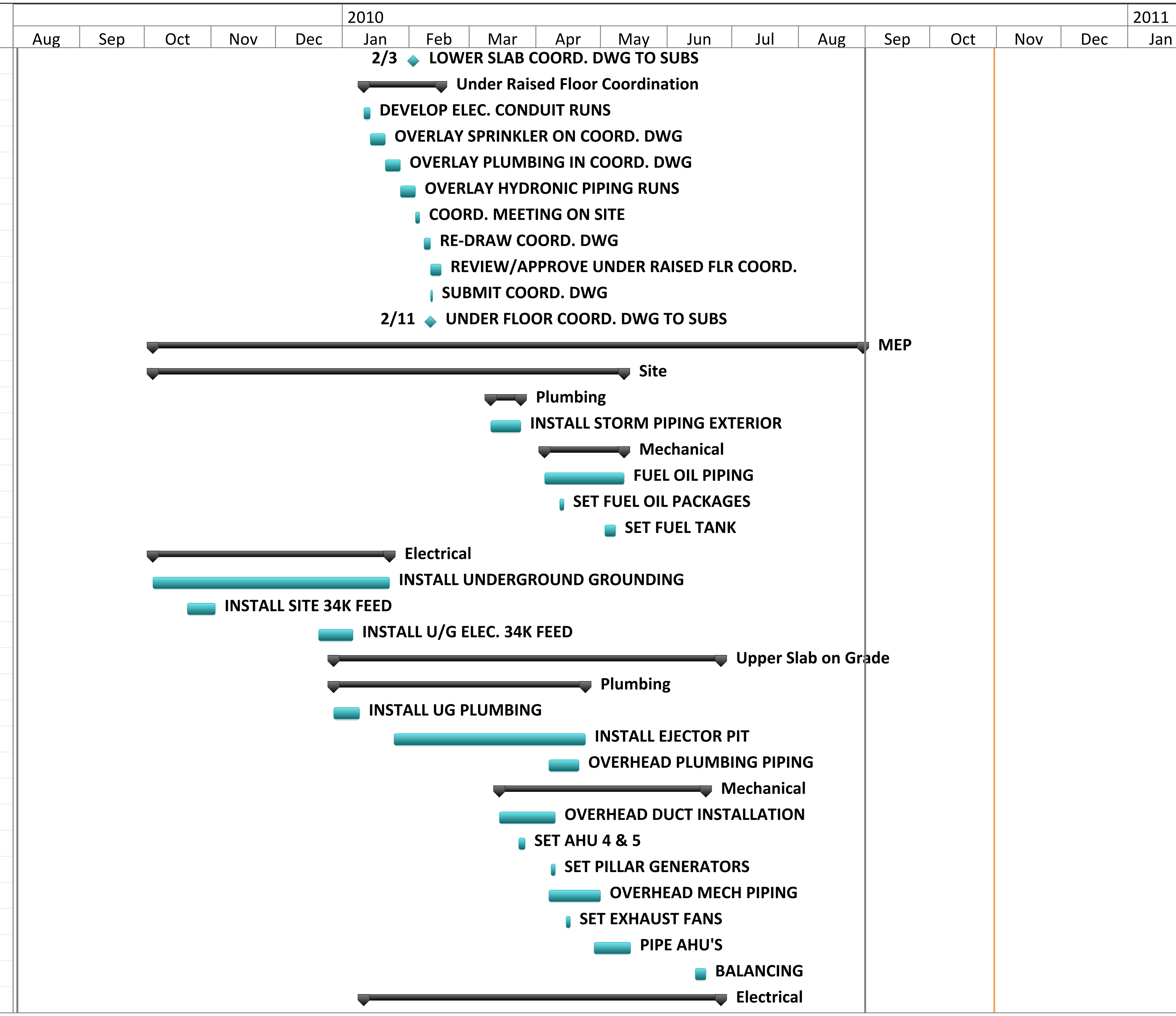
ID	Task Name	Duration	Start	Finish
75	LOWER SLAB COORD. DWG TO SUBS	0 days	Wed 2/3/10	Wed 2/3/10
76	**Under Raised Floor Coordination**	**26 days**	**Mon 1/11/10**	**Mon 2/15/10**
77	DEVELOP ELEC. CONDUIT RUNS	3 days	Mon 1/11/10	Wed 1/13/10
78	OVERLAY SPRINKLER ON COORD. DWG	5 days	Thu 1/14/10	Wed 1/20/10
79	OVERLAY PLUMBING IN COORD. DWG	5 days	Thu 1/21/10	Wed 1/27/10
80	OVERLAY HYDRONIC PIPING RUNS	5 days	Thu 1/28/10	Wed 2/3/10
81	COORD. MEETING ON SITE	2 days	Thu 2/4/10	Fri 2/5/10
82	RE-DRAW COORD. DWG	3 days	Mon 2/8/10	Wed 2/10/10
83	REVIEW/APPROVE UNDER RAISED FLR COORD.	3 days	Thu 2/11/10	Mon 2/15/10
84	SUBMIT COORD. DWG	1 day	Thu 2/11/10	Thu 2/11/10
85	UNDER FLOOR COORD. DWG TO SUBS	0 days	Thu 2/11/10	Thu 2/11/10
86	**MEP**	**236 days**	**Mon 10/5/09**	**Mon 8/30/10**
87	**Site**	**157 days**	**Mon 10/5/09**	**Tue 5/11/10**
88	**Plumbing**	**10 days**	**Thu 3/11/10**	**Wed 3/24/10**
89	INSTALL STORM PIPING EXTERIOR	10 days	Thu 3/11/10	Wed 3/24/10
90	**Mechanical**	**27 days**	**Mon 4/5/10**	**Tue 5/11/10**
91	FUEL OIL PIPING	27 days	Mon 4/5/10	Tue 5/11/10
92	SET FUEL OIL PACKAGES	2 days	Mon 4/12/10	Tue 4/13/10
93	SET FUEL TANK	5 days	Mon 5/3/10	Fri 5/7/10
94	**Electrical**	**80 days**	**Mon 10/5/09**	**Fri 1/22/10**
95	INSTALL UNDERGROUND GROUNDING	80 days	Mon 10/5/09	Fri 1/22/10
96	INSTALL SITE 34K FEED	9 days	Wed 10/21/09	Mon 11/2/09
97	INSTALL U/G ELEC. 34K FEED	12 days	Mon 12/21/09	Tue 1/5/10
98	**Upper Slab on Grade**	**130 days**	**Mon 12/28/09**	**Fri 6/25/10**
99	**Plumbing**	**85 days**	**Mon 12/28/09**	**Fri 4/23/10**
100	INSTALL UG PLUMBING	10 days	Mon 12/28/09	Fri 1/8/10
101	INSTALL EJECTOR PIT	65 days	Mon 1/25/10	Fri 4/23/10
102	OVERHEAD PLUMBING PIPING	10 days	Wed 4/7/10	Tue 4/20/10
103	**Mechanical**	**70 days**	**Mon 3/15/10**	**Fri 6/18/10**
104	OVERHEAD DUCT INSTALLATION	20 days	Mon 3/15/10	Fri 4/9/10
105	SET AHU 4 & 5	3 days	Wed 3/24/10	Fri 3/26/10
106	SET PILLAR GENERATORS	2 days	Thu 4/8/10	Fri 4/9/10
107	OVERHEAD MECH PIPING	18 days	Wed 4/7/10	Fri 4/30/10
108	SET EXHAUST FANS	2 days	Thu 4/15/10	Fri 4/16/10
109	PIPE AHU'S	13 days	Wed 4/28/10	Fri 5/14/10
110	BALANCING	5 days	Mon 6/14/10	Fri 6/18/10
111	**Electrical**	**120 days**	**Mon 1/11/10**	**Fri 6/25/10**



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