Contents

Below are symbols the Synthesis Construction Engineers will be utilizing throughout the report to illustrate how 3 main concepts (cost, schedule, and safety) are affected with regards to each report section.

Safer

Lifecycle Cost Decrease

Schedule Improvement

Appendix A: Decision Matrix

Decision Factors		
Criteria	**Wt.**	**1**
Aligns with Owner Philosophy	1	
Design Feasability	1	
Food Output/Energy Used	2	
Adaptability	3	
Initial Cost	4	
Synthesis	5	
Resource Reuse	6	
Emissions	6	
Lifecycle Cost	7	
Durability	8	
Maintenance	8	
Occupant Satisfaction/Functionality	8	
Ease of Constructability	9	
LEED Potential	10	
Weighted Score		**0**

Located above is an image of the original Decision Matrix developed by Synthesis for the Growing Power Headquarters project. It included 15 design criteria with a scoring of 1-10 for each criteria. The team soon realized this matrix was not efficient or providing a quick decision for the design process and a new matrix needed to be made.

Criteria	Definition
Learning Experience/Environment	A Synthesis goal of developing a building that encorages learning and provides an environment where one can learn efficiently.
Design Adaptability	A Synthesis goal of developing a building that can adapt to its location and the
Self Sustaining Ecosystem	A Synthesis goal of developing a building that can maintain its functionality within the building.
Lifecycle Cost	Cost of system throughout the life of the building/system.
Ease of Constructability	How difficult any system/end product is to construct with regards to its integration into the building.
Durability	How the product/system holds up over time.
Maintenance	Ease and frequency of maintenance for owner and staff.
LEED Potential	Areas in which LEED points could possibly be earned.

Synthesis developed a Weighted Decision Matrix to verify the selections the team was making were in line with the project goals as well as Growing Power. The matrix uses a simple point system multiplied by the designated criteria weighting to calculate a score for the decision factor. The updated matrix was used for the remainder of the design process. To the left is a table of descriptions to help clarify the design criteria. Each factor is given a separate rating of either "1" for a positive impact, "0" for zero impact, or "-1" for a negative impact for each decision criteria. A decision is made by comparing the proposed alternative factor's weighted score to the existing factor's weighted score, and therefore the higher score is selected.

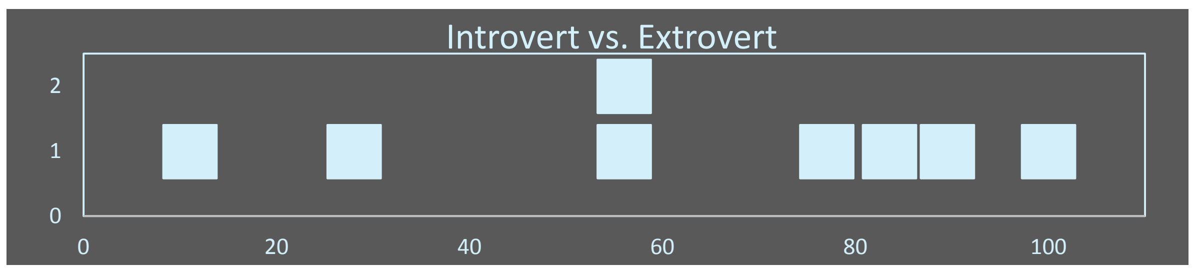
Decision	Reasoning
New Building Layout	This layout aligned more with the systems the design team was wanting to implement in the building.
Raised Floor System with UFAD	The selected system allows for a more efficient air distribution system that is also more adaptable.
Steel Structure	A steel structure can be constructed quicker, allow more natural light into the greenhouses, and adapted to different scenarios.
Modular Greenhouse System	Modular greenhouses allow for Growing Power to be able to more easily expand or retract the building in the future to adapt to other conditions they would like.
Natural HVAC System	This system is more efficient and assists in creating a self-sustaining ecosystem within the building.
Modular Façade	A modular façade allows for a quicker construction and for adaptations similar to the Modular Greenhouse System.
Polypavement	Polypavement is an environment-friendly substitute to asphalt that aligns more with the goals of Growing Power and Synthesis.
GeoPiers with Footings System	The selected system provides a solution to the soil conditions that allows the foundation system to adapt to them rather than attempt to counteract these conditions.

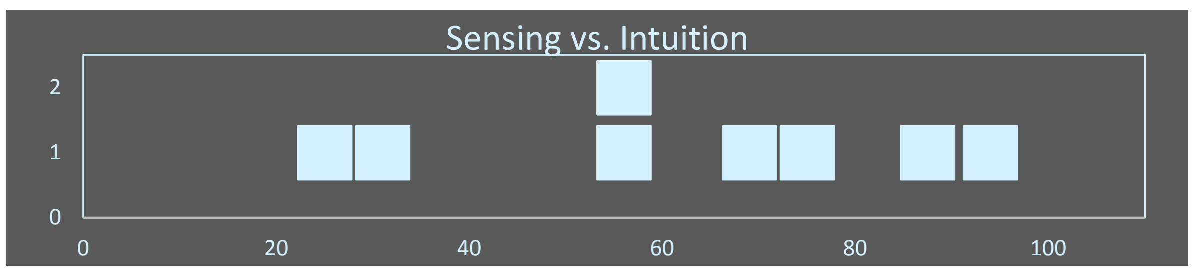
Decision Factors		**New Building Layout**	**Existing Building Layout**	**Raised Floor System with UFAD**	**Traditional Floor and Air Distribution System**	**Concrete Structure**	**Steel Structure**	**Natural HVAC System**	**Traditional HVAC System**	**Modular Greenhouse System**	**Non-Modular Greenhouse System**	**Modular Façade**	**Non-Modular Façade**	**Asphalt Paving**	**Polypavement**	**GeoPiers with Footings System**	**Mat Foundation Slab**
Criteria	**Wt.**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Learning Experience/Environment	5.0	1	0	1	0	0	1	1	-1	1	0	0	1	0	1	0	0
Design Adaptability	5.0	1	0	1	0	-1	1	1	0	1	-1	1	-1	0	0	1	-1
Self Sustaining Ecosystem	5.0	1	1	1	0	0	0	1	-1	0	0	0	0	0	1	1	0
Lifecycle Cost	4.0	0	0	1	-1	0	1	1	-1	0	0	0	0	0	0	1	0
Ease of Constructability	3.0	1	-1	0	1	-1	1	1	-1	1	-1	1	-1	0	-1	-1	-1
Durability	2.0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
Maintenance	2.0	0	0	-1	0	0	0	0	0	0	0	0	0			0	0
LEED Potential	1.0	0	0	1	0	0	0	1	0	0	0	0	0	0	1	0	0
Weighted Scores		**18**	2	**18**	1	-6	**19**	**23**	-17	**13**	-8	**8**	-3	0	**8**	**11**	-8

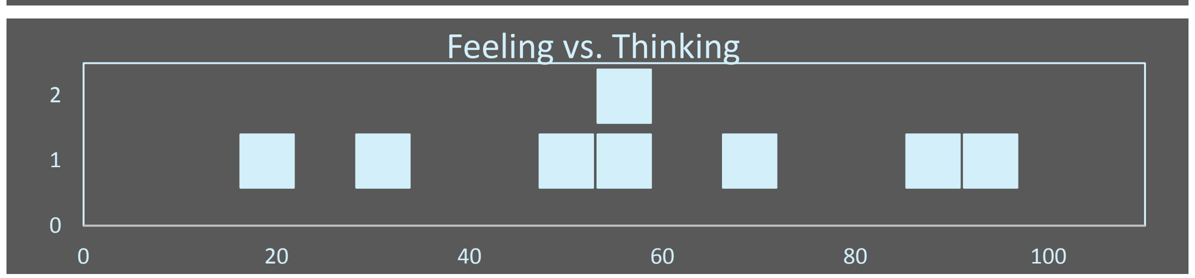
Appendix B: Team Personality Analysis

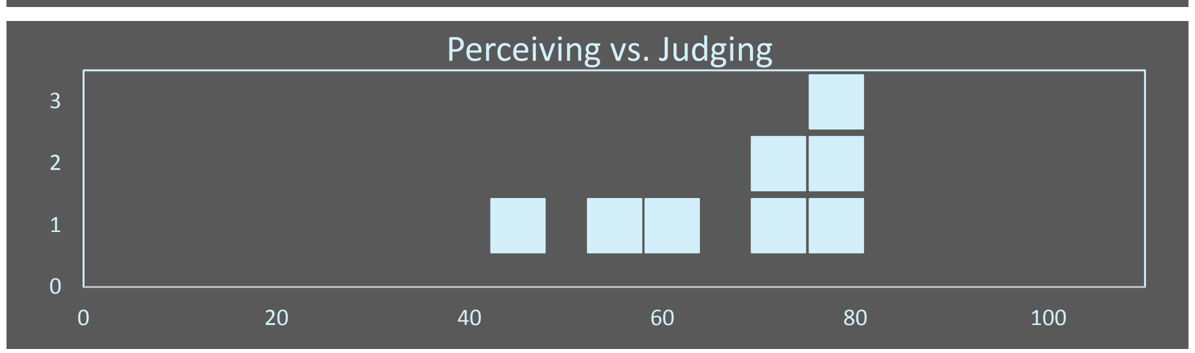
Key Terms:

Advisor – Each has an area of insight that the other lacks
Cohort – Mutually drawn to new experiences
Companion – similar nodes of expression: bear each other's company well
Complement – compatible strengths, but with opposite emphasis
Contrast – can offer a point and counterpoint discussion
Counterpart – perform similar roles in different ways
Enigma – a puzzle: totally foreign in nearly every facet
Neighbor – arrive at the same conclusion by different methods or thought processes
Novelty – intriguingly different: interestingly so
Pal – work and play well together; minimal conflict
Suitemate – each can add to the other's strengths
Tribesman – share a sense of culture, but with different interests and abilities
*All text above on this page came from www.keirsey.com/4temps/overview_temperaments.asp

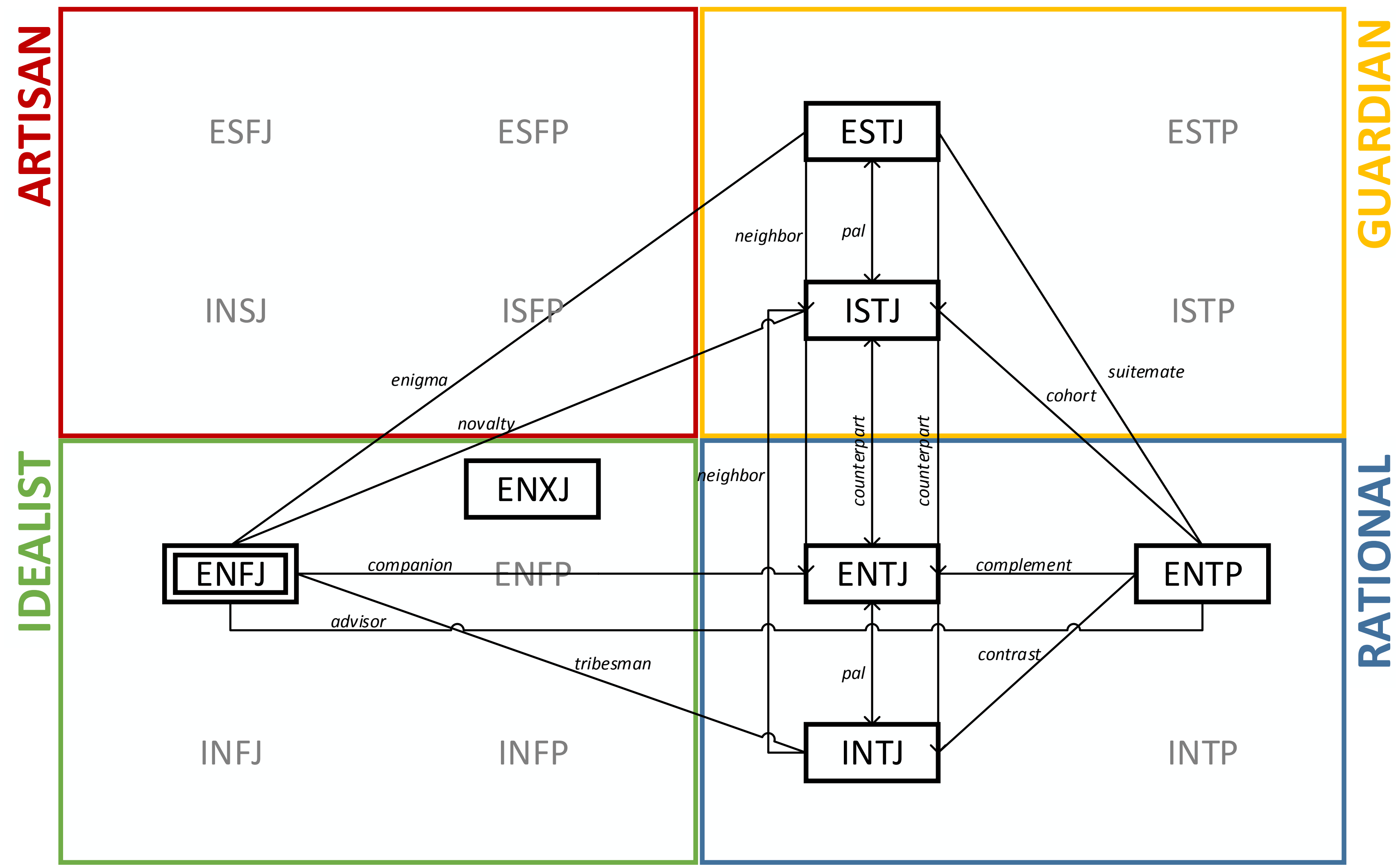








This analysis has been completed in order to understand the members of the team and how they would interact with each other. This also provided the construction engineers with managerial tactics for each group member so that an efficient and healthy work environment could be maintained throughout the process. The illustration of the team personalities and their interaction is meant to show clearly the Synthesis team chemistry and the group culture.



As Concrete Cooperators, **Guardians** speak mostly of their duties and responsibilities, of what they can keep an eye on and take good care of, and they're careful to obey the laws, follow the rules, and respect the rights of others.

As Abstract Cooperators, **Idealists** speak mostly of what they hope for and imagine might be possible for people, and they want to act in good conscience, always trying to reach their goals without compromising their personal code of ethics.

As Concrete Utilitarians, **Artisans** speak mostly about what they see right in front of them, about what they can get their hands on, and they will do whatever works, whatever gives them a quick, effective payoff, even if they have to bend the rules.

As Abstract Utilitarians, **Rationals** speak mostly of what new problems intrigue them and what new solutions they envision, and always pragmatic, they act as efficiently as possible to achieve their objectives, ignoring arbitrary rules and conventions if need be.

*All text above came from www.keirsey.com/4temps/overview_temperaments.asp

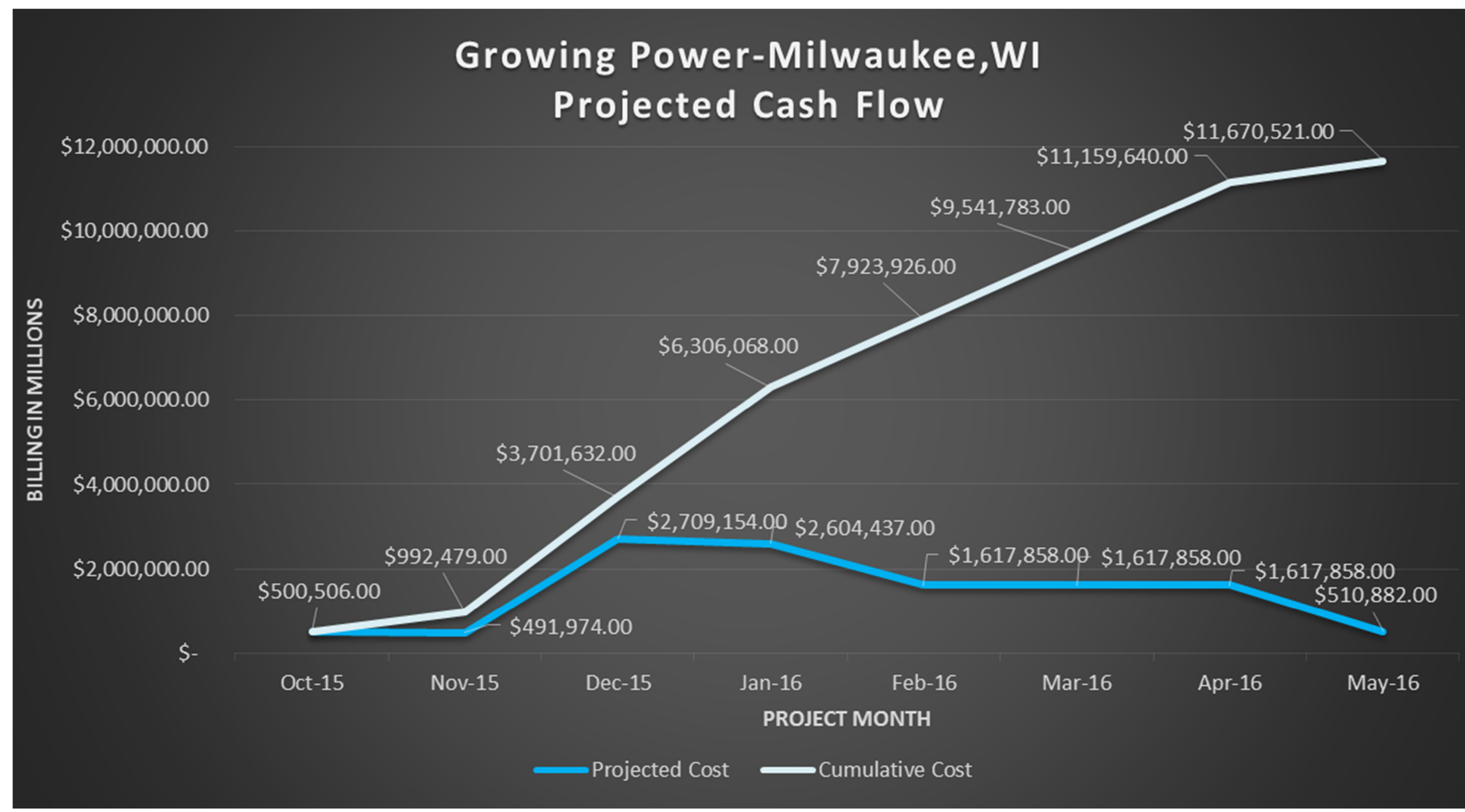
Appendix C: Cash Flow

Synthesis

Growing Power Headquarters													
Activity Code	System	Start Date	End Date	Contract Value	September	October	November	December	January	February	March	April	May
DS-1	Substructure	1-Sep-15	1-Dec-15	$ 779,989.00	$ -	$ 311,995.60	$ 311,995.60	$ 155,997.80	$ -	$ -	$ -	$ -	$ -
DS-2	Shell	1-Nov-15	1-Jan-16	$ 2,031,599.00	$ -	$ -	$ -	$ 1,523,699.25	$ 507,899.75	$ -	$ -	$ -	$ -
DS-3	Interiors	1-Nov-15	1-Apr-16	$ 2,530,201.00	$ -	$ -	$ -	$ -	$ 632,550.25	$ 632,550.25	$ 632,550.25	$ 632,550.25	$ -
DS-4	MEP	1-Nov-15	1-Apr-16	$ 3,412,117.00	$ -	$ -	$ -	$ 409,454.04	$ 750,665.74	$ 750,665.74	$ 750,665.74	$ 750,665.74	$ -
DS-5	Equipment & Furnishings	1-Nov-15	1-Jan-16	$ 367,590.00	$ -	$ -	$ -	$ 242,590.00	$ 125,000.00	$ -	$ -	$ -	$ -
DS-6	Special Construction			$ 887,577.00	$ -	$ -	$ -	$ 443,788.50	$ 443,788.50	$ -	$ -	$ -	$ -
DS-7	Building Sitework	1-Sep-15	1-May-16	$ 18,960.00	$ -	$ 9,480.00	$ -	$ -	$ -	$ -	$ -	$ -	$ 9,480.00
	Fee	1-Nov-15	1-May-16	$ 350,982.00	$ -	$ 50,140.29	$ 50,140.29	$ 50,140.29	$ 50,140.29	$ 50,140.29	$ 50,140.29	$ 50,140.29	$ -
	Direct Subtotal	1-Sep-15		$ 10,028,033.00	$ -	$ 321,475.60	$ 311,995.60	$ 2,775,529.59	$ 2,459,904.24	$ 1,383,215.99	$ 1,383,215.99	$ 1,383,215.99	$ 9,480.00
0001	General Conditions/Markups	1-Sep-15		$ 689,823.00	$ -	$ 98,546.14	$ 98,546.14	$ 98,546.14	$ 98,546.14	$ 98,546.14	$ 98,546.14	$ 98,546.14	$ -
0002	Owner Contingency	1-Sep-15		$ 100,281.00	$ -	$ 14,325.86	$ 14,325.86	$ 14,325.86	$ 14,325.86	$ 14,325.86	$ 14,325.86	$ 14,325.86	$ -
0003	Synthesis Contingency	1-Sep-15		$ 501,402.00	$ -	$ 71,628.86	$ 71,628.86	$ 71,628.86	$ 71,628.86	$ 71,628.86	$ 71,628.86	$ 71,628.86	$ -
				Monthly Total	$ -	$ 556,116.74	$ 546,636.74	$ 3,010,170.73	$ 2,694,545.38	$ 1,617,857.13	$ 1,617,857.13	$ 1,617,857.13	$ 9,480.00
				Cumulative Total	$ -	$ 556,116.74	$ 1,102,753.49	$ 4,112,924.22	$ 6,807,469.60	$ 8,425,326.73	$ 10,043,183.87	$ 11,661,041.00	$ 11,670,521.00
				Retainage	$ -	$ 55,611.67	$ 54,663.67	$ 301,017.07	$ 90,109.23	$ -	$ -	$ -	$ -
				Cumulative Retainage	$ -	$ 55,611.67	$ 110,275.35	$ 411,292.42	$ 501,401.65	$ 501,401.65	$ 501,401.65	$ 501,401.65	$ 501,401.65
				Payment Request	$ -	$ 500,505.07	$ 491,973.07	$ 2,709,153.66	$ 2,604,436.15	$ 1,617,857.13	$ 1,617,857.13	$ 1,617,857.13	$ 510,881.65
				Cumulative Received	$ -	$ 500,505.07	$ 992,478.14	$ 3,701,631.80	$ 6,306,067.95	$ 7,923,925.08	$ 9,541,782.22	$ 11,159,639.35	$ 11,670,521.00

Assumptions:

- Costs distributed evenly over a pay period
- Retainage of 10% for 50% of the contract value(or 5% of total contract value)
- Billing date is the first day of each month
- Payment terms are 30 days after date of billing

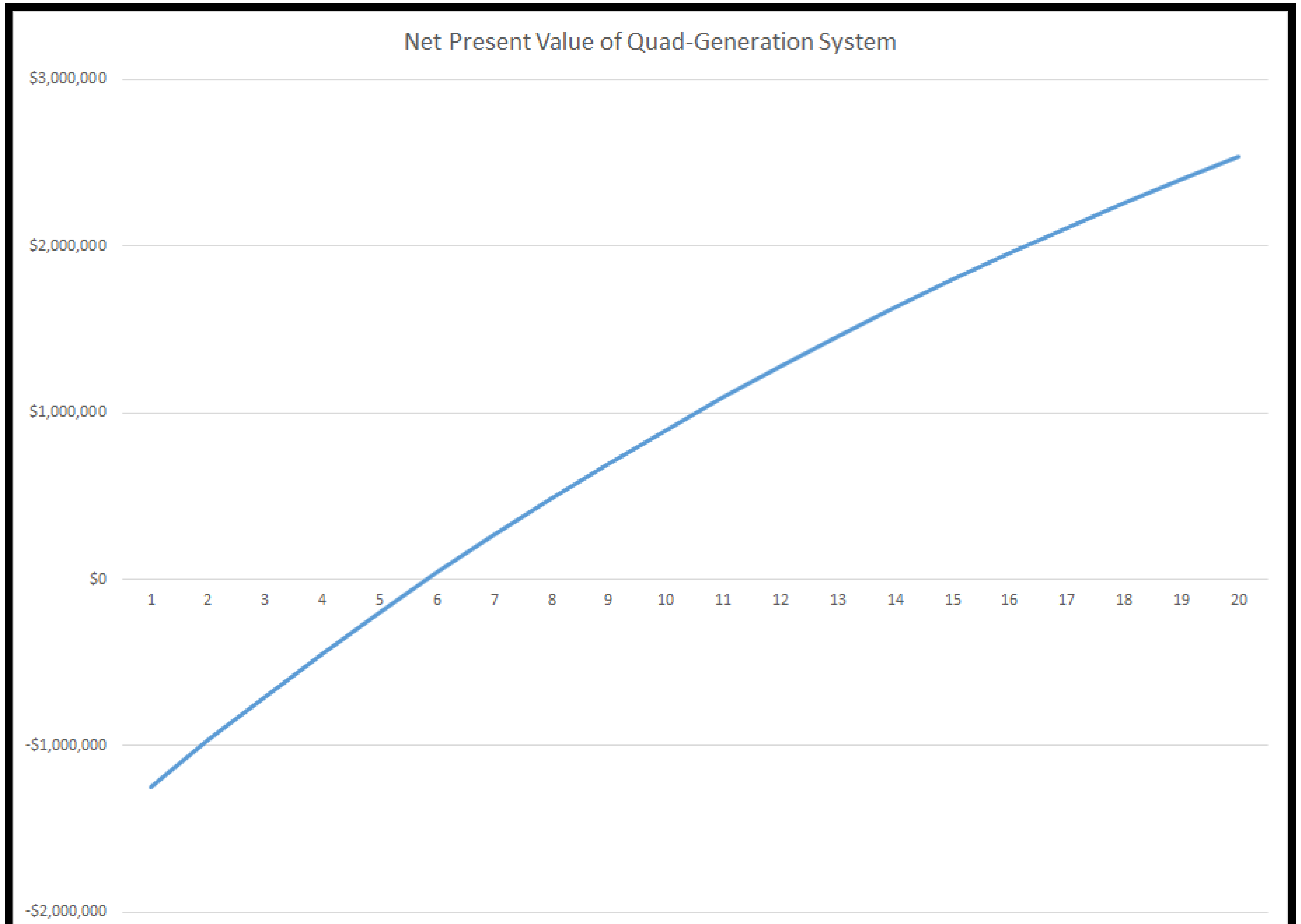


Focus on Energy	
Mechanical	$2,000
Lighting	$6,500
Kitchen Appliances	Out of Synthesis Scope, if Growing Power chooses Energy Star Appliances, incentives can be received.
Total	Between $8,500-$10,000

Item	First Cost
Anaerobic Digester and Related E(	$1,000,000
Biogas Pretreatment	$165,000
Microturbine	$333,000
Exhaust Gas Heat Exchanger	$14,390
Oxidation & SCR Catalysts	$4,000
CO_2 Piping	$15,400
CO & NOx Sensors	$408
Total:	**$1,532,198**

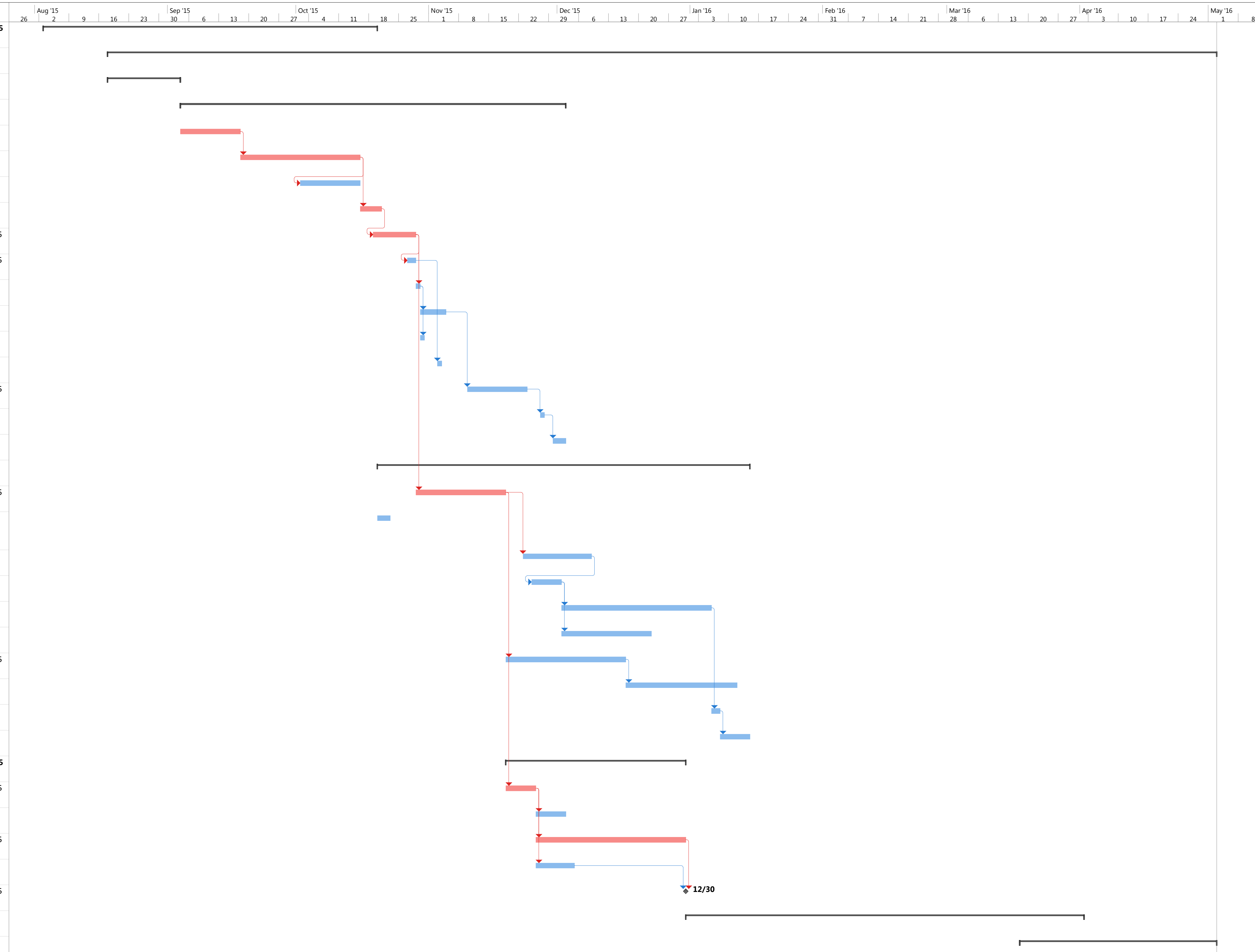
Annual Profits and Expenses		Unit	Rate	Cost
Offset Grid Electrical Usage	1,641,959	kW	$0.12	$197,035
Electricity Sold To Grid	132,041	kW	$0.04	$5,282
Natural Gas Reduction (Baseline -	19,270	Therms	$0.60	$11,562
Solid Fertilizer	730	Yards	$65.00	$47,450
40% Increase in Crop Production	*based on $5/SF/year of greenhouse profit*			$22,456
Tipping Fees	4,599	Tons	$10.00	$45,990
Operations & Maintenance	*3% of total digester cost*			-$30,000
Total:				**$299,775**

Years	Net Cash Flow	Net Present Value
0	-	-$1,532,198
1	$299,774.00	-$1,243,954
2	$299,774.00	-$966,796
3	$299,774.00	-$700,298
4	$299,774.00	-$444,050
5	$299,774.00	-$197,657
6	$299,774.00	$39,258
7	$299,774.00	$267,062
8	$299,774.00	$486,104
9	$299,774.00	$696,721
10	$299,774.00	$899,238
11	$299,774.00	$1,093,965
12	$299,774.00	$1,281,203
13	$299,774.00	$1,461,240
14	$299,774.00	$1,634,352
15	$299,774.00	$1,800,805
16	$299,774.00	$1,960,857
17	$299,774.00	$2,114,753
18	$299,774.00	$2,262,730
19	$299,774.00	$2,405,016
20	$299,774.00	$2,541,828



Total Investment	$ 1,532,198.00
First Year Utility Savings	$ 299,774.72
First Year Return on Investment	20%
Simple Payback Period (Years)	5.11
Assumed Escalation Rate	4%
Initial Investment	$ 1,532,198.00

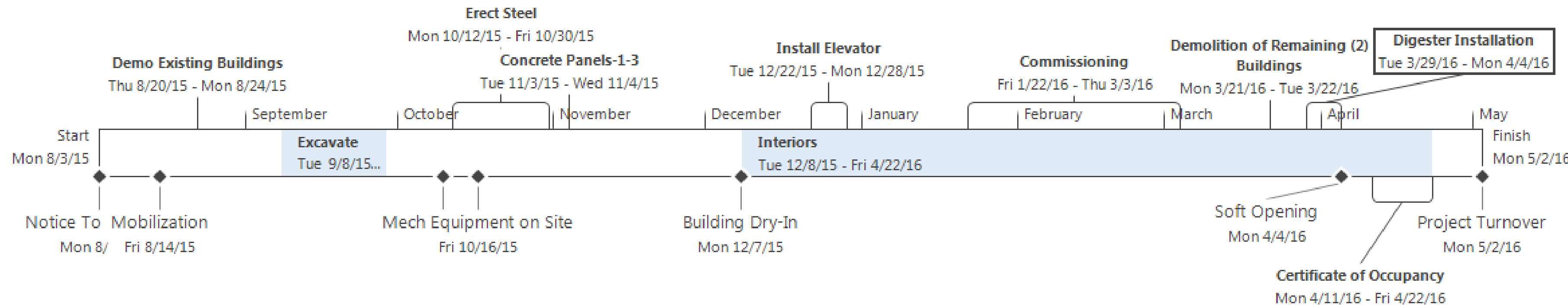
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Project Start-Up**	**56 days**	**Mon 8/3/15**	**Mon 10/19/15**
12		**Construction**	**185 days**	**Mon 8/17/15**	**Mon 5/2/16**
13		**Site Preperation**	**13 days**	**Mon 8/17/15**	**Thu 9/3/15**
18		**Substructure**	**64 days**	**Fri 9/4/15**	**Wed 12/2/15**
19		Install Sheet Piles	10 days	Fri 9/4/15	Thu 9/17/15
20		Excavate	20 days	Fri 9/18/15	Thu 10/15/15
21		Dewater Site	10 days	Fri 10/2/15	Thu 10/15/15
22		Install Geopiers	3 days	Fri 10/16/15	Tue 10/20/15
23		FRP Footings	8 days	Mon 10/19/15	Wed 10/28/15
24		FRP Sump Tub	2 days	Tue 10/27/15	Wed 10/28/15
25		Install Gravel Fill	1 day	Thu 10/29/15	Thu 10/29/15
26		FRP Basement Slab	4 days	Fri 10/30/15	Wed 11/4/15
27		Install Corrugated Pipe	1 day	Fri 10/30/15	Fri 10/30/15
28		Install Sump Pump	1 day	Tue 11/3/15	Tue 11/3/15
29		FRP Foundation Walls	10 days	Tue 11/10/15	Mon 11/23/15
30		Backfill/Compact	1 day	Fri 11/27/15	Fri 11/27/15
31		Remove Sheet Piling	3 days	Mon 11/30/15	Wed 12/2/15
32		**Superstructure**	**63 days**	**Tue 10/20/15**	**Thu 1/14/16**
33		Erect Steel	15 days	Thu 10/29/15	Wed 11/18/15
34		Install Mech Equipment in Basement	3 days	Tue 10/20/15	Thu 10/22/15
35		Erect Elevated Decks	12 days	Mon 11/23/15	Tue 12/8/15
36		Install Fall Protection/Toeboards	5 days	Wed 11/25/15	Tue 12/1/15
37		Erect CMU Cores	25 days	Wed 12/2/15	Tue 1/5/16
38		FRP Concrete on Decks	15 days	Wed 12/2/15	Tue 12/22/15
39		Erect CMU-Chimneys	20 days	Thu 11/19/15	Wed 12/16/15
40		Clad Chimneys	18 days	Thu 12/17/15	Mon 1/11/16
41		Erect Roof of Core	2 days	Wed 1/6/16	Thu 1/7/16
42		Install Elevator	5 days	Fri 1/8/16	Thu 1/14/16
43		**Façade**	**30 days**	**Thu 11/19/15**	**Wed 12/30/15**
44		Concrete Panels-1-3	5 days	Thu 11/19/15	Wed 11/25/15
45		Concrete Panels- 3-5	5 days	Thu 11/26/15	Wed 12/2/15
46		Install Polycarb GH Exterior	25 days	Thu 11/26/15	Wed 12/30/15
47		Window Install	7 days	Thu 11/26/15	Fri 12/4/15
48		Building Dry-In	0 days	Wed 12/30/15	Wed 12/30/15
49		**Interiors**	**67 days**	**Thu 12/31/15**	**Fri 4/1/16**
100		**Final Site Components**	**32 days**	**Fri 3/18/16**	**Mon 5/2/16**



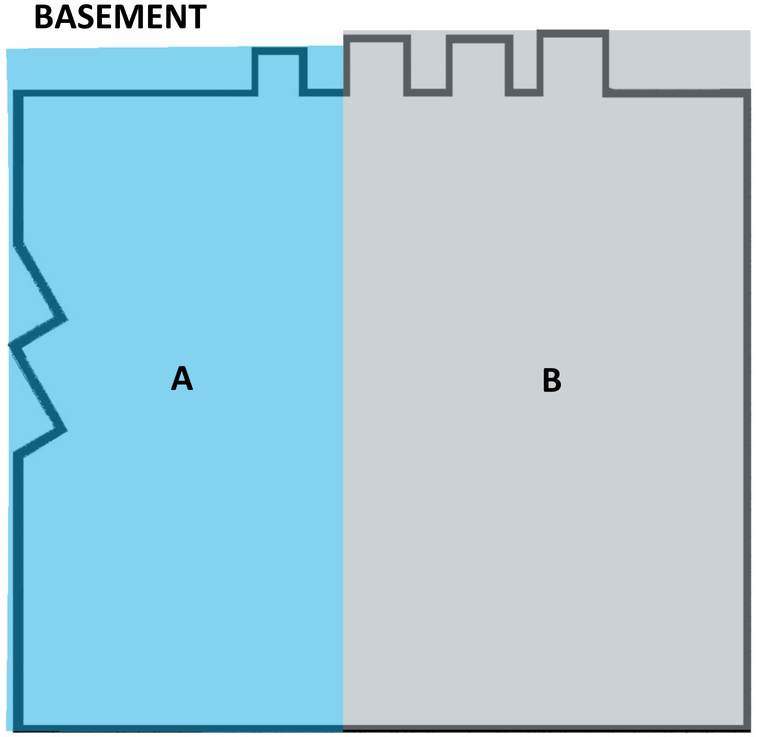
Project: Summarized Report

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

Page 1



BASEMENT



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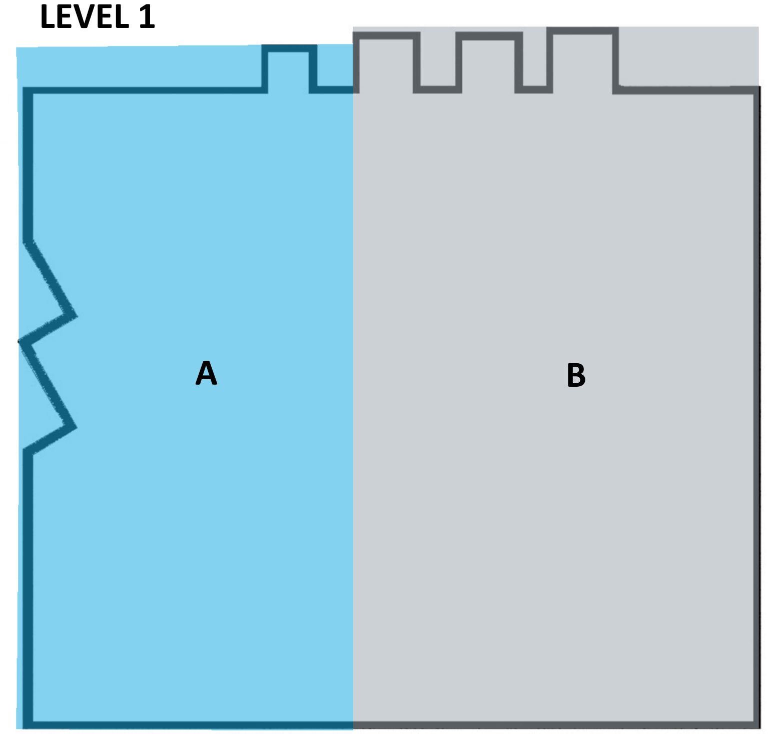

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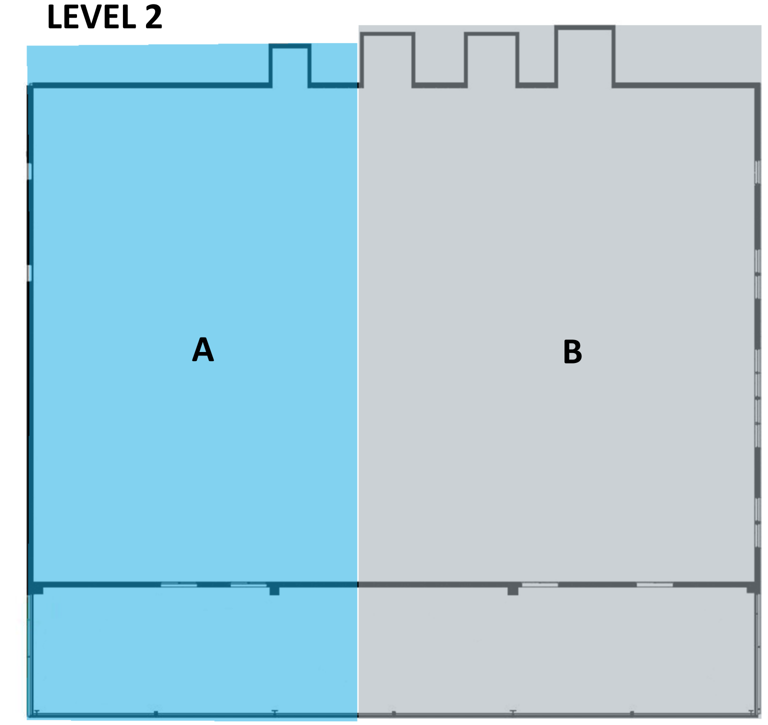

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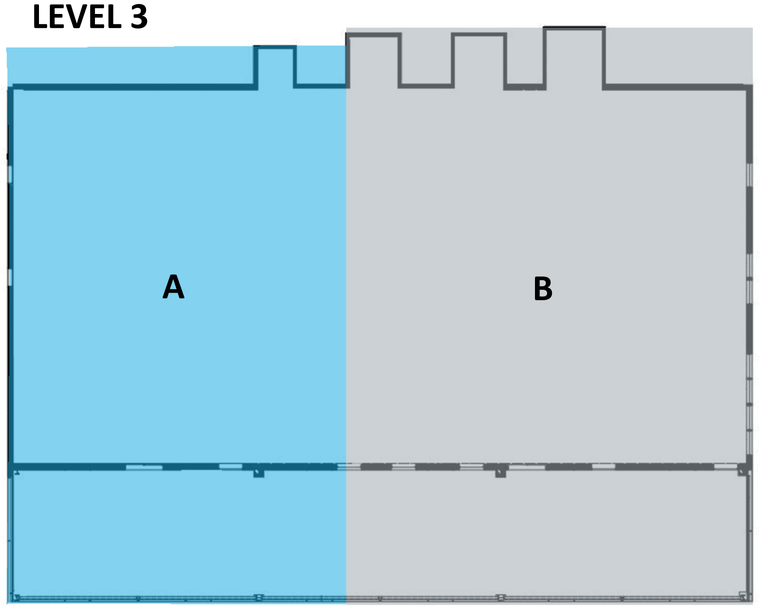

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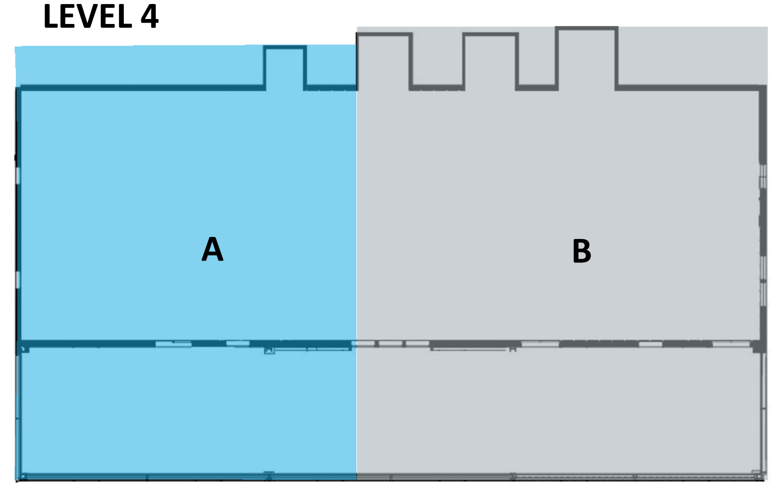

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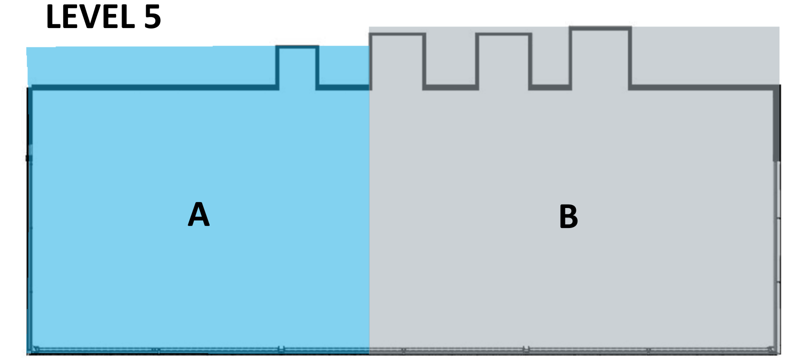
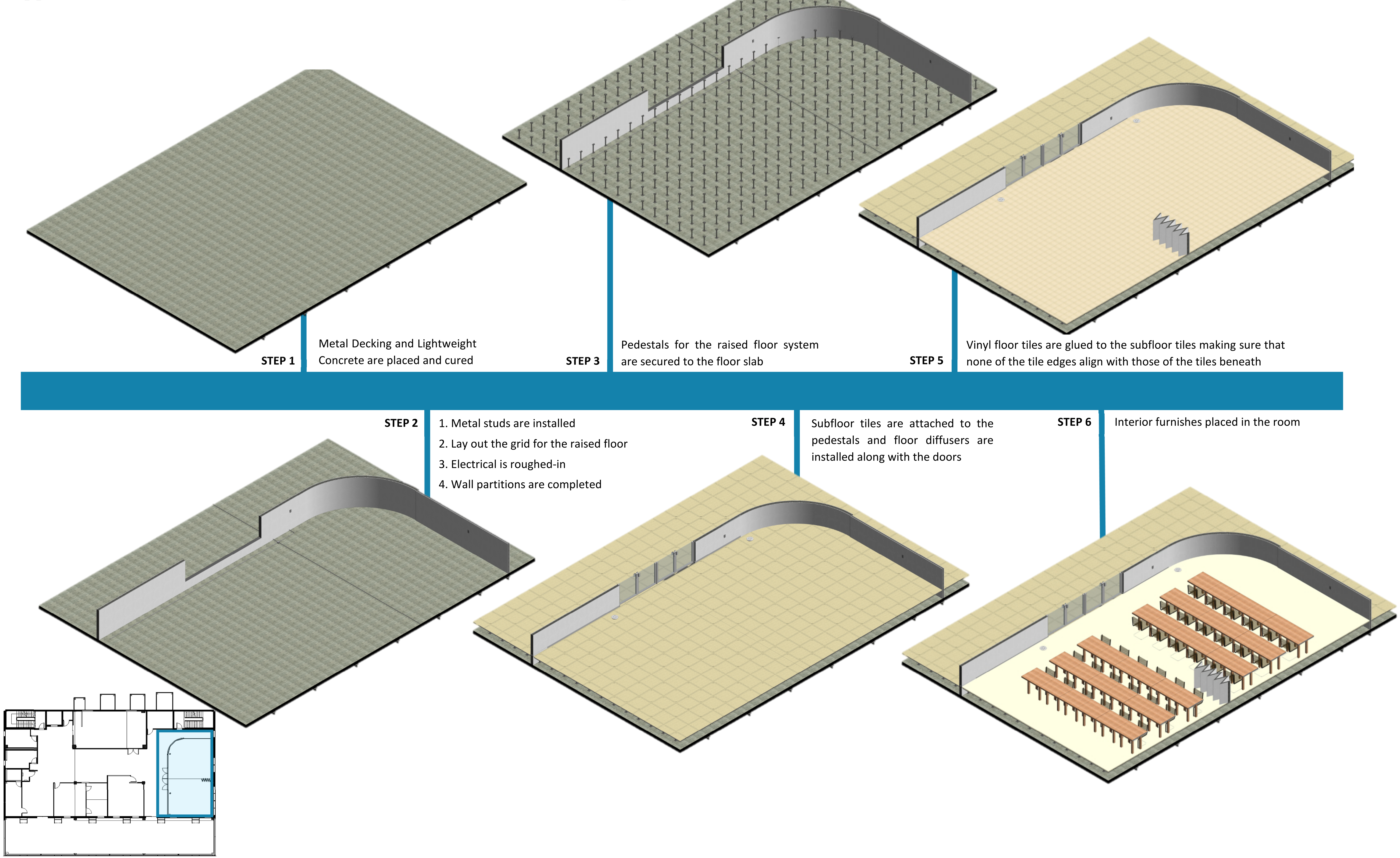
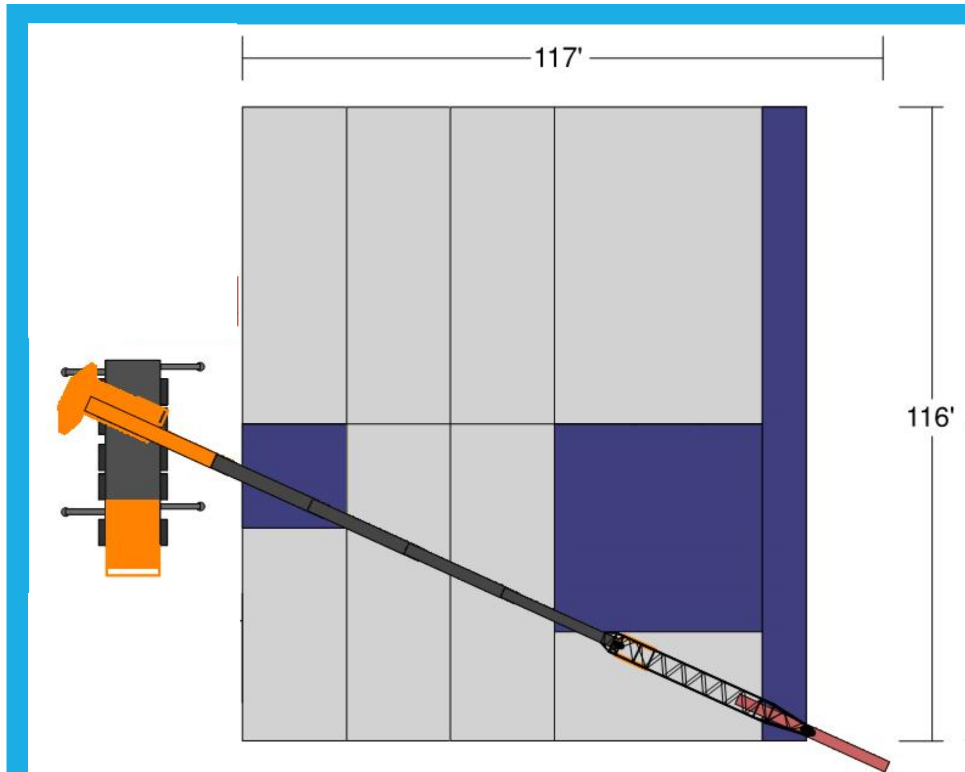


Sequencing during the superstructure construction process will consist of the steel erection beginning first in the Basement in the area labelled “A”, then once completed, the corrugated metal decking will be installed in this area while the steel begins in area B in the basement. This process will continue on each level until complete. This coordination will create a more efficient process and minimize the trades working on top of each other by keeping each in their own respective areas and creating a safer environment altogether. .

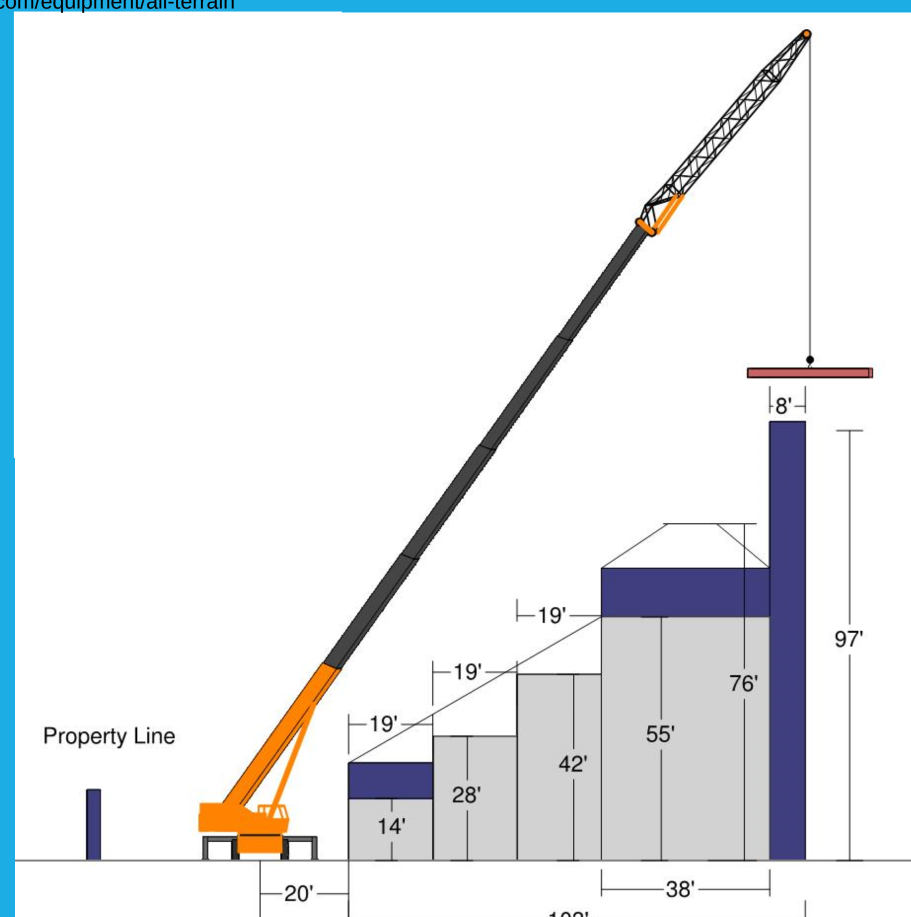
Synthesis
Engineering for Architecture



Appendix H: Crane Analysis



http://aquickpickcrane.com/equipment/all-terrain



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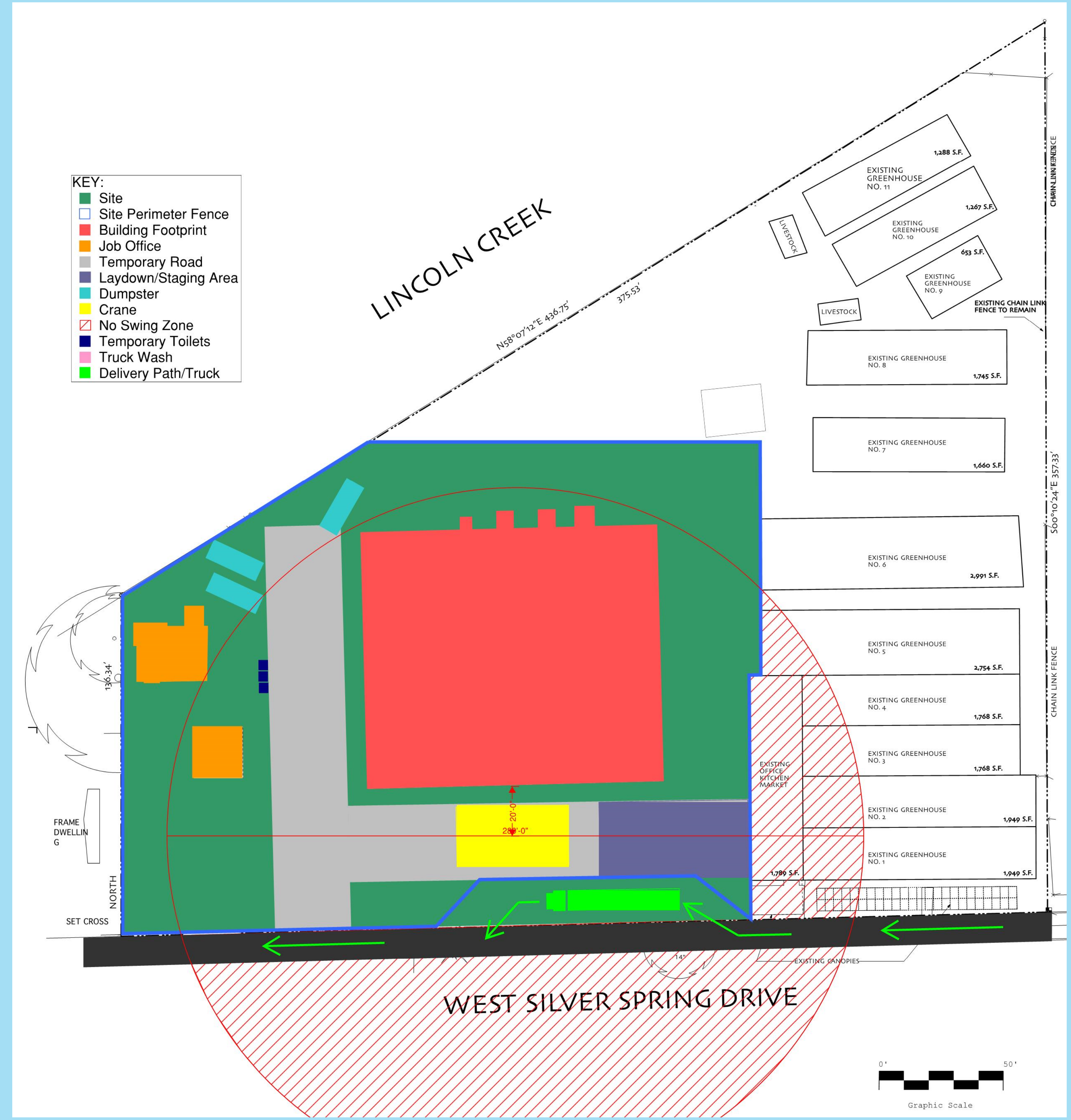
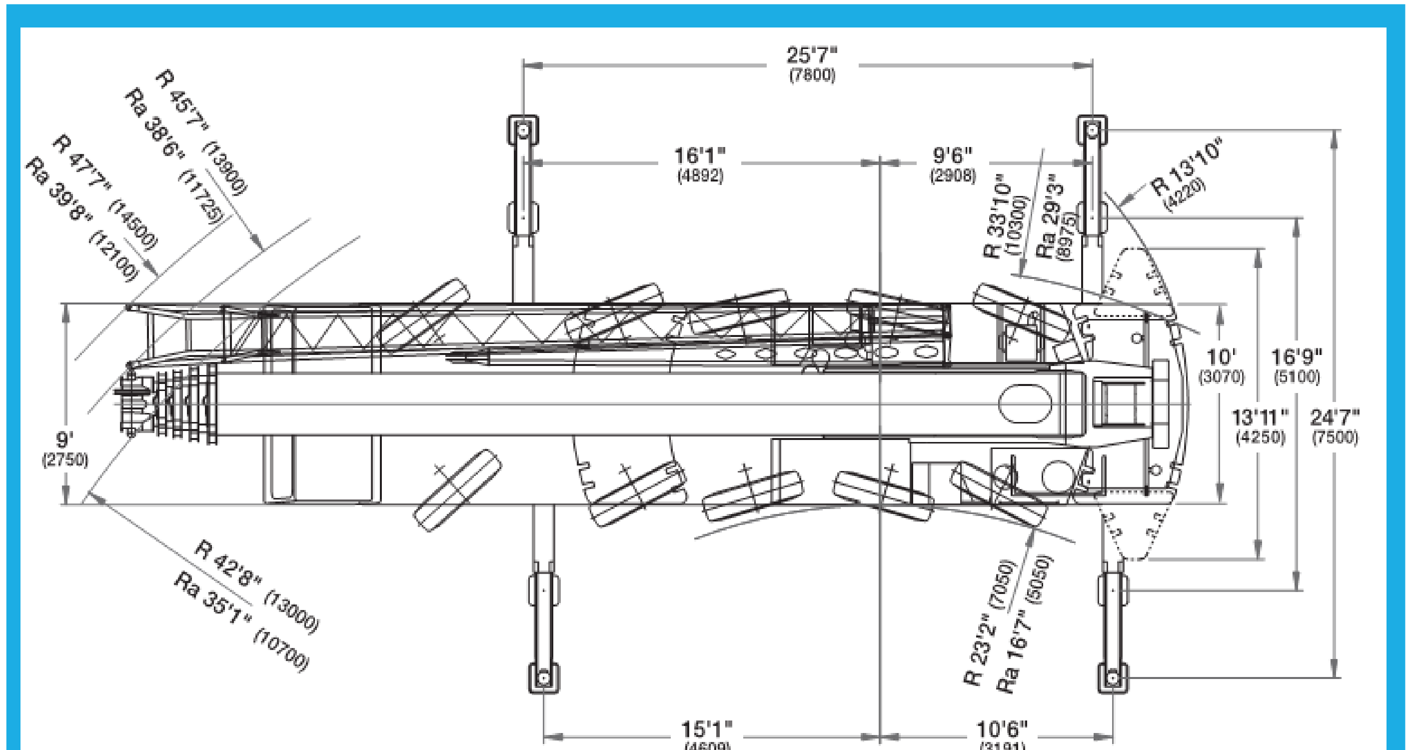
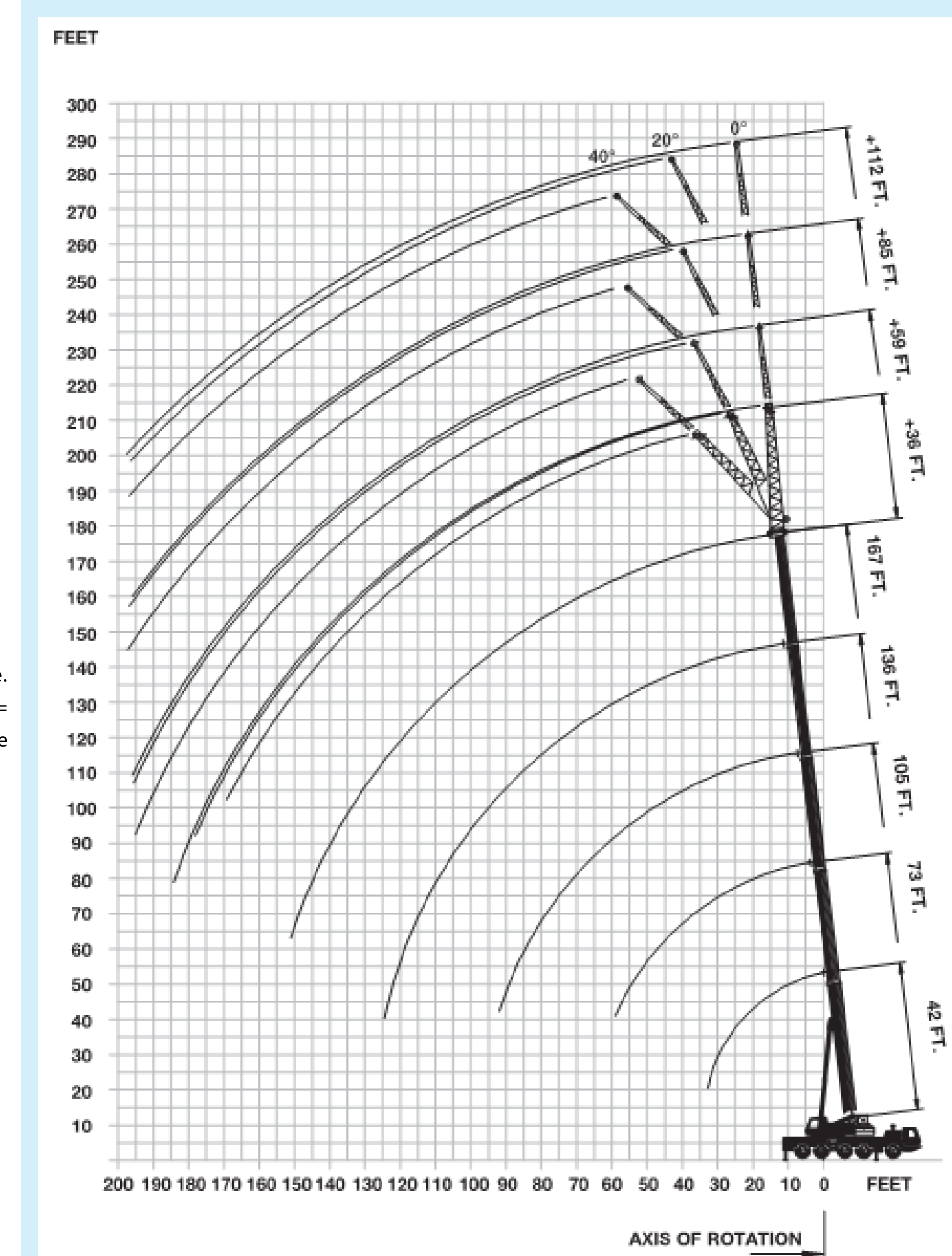


In order to reach and safely lift all material and equipment on the Growing Power site, the Construction Engineers have determined that a 120 ton GMK 5120 B All Terrain Crane with 167' of Main Boom, 59' Hydraulically Offsettable Jib and 68,300 lbs of counterweight, or equivalent All Terrain Crane to perform the following:140' maximum load radius to hoist a maximum suspended load of 7,800 lbs per attached boom geometry is what is required to complete the work. The information shown below illustrates some key features of the crane and its loading restrictions.



http://aquickpickcrane.com/equipment/all-terrain



http://aquickpickcrane.com/equipment/all-terrain

In addition to the crane load calculations it was determined that the maximum pressure exerted by one outrigger would be a 105,200 lbs reaction force. Using this and an allowable bearing pressure of 1,500 psf, the area of dunnage required under each outrigger was determined. Utilizing the formula: $\frac{P}{A} = Bearing\ Capacity$, it was determined that approximately 71sf of dunnage area would be required under each outrigger. It is also important to note that once this crane is brought to site and placed, it will not be moved during its time on the Growing Power site.

****The following exceprt is taken from OSHA 3433-05 2011 SECTION 1402 – GROUND CONDITIONS to show the Synthesis team has awareness of their due diligence with regards to the crane on site.**

"IMPORTANCE OF GROUND CONDITIONS: Adequate ground conditions are essential for safe crane operations because the crane's capacity and stability depend on such conditions being present. If, for example, the ground is muddy or otherwise unstable, a crane could overturn even if operated with the load limits specified by the manufacturer.

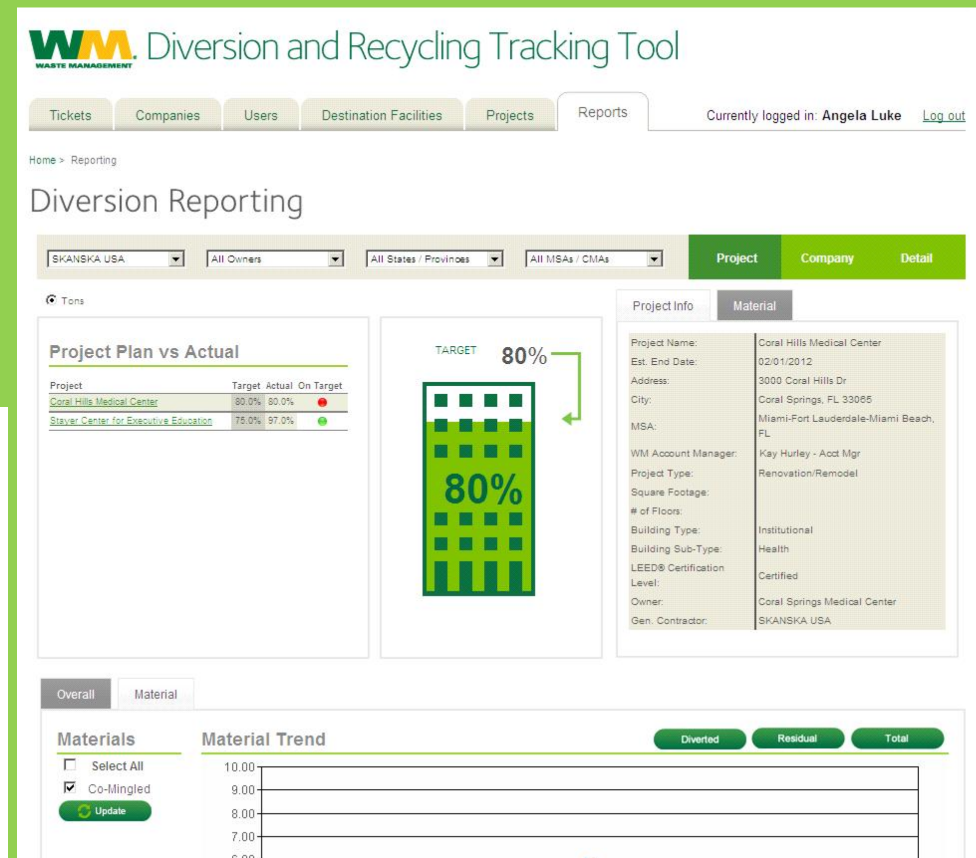
BASIC RULE: You must not assemble or use a crane unless ground conditions are firm, drained, and graded to a sufficient extent so that, in conjunction (if necessary) with the use of supporting materials (such as blocking, mats, cribbing, or marsh buggies (in marshes/wetlands)), the equipment manufacturer's specifications for adequate support and degree of level of the equipment are met. The requirement for the ground to be drained does not apply to marshes/wetlands.

RESPONSIBILITIES OF CONTROLLING ENTITY: A contractor operating a crane on a construction site may not have the ability or authority to provide for adequate ground conditions at the site. The standard therefore places the responsibility for ensuring that the ground conditions are adequate on the "controlling entity" at the site, that is the prime contractor, general contractor, construction manager, or other legal entity with overall responsibility for the project's planning, quality, and completion.

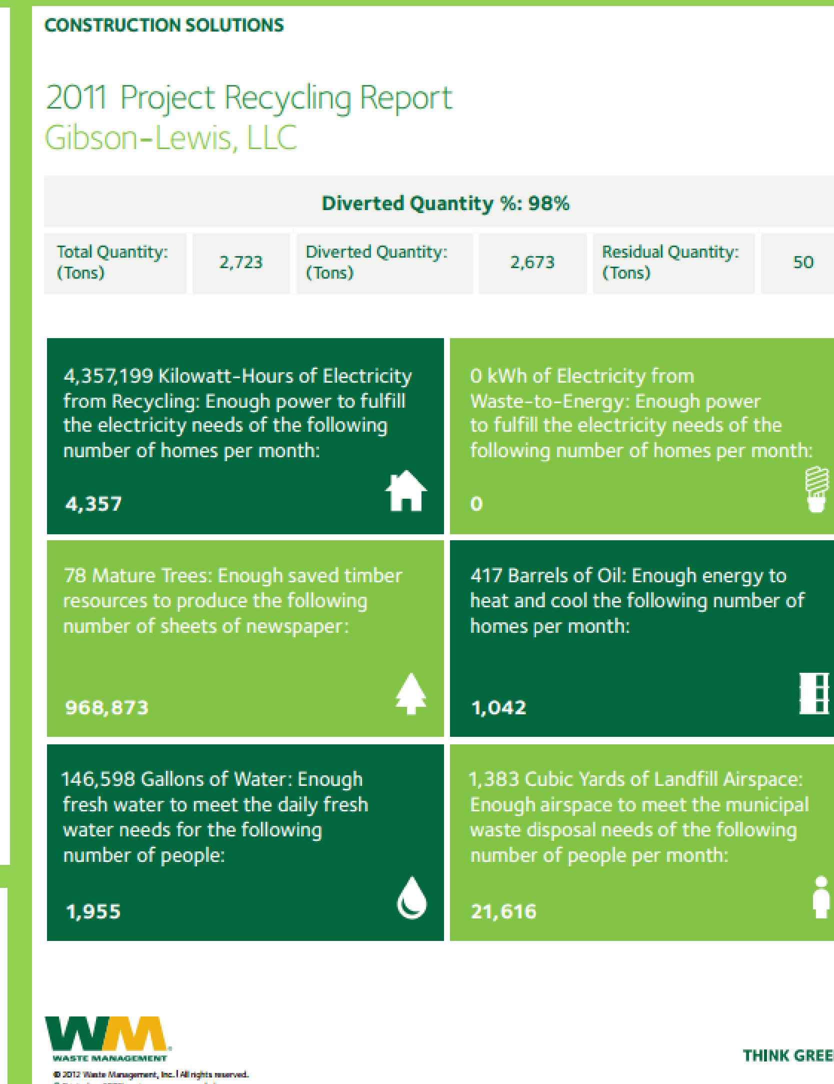
The controlling entity must also inform the user and operator of the equipment of hazards beneath the equipment set-up area (such as voids, tanks, utilities) if those hazards are identified in documents (such as site drawings, as-built drawings, and soil analyses) in the possession of the controlling entity (whether at the site or off-site) and of any other hazards known to the controlling entity."

Appendix I: Waste Management & Natural Materials Analysis

The first image on the left is an example of the Waste Management Dashboard where all the site-specific data will be accessible to the Project Team. From here, "green facts" – similar to those shown in the example on the far left – can be obtained for the project thus far. As stated previously in the report, these statistics can be translated into charts and graphs to be displayed for the public, site tour participants, Growing Power, and the construction workers. DART allows the Project Team to easily develop the graphics so that they can focus on the project but still be able to educate everyone about the work they are doing. This software will assist in spreading the word about Growing Power's new headquarters, and hopefully intrigue them to visit during and after the building is completed.



https://www.wm.com/documents/Executive-dashboard.JPG



https://www.wm.com/documents/Green-Facts.pdf

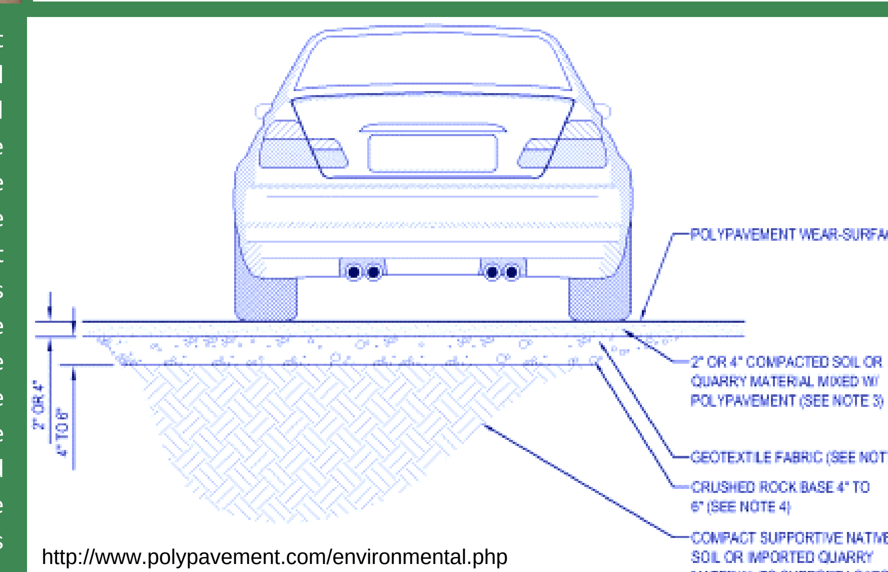
PolyPavement™ The Natural Soil Pavement

The Application Process:

1. Site soil is tested for Soil Solidifier requirements
   a. If needed, other soil types are added
2. Soil is placed on top of the subgrade and compacted until desired elevation is reached
3. Soil is tilled to the depth of treatment required
4. Diluted PolyPavement is evenly applied to the soil via a sprayer
5. Soil is tilled again to properly mix the PolyPavement and soil
6. Re-compact the soil with a roller
7. Spray-apply the diluted PolyPavement
8. Let soil dry and cure

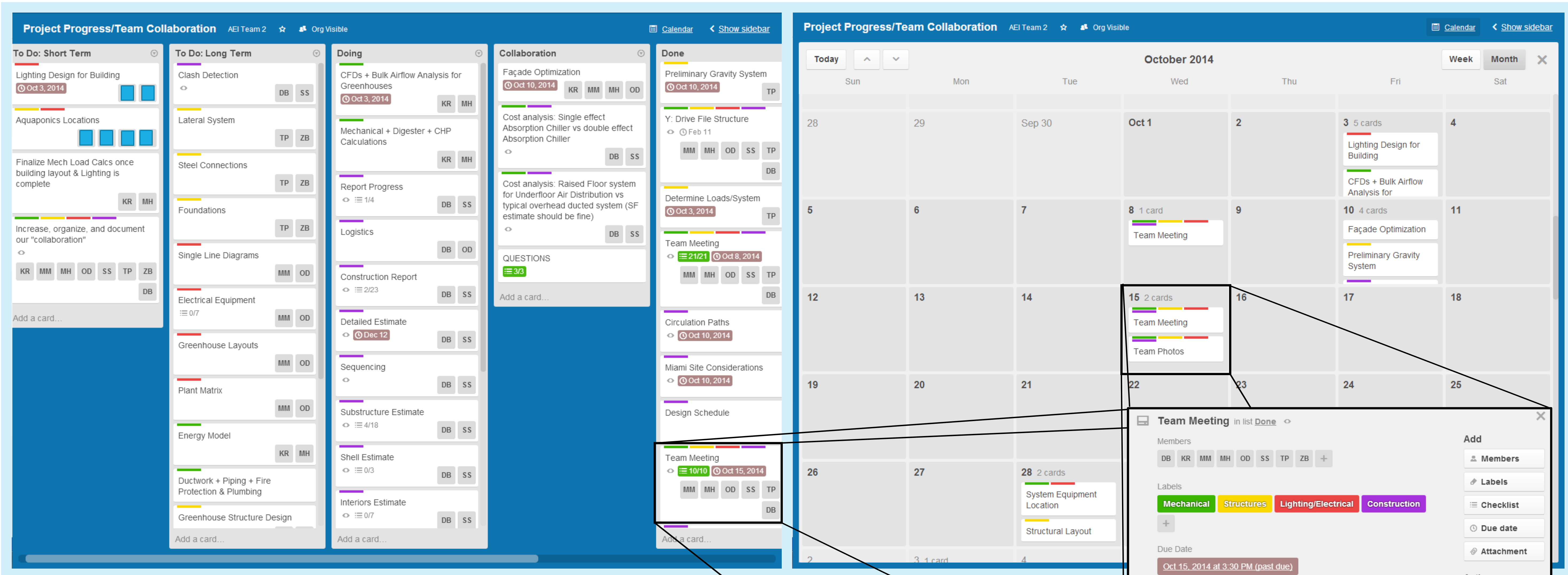
http://www.polypavement.com/environmental.php

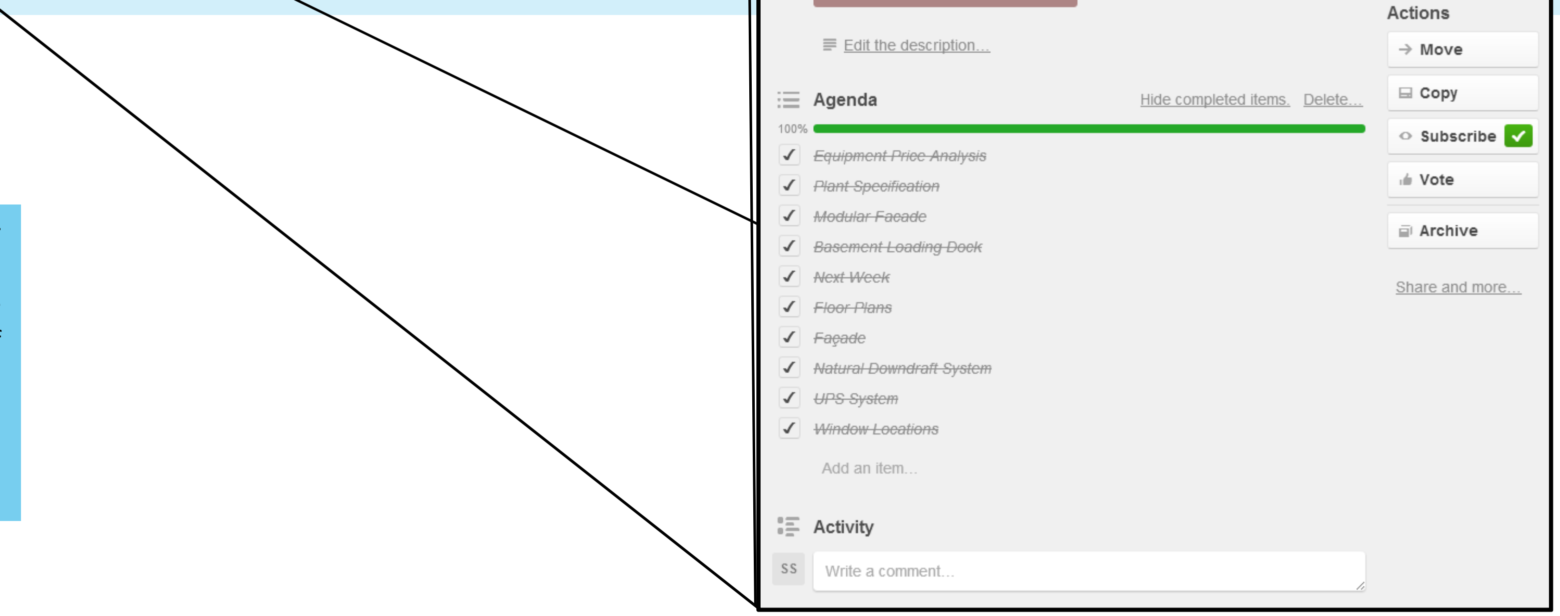
PolyPavement is a LEED compliant non-toxic mixture that can be used in place of concrete or asphalt in many cases; for example, service roads, driveways, parking lots, landing strips, and storage yards. The soil solidifier mixture can also prevent against dust, vegetation, and erosion. Similar to asphalt and concrete parking areas, sloping for drainage will be important in making the PolyPavement last longer. According to PolyPavement, the surface can last 5-10 years without needing maintenance or repairs, but some maintenance should be performed more often. Factors that determine its surface life include the treatment of the surface during the initial application, the amount of wear it will undergo, the particle hardness of the soil used, and the weather conditions. Due to trucks needing access to the building, a "Toughening Coat" will be applied to the paved area. This coat is prefer by PolyPavement to give it additional resistance to wear, which are being accounted for with the loading/unloading of large trucks. The soil that is currently on site will be tested by the company to see if it can be used as is with the PolyPavement mixture. If it is not found suitable, other soil types will be added to the existing. Soils that have worked best with the additive are those that naturally exist and contain a proper amount of fines. Fines are important because they minimize voids and provide more contact points between all the soil particles. In a cool climate like Milwaukee, there will be a concern of freeze/thaw. Under these conditions, the Polypavement will continue to act like untampered soil: it will expand and contract as the temperature changes without the need for expansion joints. When the surface is in need of repairs, more of the Soil Solidifier is applied. This means that, unlike asphalt, it will never need to be removed or replaced. One benefit associated with this is that the cost associated with repairs is much cheaper than the initial application cost; therefore, instead of needing to pay for the removal and replacement of an asphalt lot, Growing Power will pay a fraction of the initial cost of PolyPavement to have a new fully-functioning paving area. Proper drainage can positively impact the surface life. Synthesis is specifying for the coarse aggregate and geofabric used for vehicular traffic on site during construction, will remain to become a subgrade for the Polypavement. While the Soil Solidifier is water resistant similar to asphalt, a good subgrade is important in areas like the Growing Power site because of the high water table and the possibility of moisture in the soil. Along with the subgrade, the paved area is sloped to allow any surface water to be removed quickly. Before the paving area can be used, the PolyPavement must complete a two-stage process: dry and cure. The first allows the moisture to evaporate out of the soil mixture, while the curing allows the soil solidifier to fully degrade. The time it takes for the mixture to dry is dependent on the weather conditions, but will take no longer than a day. The mixture takes around 30 days to cure, but this process could be quicker with sunlight and daylight.



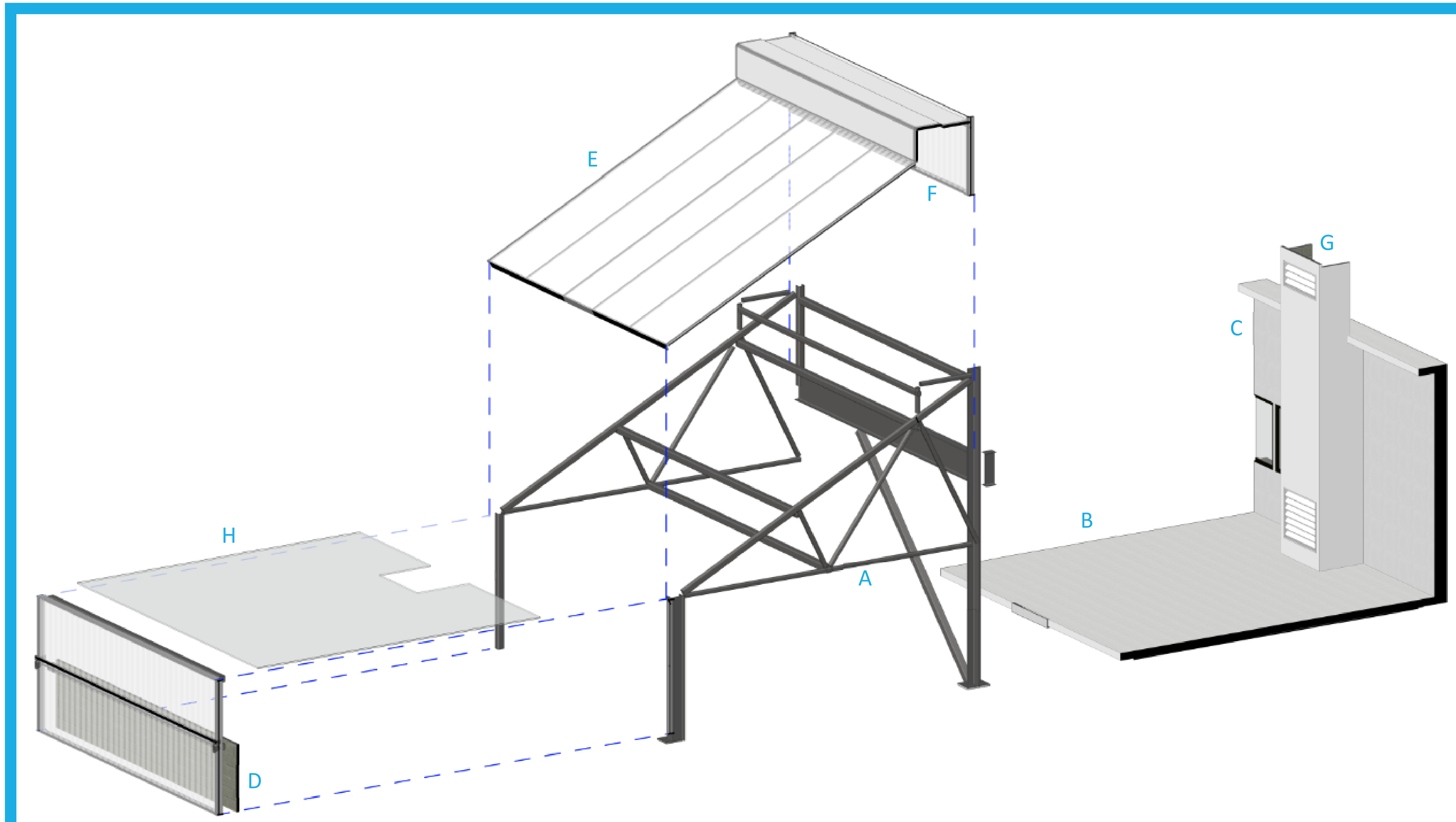
http://www.polypavement.com/environmental.php

Appendix J: Collaboration through Trello



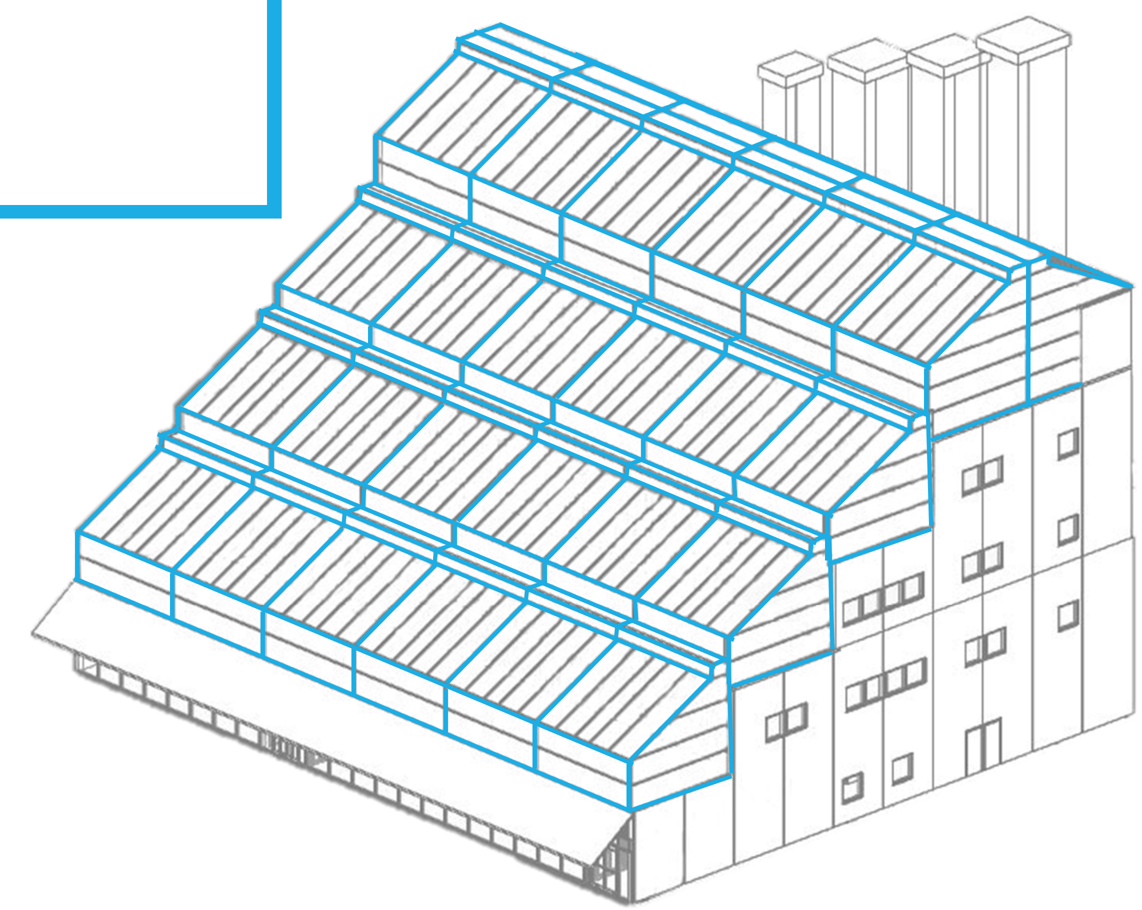


As discussed in the report, Synthesis used Trello to collaborate throughout the Design Phase of the Growing Power Headquarters Project. Shown in these images is how Trello can assist in organizing action items, scheduling meetings, and staying efficient. The example card chosen displays one of the many Team Meetings Synthesis had. On the card are the members who were invited to the meeting, the disciplines that it affects, the date the meeting is to occur, and the list of agenda items for this particular meeting. The card can be accessed at any time via the Synthesis Board Calendar or the Synthesis Board Lists. It is truly a preference, but the Calendar is a great way to see what Due Dates are approaching and the List view shows the cards by their given category. Previously mentioned in the report, the cards can be selected and moved into any List that it belongs to at that time. At the end of this project phase, all cards were moved to the "Done" List.



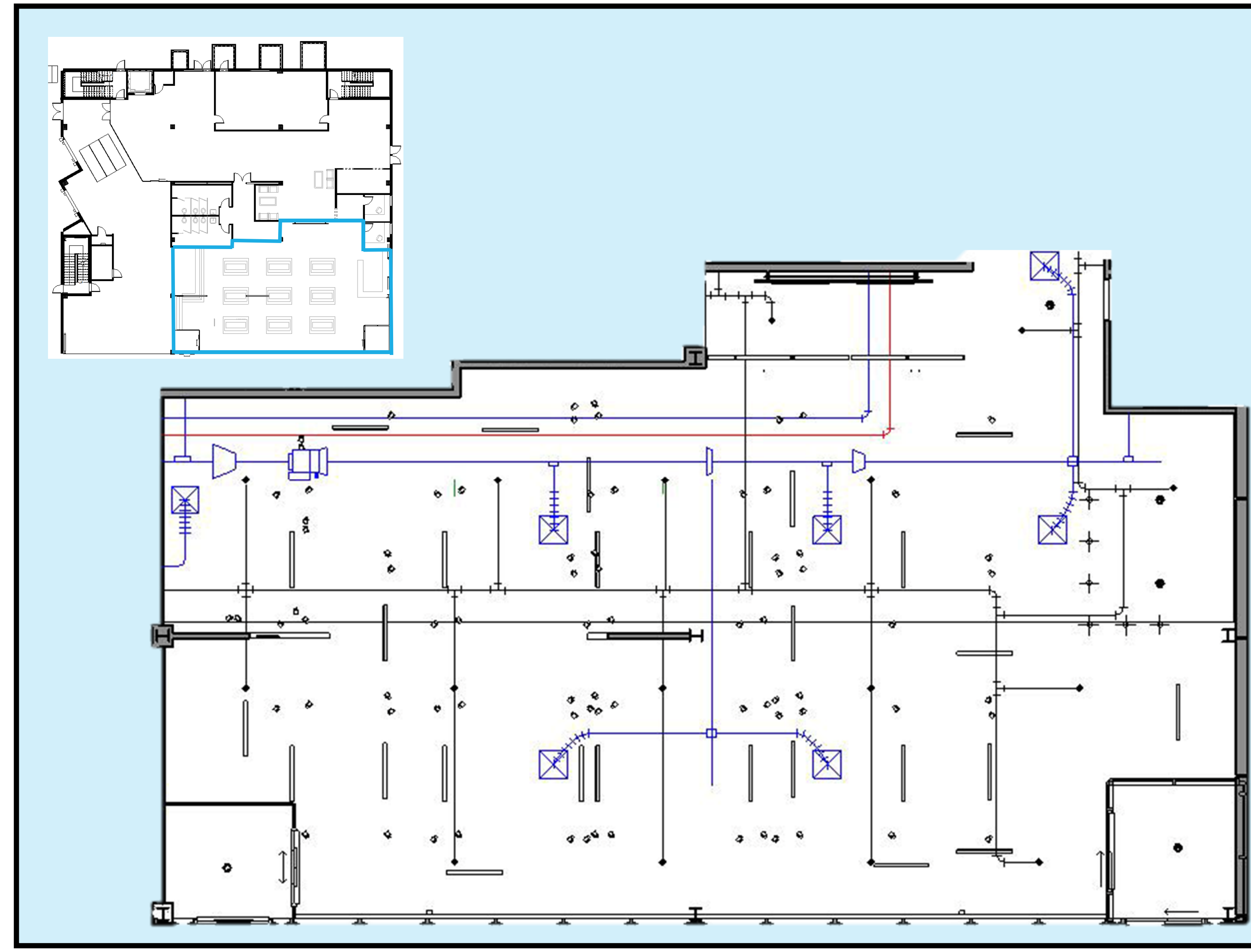
Cost Breakdown of a Greenhouse "Module"		
A	Steel Truss System	$5,525.95
B	Concrete Slab & Decking	$1,990.44
C	CMU Interior Wall	$1,839.11
D	CMU Backup Wall	$367.92
E	Polycarbonate Glazing	$11,196.31
F	Curtain Wall Mullions	$1,930.39
G	HVAC Shaft Assembly	$2,259.40
H	Horizontal Polycarbonate	$2,329.02
TOTAL		**$27,438.54**

The Cost Breakdown includes all items that are specific to the Greenhouse "Module." All items not accounted for are considered part of the cost associated with expanding the building (i.e. steel superstructure, windows).



Impact of the Greenhouse "Module" System on Construction	
+/-	Description
+	Prefabrication of the Polycarbonate Panels increases quality and decreases waste on site
+	Prefabrication of the Steel Trusses increases quality and decreases waste on site
+	Prefabrication of the Mullions increases quality and decreases waste on site
-	Segmental CMU walls increase the schedule

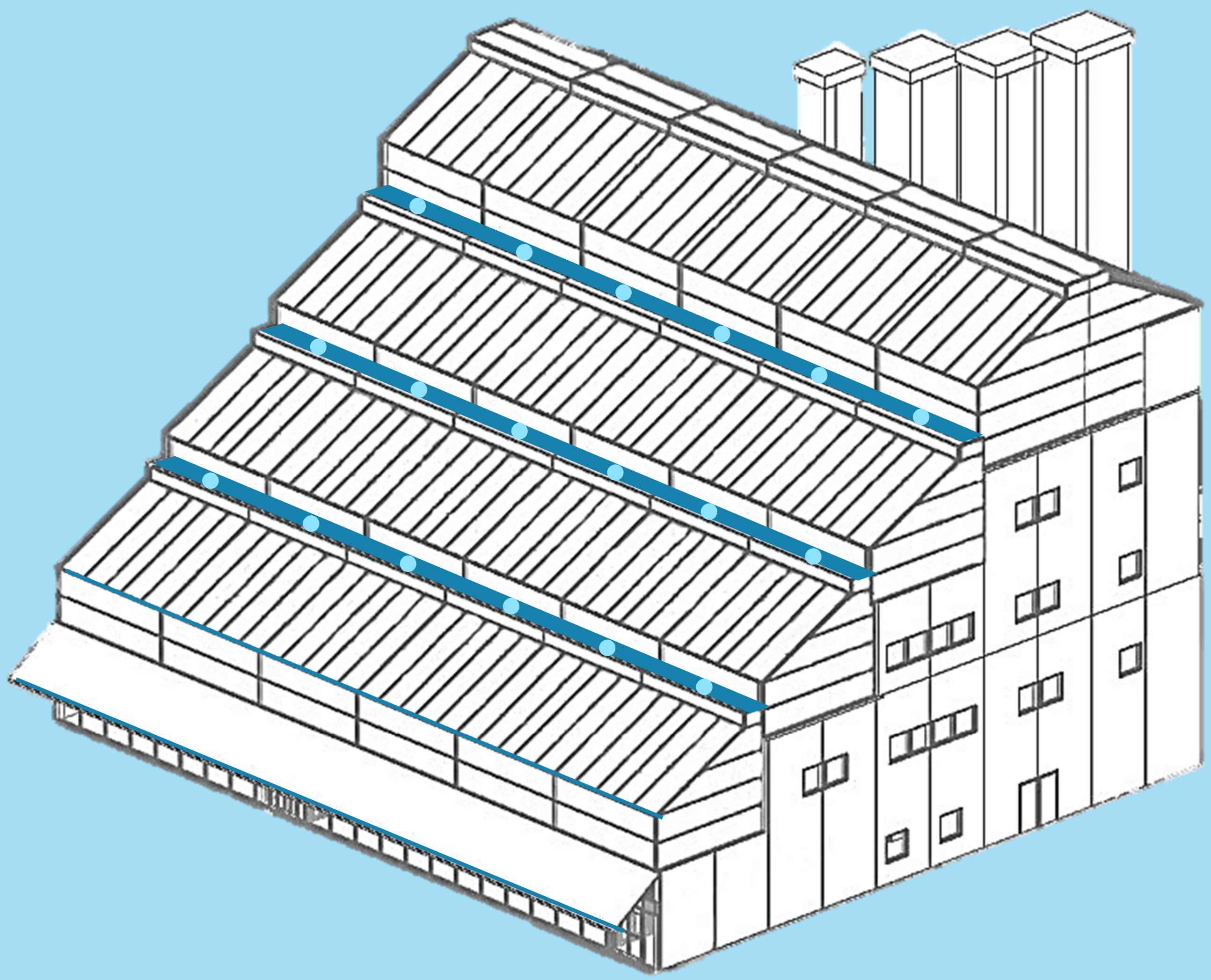
See [Integration Report Drawing A108] for a complete idea of the integrated greenhouse "module" system design.



Impact of the Market Space on Construction	
+/-	Description
+	Exposed ceilings allow trades to complete work at their own pace without interfering with each other.
+	Eliminating a drop ceiling removes additional work that needs to be completed in the space.
-	All overhead work must be installed and properly sealed before the ceiling can be painted or work could be damaged.
-	The exposed ceiling requires coordination so the appearance of the trades running overhead is neat an appealing.

Rainwater and Snow Drainage System

The Growing Power Headquarters building features a hidden gutter and roof drain system to allow for water and snow collection. At each tier of greenhouse space, there is a gutter that spans the length of the building along the top horizontal piece of the roof. The hot air produced in the closed greenhouse system will be used to melt any ice or snow. Roof drains have been placed within the gutter to properly transport the water from the roofs to greywater storage tanks located in the basement of the building. There is one drain located in the center of each greenhouse "module"; therefore, there are six drains on a tier. Two smaller gutters are located on the PV awning and the edge of the roof on the Level 2 greenhouse tier. This drainage system was developed by the Mechanical Engineers at Synthesis, and for more information on it, see the **[Mechanial Engineer Report Appendix F]**.



Tower Maintenance

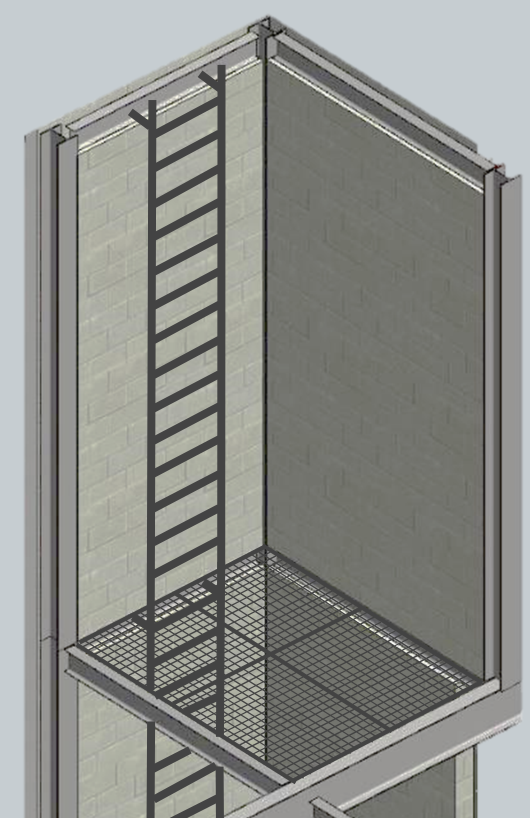
As discussed in the report, the building features 4 towers along the rear for the HVAC system. This section represents the tower supplying the underfloor air plenum on Level 3.

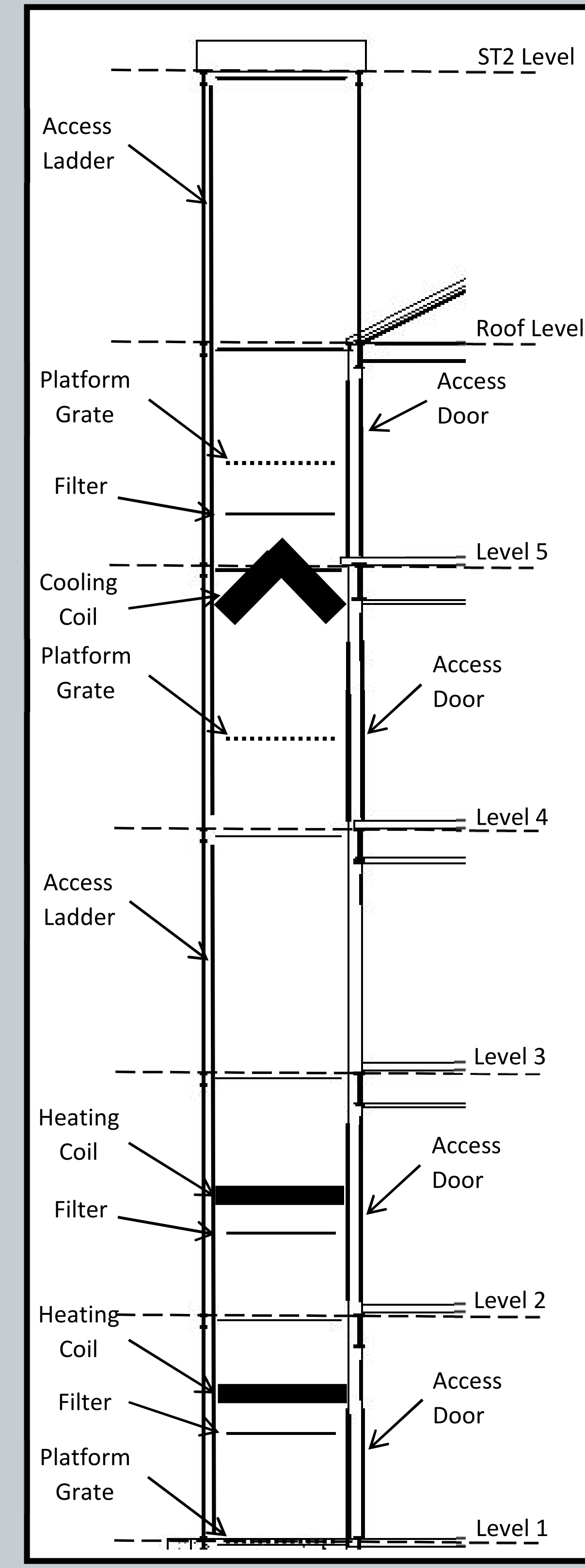
The Construction Engineers worked with the Mechanical Engineers to develop a way for the interior of the towers to be accessed for maintenance and cleaning purposes. Metal grate platforms were chosen because they would allow individuals to enter the towers at certain levels and would not greatly obstruct the air flow through the towers. The locations of these grates were coordinated with the placement of the tower's cooling and heating coils. In this example, grates are located in Level 1, Level 2, Level 4, and Level 5.

Doors have also been placed on their respective floors for access from inside in the building to the grates and coils. All doors located on floors with access to the coils and filters are of adequate size to maintain the coils and change the filters. If the grate is above the floor level for the access point, a fold down ladder will be available to the worker to climb to the grate's level.

An access ladder is to be attached to the back wall of the tower for workers to reach above and below the coils to maintain them and the towers themselves.

All towers can be accessed via the basement.





Appendix N: UFAD Plenum Quality Control Inspections and Testing Procedure

Purpose:

To ensure the integrity of the under floor plenum for air tightness, by means of rigorous Quality Control (QC) inspections and follow-up pressure testing procedure, described below.

Application:

The QC inspections and pressure testing procedures will apply to all raised access floor plenums throughout the project, (Classrooms, Gathering Spaces, and Office Space).

Quality Control:

Prior to installation of the raised access floor a 'Raised Access Floor (RAF) Close-in Inspection' of the under floor area to be covered is completed. The inspection will be documented and will require sign-off from responsible subcontractors and Synthesis to verify that work is completed and properly installed to provide an air leakage rate equal to or less than 5% in the plenum area to be covered.To capture any changes between the RAF Close-in inspection and the installation of the RAF the area to be covered in a given day will be inspected with Synthesis and responsible sub contractors. Any changes that need to be corrected will be completed. After RAF installation no underfloor work will be allowed until after successful pressure testing of the plenums that make up the floor. The plenum dividers installed during RAF installation will be inspected by Synthesis prior to the pressure testing procedure to verify divider integrity. This inspection will also be documented requiring sign-off from Synthesis and subcontractors to verify that the plenum divider and penetrations through them is complete and divider integrity.

Testing:

Plenum boundary (top, bottom and all sides) leakage is not to exceed 0.05 cfm/ft2 at 0.05 in.w.g. (this equates to 5% of the total supply air volume over the served access floor area). Each plenum section has a different floor surface area that is pressurized and will therefore have a different maximum leakage target air volume. Each plenum's boundaries and surface area will be identified and calculated and provided with each test. Any tested zone which exceeds this leakage rate will be considered to have failed the test and source of leak found, documented in QC reports, fixed/repaired and inspection techniques/methods revised will be corrected and retested until the leakage rate is less than the allowable 5%.

Reference: This recommended leakage rate is excerpted from an Internal Design Guideline dated June 2005, published by CBE (Center for the Built Environment), the leading research organization in the U.S.A. with regard to UFAD systems.

Preparation for Test:

An entire floor will undergo leakage testing once the entire RAF system, including plenum dividers, is installed, cleaned and sealed. In addition to the QC inspections described above, some additional requirements in preparation for testing are as follows:

- Any openings in the sheet metal divider under the floor must be sealed.
- Any openings in the raised floor itself must have safety panel covers in place, sealed with tape. This applies to swirl diffuser and electrical outlet openings.
- Permanently disconnect power to the fire/smoke dampers on the floor being tested.
- HVAC dampers, both controlled and manual, need to be placed in an open position to allow airflow through the plenum section.
- Protective covers on duct work need to be removed to allow airflow through duct work that passes between sections of the same plenum section.
- All seams between floor panels must be sealed. The intent is to fully seal the surface of the raised floor itself.

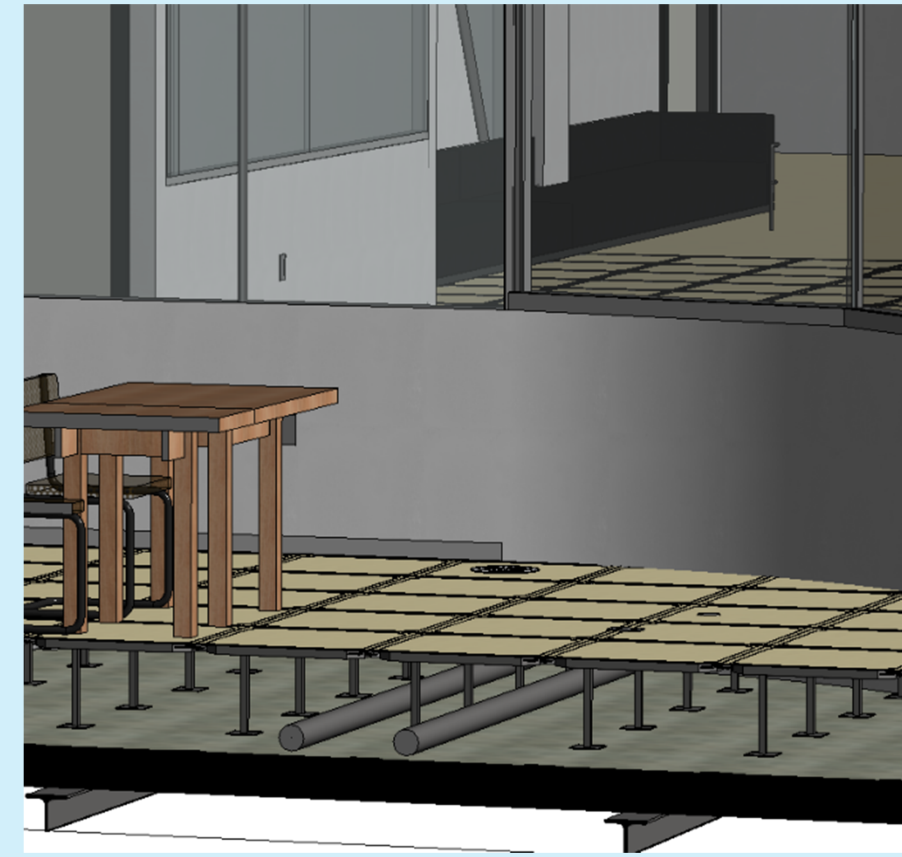
*********These steps are reversible after the test.***

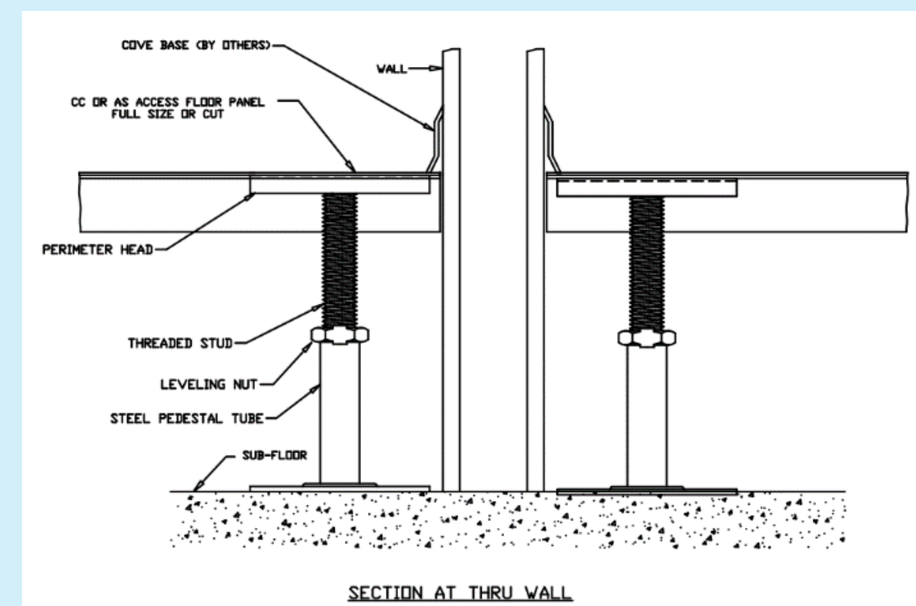
*********Please note a supplemental fan will be needed to run the below test***

Test Procedure:

1. Determine the plenum boundaries for each plenum on a floor.
2. Calculate the surface area (FT2) for each plenum section of the floor.
3. Calculate the allowable leakage (CFM) for each plenum section of the floor. For sections that have fire smoke dampers, add the calculated leakage rate of the closed fire smoke dampers (2.25 cfm/sq.ft. of damper face area = 13 cfm for each 72" x 12", 8 cfm for each 46" x 12" and 4 cfm for each 22" x 12" damper), to obtain the final allowable leakage rate.
4. Install test fans in each section of the floor and ensure they are sealed airtight to the floor.Start each fans and adjust the output to the allowable leakage rate variable inlet openings until the calculated allowable leakage for each plenum is being provided.
5. Measure the differential pressures in each plenum section of the floor.
6. Verify all plenum sections measure above 0.05 in. w.g. If a plenum section on the floor is below 0.05 in. w.g. remedial work to the floor plenum joints under the raised access floor is required before testing continues.If the plenum pressure is significantly above 0.05 in. w.g. (i.e. 0.06 in. w.g. or greater) at the calculated allowable leakage adjust the air flow rate going into the plenum section down until the plenum pressure is below 0.06 in. w.g. but above 0.05 in. w.g.
7. Record the stabilized volume of air produced by the test rig once set up is complete. Once all plenum sections for the floor are verified to be above 0.05 in. w.g. and below 0.06 in. w.g. begin 15 minute stabilization period.After stabilization period record a 15 minute period of pressure data for each plenum section.
8. Record readings for one continuous 15 minute intervalsIf the average of the continuous readings is above 0.05 in. w.g., that section of the underfloor plenum is considered passed. When all the plenum sections for a floor have passed then that whole floor is considered passed.
9. If the test of a plenum sections fails, remedial work to the floor plenum joints under the raised access floor is required before re-testing, and if necessary the QC procedure revised to incorporate any additional leakage points found.

If retest is required for a section only the section that failed and the sections that share plenum dividers with that section are required to be pressurized for retesting.

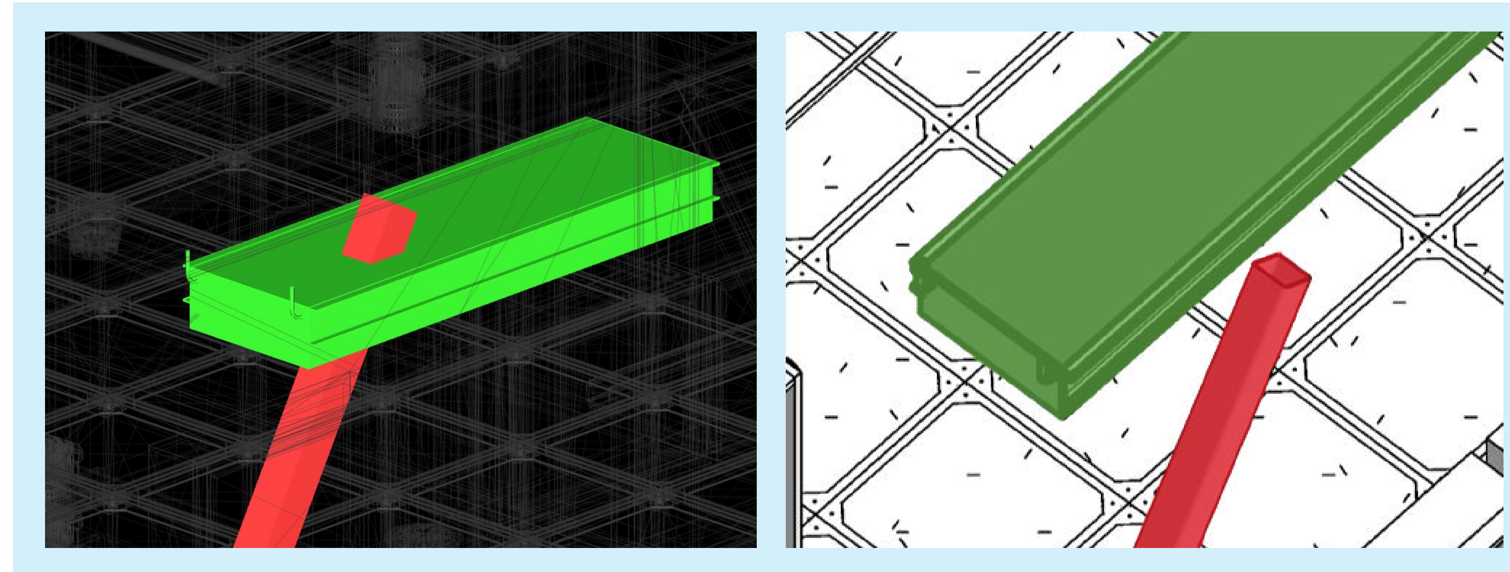


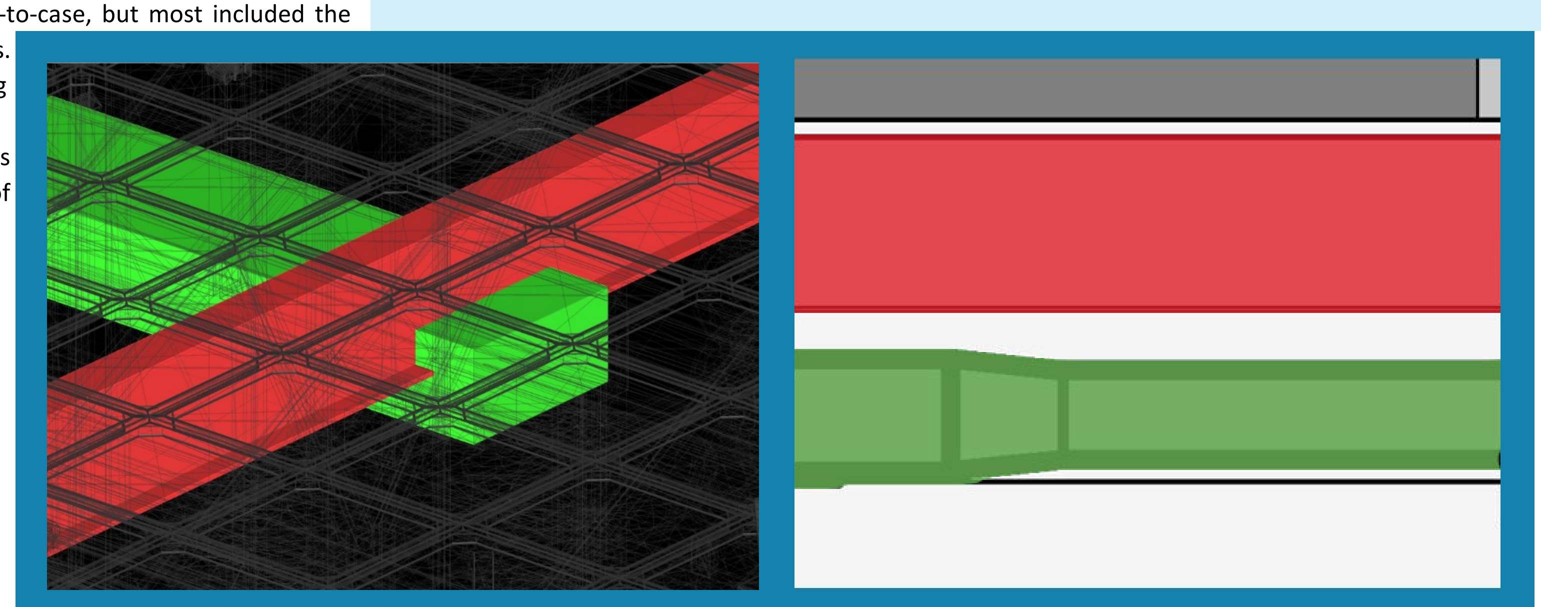


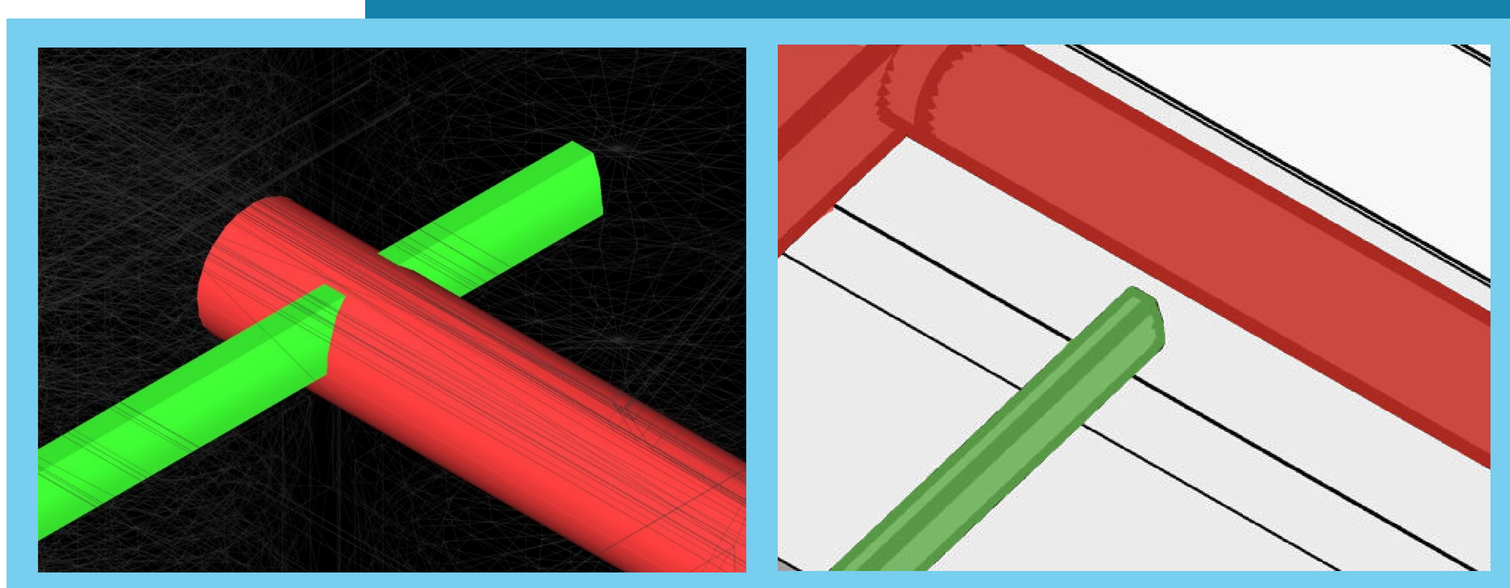
http://tateinc.com/products/access_floors.aspx

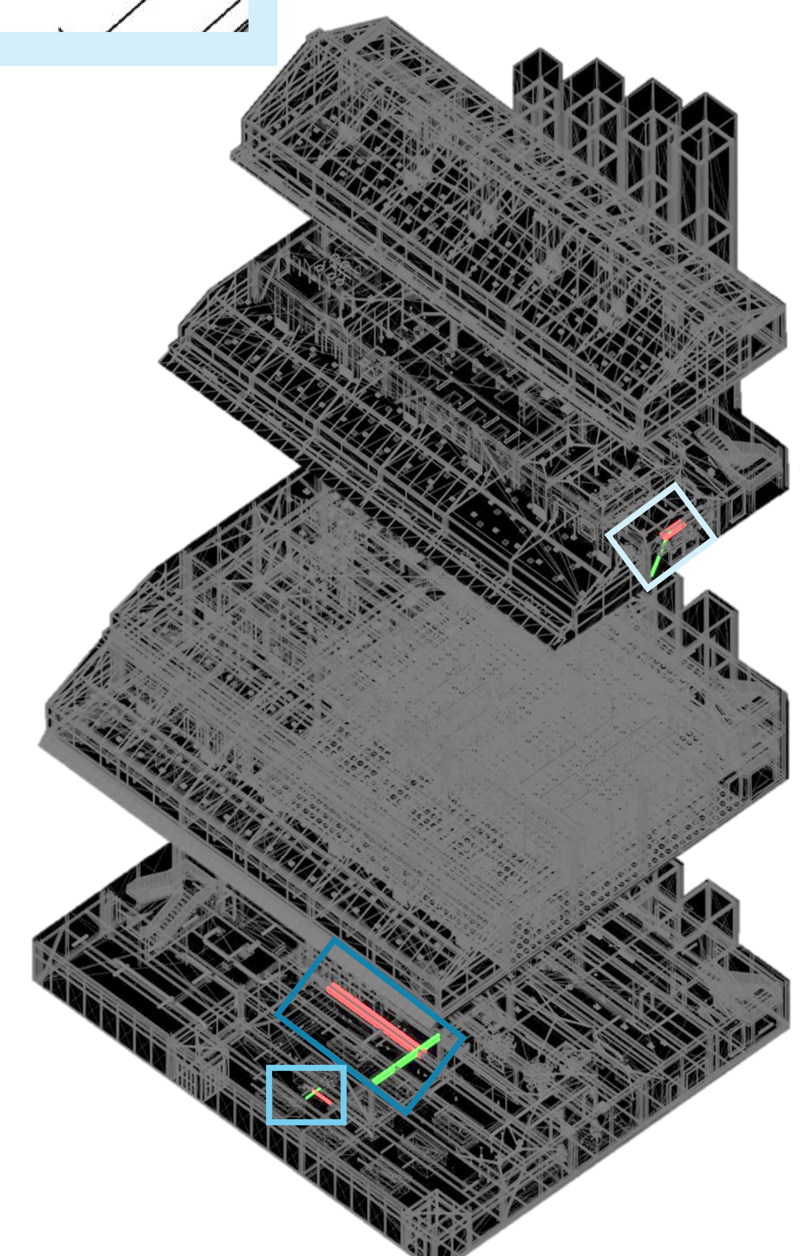
Appendix O: Clash Detection

Synthesis, with the use of Autodesk Navisworks, was able to run clash detection tests on the mechanical, plumbing, electrical, lighting, fire protection, structure, and architecture. When the systems were first tested, several interruptions occurred between components. The test reports were then analyzed and clashes assigned to the appropriate design engineers to be resolved. The clashes were fixed in various ways. One major type of component conflict was the chilled beams intersecting the steel structural system members. An example of this type is represented in the first image to the right, where the chilled beam has a lateral brace puncturing through it. To overcome these clashes, the mechanical engineers were able to relocate the chilled beams to attach below other structural beams in their designated rooms. Another major category of clashes can be seen in the second image on the right, which arose between the structural beams and the rectangular mechanical ductwork. To fixes these issues, the ductwork runs were lowered to a height below the bottom flange of the beams. An example of a third type of clash found in the building design is the bottom image on the right. These clashes developed with the lighting fixtures and the round mechanical ductwork. Solutions varied case-to-case, but most included the ductwork runs shifting to the side of the light fixtures. Overall, discovering and eliminating all clashes during the design phase of this project will save time and money during the building's construction. This allows for the Owner to feel even better about the quality of work put into the project by the design team.



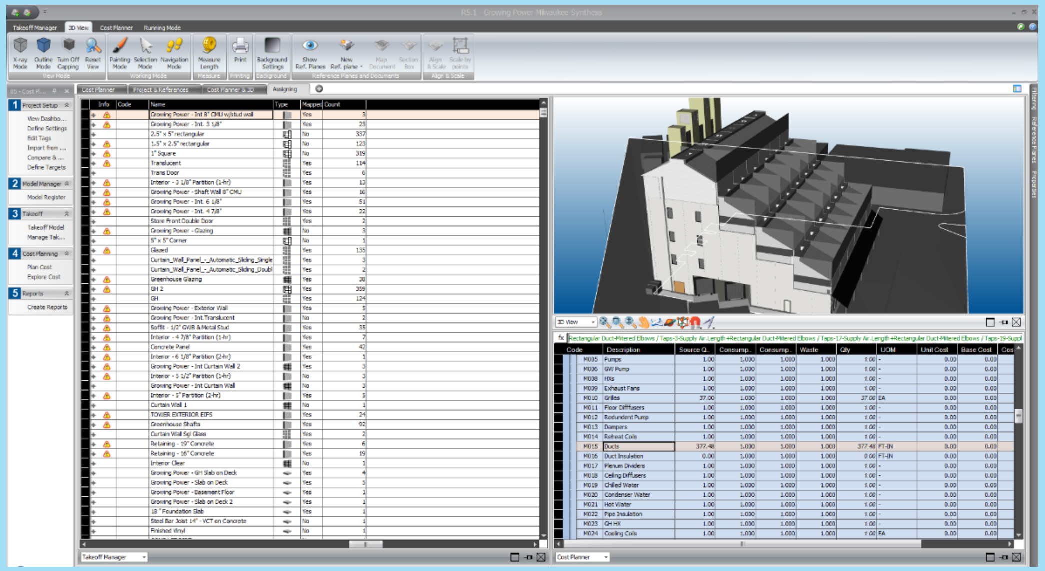




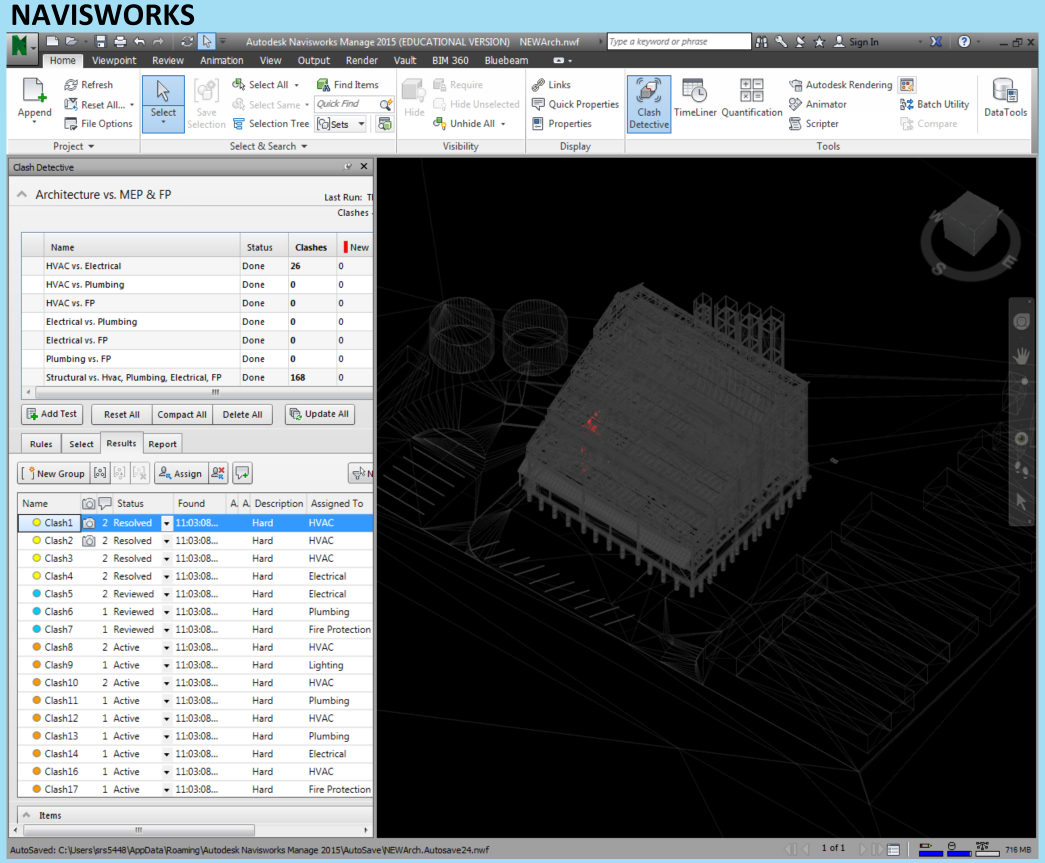


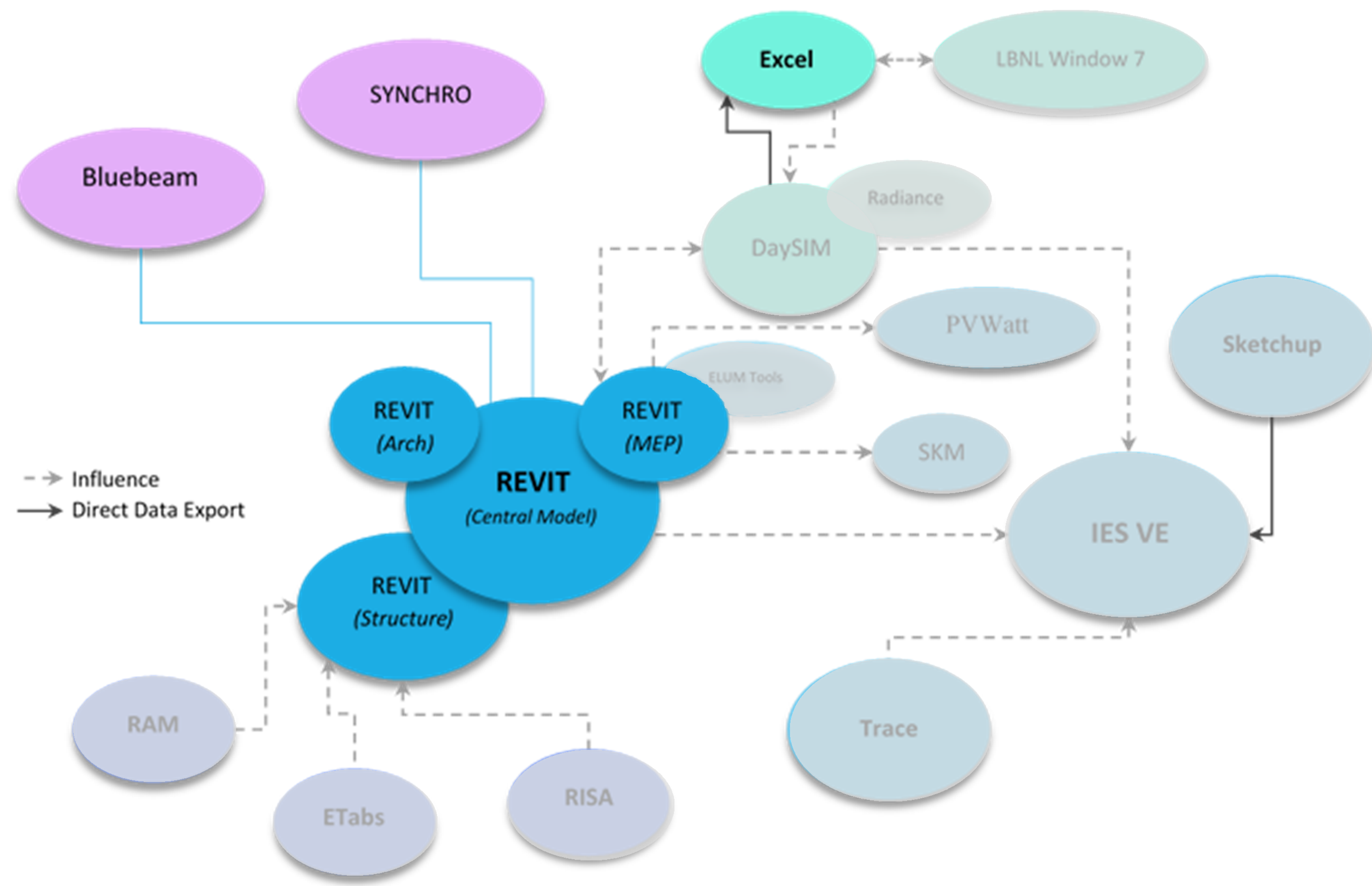
Analysis Topic	Purpose	Software
Lifecycle Cost	Analyze the overall cost of the building and the amount of time it would pay itself back	Microsoft Excel
Clash	Assist in eliminating components of the building intersecting each other to minimize	Navisworks
Crane	Determine the crane size and type that would best fit the project and how it would fit on site	N/A
Phasing	Analyze the construction of the building dependent on the previously determined Project Schedule	Synchro
Production Line	Determine how large, how many, and how the trade crews would move among the building to optimize production	Vico
Project Cost	Estimate the cost of the building components and additional costs of completing the project	Bluebeam, Microsoft Excel, & Revit
Project Schedule	Estimate the duration needed to complete the project for the estimated Project Cost	Microsoft Project

VICO



NAVISWORKS





Synthesis

LEED v4 for BD+C: New Construction and Major Renovation

Project Checklist

Project Name: Growing Power Headquarters

Date:

Y	?	N			
1			Credit	Integrative Process	1
4	**1**	**21**		**Location and Transportation**	**16**
		16	Credit	LEED for Neighborhood Development Location	16
1			Credit	Sensitive Land Protection	1
		1	Credit	High Priority Site	2
			Credit	Surrounding Density and Diverse Uses	5
1		4	Credit	Access to Quality Transit	5
1			Credit	Bicycle Facilities	1
1			Credit	Reduced Parking Footprint	1
	1		Credit	Green Vehicles	1
6	**0**	**4**		**Sustainable Sites**	**10**
Y			Prereq	Construction Activity Pollution Prevention	Required
1			Credit	Site Assessment	1
		2	Credit	Site Development - Protect or Restore Habitat	2
1			Credit	Open Space	1
3			Credit	Rainwater Management	3
		2	Credit	Heat Island Reduction	2
1			Credit	Light Pollution Reduction	1
11	**0**	**0**		**Water Efficiency**	**11**
Y			Prereq	Outdoor Water Use Reduction	Required
Y			Prereq	Indoor Water Use Reduction	Required
Y			Prereq	Building-Level Water Metering	Required
2			Credit	Outdoor Water Use Reduction	2
6			Credit	Indoor Water Use Reduction	6
2			Credit	Cooling Tower Water Use	2
1			Credit	Water Metering	1
31	**0**	**0**		**Energy and Atmosphere**	**33**
Y			Prereq	Fundamental Commissioning and Verification	Required
Y			Prereq	Minimum Energy Performance	Required
Y			Prereq	Building-Level Energy Metering	Required
Y			Prereq	Fundamental Refrigerant Management	Required
6			Credit	Enhanced Commissioning	6
18			Credit	Optimize Energy Performance	18
1			Credit	Advanced Energy Metering	1
			Credit	Demand Response	2
3			Credit	Renewable Energy Production	3
1			Credit	Enhanced Refrigerant Management	1
2			Credit	Green Power and Carbon Offsets	2
4	**6**	**3**		**Materials and Resources**	**13**
Y			Prereq	Storage and Collection of Recyclables	Required
Y			Prereq	Construction and Demolition Waste Management Planning	Required
2		3	Credit	Building Life-Cycle Impact Reduction	5
	2		Credit	Building Product Disclosure and Optimization - Environmental Product Declarations	2
	2		Credit	Building Product Disclosure and Optimization - Sourcing of Raw Materials	2
	2		Credit	Building Product Disclosure and Optimization - Material Ingredients	2
2			Credit	Construction and Demolition Waste Management	2
13	**1**	**0**		**Indoor Environmental Quality**	**16**
Y			Prereq	Minimum Indoor Air Quality Performance	Required
Y			Prereq	Environmental Tobacco Smoke Control	Required
2			Credit	Enhanced Indoor Air Quality Strategies	2
2			Credit	Low-Emitting Materials	3
1			Credit	Construction Indoor Air Quality Management Plan	1
2			Credit	Indoor Air Quality Assessment	2
	1		Credit	Thermal Comfort	1
2			Credit	Interior Lighting	2
2			Credit	Daylight	3
1			Credit	Quality Views	1
1			Credit	Acoustic Performance	1
6	**0**	**0**		**Innovation**	**6**
5			Credit	Innovation	5
1			Credit	LEED Accredited Professional	1
0	**0**	**0**		**Regional Priority**	**4**
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
			Credit	Regional Priority: Specific Credit	1
76	**8**	**28**		**TOTALS** Possible Points:	**110**

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

Achieved: Gold

Strive for: Platinum

Meeting Agenda

Team Collaboration Meeting #6

10/08/2014

4:30pm

Team Office

Topics for Discussion:

Team

- Determine the Team Project Goals
- Provide an overview of Trello and its implication for the design process
- Develop a Decision Matrix to be used for major design decisions
- Determine topics for upcoming Design Progress Presentation

Building

- Review floor plan changes
- Façade material criteria
- Structural system material options
- Code findings for egress requirements
- Classification of spaces that require dropped ceiling and those that could potentially be exposed ceilings
- Needs for the Electrical Design

Greenhouse Spaces

- Overall function/layout of the greenhouses
- Requirements for glazing material – mechanical and lighting
    - Daylight Analysis
- Developments of the Passive Downdraft HVAC System
- Implications of a Raised Floor System – what does it mean?
- What data should be included in the Plant Matrix?

Project Management

- Requests for cost analyses of systems/components?
- Review Square Foot Estimate progress
- Design Schedule updates/progress

Meeting Minutes

Team Collaboration Meeting #6

10/08/2014

4:30pm

Team Office

Action Items:

1. Team is to begin gathering information for upcoming Design Progress Presentation.
2. Further adjustments of new floor plans are to be made in Revit model.
3. Research will begin on possible façade materials.
4. Research glazing, windows in non-greenhouse, passive downdraft HVAC system, and implications of a Raised Floor System.
5. Research will continue to research the function and layout of the greenhouse, the needs for the electrical design, and information needed for the Plant Matrix.
6. A daylighting analysis will be started for glazing types to be used in greenhouses.
7. Research needs to be done to determine the code requirements for enclosing the staircase in the top tier of the building.
8. Cost Analysis of various mechanical systems
9. Design Schedule
10. Team Photographs are scheduled for Wednesday at 3:30 PM

Completed Items:

1. Team decided the locations of having a drop ceiling and an exposed ceiling.
2. The building will have a steel structure.
3. A Square Foot Estimate has been completed for the building.

Lessons Learned

Throughout the design process, the Synthesis construction engineers encountered numerous challenges along the way. To overcome these hurdles, the entire Synthesis team worked as an integrated group to solve each problem in the most effective way possible while keeping all of the team goals and ideals in mind. To illustrate these problems and solutions, this section of the report will explain a few of the key hurdles that were overcome.

Excavation

While undergoeing the decision of how to combat the high water table and poor soils on site, the initial thought was to utilize soldier pile and lagging. After investigating and finding the alternative of sheet piling, the team did a side by side analysis and determined that sheet piling would be cheaper and more environmentally friendly. Lesson Learned: Soldier pile and lagging may be the more common solution but it isn't the only solution to holding back poor soils and a high water table.

Design Schedule

During the design process, it was discovered that the schedule should be updated often or team members forget about deadlines that were agreed to. It also became necessary to incorporate different ways of tracking the schedule and information transfer between disciplines. The different types of media increased the visibility of the schedule and held the team members accountable to the design deadlines.

Team Chemistry

In a team of eight, there is a high likelihood that team members would have differing temperaments and personalities. This can sometimes create tense situations when debating ideas that people are passionate about. In order to combat this, it was determined that the personality analysis performed was necessary to keep tensions low during the design process. The analysis provided the construction engineers with a better picture of how to approach situations when team members were likely to become irritated or defensive and prevent a large team conflict.

Team Environment

In the small room provided in the university lab, the team was in close quarters and had to learn to share both space and equipment. Due to the fact that people work at different times and in different atmosphere, the team needed to be flexible so each person had the ability to work in the way he/she thrived.

References

(2015). "Access Floor Systems." *Tate Access Floors, Inc.,* <http://tateinc.com/products/access_floors.aspx> (Nov. 24, 2014).

(2015). "All Terrain Cranes." a-quick pick Crane & Rigging, <http://aquickpickcrane.com/equipment/all-terrain> (Jan. 8, 2015).

(2015). "Construction Services." *Waste Management, Inc*., <https://www.wm.com/store/catalog/business/construction-solution?zipCode=53218> (Dec. 13, 2014).

"Environmental." *PolyPavement,* <http://www.polypavement.com/environmental.php> (Jan. 10, 2015).

(2015). "LEED v4 for Building Design and Construction." *Resources,* <http://www.usgbc.org/resources/leed-v4-building-design-and-construction-checklist> (Nov. 12, 2014).

"Overview of the Four Temperaments." Keirsey.com, <www.keirsey.com/4temps/overview_temperaments.asp> (Sept. 15, 2014).

(2014). "Waterproofing - Detail Drawings." *Grace*, <https://grace.com/construction/en-us/waterproofing-detail-drawings> (Oct. 24, 2014).

"What is Design-Build?" Design Build Institute of America, <http://www.dbia.org/about/Pages/What-is-Design-Build.aspx> (Jan. 5, 2015).

www.johnsonite.com
www.bls.gov
focusonenergy.com
www.thermomass.com
ds.arcelormittal.com/
www.fireglass.com