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Senior Thesis Final Report

Penn State AE Senior Capstone Project

New Indian Valley High School

Lewistown, PA

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1.0 Executive Summary

Senior Thesis Final Report is intended to provide a thorough in-depth analysis of the New Indian Valley High School construction project. Areas of research include a broad investigation into client information, project delivery, key project team members, existing conditions and major building systems. In addition, this report also provides research into four different analysis topics encompassing several different disciplines of engineering and building construction.

The four analysis topics illustrated in this report include feasibility and design study of a photovoltaic energy system, the development of a short interval production schedule, re-orientation of current vertical closed-loop geothermal mechanical system and the possibility of building re-orientation/design excavation effects. The four analyses were developed to revolve around the critical industries issues of raising efficiencies and eliminating unnecessary spending.

Analysis #1: Feasibility and Design Study for Photovoltaic Energy System

The New Indian Valley High School design utilizes only a few sustainable design techniques. However, the implementation of a photovoltaic energy system could provide a substantial financial benefit to the new high school. This analysis will focus on the design and feasibility of a rooftop PV system. The analysis showed that incorporating a total of 20000SF of PV arrays, along with limited use of off-the-grid electricity that substantial savings could be rendered throughout the life of the building. Preliminary analysis and research into cases studies showed potential savings of $25,000 a year could be achieved. Taking into consideration the rebate/incentive programs within the state of Pennsylvania and yearly savings on energy, the school district could see a full return of investment throughout the proposed lifetime and use of the school.

Analysis #2: Implementation/Development of Short Interval Production Schedule

Short Interval Production Scheduling (SIPS) is the focus for the second analysis. Two of the five phases of construction of the new school house a vast majority of the classrooms. The repetitive nature of these phases of the project provides a perfect opportunity to attempt to bring a high level of efficiency and quality to the construction process, not only saving time but also money. The shortened duration has the potential to generate savings in rising general conditions costs and assure a more quality project due to the rapid repetitive nature of the schedule.

Analysis #3: Re-orientation of Vertical Closed Loop Geothermal Mechanical System

The New Indian Valley High School has been designed with a vertical closed loop geothermal mechanical system. This highly efficient mechanical system is one of the few sustainable features of the building. However, unforeseen rock conditions in proposed well field sites caused project delays. The re-orientation of a horizontal closed loop geothermal mechanical system would eliminate extra installation costs of the deep vertical wells coupled with the elimination of construction delays. The new school has efficient land area to incorporate the horizontal changes to part of the closed loop system.

Analysis #4: Building Orientation/Re-design Excavation Effects

Site properties open a door for potential building re-orientation/footprint design due to the amount of excavation work needed on this project. The ridge line north of the current high school serves as the new location of the new school. This ridge line consists of a moderate slope which requires extensive excavation, grading, earth reinforcement and the placement of retaining walls to prepare the site for use. The goal of this analysis was to show potential savings from excavation and site work without sacrificing owner wants/expectations.

2.0 Acknowledgments

Throughout the course of my Senior Thesis, I would like to personally thank all the individuals that provided me with assistance along with way. Without the help and cooperation of the following people and companies, I would not have been able to accomplish what I have over the past two semesters.

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- Mr. Craig Dubler

- Mr. Jerry Myers

- Mr. David S. Runk –Superintendent (Ret.)
- Mr. James A. Estep – Superintendent
- Mrs. Carolyn D. Wray – Secretary to the Superintendent

Finally a tremendous amount of gratitude is owed to my friends and my family whose help, support and encouragement lit the way for me to complete the AE Senior Capstone Stone Thesis Project. THANK YOU ALL!

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3.0 Project Overview

3.1 Introduction

The New Indian Valley High School construction project is one of the biggest construction projects to begin in Mifflin County in the last twenty years. The small rural county is a closed knit community where passersby on the street commonly know everybody's name and are familiar with each other's families. The existing high school has been in use since the late 1960's where it has seen transformations between several different high schools. Hayes-Large Architects were assigned to the design of a new state of the art school that could with stand the test of time and be in use for many generations to come.

The new building 3-story structure sits on grade with brand new amenities such as a full sized gymnasium, stadium style auditorium, auxiliary gymnasium, wrestling room and a brand new music/band suite. New classrooms and locations provide departmental break downs of academics which allows for ease of collaboration for teachers and attempts to separates noise pollution from daily school activities and academics.

The current school showing sizes of wear, and the overcrowding of hallways and classrooms prompted the decision to pursue a new school. Modular units have been incorporated to the current school to address overcrowding in the classrooms, but were only looked upon as a temporary means of fixing the problem. Overall, the new school design will meet and exceed the increase in enrollment along with providing excellent extracurricular facilities for students to come for many years.

Building Name	New Indian Valley High School
Location	501 Sixth Street, Lewistown Pennsylvania
Gross Building Area	250,000 SF
Number of Stories	3 stories
Construction Dates	08-25-2008 to 12-22-2010
Contract Amount	~ 60 million
Project Delivery Method	CM at Risk

Table 1: General Building Information

3.2 Project Location

The site for the New Indian Valley High School is located on a vacant ridge just north of the existing high school as seen in figure 2 below. The project is located in a small rural town, Lewistown Pennsylvania, roughly 35 miles south of State College, Pennsylvania. The proposed lot, owned vastly by the Mifflin County School District encompasses approximately 41 acres of land. The construction site itself is surrounded by quiet country roads and homes and the area is most busy on school days at times of operation. The most major of concerns with the site is that of excavation and site work prior to construction. The proposed site had little to no previous utility line concerns and construction traffic would be the biggest contributor to site congestion.

Fig.1 Aerial View of site 10-26-08

3.3 Client Information

Before Late February 2011, the Indian Valley High School was one of two public high schools in Mifflin County, Pennsylvania, in the Mifflin County School District. The decision to build a new high school has been a matter of concern since 1999 when the first feasibility studies were conducted. The Mifflin County School District consists of two high schools, three middle schools and eight elementary schools before late February, along with being a part of the Mifflin-Juniata Vocational Career and Technology

Center. In 1999 however, the school district consisted of more elementary schools; Seventh Ward and Derry Elementary Schools. These buildings were addressed first. A second feasibility study was completed as an update in February 2004. This time the study was directly geared at addressing the Indian Valley High and Middle Schools. The Indian Valley Middle School was constructed in 1952 with an addition in 1962. The building is approximately 96,000 square feet. The Pennsylvania Department of Education (PDE) Full Time Equivalent (FTE) capacity for the building is 739, in 2004 when the study was conducted, was found to be 810. The high school, old but not as in as bad condition, also over crowded needed to address serious concerns. Doors not being ADA compliant, single pain windows and cracked brick facades were only the beginning of the buildings' physical problems. Indoor equipment was failing after forty years of use. The schools were ill equipped structurally and physically, and let no room for growth to accommodate the changing educational programs. However, in light of recent school district activities to address growing deficits, the decision has been made to once again consolidate schools. The school board recently decided to close 4 schools in the school district and consolidate its two high schools into the new high school, now to be known as the Mifflin County High School, along with several elementary schools throughout the district. For concerns of this report, it will continue to be referred to as the New Indian Valley High School Project.

The school board has many expectations for this project such as creating a campus type setting, relief from overcrowding, room and facilities to accommodate changing curriculums, upgrades to out of date athletic facilities and expansion of extracurricular programs. The school board approved a design of the building to separate the classrooms from other areas of the building such as the gymnasium, auditorium and cafeteria to not only provide a better learning environment but to also have after school activities limited to one area of the building instead of multiple areas spread out as with the current high school.

Indian Valley High School is a public high school in the Pennsylvania school system, and for the small community **cost** was more of a driving factor than schedule. The small rural community has taken on the financial burden with some friction as not all in the community supported the idea. This makes a concise budget with little wasteful spending a key concern.

3.4 Project Delivery Method

The New Indian Valley High School project utilizes a **CM @ Risk** project delivery method. The owner holds industry standard AIA contracts for the architect, construction manager and all contractors [AIA

B141 CMa, AIA B801 CMa and AIA A101 respectively]. This is a typical project delivery method for state funded school projects. A construction manager provides a party with knowledge of the process at hand, directly to the owner. Contracting with Reynolds Construction Management, the CM on the project, and Hayes-Large Architects, the design firm, provided sound preconstruction management and supervision on the project.

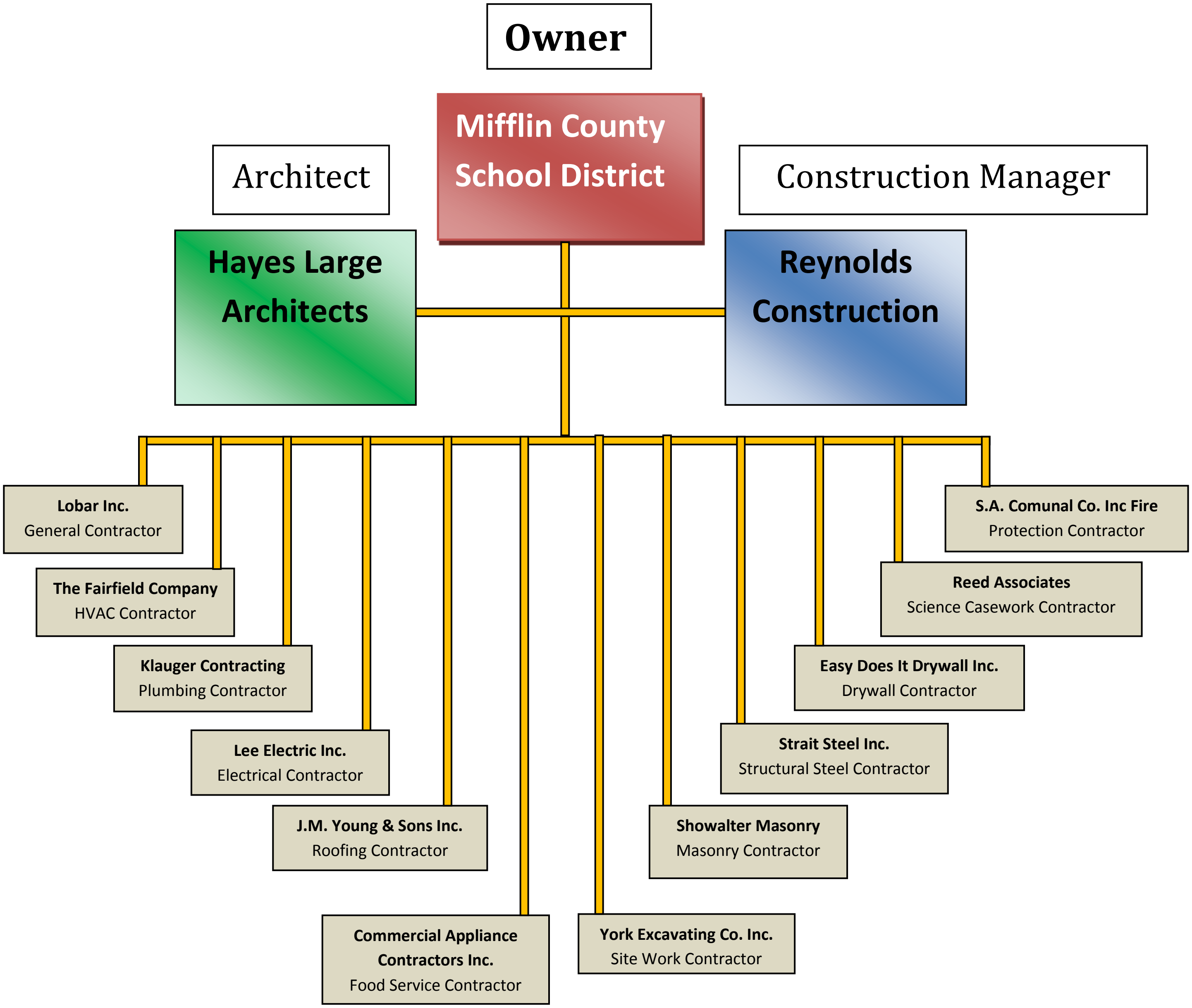


Fig. 2 Project Delivery Method Organizational Chart

3.5 Project Team Staffing Plan

Reynolds Construction staffs projects based on size, availability, experience and need of the particular project. The standard staffing for Reynolds typically includes a project manager, assistant project manager, on-site construction manager and different project coordinators for the construction phase of the project, along with a separate preconstruction team in the form of a vice-president of preconstruction, a preconstruction manager and necessary estimators as shown in figure 3 below. At

Reynolds a project executive oversees several construction groups, and project managers are responsible for several project teams.

On this project the preconstruction team was based out of Reynolds office headquarters, where project managers would be on site at several different projects several days a week to handle progress meetings, safety inspections and conflict resolution, with the rest of the team being stationed in the field offices a majority of the time.

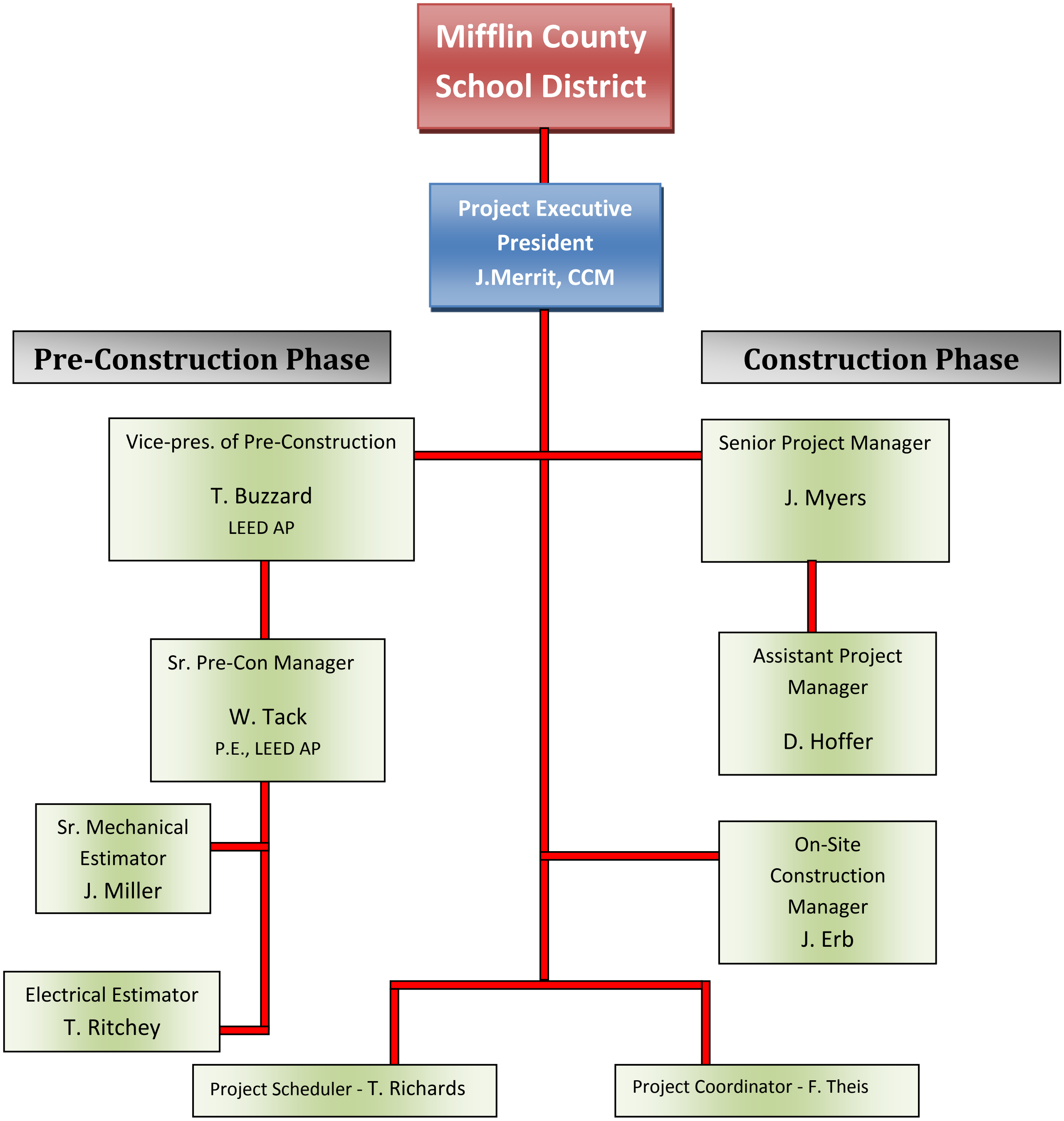
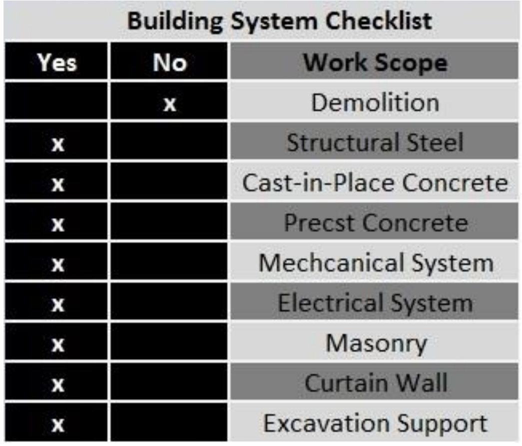


Fig. 3 Staffing Plan – Provided by Reynolds

4.0 Design and Construction Overview

4.1 Building Systems Summary



Building System Checklist		
Yes	**No**	**Work Scope**
	x	Demolition
x		Structural Steel
x		Cast-in-Place Concrete
x		Precst Concrete
x		Mechcanical System
x		Electrical System
x		Masonry
x		Curtain Wall
x		Excavation Support

Table 2: Building Systems Checklist

4.1.1 Structural Steel

Structural steel rests upon 8" CMU walls throughout a majority of the building. Framing makes way for metal decking and concrete slabs. Steel grid like frames that hold the elevated slabs of the building are comprised with an array of different beams, most commonly W10x12 and W21x44. Primarily found in Areas A and B.

Fig. 4 Steel Framing

Truss and joist members carry the roof load of the new school with Truss "M" and "N" which span the entire width of Areas C, D and E, which ranges from 173' to 121' in width.

4.1.2 Cast-in-Place Concrete

Reinforced cast-in-place concrete in the structure is found in footings, slab-on-grade (SOG) and elevated slabs. The sequencing of placement was separated into five phases [see Fig. 1 above]. The same plan is followed for SOG as elevated slabs. Elevated slabs are placed on composite metal decking; a bed of stone provides the base for SOG.

4.1.3 Precast Concrete

A system of precast concrete risers gives shape to the new auditorium of the high school. Each precast riser is 4" thick. The risers provide a tunnel entry effect with two different levels of risers approaching the stage.

Fig. 5 Precast Auditorium risers

4.1.4 Mechanical System

A pair of geothermal fields boarder the building to Southwest. The two fields are 135'x245' and 165'x135'. Combined the fields consist of over 200 wells approximately 500' deep. Causing the most unforeseen problems on site, the geothermal system provides an economic/sustainable method of heating and cooling. The HVAC systems are powered by five rooftop air handling units (AHU), each assigned to a phase or part of the building. The mechanical room is located on the first floor of "Area A". Units range from approximately 3,500 cpm to 20,000 cpm. Three water pumps supply the high school, but one is stand by and only two are required for the building load.

4.1.5 Electrical System

Inner distribution of power is done among nine different transformers located throughout the building. The building feeds are 480/277V, 3 phase, 4 wire feeds. A 3000kWa emergency generated provides a back-up power source for the building.

4.1.6 Masonry

Enclosing the school is a two toned face brick facade that covers the entire building excluding the glass curtain walls and roof. CMU walls and columns aid in the support in the

Fig. 6 Face brick facade construction

structural steel framing throughout the building. ***Ivanny*** walls create the base of the rear of the structure through areas C, D and E. Ivanny walls are reinforced CMUs that are meant to imitate cast-in-place walls as a value engineering alternative.

4.1.7 Curtain Wall

There are three glass curtain walls that provide light to the inner part of the school. The school, shaped like a giant letter "I", middle contains the large aluminum glass curtain wall. This area houses the cafeteria and extends to the floor above. The fitness center in area C also has an aluminum glass curtain wall that can look into the cafeteria.

4.1.8 Excavation Support

The extreme slopes of the hill required grading activities to level and prepare the site. The huge retaining wall spans the whole length of the site. The wall is drilled and tied back deep within the ridge the new site sits on. There is a cosmetic stone covering over the original wall with a safety fence guarding the top.

4.2 Project Cost Evaluation

The actual construction costs of the build are based on a detailed cost estimate supplied by Reynolds Construction. The amounts may be altered and rounded for comparison purposes. All costs shown do not represent actual bid costs for the project.

Project Parameters

Square Footage:	251,095
Building Perimeter (ft):	2,532.3

Construction Costs

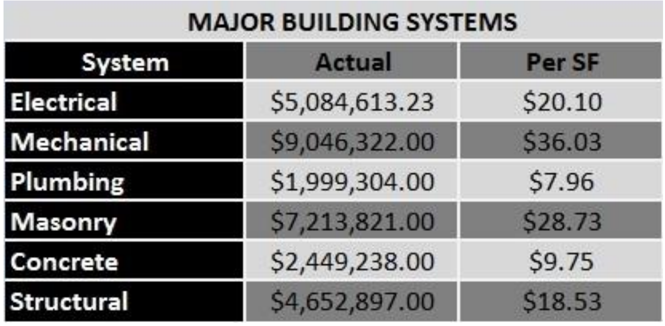
Actual:	$51,580,000
Per SF:	$205.42

Total Costs

Actual: $60,588,000

Per SF: $241.29

Major Building Systems Cost Estimate



MAJOR BUILDING SYSTEMS		
System	**Actual**	**Per SF**
Electrical	$5,084,613.23	$20.10
Mechanical	$9,046,322.00	$36.03
Plumbing	$1,999,304.00	$7.96
Masonry	$7,213,821.00	$28.73
Concrete	$2,449,238.00	$9.75
Structural	$4,652,897.00	$18.53

Table 3: Major Building Systems Cost Estimate

4.3 Local Conditions

The New Indian Valley High School is located, north of the existing high school at 501 Sixth Street, Lewistown Pennsylvania, and is approximately 35 miles south State College. The lot, owned by the Mifflin County School District is roughly 41 acres. This small rural town does not often build buildings of this magnitude, nor is there a real precedence to follow. The construction site is immediately surrounded by quiet country roads, positioned north and west of busier roads, being busiest hours of school days/operation. The construction site shown below and surrounding rural areas leave adequate room for construction parking with little to no traffic on the roads during most of the day. The site is tucked back in behind any major road ways. Construction traffic caused by the site is a greater concern.

The borehole date results reported that the first 68' feet were that of clay or gravel. The next 4' were shale followed by 46' of limestone. The bore produced water at 5 gpm at 125'.

Joe Krentzman and Sons Inc. is a local recycling facility that is able to be utilized and local land owners allow clean fill dumping on private property for a fee.

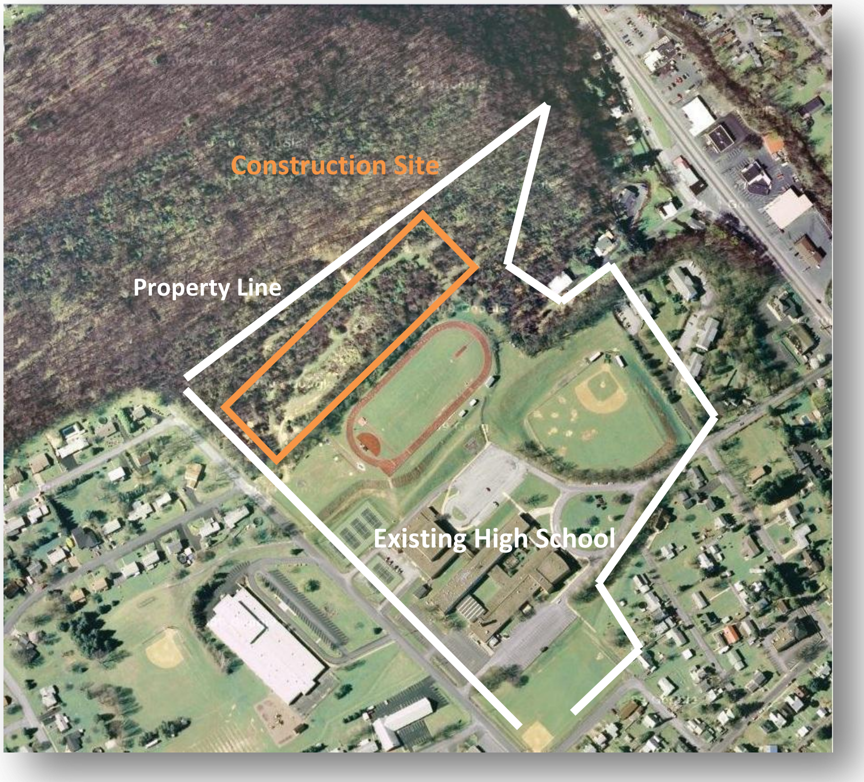


Fig. 8 Existing Site Conditions

4.4 Detailed Project Schedule

*** Refer to Appendix C for Detailed Project Schedule**

Performing work on school campuses requires special attention to scheduling throughout the building process. Heavier than normal traffic patterns, increased population density and obstacles requires scheduling for schools to be accurate and precise, without any variance from the schedule. Failing to adhere to scheduling can result in costly damages to the project. The new Indian Valley High School was planned to open in January 2011. A technique used by a recently completed elementary school, however, with the new reorganization of the county high schools will be postponed until August 2011.

Construction was completed in a phased/area scenario. The schedule addresses five different phases of construction. Phases A and B are the classroom areas of the building. These two together make up what is the front of the school. Phases C, D and E make up the rear wing of the building. Separated from the classrooms, are the gymnasium, wrestling room, fitness center, library, cafeteria, auditorium music suite and wood shops.

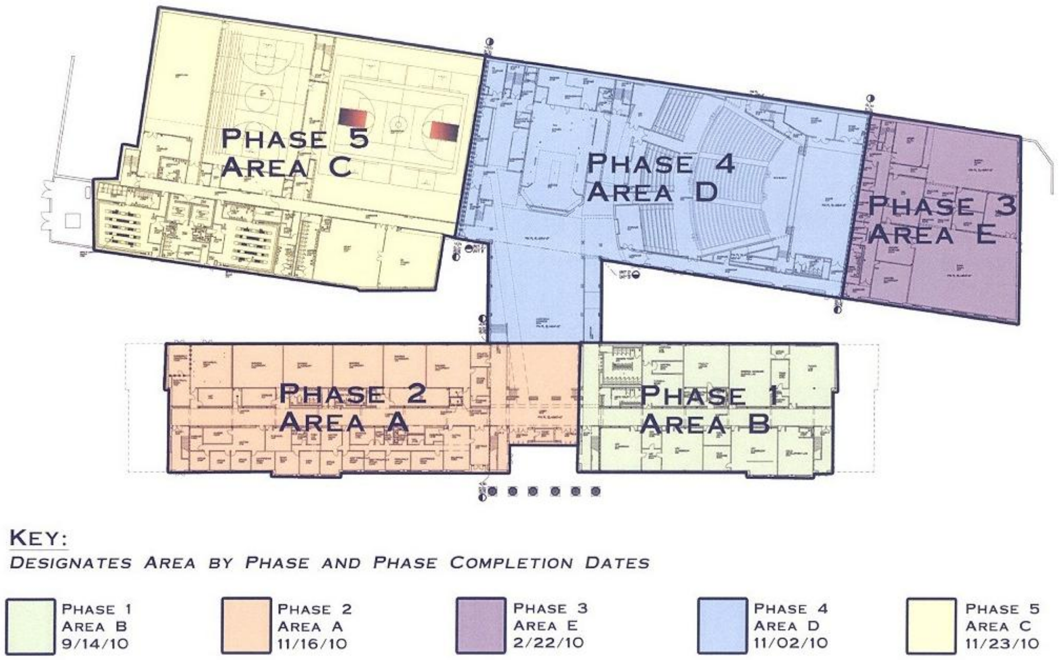


Fig. 9 Phasing Plans Provided by Reynolds

4.5 Site Layout Planning

The site of the New Indian Valley High School is located just to the North of the existing high school. As shown in the figure above, construction traffic flow has little impedance, except for the peak hours of school days. Construction traffic will use Sixth Street to the Southern edge of the site, and Cedar Street along the Southeast edge for the bulk of construction flow off the site. Once on the site construction traffic has a lenient traffic pattern due to the rural-ness of the site. There is plenty of area for job site parking, trailer placement and material storage/layout.

Excavation Site Layout

During the excavation phase of the project the site begins to take shape. A once tree riddled hill is turned into a flat muddy construction site. Two large geothermal well fields are dug along the south and southeast edges of the construction site during this phase. The site is retained by a retention wall placed along the northwest edge of the site. Grading of future driveways, parking lots and bus access is also completed.

Superstructure Site Layout

The superstructure of the school is done in five phases. The first two phases, A and B, are the front of the school which holds the classroom areas. Three story typical bays are constructed for both phases A and B. Phases A and B also take into consideration classroom/subject break down. This puts areas of building closer to related areas of the building so similar classes/subjects are grouped together. Phases C, D and E create the rear of the building and house gymnasium, auditorium, cafeteria, wood shop and music suites of the building. These activities often encompass extra-curricular/after school activities so providing a buffer between educational and after school activities was a concern.

4.6 General Conditions Estimate

*** Refer to Appendix E for the complete General Conditions estimate**

A general Conditions estimate was prepared for the new Indian Valley High School Project. The estimate includes any applicable items that were implemented directly by the project team and construction crews but does not account for home office overhead. The estimate is based on a 28 month construction schedule designed for the project.

Below the table breaks down the major categories of the general conditions estimate and the values for each. These numbers are an approximation and do not reflect the actual amounts contracted between Reynolds Construction.

Description	Costs
Staffing	610,400
Administrative Facilities and Supplies	58,589.38
Safety	27,964
Cleanup	124,939
Jobsite Work Requirements	215,440
Permitting	37,800
Bonds and Conditions	50,000
Total	**1,125,132**

Table 4: General Conditions Estimate Summary

Staffing costs account for the majority of the general conditions costs, which can be attributed to key project team personnel assigned full time to this specific job. Durations and costs associated with the entire project team are detailed in the general conditions estimate. Jobsite work requirements and cleanup account for the other two bulk items within the general conditions. Upon comparison to other projects estimates were found to be typical per other projects of similar size and scope.

5.0 Feasibility and Design Study for Photovoltaic Energy System

5.1 Problem Identification

The New Indian Valley High School utilized very few sustainable techniques that could provide a financial benefit. Features like photovoltaic (PV) roof panels present a viable possibility to take advantage of one of these techniques.

5.2 Research Goal

The goal of this analysis is to perform a preliminary design of a roof top PV energy system and to investigate the financial feasibility to incorporate the system into the existing electrical system to reduce energy costs.

5.3 Methodology

- Research PV panel technologies and sustainable design techniques
- Research into case studies of similar size schools
- Determine the quantity of panels to be placed on roof and amount of kWh able to be produced
- Analyze how the PV system will connect to the existing electrical power system
- Perform feasibility analysis on life-cycle cost and payback period

5.4 Background Information

The New Indian Valley High School project did not consider sustainable energy techniques a driving factor during the design phase of the building. The small community's limited budget did not allow for very much exploration into these new techniques. As with all schools within the Mifflin County School District, the district intends on using the new building for multiple generations. The current High School was built in the late 1960's and the current middle school was built in the early 1950's. The school district uses their schools for a long period of time and a lifespan of 50+ years for the new school is not out of the question. This long lifespan is very attractive to the possibility for a photovoltaic solar array that recoups initial installation costs over a long period of time and continues to reduce energy costs throughout the occupancy of the building.

PV systems have increased efficiency in leaps and bounds over the last decade and are gaining popularity. The average cost of an installed PV system is dropping; government incentives and rebates are increasing along with the cost of electricity. A grid-tied system would ideal for this school due to the sheer size of the building. Developing a system that would render the building completely off the grid is not feasible. However, with the large available roof space and the fact that the roof is free from shading from surrounding buildings, a significant portion of energy could be produced to lower energy costs to the school. Coupled with smart energy consumption during peak energy use times could result in significant savings for the school for many years to come.

5.5 Preliminary PV Array Design

5.5.1 Orientation

The orientation of the New Indian Valley High School is optimal for a roof PV array. Table 5 details design parameters for the PV system. The school will be the tallest structure on the ridge so shading from adjacent buildings during the day is not a concern. The front sloped roof of the school faces directly south, perfect for the collection of solar radiation from the sun.

Design Parameters For PV System	
Location	Lewistown, PA
Latitude	40.5 N
Longitude	77.5 W
Elevation	189.34 m
Sun hours/day	3.65

Table 5: Design Parameters for PV System

5.5.2 System Size and Layout

As previously stated, case studies of similar building sizes and sun hours/day were considered in the design of the PV system. The Northwestern Regional School District No. 7 located in Winstead, Connecticut was investigated for this analysis. This school is 250,000 SF and has a similar sun hours/day solar radiation production of 3.72. The school designed a PV system of nearly 2000 panels spanning 40000SF of roof space, see figure 10. School buildings are considered “black holes” of energy consumption. Schools often are in use early in the morning and occupancy continues sometimes late into the night. School buildings can use hundreds of thousands of fossil fuels each year; however, the New Indian Valley High School incorporates a

Fig. 10: Northwester Regional No. 7 PV system

highly efficient geothermal mechanical system into the building which is run primarily through electric power. This makes the New Indian Valley High School project even more appropriate for the installation of such a PV System.

Due to the odd shape of the roof on the new school, 8 arrays were considered to fit the shape of the roof. The main section of arrays would be placed on the front sloped roof section of the building. Four arrays spaced across the front roof of building sections A and B, and four more across the top of the gymnasium and cafeteria kitchen roofs were considered. Table 6 below breaks down the size of each of the eight arrays.

	Length (ft)	Width (ft)	Area (SF)
Front Roof Section 1	73	32	2336
Front Roof Section 2	100	32	3200
Front Roof Section 3	100	32	3200
Front Roof Section 4	13	32	416
Gym Row 1	130	32	4160
Gym Row 2	100	32	3200
Row 1	75	25	1875
Row 2	75	25	1875
		Total Area	**20262**

Table 6: PV array Breakdown Chart

Based on Sanyo HIT Double PV modules and mounting components it was determined that at a typical module size of 15.536SF, 1304 panels would be needed to achieve a 20262SF system.

5.6 Energy and Electrical Impact

5.6.1 Energy Production

Prior to determining the financial feasibility of the PV system, the yearly value of energy produced was calculated based on the given parameters for the array design and local conditions. Based on Sanyo's HIT double PV modules energy output of 19.1 W/SF it was determined that given this system size and local parameters that roughly 1413 kWh of energy could be produced per day. Consideration was given to overall system efficiency and loss of performance due to inverter loss etc. an 80% efficiency was considered to be reasonable for the system output, or roughly 1130 kWh per day. Table 7 highlights the results from considering energy production throughout different months of the year. The PV arrays would run DC or direct current electricity into combiner boxes that would then direct the power into inverters where the electricity is turned into AC or alternating current, rendering it suitable for everyday use. The findings show that at the systems optimum performance that savings of nearly $42,000 could be achieved per year. Integrating this system with efficient daily energy consumption could produce even more yearly energy savings.

PV Watts Energy Production Results @ $0.1/kWh			
Month	Solar Radiation	Energy	Energy Value
	kWh/m^2/day	kWh	$
1	1.84	17659.584	1765.9584
2	2.65	25433.64	2543.364
3	3.47	33303.672	3330.3672
4	4.36	41845.536	4184.5536
5	5.00	47988	4798.8
6	5.48	52594.848	5259.4848
7	5.49	52690.824	5269.0824
8	4.83	46356.408	4635.6408
9	4.07	39062.232	3906.2232
10	3.08	29560.608	2956.0608
11	1.93	18523.368	1852.3368
12	1.56	14972.256	1497.2256
		419990.976	$41,999.10

Table 7: Energy Production for Months of the Year

Techniques recommended by the U.S. EPA (United States Environmental Protection Agency) and U.S. DOE (United States Department of Energy) are swapping incandescent bulbs with compact fluorescent bulbs, which use 25 to 30% less energy and last ten times longer. They also encourage upgrading fluorescent bulbs from T-12 to T-8 which can save up to 30% of lighting energy and decreases electric bill by as much as 6%. Installing timers or motions sensors that automatically turn off lights in unoccupied spaces best suited for classrooms, restrooms, offices and libraries. Even more advanced strategies such as energy management plans can be implemented to optimize energy consumption.

5.6.2 Electrical Components and System Tie-in

A driving factor in determining the required electrical components for the PV system is the system tie-in design. A PV system of this size would have to tie-in to the existing electrical system via a supply-side interconnection. This means that the PV array supply from inverters must tie in with the utility power supply at a meter box before the main distribution panel of the building. The power supplies are combined in the meter box and then sent to the distribution panel to meet the building loads.

A supply-side interconnection system requires the following electrical components to connect the PV arrays to the existing electrical system in the building: (Loss of system efficiency accounted for above)

- DC Wire Runs – Connects panels to combiner boxes and then combiner boxes to inverter
- DC Disconnects
- Inverter – Converts DC power to AC power
- AC Disconnects
- AC Wire Run – Connects inverter to meter box
- Service-Tap Meter Box – Combines PV power feed with utility power feed

Oversized and longer DC wire runs present a possibility of large voltage drops and are more costly due to DC wire being significantly more expensive than AC wire. Minimizing long wire runs and the use of combiner boxes along with locating inverters on the roof level would be the best design scenario for this system. Typical inverters are similar in shape and size to typical AHUs (Air Handling Units), the buildings current AHUs are hidden by the front sloping roof, with other mechanical components hidden in the pitched area of the roof, therefore there would be minimal effects on the architecture of the building. Placement of the inverters inside the pitched area of the roof would be best because it is recommended that inverters be housed in ventilated enclosures away from direct sunlight which maintain cooler operating temperatures.

5.7 Feasibility Analysis

5.7.1 System Costs

In order to determine the financial feasibility of the photovoltaic arrays to be used, an approximate cost of the system was determined from an average cost per watt as reported by the U.S. DOE. Average values suggest that the cost of the system would be approximately $7/W. Alternate sources suggest that average cost of installation of PV energy systems ranges between $7-9/W produced confirming the estimated average. Table 8 below represents the estimated cost for the PV systems designed for the New Indian Valley High School project.

Estimated Cost of PV System		
Size (kW)	$/W	Cost
387.0042	7	$2,709,000.00

Table 8: Estimated PV Array Cost

5.7.2 Rebates and Incentives

The state of Pennsylvania, as with all states can receive a federal tax credit of 30% of the gross installation cost. There is also an Alternative Energy Credit (AEC) which allows 2.2 cents per kW produced. Another idea for incentives is a Public/Private Partnership which would allow the school district to find a private company to install and maintain the solar facility on its rooftop and through a Power Purchase Agreement (PPA) pay a discounted rate for the power produced onsite. This was the case for Northwestern Region No. 7; they formed a partnership with MP2 Capital and groSolar. Theses private companies qualify for numerous tax credits which were more cost effective than the school taking on the task alone. There are also state grants, often around $25,000 and usually limited to $1 million, but certain exceptions can be made. The Northwestern Regional No. 7 received a grant from the Connecticut Clean Energy Fund of $1.72 million, although not typical can be sought out and obtained, which significantly offset the cost of installation.

5.7.3 Payback Period

The purpose of the installation of PV energy systems is to recuperate the initial costs of installation within an acceptable payback period. Determining this time for a system that has not been built, nor knows of potential grants and corporate partners the only way to see if an energy system of this size is feasible is to look at the cost of the electricity and the AECs that it would produce over the lifespan of the building. The feasibility study assumed that the cost of electricity to be $0.10/kWh with a yearly inflation of 1.00%. Table 9 below shows an estimate of the savings on electricity alone over a 50 year time span, roughly the lifetime of current schools within the district.

50 Year Financial Calculations

Year	Cost $/kWh	Savings/Year	AECs	Total/Year	Monthly Savings	Cumulative Savings
1	0.100	$41,999.10	$923.98	$42,923.08	$3,576.92	$42,923.08
2	0.101	$42,419.09	$923.98	$43,343.07	$3,611.92	$86,266.15
3	0.102	$42,843.28	$923.98	$43,767.26	$3,647.27	$130,033.41
4	0.103	$43,271.71	$923.98	$44,195.69	$3,682.97	$174,229.10
5	0.104	$43,704.43	$923.98	$44,628.41	$3,719.03	$218,857.51
6	0.105	$44,141.47	$923.98	$45,065.45	$3,755.45	$263,922.96
7	0.106	$44,582.89	$923.98	$45,506.87	$3,792.24	$309,429.83
8	0.107	$45,028.72	$923.98	$45,952.70	$3,829.39	$355,382.53
9	0.108	$45,479.00	$923.98	$46,402.98	$3,866.92	$401,785.51
10	0.109	$45,933.79	$923.98	$46,857.77	$3,904.81	$448,643.29
11	0.110	$46,393.13	$923.98	$47,317.11	$3,943.09	$495,960.40
12	0.112	$46,857.06	$923.98	$47,781.04	$3,981.75	$543,741.44
13	0.113	$47,325.63	$923.98	$48,249.61	$4,020.80	$591,991.06
14	0.114	$47,798.89	$923.98	$48,722.87	$4,060.24	$640,713.93
15	0.115	$48,276.88	$923.98	$49,200.86	$4,100.07	$689,914.79
16	0.116	$48,759.65	$923.98	$49,683.63	$4,140.30	$739,598.42
17	0.117	$49,247.24	$923.98	$50,171.23	$4,180.94	$789,769.64
18	0.118	$49,739.72	$923.98	$50,663.70	$4,221.97	$840,433.34
19	0.120	$50,237.11	$923.98	$51,161.09	$4,263.42	$891,594.43
20	0.121	$50,739.49	$923.98	$51,663.47	$4,305.29	$943,257.90
21	0.122	$51,246.88	$923.98	$52,170.86	$4,347.57	$995,428.76
22	0.123	$51,759.35	$923.98	$52,683.33	$4,390.28	$1,048,112.09
23	0.124	$52,276.94	$923.98	$53,200.92	$4,433.41	$1,101,313.01
24	0.126	$52,799.71	$923.98	$53,723.69	$4,476.97	$1,155,036.71
25	0.127	$53,327.71	$923.98	$54,251.69	$4,520.97	$1,209,288.40
26	0.128	$53,860.99	$923.98	$54,784.97	$4,565.41	$1,264,073.36
27	0.130	$54,399.60	$923.98	$55,323.58	$4,610.30	$1,319,396.94
28	0.131	$54,943.59	$923.98	$55,867.57	$4,655.63	$1,375,264.51
29	0.132	$55,493.03	$923.98	$56,417.01	$4,701.42	$1,431,681.52
30	0.133	$56,047.96	$923.98	$56,971.94	$4,747.66	$1,488,653.46
31	0.135	$56,608.44	$923.98	$57,532.42	$4,794.37	$1,546,185.88
32	0.136	$57,174.52	$923.98	$58,098.50	$4,841.54	$1,604,284.38
33	0.137	$57,746.27	$923.98	$58,670.25	$4,889.19	$1,662,954.63
34	0.139	$58,323.73	$923.98	$59,247.71	$4,937.31	$1,722,202.34
35	0.140	$58,906.97	$923.98	$59,830.95	$4,985.91	$1,782,033.29
36	0.142	$59,496.04	$923.98	$60,420.02	$5,035.00	$1,842,453.30
37	0.143	$60,091.00	$923.98	$61,014.98	$5,084.58	$1,903,468.28
38	0.145	$60,691.91	$923.98	$61,615.89	$5,134.66	$1,965,084.17
39	0.146	$61,298.83	$923.98	$62,222.81	$5,185.23	$2,027,306.98
40	0.147	$61,911.82	$923.98	$62,835.80	$5,236.32	$2,090,142.77
41	0.149	$62,530.93	$923.98	$63,454.91	$5,287.91	$2,153,597.69
42	0.150	$63,156.24	$923.98	$64,080.22	$5,340.02	$2,217,677.91

43	0.152	$63,787.81	$923.98	$64,711.79	$5,392.65	$2,282,389.69
44	0.153	$64,425.68	$923.98	$65,349.66	$5,445.81	$2,347,739.36
45	0.155	$65,069.94	$923.98	$65,993.92	$5,499.49	$2,413,733.28
46	0.156	$65,720.64	$923.98	$66,644.62	$5,553.72	$2,480,377.90
47	0.158	$66,377.85	$923.98	$67,301.83	$5,608.49	$2,547,679.72
48	0.160	$67,041.62	$923.98	$67,965.60	$5,663.80	$2,615,645.33
49	0.161	$67,712.04	$923.98	$68,636.02	$5,719.67	$2,684,281.35
50	0.163	$68,389.16	$923.98	$69,313.14	$5,776.10	$2,753,594.49
	TOTAL	$2,707,395.48	$46,199.01	$2,753,594.49		

Table 9: Estimated Return Based on Electricity Costs

The feasibility study shows that over a 50 year time period the school could save over $2.7 million dollars. Applying the 30% government tax credit the school would receive over $800,000 and any grants they could receive would offset the cost and payback period even more.

5.8 Recommendation and Conclusion

Based on the information gathered in section 5.0, the orientation of building suggests a viable scenario for PV system installation. The payback period generated suggests based on no outside grants that a period of roughly 30 years could be achieved with significant grants reducing this even more. Section 5.0 also suggest that a PPA could offset costs even more and would allow an outside entity to maintain the rooftop PV system, opposed to the school district taking on this task themselves. Since the Mifflin County School District is known for utilizing schools over this amount of time it could be very beneficial than originally thought to install a rooftop PV system that throughout the lifespan of the building.

6.0 Short Interval Production Schedule Development

6.1 Problem Identification

The two phases that have been proposed for a Short Interval Production Schedule (SIPS) are the parts of the phases A and B of the construction process that house the classroom units. The interior finishes that are involved with the completion of the classrooms are repetitive from room to room and from floor to floor. This area of the building is where the majority of the occupancy will be on a day to day basis, so it is extremely important to the Mifflin County School District and the project team that the this phase of the construction process be finished in a timely fashion at the highest quality. The interior finishes schedule will need to be very consistent and predictable in order to deliver a product to these standards.

6.2 Proposed Solution

The repetitive nature of the work involved with interior finishes of the classroom areas produces an ideal location to develop a more efficient SIPS. This particular scheduling method has often been used in areas of construction that are very repetitive in nature.

6.3 Methodology

- Gain a full understanding of the interior finishes schedule
- Identify project milestones and interior finishes timeframe
- Identify each individual trades that are involved in the sequence
- Determine the specific trades that will be driving the critical path of the schedule
- Define the specific activity durations along with basic crew sizes for the specific trades that were identified to be driving the schedule
- Establish the project specific sequence of work for a typical unit
- Ensure that resources can attain/allow consistent work durations
- Develop the Short Interval Production Schedule
- Compare the SIPS duration with the existing project schedule
- Evaluate the cost implications of any changes in resources

6.4 Resources

- Critical Path Project Schedule
- Reynolds Construction Project Manager
- RS Means Cost Data
- Penn State Architectural Engineering Faculty Members
- AE 473: Building Construction Management & Control

6.5 Expected Outcome

The development of a Short Interval Production Schedule will result in an overall reduction of the project schedule. The highly repetitive work associated with this phase of construction will in turn lead to a more efficient workforce. The implementation of this scheduling technique will help to organize and optimize activity durations, while also achieving the highest quality of work.

The benefits associated with this type of scheduling technique include optimizing durations and achieving high quality of work. A SIPS is more predictable than other forms of scheduling, which in turn makes it easier to track and communicate the progress of the schedule.

6.6 Introduction to Short Interval Production Scheduling

Short Interval Production Scheduling (SIPS) is a scheduling method that is often implemented to construction buildings that exhibit an immense amount of repetitive tasks. This technique is most often found applied to high rise office buildings, apartment buildings and hotels. The classroom areas of the New Indian Valley High School project show the signs of this kind of repetitive work. Each classroom, though different in sizes, utilize the same interior finishes from room to room. This scheduling approach would bring an assembly line feel to each room. This would then allow the different trades of each interior finish application to increase their efficiency as they move from room to room through this portion of the building. Each trade would complete their assigned job and then move to the next unit and repeat, making room for the next trade to come in behind them to work where they have just vacated. SIPS also avoids trade stacking in the same area that can lead to confusion, congestion and overall inefficiencies in the project schedule by not overloading one zone of construction with multiple trades.

The development of the SIPS begins by breaking down the building into individual units that involve manageable scopes of work (i.e. classrooms). The schedule development will consider each room as its own unit. The typical classroom in the New Indian Valley High School is roughly 800SF with some bigger rooms getting to be as large as 1100SF. The vast majority of rooms are comprised of the same flooring, wall, ceiling and casework for each room, with quantities of each varying slightly.

The next step in SIPS development is to determine which of the activities will be driving the critical path of the finishes schedule and the overall time frame that these tasks must be completed. Once the critical path is developed, quantity take offs must be completed to determine the amount of each material in their respective units. Appendix ?? shows the take offs for the New Indian Valley High School project for each classroom. The materials that were estimated include gypsum wall board, vinyl composition tile, interior paint, acoustical ceiling tile and casework. After all quantities for the units are established the project specific sequence needs to be established. This step is critical for **ALL** activities because of the start-finish relationships that will be present with each trade.

The final step of the process involves resource leveling. This practice includes looking at each of the trades and either increasing or decreasing their crew size in order to create an equivalent duration for each of the trades involved in the finish schedule. This practice helps to avoid the issue of trade stacking in a particular unit. In the construction industry, trade stacking is a common inconvenience on any project that can put production rates into jeopardy. A SIPS will attempt to negate this common inconvenience by only allowing a limited quantity of workers in a specific unit at any given time.

After all of the steps are completed for an individual unit, the results can then be applied to all of the units through the scope of the finish schedule. The finished product provides an alternative to traditional Critical Path scheduling and is known as a Short Interval Production Schedule.

6.7 Project Constraints

The start of the interior finishes is dependent on the Building Dry milestone, and is scheduled to be completed on December 15, 2009. The current Critical Path Schedule has substantial completion for the considered areas as of November 10, 2010. This allows roughly 47 weeks to complete **ALL** activities involved with building Phases A and B according to the critical path schedule. Building Phases C, D and E are scheduled to be completed in a simultaneous fashion with building substantial completion set for a later date and were not considered to be a part of the SIPS.

Once the Building Dry milestone is established, the building should be free from any unwanted moisture and all of the interior work can be put into place without running the risk of damaging finishes. Pertaining to the SIPS schedule only finishes were considered and MEP rough-ins and in-wall quality inspections were not considered.

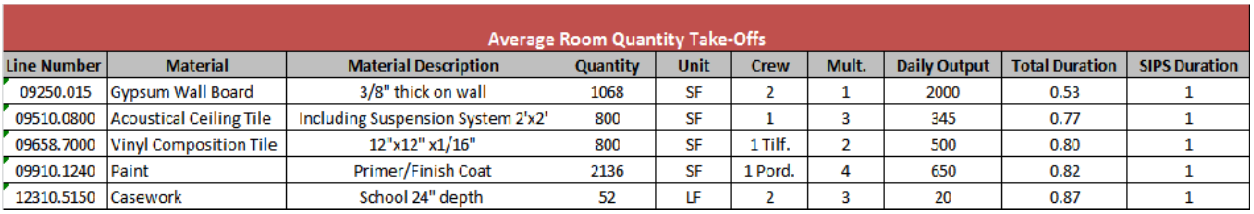
6.8 SIPS Development

The SIPS for the New Indian Valley High School was generated for the finish activities for building phases A and B which house the academic classrooms of the building. Building phases C, D and E house the gymnasium, cafeteria/kitchen and auditorium and music suite respectively. These three phases were not considered in the development of the SIPS. Building phases A and B are both three stories and the number of units differs per level. Table 10 shows the number of **classroom** units per each phase and story of the SIPS.

Once the quantities of each material are determined RS Means can be utilized to determine daily production rates and the corresponding crew sizes. In most cases the crew sizes needed to be adjusted in order to establish activity durations as close as possible to the others. Attaining optimum results with SIPS requires this tactic so that each crew and move from zone to zone without interruption or delay from the previous crew that was just there. Table 11 below shows the all the individual quantities that were estimated and their corresponding crew sizes.

Building Zones	
Level	Units
A-1	6
B-1	7
A-2	9
B-2	14
A-3	14
B-3	11
Totals	**61**

Table 10: Number of Units for Each Floor/Phase



Average Room Quantity Take-Offs									
Line Number	Material	Material Description	Quantity	Unit	Crew	Mult.	Daily Output	Total Duration	SIPS Duration
09250.015	Gypsum Wall Board	3/8" thick on wall	1068	SF	2	1	2000	0.53	1
09510.0800	Acoustical Ceiling Tile	Including Suspension System 2'x2'	800	SF	1	3	345	0.77	1
09658.7000	Vinyl Composition Tile	12"x12" x1/16"	800	SF	1 Tilf.	2	500	0.80	1
09910.1240	Paint	Primer/Finish Coat	2136	SF	1 Pord.	4	650	0.82	1
12310.5150	Casework	School 24" depth	52	LF	2	3	20	0.87	1

Table 11: Material Take-Off

All zone materials now have take-offs for their respective activities. The project sequence for the entire building can now be determined. Consideration that the critical path schedule accounts for areas not included in the SIPS development now has to be accounted for. Based on time durations for reasonable crew sizes the crew would be able to complete one classroom for their specific activity per day. However, the critical path schedule includes offices, restrooms, corridors, lobbies and stairwells that were not taken into consideration in developing durations for the SIPS. Therefore, estimates will be made on how the SIPS can affect the critical path schedule based on the quantity of materials in the classrooms, and that of the rest of the building areas included in building phases A and B.

6.9 Cost and Scheduling Impacts

After taking into considerations the other areas of building phase A and B that were not in the SIPS, it was determined that the critical path schedule could be reduced by approximately 2-3 weeks. This of course is a reasonable estimate due to the many other facets of the building that are included in the critical path schedule. Since the SIPS does not completely encompass the entirety of building phases A and B it is difficult to estimate exactly how much time the SIPS could **ACTUALLY** save.

6.10 Conclusions and Recommendations

Implementing a Short Interval Production Schedule into the classroom areas finishes schedule, the project team could be potentially be provided with a schedule that has a total duration that is 2-3 weeks shorter than the critical path schedule. This acceleration is possible due to the streamline repetitiveness of the work. This technique not only accelerates the schedule but it also provides the project team with additional float time. This can assure that any unforeseen delays and stoppages can be accounted for without throwing off the rest of the critical path schedule. The substantial completion milestone is critical to both the Mifflin County School District and the project team as the school must be ready for occupancy. There are significant liquidated damages written into the contract and this technique could alleviate incurring such damages by the construction manager. In conclusion, the Short Interval Production Schedule has the potential to generate results that would be beneficial to both the Mifflin County School district by assuring a high quality of work due repetitive tasks, and the project team could build in an amount of float to assure the project stays on schedule.

7.0 Re-Orientation of Vertical Closed Loop Geothermal Mechanical System

7.1 Problem Identification

The New Indian Valley High School project has not totally neglected the idea of sustainable energy. The school is designed with a 220 ton vertical closed loop geothermal mechanical system. Vertical closed loop geothermal energy systems require extensive excavation for installation. During the installation of this system the project team ran into unforeseen limestone conditions which are not conducive to borehole drilling. There are two well fields consisting of 220 wells at roughly 525 feet, far exceeding an average depth of 200-400 feet for more common wells.

7.2 Research Goal

The goal of the research is to investigate the feasibility of the re-orientation of the current 2 field vertical design to a hybrid vertical-horizontal, or full horizontal design. The investigation will look into the financial benefit to alternative design scenarios along with system efficiency.

7.3 Methodology

- Research Geothermal Mechanical technologies and design techniques
- Analyze the available land space
- Perform preliminary cost scenarios for each system
- Perform feasibility analysis for different scenarios

7.4 Background Information

Geothermal mechanical systems come in many sizes and varieties. Systems can be designed to heat and cool residential homes as well as large buildings such as hospitals or schools. Geothermal mechanical systems are very attractive to new home/building owners because of their incredible efficiency. Geothermal heat pump systems use 25-50% less electricity than their conventional counterparts. However, these systems have initial upfront costs that can deter people from implementing them. Considering these upfront costs there is often a rate of return on investment that in some cases can be lengthy. Schools, however, are built with longevity in mind, and yearly savings on energy costs make schools perfect candidates for geothermal mechanical systems

Closed loop geothermal mechanical systems, also called ground source heat pumps (GSHPs), operate by exchanging heat between piping loops buried in the earth. These loops can be vertical or horizontal in orientation, and typically pump a water/antifreeze mixture through the pipes. These systems are more efficient than typical heating systems because they are exchanging heat from a moderate constant temperature location, the earth. After digging down a distance of 10-12 feet, soil temperatures remains fairly constant. This constant temperature allows for a more efficient heat exchange than to varying outdoor air temperatures. In the central Pennsylvania region these ground temperature hover around 52-55 degrees Fahrenheit over the entire year. During summer months the process can be reversed to cool the building.

7.4.1 Vertical Closed Loop Geothermal Mechanical Systems

Vertical closed loop geothermal mechanical systems are comprised of pipes that run vertically in the ground. Placing these pipes requires boring holes, typically 100-400 feet deep. Pipe pairs in the hole are then joined with U-shaped connectors at the bottom of the hole. Boreholes are then commonly filled with bentonite grout to surround the pipe to provide a better heat exchange with surrounding rock conditions, see figure 11 for vertical well hole boring. Vertical Loops are primarily used where space is a factor. Deep wells negate the need for large well fields because they are drilled vertically. In a vertical system each hole requires roughly 250SF of land area. Borehole layout is critical component in geothermal design. If boreholes are placed too close together heat will not be able to dissipate, resulting in rising ground temperature over time. Boreholes must also be drilled as close to vertical as possible, for even the smallest angle off center over several hundred feet can cause piping to run into each other.

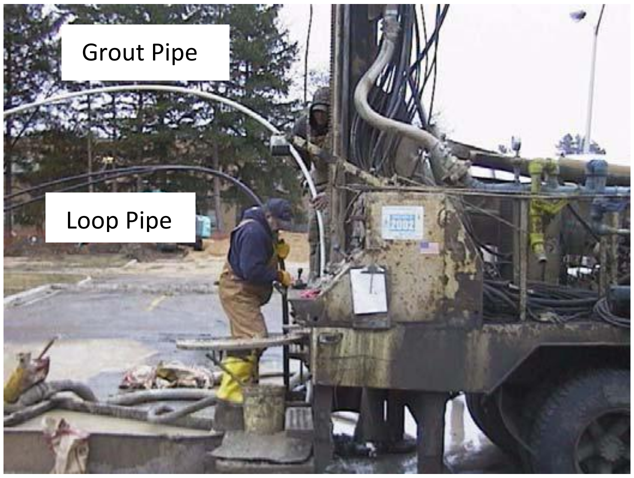


Fig. 11: Vertical well hole boring

7.4.2 Horizontal Closed Loop Geothermal Mechanical Systems

Horizontal closed loop mechanical systems consist of parallel pipes that run horizontally in the ground. Instead of requiring deep boreholes for installation, horizontal systems require long horizontal trenches that are deeper than the frost line. Due to the shallowness of trenches compared to that of boreholes the cost of excavation in a horizontal system is nearly half of that in a vertical system. The drawback with horizontal system is that they require a far greater amount of land area for installation roughly 2500SF per ton (the length of a run). Horizontal systems can also be susceptible to variances in ground temperature, though the deeper the system is placed the last drastic the change. Figure 12 below illustrates the change in average ground temperatures for different days throughout the year.

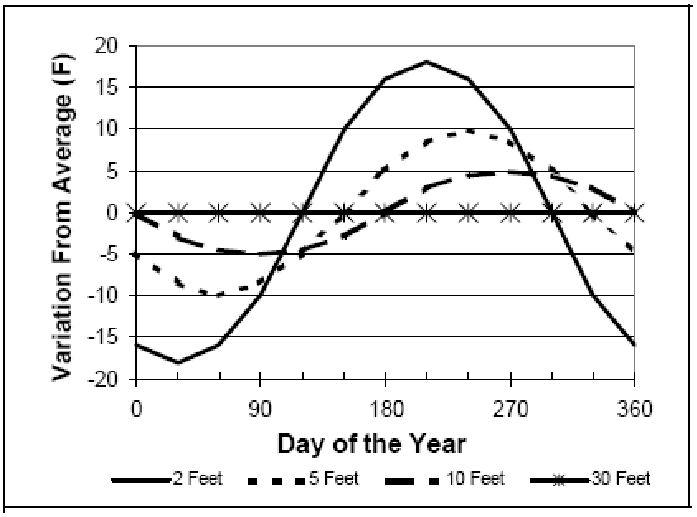


Fig. 12: Daily Variance in Average Ground Temperatures

Most systems are placed at least 5 feet below ground so this could have a potential total variance of 20 degrees from the assumed average ground temperature on the hottest of hot days and coldest of cold days. This could potentially cause heat pumps to use more electricity than vertical wells, however, that would only be for the most extreme heating/cooling days of the year. After 30 feet there is no significant variance in the average ground temperature for any day throughout the year. Figure 13 below Illustrates the physical differences between horizontal and vertical closed loop geothermal mechanical systems. A horizontal loop may also be installed via mini horizontal directional drilling (mini-HDD). This technique can place piping under yards, driveways and other structures without disturbing with them costs between that of trilling and trenching.

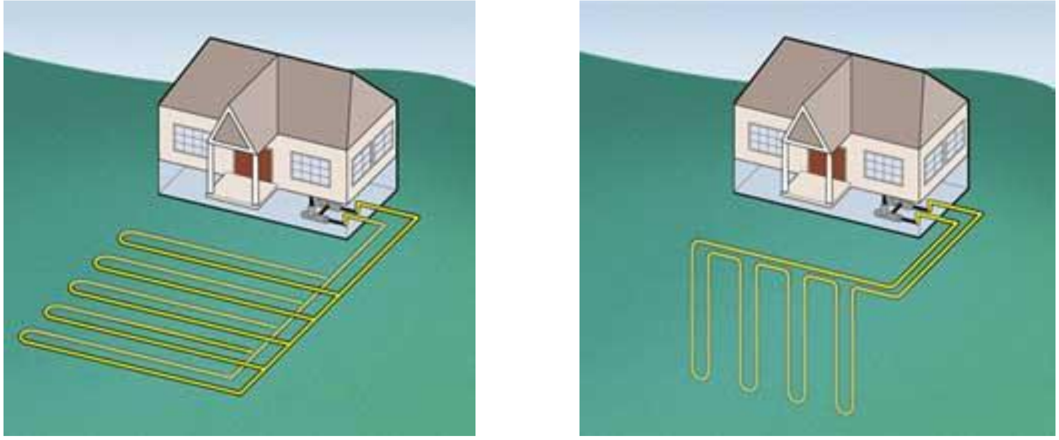


Fig. 13: Horizontal vs. Vertical Closed Loop Layout

7.5 Available Land Area Feasibility

As previously mentioned in sections 7.4.1 and 7.4.2 the amount of land needed to drill one bore hole is approximately 250SF per hole and roughly 2500SF is needed per ton for horizontal systems. This requires roughly 10 times the amount of land to build an equivalent horizontal system as it does vertical. The New Indian Valley High School sits on a 41 acre lot, which is more than enough to accommodate this need. However, it is recommended for horizontal systems that they do not lie underneath parking surfaces. The New Indian Valley High School has two large parking surfaces build on its East and West sides that would make land unavailable for this method. The property line off the east end of the building extends providing roughly 5 acres or roughly 200000SF of useable land area upon grading of the sloped ridge. Assumed extra site work would be less costly if done at the beginning of the project then if decided upon later.

7.6 Installation Costs

7.6.1 Installation Cost of Vertical Geothermal Mechanical System

Vertical closed loop geothermal mechanical systems provide are the best design scenario to use whenever space is limited, however, this sacrifice of space comes at a cost. Average installation costs for vertical closed loop geothermal mechanical systems are roughly $2000-$2400 per ton installed based on soil types encountered. The New Indian Valley High School utilizes a 220 ton system that encountered limestone build ups, which slowed and added money to construction. This estimate then will consider the upper limit for estimation. That means based on average date the New Indian Valley High School project would have cost roughly $525,000 installed, without the construction delays. A fair financial estimate on the amount of damages done by the delays was unavailable for this report.

7.6.2 Installation Cost of Horizontal Geothermal Mechanical System

Horizontal closed loop geothermal mechanical systems provide the cheapest installation cost of geothermal energy systems. However, this alternative comes at the expense of needed land area. If access to necessary amounts of land cannot be met there is not use in exploring this scenario. However, as previously stated the New Indian Valley High School has roughly 5 acres of ridge line that it could utilize. Average installation costs for horizontal closed loop geothermal mechanical systems are roughly $1300-$1500 per ton installed. This would roughly estimate the New Indian Valley High School project at 220 tons to be $300,000 for a horizontal closed loop system. A horizontal system utilizing mini-HDD would not require excavation, grading and site work to the 5 acres of ridgeline off the Eastern edge of the building.

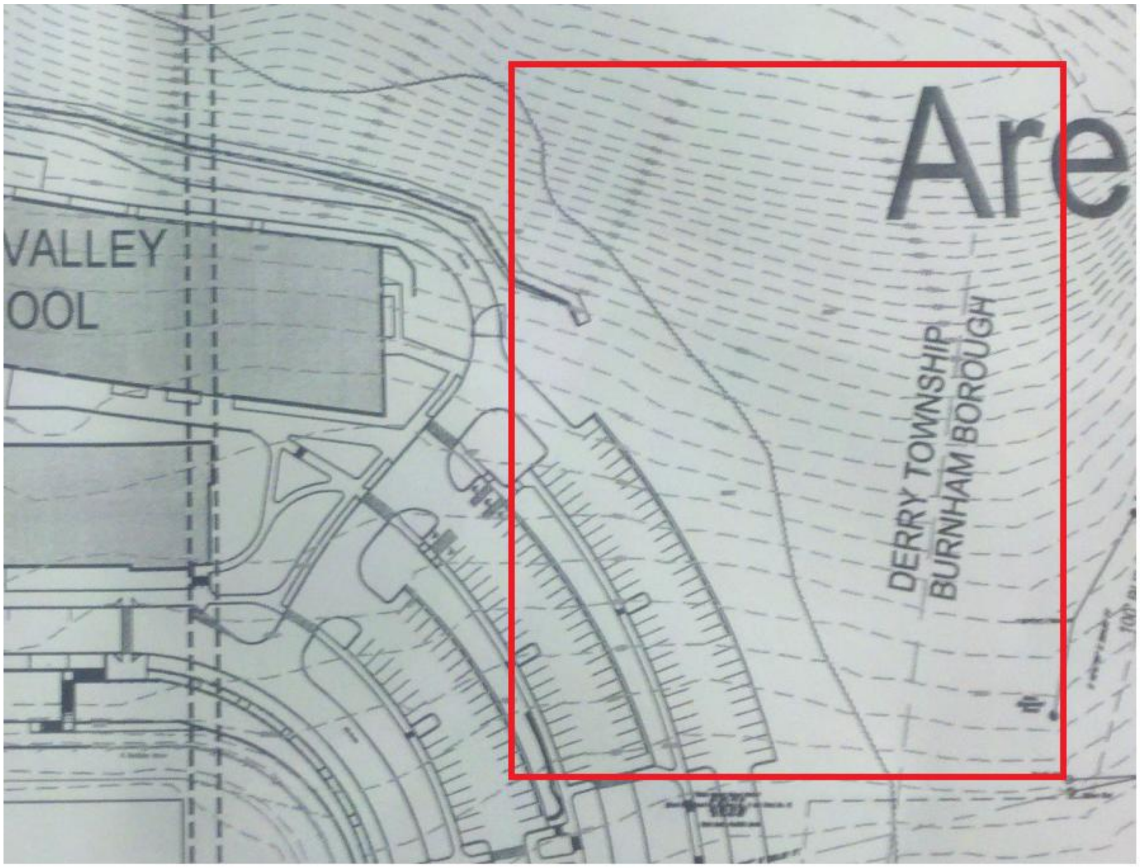


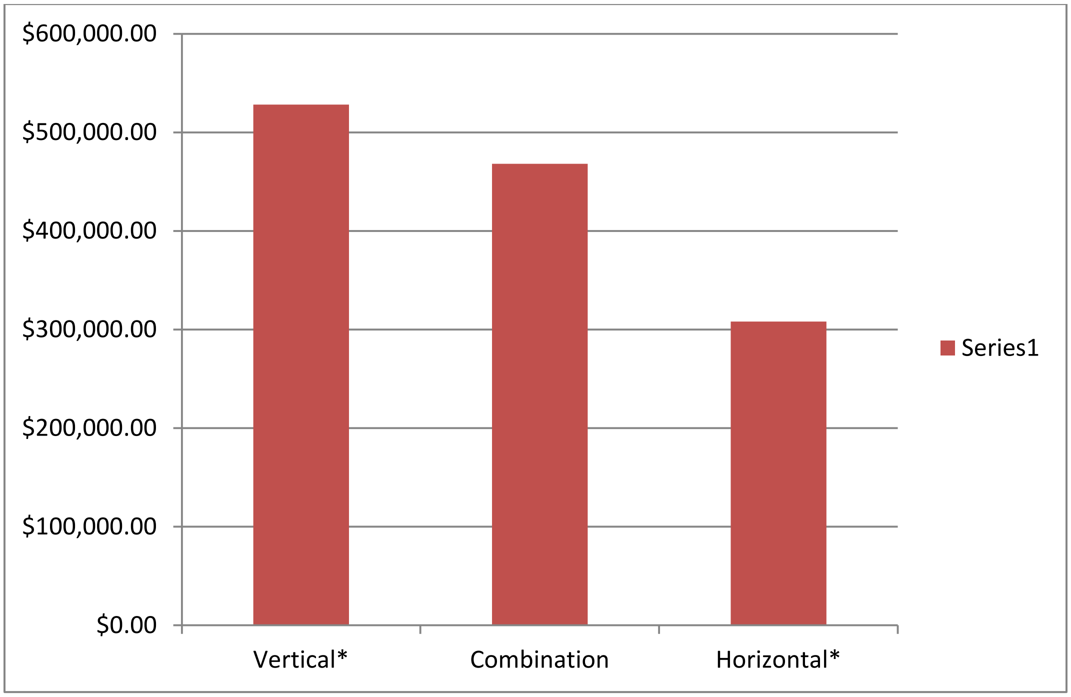
Fig. 14: Available Land Area of Easter edge of school

Figure 14 on the previous page highlights the area that could potentially be used for a horizontal closed loop geothermal mechanical field.

7.7 Feasibility of Design Re-Orientation

Based on industry average installation costs it was found that the difference between both types of systems was over $200,000. However, to be a trench installed horizontal system would require extra grading and excavation to the current site. A mini-HDD system is between that of a vertical system and horizontal system. Approximate estimates for a mini-HDD system would cost $1900 per ton installed. This means a total horizontal mini-HDD system would cost roughly $420,000. This would produce a savings of roughly $100,000 from the current vertical system layout.

The New Indian Valley High School project experienced delays in only one of the 2 well fields. The Indian Valley High School could potentially incorporate one of the vertical well fields and a mini-HDD system or remove the problem area of the vertical well field and install it via the mini-HDD method.



Graph 1: Cost of Installation of Each System Type

The graph above shows the relationship of the current vertical system that was installed ("*" associated extra costs) without the extra costs of delay damages, the cost of a combination system that redesign one field of 120 wells into a mini-HDD field, with the other 100 well field left as designed, and the cost of installation of a completely horizontal well field without the extra costs of excavation and grading.

Based on installation costs alone, by utilizing the combination well field design, the project could save roughly $60,000. Mini-HDD would not disturb the ridge line above and would actually end up being deeper in the ground as it drives back into the ridge. The proposed site of the mini-HDD well field has roughly a 10% grade, which at the farthest end of the field is 100 feet in the ground making it unsusceptible to varying ground temperature conditions unlike a trenched horizontal system.

All systems designed are closed loop systems with the same basic rate of returns on each system. Horizontal trench systems often require more electrical input to the heat pumps due to varying ground temperatures causing heat pumps to work harder. This extra work reduces the savings per year of a horizontal system; however, it is still far more efficient than traditional air to air heat exchanges systems.

7.8 Conclusions and Recommendations

Based on the investigation in section 7.0, there were potential savings to be found with the utilization of a combination closed loop geothermal mechanical system. Closed loop geothermal mechanical systems present the opportunity to achieve 25-50% savings on energy costs each year. Without knowing the cost of delays due to vertical well borehole drilling, roughly $60,000 upfront could be saved from the implementation of this system, while still gaining the roughly the same amount of return on investment. Executing a mini-HDD system may require the assistance of extra machinery, but savings in time and baseline installment should offset this, resulting in a net savings for the installation of a combination closed loop system.

8.0 Building Orientation/Re-Design Excavation Effects

8.1 Problem Identification

The New Indian Valley High School project is located just north of the existing high school on a previously vacant ridge line. The construction site required extensive excavating, site work and the placement of a soil nail retention wall at the rear of the site. The soil nail wall is approximately 600 feet long and ranges from 5 feet high to 20 feet high. Eliminating extra excavation and placement of part of the soil nail retaining wall could supplement the high costs of excavation on site.

8.2 Research Goal

The goal of the research will be to investigate the possibility of reduction of overall building footprint size and elimination of part of the soil nail retention wall to help supplement excavation costs without sacrificing owner wants/expectations.

8.3 Methodology

- Investigate size and occupancy of spaces to be moved
- Investigate building re-orientation on site
- Determine soil nail wall size reduction
- Determine the SF of building footprint eliminated
- Cost estimate of soil nail wall reduction

8.4 Movement of Building Spaces and Re-Orientation

Building phase B, the East wing of classrooms is approximately 176 feet long and 90 feet wide in building footprint. This accounts for roughly 16000SF of building footprint. This is the smaller wing of class rooms and can easily be moved atop building phase A, the West wing of classrooms, which is approximately 19000SF of the building footprint. The gymnasium area, or building phase C, is roughly 35000SF, moving the front edge of the building forward 30 feet would allow for the accommodation of gymnasium area footprint. Moving building area C, or the gymnasium, to where building phase B, the East wing of classrooms was will also require moving building phases D and E the auditorium and cafeteria kitchen areas back 30 feet. These 60 feet of correction allows for all building spaces to keep their original geometry in different physical spaces, without adding to extra excavation costs. Sacrificing of total building area was avoided using this re-orientation method. The parking lots on the Eastern and Western edges of the building would remain untouched. This also allows to keep academic areas separate from “after school” areas of the building as were design considerations. Figure 15 below illustrates the change in overall building footprint.

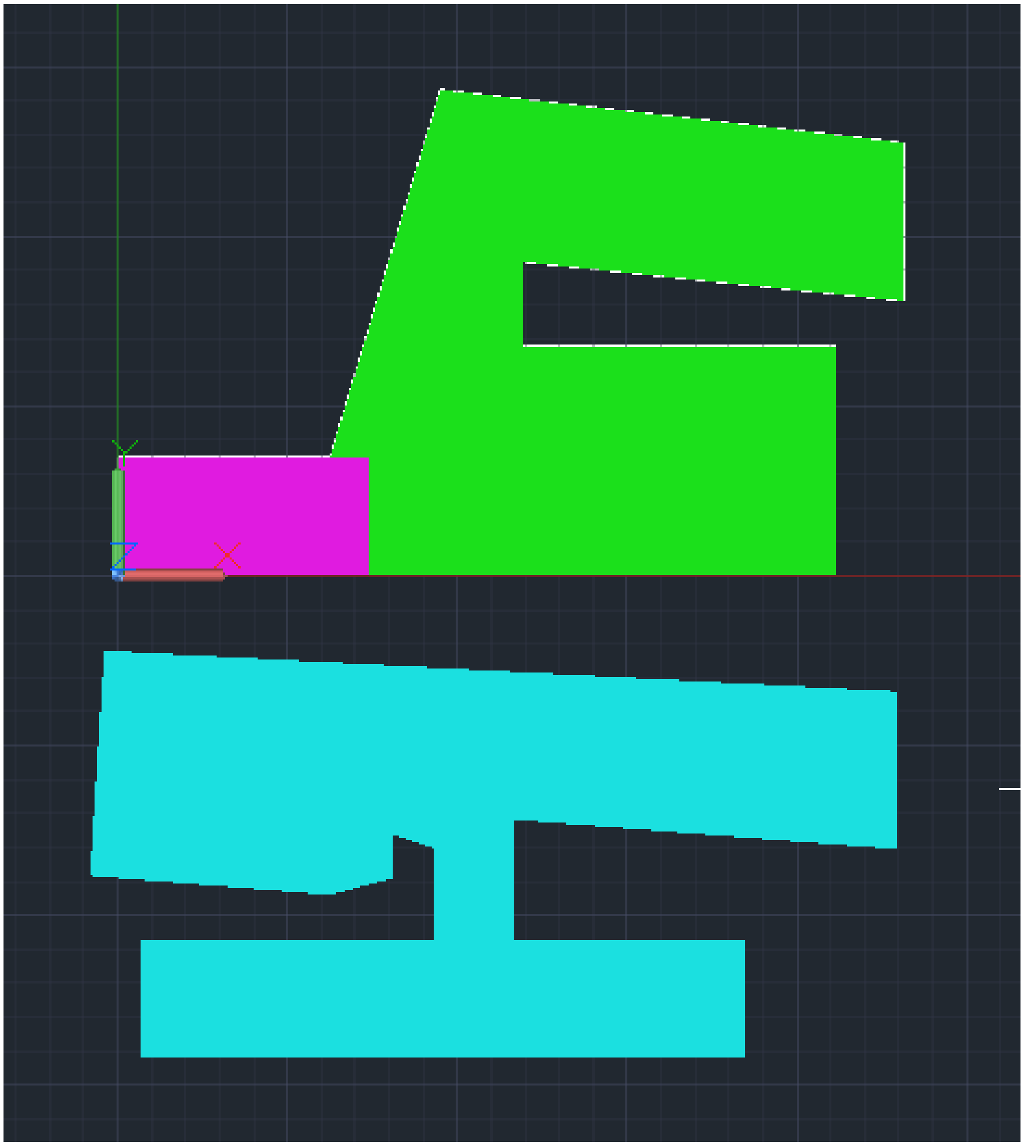


Fig. 15: Original and Re-Oriented Building Footprints

8.5 Soil Nail Retaining Wall Size Reduction

The soil nail retaining wall at the rear of the site is roughly 600 feet long. The soil nails lengths into the ridge very from 20 feet to 30 feet based on the height of the wall. The change in building footprint would allow for the reduction of the soil nail retaining wall by nearly 200 feet. This would allow for a slight sloping grade from the Northern edge of building phase A to the place formerly held by the retaining wall, thus eliminating the need for the wall in this area. The overall area of the soil nail wall reduction is roughly 2000SF due to the varying height of the retaining wall, which will be the driving factor when determining soil nail cost estimates via RS Means. Figure 16 below highlights the section of wall to be removed.

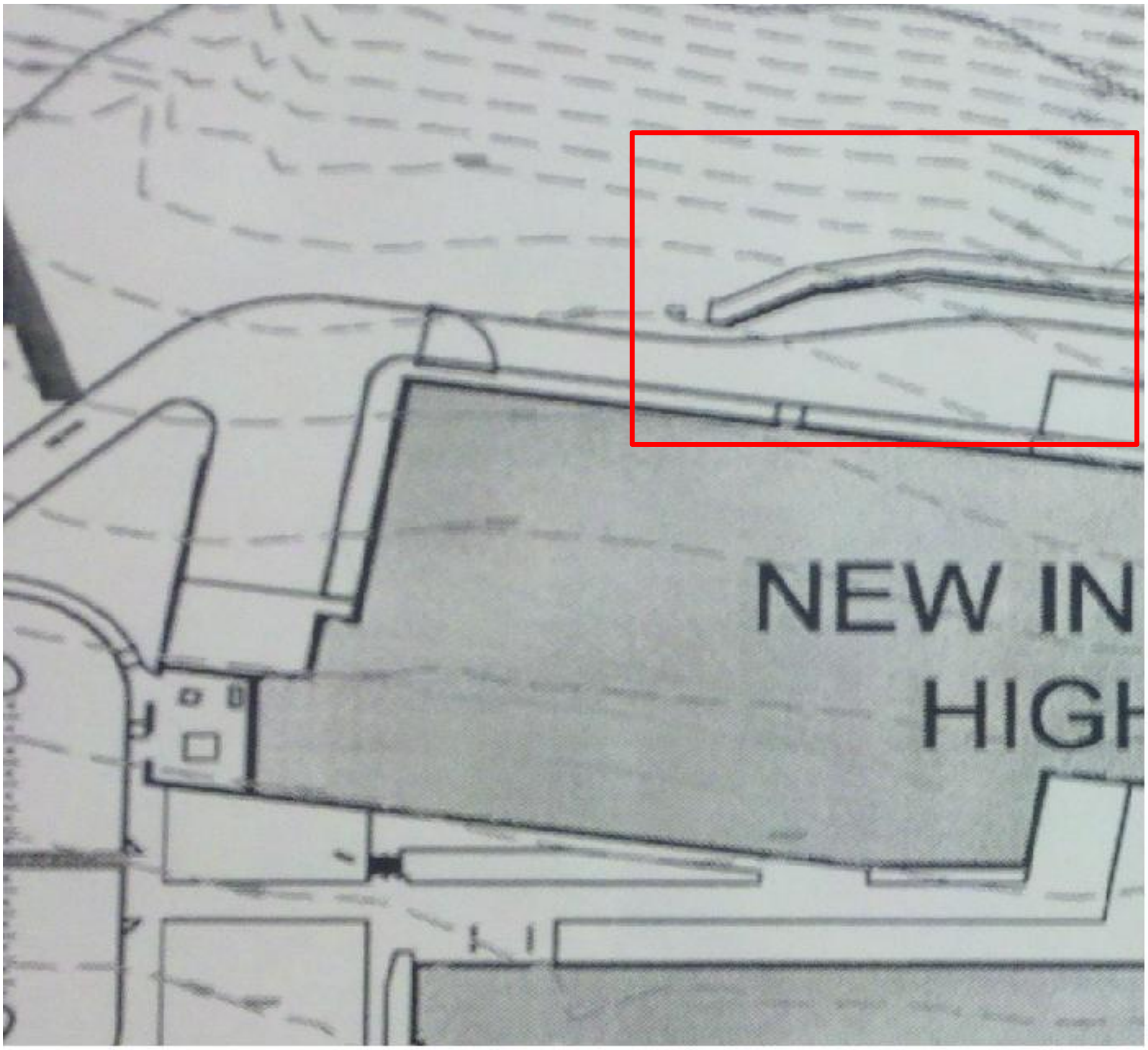


Fig. 16: Soil Nail Retention Wall Reduction

8.6 Soil Nail Retaining Wall Size Reduction Cost Estimations

The height of the soil nail wall to be removed varies from 10 feet to 12 feet. The wall length to be removed is roughly 200 feet. This brings the rough square footage of the wall to approximately 2000SF. The daily output on 10 foot retaining walls is 580SF, and 530SF for 12 foot walls based on RS Means data. This accounts for roughly four days of work on the critical path schedule. Equipment costs to shot-crete the walls is roughly $2,800 for the week or $965 per day, and crew costs are $650 per day. The soil nail walls final thickness is 8 inches or 0.75 feet, resulting in roughly 62CY of concrete. Concrete material costs for retaining walls are roughly $70/CY. This brings a concrete material cost of $4,340 and a labor cost for four days to $5,400. The soil nail retention wall also comes with an aesthetic architectural face. This architectural face was originally considered for a value engineering removal. Based on construction documents the total cost of the architectural face for the retaining wall was $127,000 based on bid alternatives. The wall reduction is roughly 1/3 of the original size, producing savings of $40,000.

<u>Material Cost</u>

2000SF(.75FT) = 1650/27 = 62 CY

62CY($70/CY) = $4,340

<u>Labor/Equipment Costs</u>

Shot-crete equipment rental = $2,800/wk or $965/day

Labor costs = $650/day(4 days) = $2,600

<u>Architectural Face Savings</u>

$40,000

<u>Total Savings</u>

$4340 + $2,800 + $2,600 + $40,000 = $49,740

8.7 Recommendations and Conclusions

Reducing the overall building footprint by roughly 16500SF eliminates the need for roughly 200 feet of soil nail retaining wall. Reducing the length of the very long retaining wall could produce cost savings of nearly $50,000. In the original bid documents, the architectural face placed on the shot-crete soil nail retaining wall was roughly $127,000. This left potential for significant savings by re-orienting the building, providing availability for the reduction of the large retaining wall. Re-orienting building spaces would not sacrifice building spaces, or jeopardize owner wants/expectations. Based on the investigation in section 8.0, there is sufficient data that would lead to substantial savings in excavation/retaining wall costs if this re-design was implemented.

9.0 Recommendations and Conclusions

During the fall and spring semesters, the New Indian Valley High School project has been evaluated to identify and optimize certain areas of design and construction on the new project. This final report represents the culmination of research, investigation and analysis into four main topics: Feasibility of PV Arrays, SIPS Implementation, Geothermal Mechanical System Configurations and Building Re-Orientation/Re-Design Effects. The findings in the report do NOT reflect any perceived mistakes by the actual project team and are purely for theoretical and academic analysis performed for the purpose of the senior thesis capstone project.

The first analysis and electrical breadth, was a feasibility and design study for implementation of building integrated photovoltaic system. A thorough design analysis revealed that the orientation of the school had potential to house a 387kW rooftop PV array. This would produce sufficient energy, coupled with energy smart power usage to provide savings of roughly $40,000 a year. Given the size of the system a supply-side interconnection with inverters located at roof level would connect the PV array to the building's electrical system. The overall cost of the installation would roughly be $2.7 million with over $800,000 in rebates and incentives. Its recommend that the school district seek out a PPA agreement to implement this system due to not having to perform routine maintenance on the system themselves and with a smaller upfront expenditure.

Through completion of the second analysis on Short Interval Production Scheduling, it has been determined that the academic classroom areas of the New Indian Valley High School would be a prime candidate for this scheduling technique, as it involves many repetitive activities. Throughout completion of these activities the contractor would be able to maximize their rates of production, while still being able to achieve the highest quality of work. The schedule would also receive acceleration providing possible float time that the contractor could then utilize on other phases of the building or could result in potential savings in general condition costs.

Re-Orienting part of the geothermal well fields was the focus of the mechanical breadth and analysis three. Investigation into the different options when installing geothermal mechanical systems allowed the potential to make better judgments on what type of systems could be used. Vertical closed loop systems are the best and only type of system to use when space is limited, however, land space available at the New Indian Valley High School construction site made the exploration into horizontal closed loop systems available. Through research and analysis it was determined that the implementation of a combination vertical/mini-HDD well field system that the project team could eliminate the issue of unforeseen limestone conditions and delay damages along with saving money in the installation of mini-HDD well fields because of the greater expense of the vertical well counter parts. It was determined that considerable savings could be attained through this process without significantly effecting energy production into the heat pumps due to varying ground temperature conditions and the same efficient product could be achieved.

Finally the fourth and final analysis looked into the exploration in building re-design/re-orientation, without the sacrifice of owner wants or expectations. By creating the classrooms in one single wing of the school, the footprint was able to be reduced by nearly 16000SF which then in turn could lead to the removal of approximately 200 feet of soil nail retaining wall at the rear of the site. This could come as a concern because the students would then have to travel between six stories of classrooms opposed to only three. The savings of the wall reduction were considerable and at the very least could be considered as a value engineering alternative.

Through the completion of these four analysis topics, it has been revealed that the results have the potential to increase efficiencies in multiple aspects of the project along with the potential of considerable financial savings. When combined, all four analysis topics have the ability to present the New Indian Valley High School with a high quality product that they can occupy and be proud of for many years to come.

10.0 References

A Textbook Example: Why American Schools Must Go Green. Retrieved on February 10, 2011, http://www.renewableenergyworld.com/rea/news/article/2010/09/a-textbook-example-why-american-schools-must-go-green

Adam T. Inc. *Geothermal Power.* Retrieved March 2010, http://www.adamtinc.com/geothermal.shtml

Electric Power Monthly. *Average Retail price of Electricity to Ultimate Customers by End-Use Sector, by State*. Retrieved on February 10, 2011, http://www.eia.doe.gov/cneaf/electricity/epm/table5_6_a.html

Florian Solar. *Solar Canopies, Solar Carports, and Racking Kits.* Retrieved February 08, 2011, http://www.floriansolarproducts.com/Sizes.pdf

Geothermal Systems LLC. *Gethermal Costs.* Retrieved March 10, 2011, http://geothermalsystemsllc.com/Costs.html

McQuay International. *Geothermal Heat Pump Design Manual.* Retrieved on March 10, 2011, http://www.mcquay.com/mcquaybiz/literature/lit_systems/AppGuide/AG_31-008_Geothermal_021607b.pdf

Mifflin County School District. Retrieved Januaray 26, 2011, http://www.mcsdk12.org

Myers, J (2010-2011). Reynolds Construction (R. Korona, Interviewer)

Sanyo. (2011). *Solar Electric Catalog.* Solar by Sanyo, http://us.sanyo.com/HIT-Power-Double/HIT-Double-Bifacial-Photovoltaic-Module

Solar Energy Rebates and Incentives for Installing Solar Power. Retrieved February 08, 2011, http://www.solar-estimate.org/index.php?verifycookie=1&page=solar-incentives&subpage=&external_estimator=

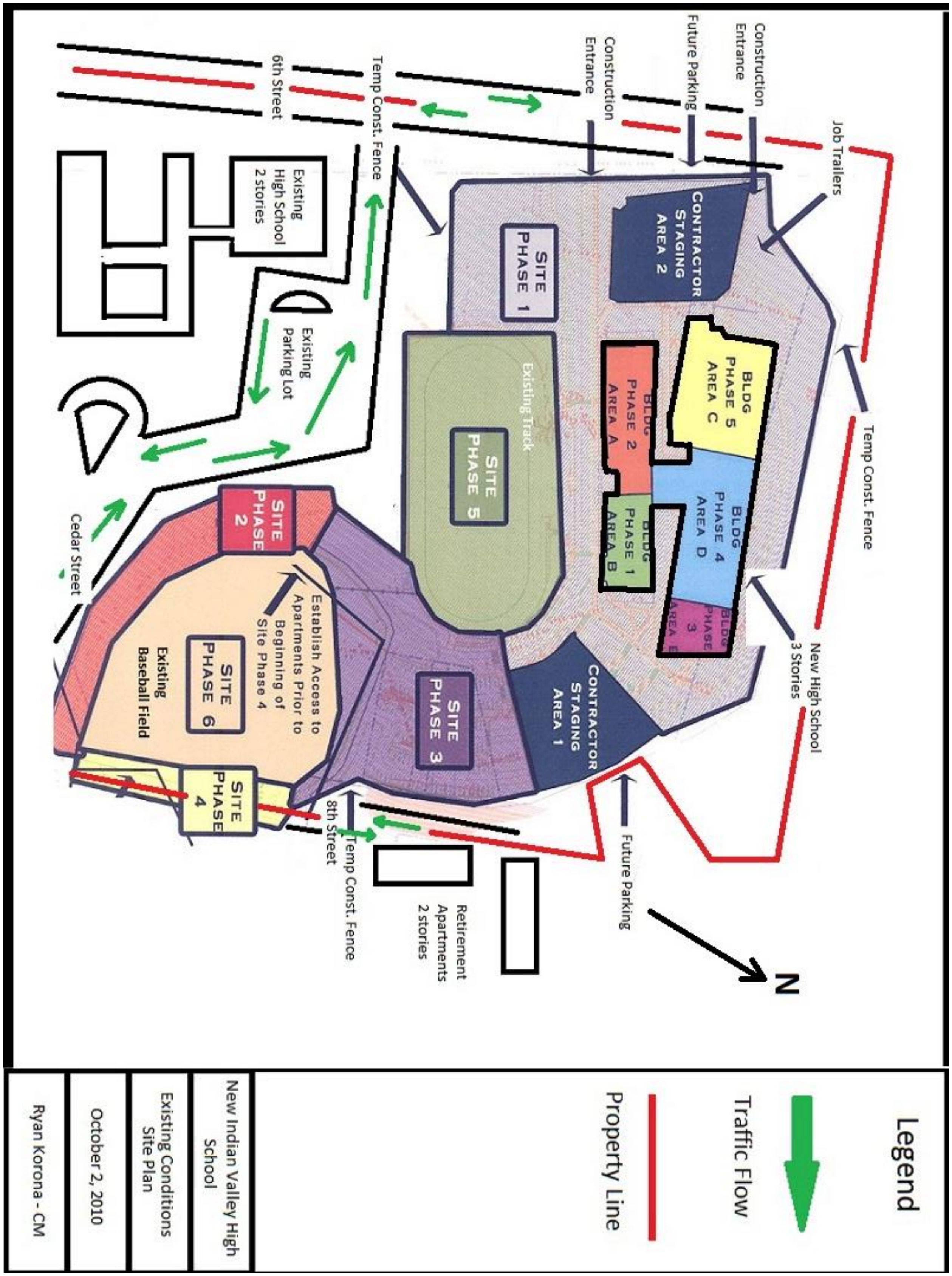
U.S. Department of Energy. *Energy Savers: Benefits of Geothermal Heat Pump Systems.* Retrieved on March 10, 2011, http://www.energysavers.gov/your_home/space_heating_cooling/index.cfm/mytopic=12660

U.S. Department of Energy. *EnergySmart Schools Tips: Retrofitting, Operating, and Maintaining Existing Buildings.* Retrieved February 14, 2011, http://apps1.eere.energy.gov/buildings/publications/pdfs/energysmartschools/ess_quick-wins_fs.pdf

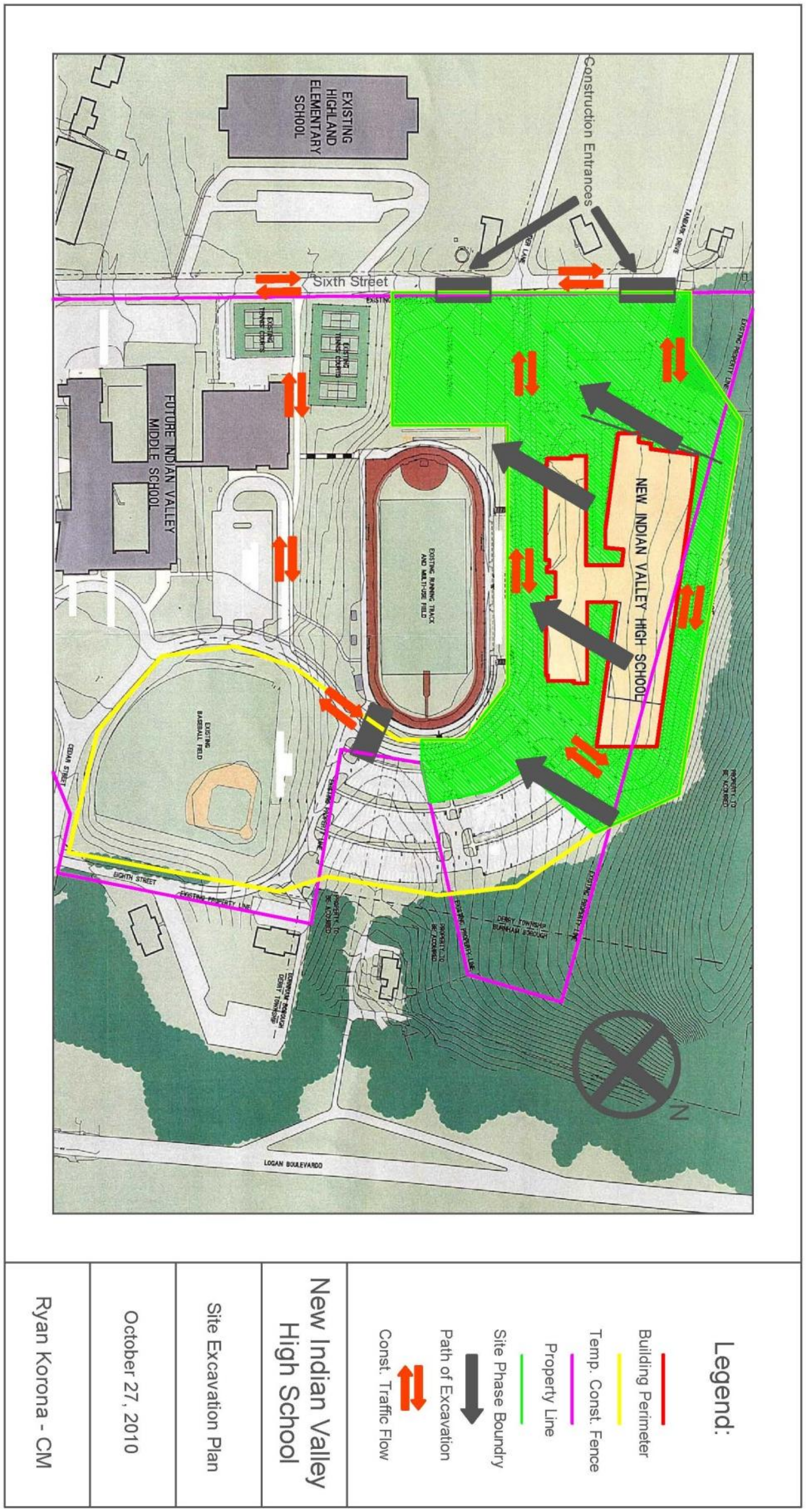
U.S. Department of Energy. (January 2010). *Solar Technologies Report.* NREL.

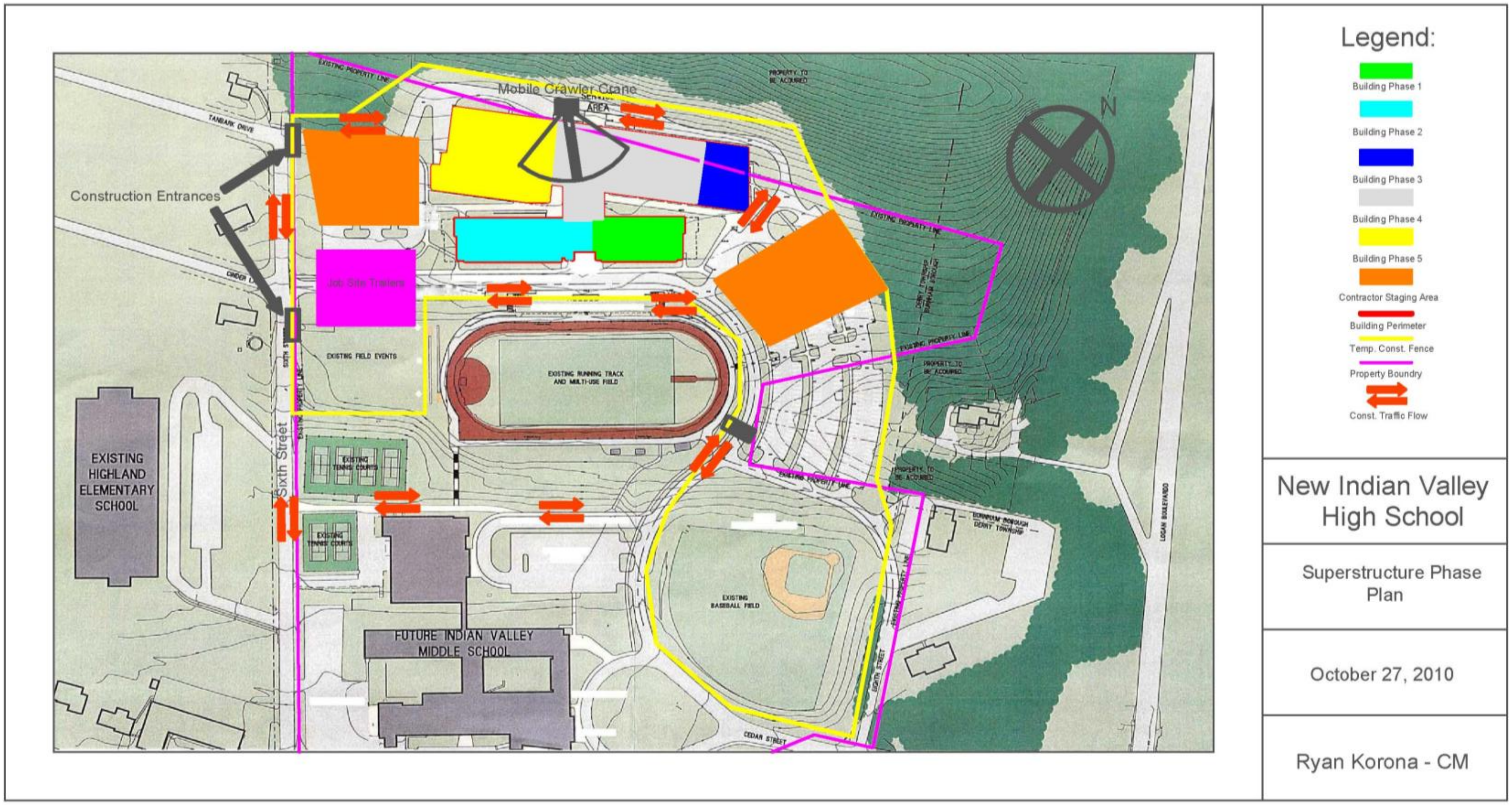
Wikipedia. *Geothermal Heat Pump.* Retrieved March 2011, http://en.wikipedia.org/wiki/Geothermal_heat_pump

APPENDIX A: Existing Site Conditions Plan


Construction Entrance
Future Parking
Construction Entrance
Temp Const. Fence
6th Street
Job Trailers
CONTRACTOR STAGING AREA 2
SITE PHASE 1
Existing High School 2 stories
Existing Parking Lot
Existing Track
SITE PHASE 5
BLDG PHASE 5 AREA C
BLDG PHASE 2 AREA A
BLDG PHASE 4 AREA D
BLDG PHASE 1 AREA B
BLDG PHASE 3 AREA E
Temp Const. Fence
New High School 3 Stories
SITE PHASE 2
Cedar Street
Establish Access to Apartments Prior to Beginning of Site Phase 4
SITE PHASE 6
Existing Baseball Field
SITE PHASE 3
CONTRACTOR STAGING AREA 1
SITE PHASE 4
8th Street
Temp Const. Fence
Retirement Apartments 2 stories
Future Parking
N
Legend
Traffic Flow
Property Line
New Indian Valley High School
Existing Conditions Site Plan
October 2, 2010
Ryan Korona - CM

APPENDIX B: Site Layout Plans


EXISTING HIGHLAND ELEMENTARY SCHOOL
Construction Entrances
Sixth Street
EXISTING TENNIS COURTS
FUTURE INDIAN VALLEY MIDDLE SCHOOL
EXISTING RUNNING TRACK AND MULTI-USE FIELD
NEW INDIAN VALLEY HIGH SCHOOL
EXISTING BASEBALL FIELD
CEDAR STREET
EIGHTH STREET
LOGAN BOULEVARD
N
Legend:
Building Perimeter
Temp. Const. Fence
Property Line
Site Phase Boundry
Path of Excavation
Const. Traffic Flow
New Indian Valley High School
Site Excavation Plan
October 27, 2010
Ryan Korona - CM


Construction Entrances
Mobile Crawler Crane
AREA
Job Site Trailers
Sixth Street
EXISTING HIGHLAND ELEMENTARY SCHOOL
FUTURE INDIAN VALLEY MIDDLE SCHOOL
EXISTING FIELD EVENTS
EXISTING RUNNING TRACK AND MULTI-USE FIELD
EXISTING TENNIS COURTS
EXISTING BASEBALL FIELD
TANBARK DRIVE
CEDAR STREET
SIXTH STREET
LOGAN BOULEVARD
EXISTING PROPERTY LINE
PROPERTY TO BE ACQUIRED
DERRY TOWNSHIP
N
Legend:
Building Phase 1
Building Phase 2
Building Phase 3
Building Phase 4
Building Phase 5
Contractor Staging Area
Building Perimeter
Temp. Const. Fence
Property Boundry
Const. Traffic Flow
New Indian Valley High School
Superstructure Phase Plan
October 27, 2010
Ryan Korona - CM

APPENDIX C: Detailed Project Schedule

REYNOLDS CONSTRUCTION
MANAGEMENT, INC.

Indian Valley High School

Phase 1 - Area B

Building Shell

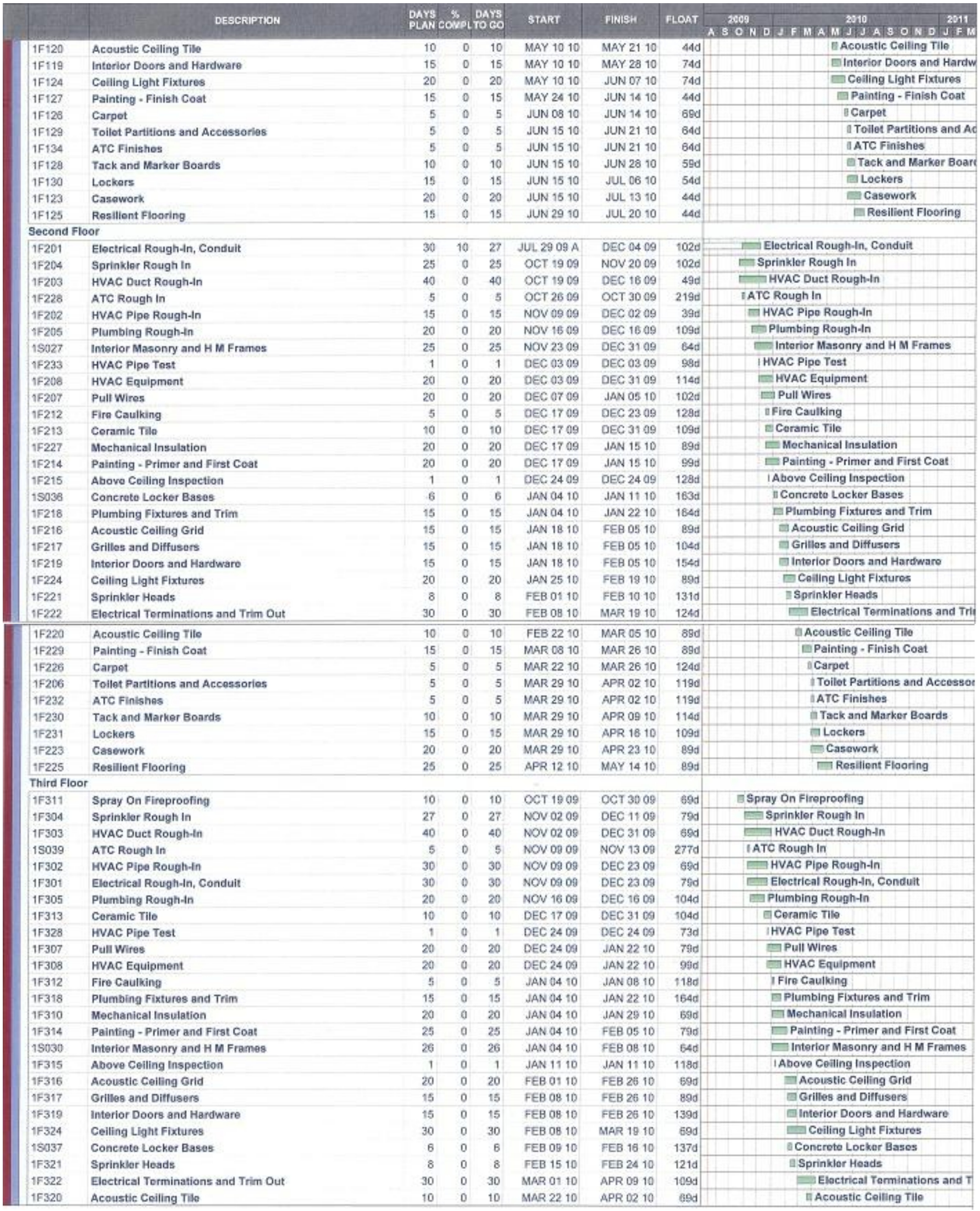
1S002	Waterproof and Backfill	3	95	0	MAR 18 09 A	AUG 14 09	-10d
1S017	CMU Backup and Stair Tower Masonry - 2nd	7	75	2	JUL 07 09 A	SEP 01 09	56d
1S023	CMU Backup and Stair Tower Masonry - 3rd	7	75	2	JUL 13 09 A	SEP 03 09	56d
1S012	CMU Backup and Stair Tower Masonry - 1st	7	75	2	JUL 17 09 A	AUG 28 09	56d
1S024	Metal Stud Parapet and Soffit Framing	15	40	9	JUL 17 09 A	SEP 17 09	57d
1S025	Light Gauge Roof Framing and Decking	20	60	8	AUG 10 09 A	AUG 26 09	49d
1S031	Penthouse Slab on Deck	5	66	2	AUG 11 09 A	AUG 28 09	62d
1S014	Cupola Metal Stud Framing	5	0	5	AUG 27 09	SEP 03 09	57d
1S026	Metal Roof, Insulation and Sheathing	20	0	20	AUG 27 09	SEP 25 09	49d
1S032	Penthouse Metal Stud Backup	10	0	10	SEP 01 09	SEP 15 09	62d
1S021	Cupola Dome and Flashing	5	0	5	SEP 04 09	SEP 11 09	74d

	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
1S018	Cupola Windows	7	0	7	SEP 04 09	SEP 15 09	57d
1S013	Metal Pan Stairs	15	0	15	SEP 04 09	SEP 25 09	164d
1S033	Penthouse Metal Siding	10	0	10	SEP 16 09	SEP 29 09	62d
1S010	Membrane Roofing	10	0	10	SEP 18 09	OCT 01 09	53d
1S020	Composite Metal Panels at Cupola	15	0	15	SEP 28 09	OCT 16 09	49d
1S040	Set Roof Top HVAC Equipment	5	0	5	OCT 02 09	OCT 08 09	95d
1S016	Dry In	0	0	0		OCT 16 09	49d
1S019	Masonry Veneer and Cleaning	38	0	38	NOV 11 09	JAN 22 10	37d
1S028	Roof Copings, Soffit and Trim	20	0	20	JAN 25 10	FEB 19 10	79d
1S022	Metal Studs and EIFS Panels	20	0	20	JAN 25 10	FEB 19 10	84d
1S029	Windows and Entrances	60	0	60	JAN 25 10	APR 16 10	44d

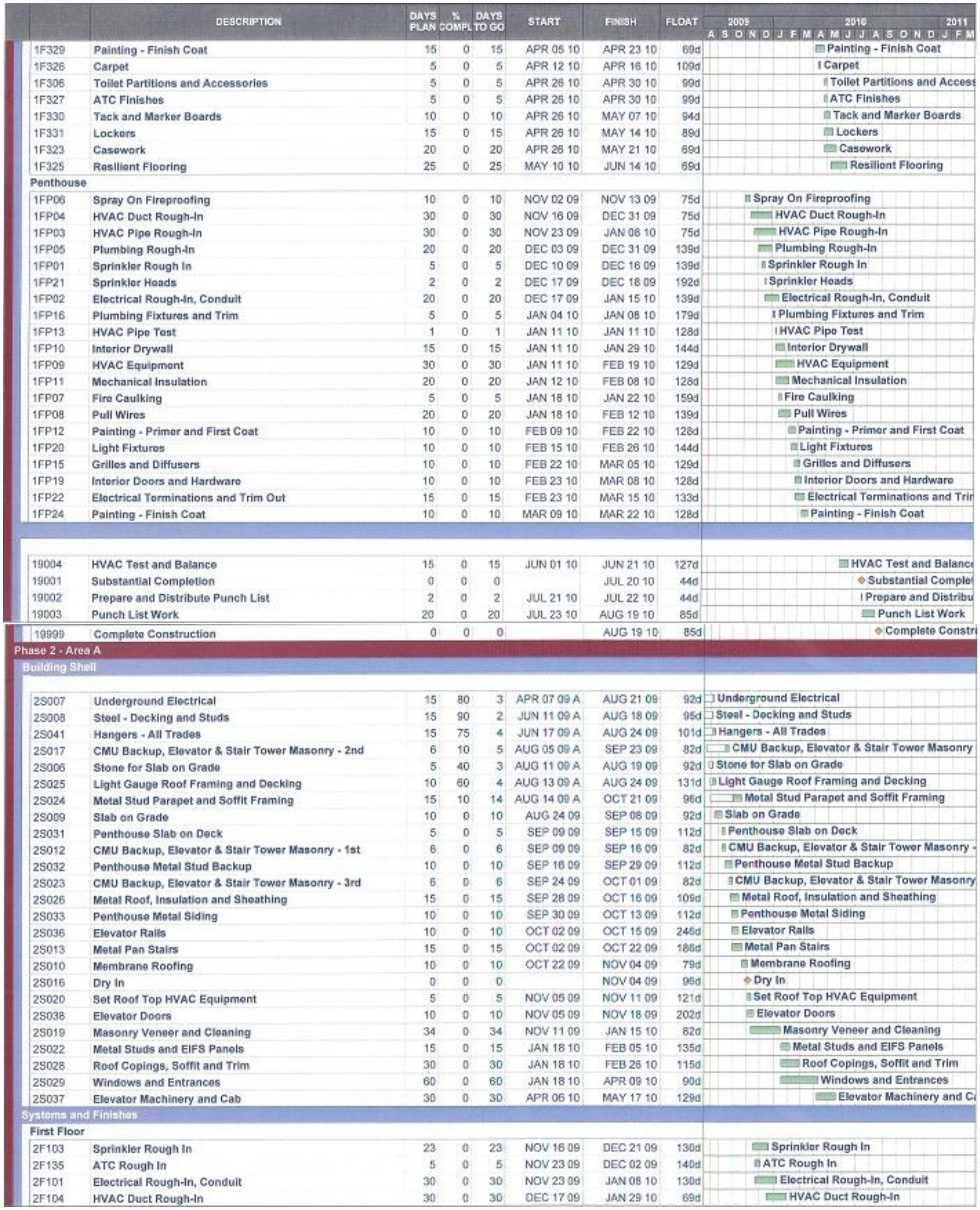
Systems and Finishes

First Floor

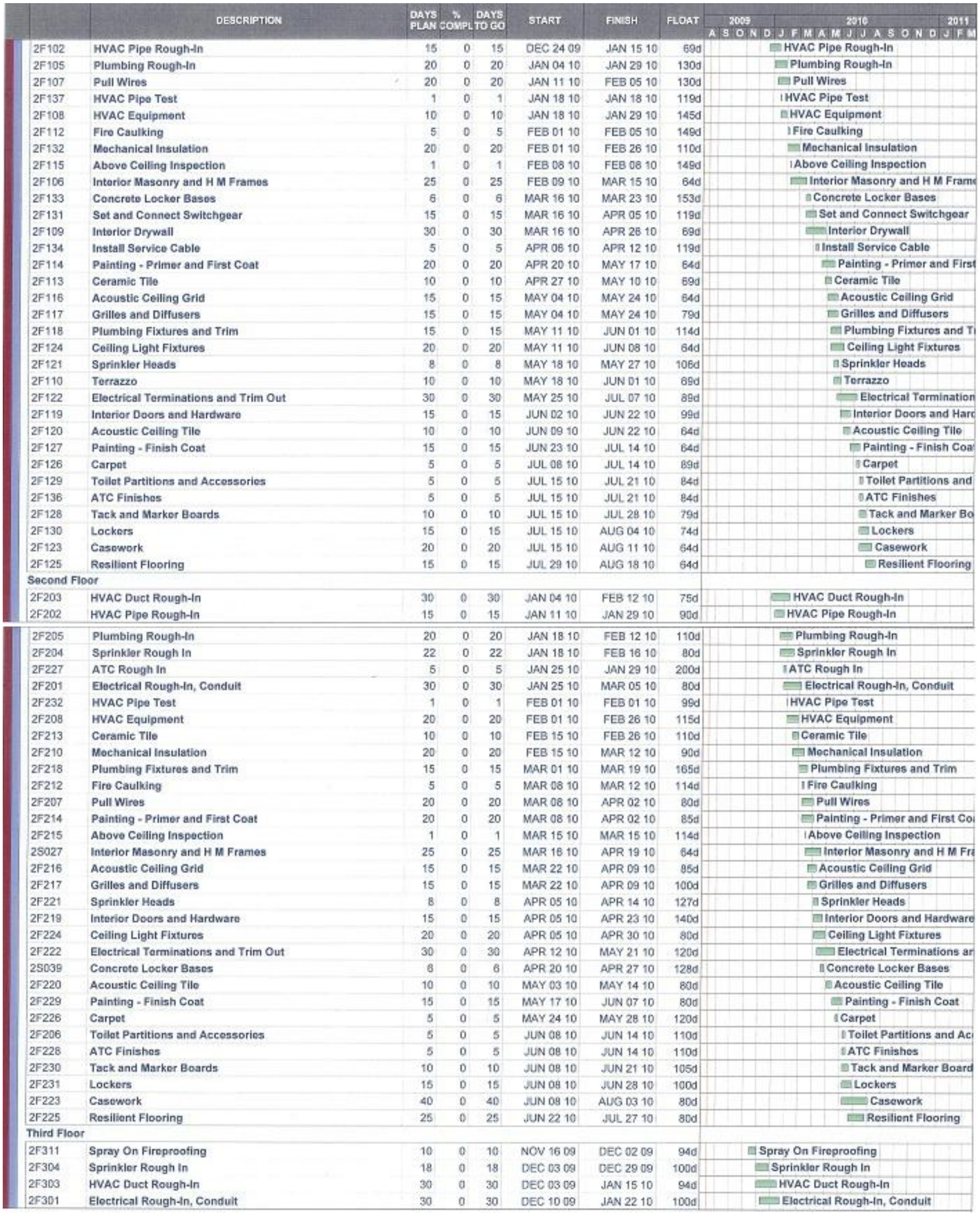
	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
1F101	Electrical Rough-In, Conduit	30	10	27	JUL 29 09 A	DEC 04 09	117d
1F104	HVAC Duct Rough-In	40	90	4	AUG 03 09 A	OCT 22 09	85d
1F108	HVAC Equipment	10	15	9	AUG 13 09 A	NOV 19 09	150d
1F102	HVAC Pipe Rough-In	15	0	15	OCT 19 09	NOV 06 09	85d
1F106	Interior Masonry and H M Frames	25	0	25	OCT 19 09	NOV 20 09	64d
1F103	Sprinkler Rough In	25	0	25	OCT 19 09	NOV 20 09	117d
1F133	ATC Rough In	5	0	5	OCT 26 09	OCT 30 09	219d
1F105	Plumbing Rough-In	30	0	30	OCT 26 09	DEC 09 09	124d
1F135	HVAC Pipe Test	1	0	1	NOV 09 09	NOV 09 09	138d
1F131	Mechanical Insulation	20	0	20	NOV 10 09	DEC 10 09	138d
1F132	Concrete Locker Bases	6	0	6	NOV 23 09	DEC 03 09	188d
1F107	Pull Wires	20	0	20	DEC 07 09	JAN 05 10	137d
1F112	Fire Caulking	5	0	5	DEC 10 09	DEC 16 09	143d
1F113	Ceramic Tile	10	0	10	DEC 10 09	DEC 23 09	124d
1F115	Above Ceiling Inspection	1	0	1	DEC 17 09	DEC 17 09	143d
1F118	Plumbing Fixtures and Trim	15	0	15	DEC 24 09	JAN 15 10	169d
1F114	Painting - Primer and First Coat	20	0	20	MAR 22 10	APR 16 10	44d
1F116	Acoustic Ceiling Grid	15	0	15	APR 05 10	APR 23 10	59d
1F117	Grilles and Diffusers	15	0	15	APR 05 10	APR 23 10	59d
1F121	Sprinkler Heads	8	0	8	APR 19 10	APR 28 10	85d
1F110	Terrazzo	15	0	15	APR 19 10	MAY 07 10	44d
1F122	Electrical Terminations and Trim Out	30	0	30	APR 26 10	JUN 07 10	69d



	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
1F120	Acoustic Ceiling Tile	10	0	10	MAY 10 10	MAY 21 10	44d
1F119	Interior Doors and Hardware	15	0	15	MAY 10 10	MAY 28 10	74d
1F124	Ceiling Light Fixtures	20	0	20	MAY 10 10	JUN 07 10	74d
1F127	Painting - Finish Coat	15	0	15	MAY 24 10	JUN 14 10	44d
1F126	Carpet	5	0	5	JUN 08 10	JUN 14 10	69d
1F129	Toilet Partitions and Accessories	5	0	5	JUN 15 10	JUN 21 10	64d
1F134	ATC Finishes	5	0	5	JUN 15 10	JUN 21 10	64d
1F128	Tack and Marker Boards	10	0	10	JUN 15 10	JUN 28 10	59d
1F130	Lockers	15	0	15	JUN 15 10	JUL 06 10	54d
1F123	Casework	20	0	20	JUN 15 10	JUL 13 10	44d
1F125	Resilient Flooring	15	0	15	JUN 29 10	JUL 20 10	44d
Second Floor							
1F201	Electrical Rough-In, Conduit	30	10	27	JUL 29 09 A	DEC 04 09	102d
1F204	Sprinkler Rough In	25	0	25	OCT 19 09	NOV 20 09	102d
1F203	HVAC Duct Rough-In	40	0	40	OCT 19 09	DEC 16 09	49d
1F228	ATC Rough In	5	0	5	OCT 26 09	OCT 30 09	219d
1F202	HVAC Pipe Rough-In	15	0	15	NOV 09 09	DEC 02 09	39d
1F205	Plumbing Rough-In	20	0	20	NOV 16 09	DEC 16 09	109d
1S027	Interior Masonry and H M Frames	25	0	25	NOV 23 09	DEC 31 09	64d
1F233	HVAC Pipe Test	1	0	1	DEC 03 09	DEC 03 09	98d
1F208	HVAC Equipment	20	0	20	DEC 03 09	DEC 31 09	114d
1F207	Pull Wires	20	0	20	DEC 07 09	JAN 05 10	102d
1F212	Fire Caulking	5	0	5	DEC 17 09	DEC 23 09	128d
1F213	Ceramic Tile	10	0	10	DEC 17 09	DEC 31 09	109d
1F227	Mechanical Insulation	20	0	20	DEC 17 09	JAN 15 10	89d
1F214	Painting - Primer and First Coat	20	0	20	DEC 17 09	JAN 15 10	99d
1F215	Above Ceiling Inspection	1	0	1	DEC 24 09	DEC 24 09	128d
1S036	Concrete Locker Bases	6	0	6	JAN 04 10	JAN 11 10	163d
1F218	Plumbing Fixtures and Trim	15	0	15	JAN 04 10	JAN 22 10	164d
1F216	Acoustic Ceiling Grid	15	0	15	JAN 18 10	FEB 05 10	89d
1F217	Grilles and Diffusers	15	0	15	JAN 18 10	FEB 05 10	104d
1F219	Interior Doors and Hardware	15	0	15	JAN 18 10	FEB 05 10	154d
1F224	Ceiling Light Fixtures	20	0	20	JAN 25 10	FEB 19 10	89d
1F221	Sprinkler Heads	8	0	8	FEB 01 10	FEB 10 10	131d
1F222	Electrical Terminations and Trim Out	30	0	30	FEB 08 10	MAR 19 10	124d
1F220	Acoustic Ceiling Tile	10	0	10	FEB 22 10	MAR 05 10	89d
1F229	Painting - Finish Coat	15	0	15	MAR 08 10	MAR 26 10	89d
1F226	Carpet	5	0	5	MAR 22 10	MAR 26 10	124d
1F206	Toilet Partitions and Accessories	5	0	5	MAR 29 10	APR 02 10	119d
1F232	ATC Finishes	5	0	5	MAR 29 10	APR 02 10	119d
1F230	Tack and Marker Boards	10	0	10	MAR 29 10	APR 09 10	114d
1F231	Lockers	15	0	15	MAR 29 10	APR 16 10	109d
1F223	Casework	20	0	20	MAR 29 10	APR 23 10	89d
1F225	Resilient Flooring	25	0	25	APR 12 10	MAY 14 10	89d
Third Floor							
1F311	Spray On Fireproofing	10	0	10	OCT 19 09	OCT 30 09	69d
1F304	Sprinkler Rough In	27	0	27	NOV 02 09	DEC 11 09	79d
1F303	HVAC Duct Rough-In	40	0	40	NOV 02 09	DEC 31 09	69d
1S039	ATC Rough In	5	0	5	NOV 09 09	NOV 13 09	277d
1F302	HVAC Pipe Rough-In	30	0	30	NOV 09 09	DEC 23 09	69d
1F301	Electrical Rough-In, Conduit	30	0	30	NOV 09 09	DEC 23 09	79d
1F305	Plumbing Rough-In	20	0	20	NOV 16 09	DEC 16 09	104d
1F313	Ceramic Tile	10	0	10	DEC 17 09	DEC 31 09	104d
1F328	HVAC Pipe Test	1	0	1	DEC 24 09	DEC 24 09	73d
1F307	Pull Wires	20	0	20	DEC 24 09	JAN 22 10	79d
1F308	HVAC Equipment	20	0	20	DEC 24 09	JAN 22 10	99d
1F312	Fire Caulking	5	0	5	JAN 04 10	JAN 08 10	118d
1F318	Plumbing Fixtures and Trim	15	0	15	JAN 04 10	JAN 22 10	164d
1F310	Mechanical Insulation	20	0	20	JAN 04 10	JAN 29 10	69d
1F314	Painting - Primer and First Coat	25	0	25	JAN 04 10	FEB 05 10	79d
1S030	Interior Masonry and H M Frames	26	0	26	JAN 04 10	FEB 08 10	64d
1F315	Above Ceiling Inspection	1	0	1	JAN 11 10	JAN 11 10	118d
1F316	Acoustic Ceiling Grid	20	0	20	FEB 01 10	FEB 26 10	69d
1F317	Grilles and Diffusers	15	0	15	FEB 08 10	FEB 26 10	89d
1F319	Interior Doors and Hardware	15	0	15	FEB 08 10	FEB 26 10	139d
1F324	Ceiling Light Fixtures	30	0	30	FEB 08 10	MAR 19 10	69d
1S037	Concrete Locker Bases	6	0	6	FEB 09 10	FEB 16 10	137d
1F321	Sprinkler Heads	8	0	8	FEB 15 10	FEB 24 10	121d
1F322	Electrical Terminations and Trim Out	30	0	30	MAR 01 10	APR 09 10	109d
1F320	Acoustic Ceiling Tile	10	0	10	MAR 22 10	APR 02 10	89d

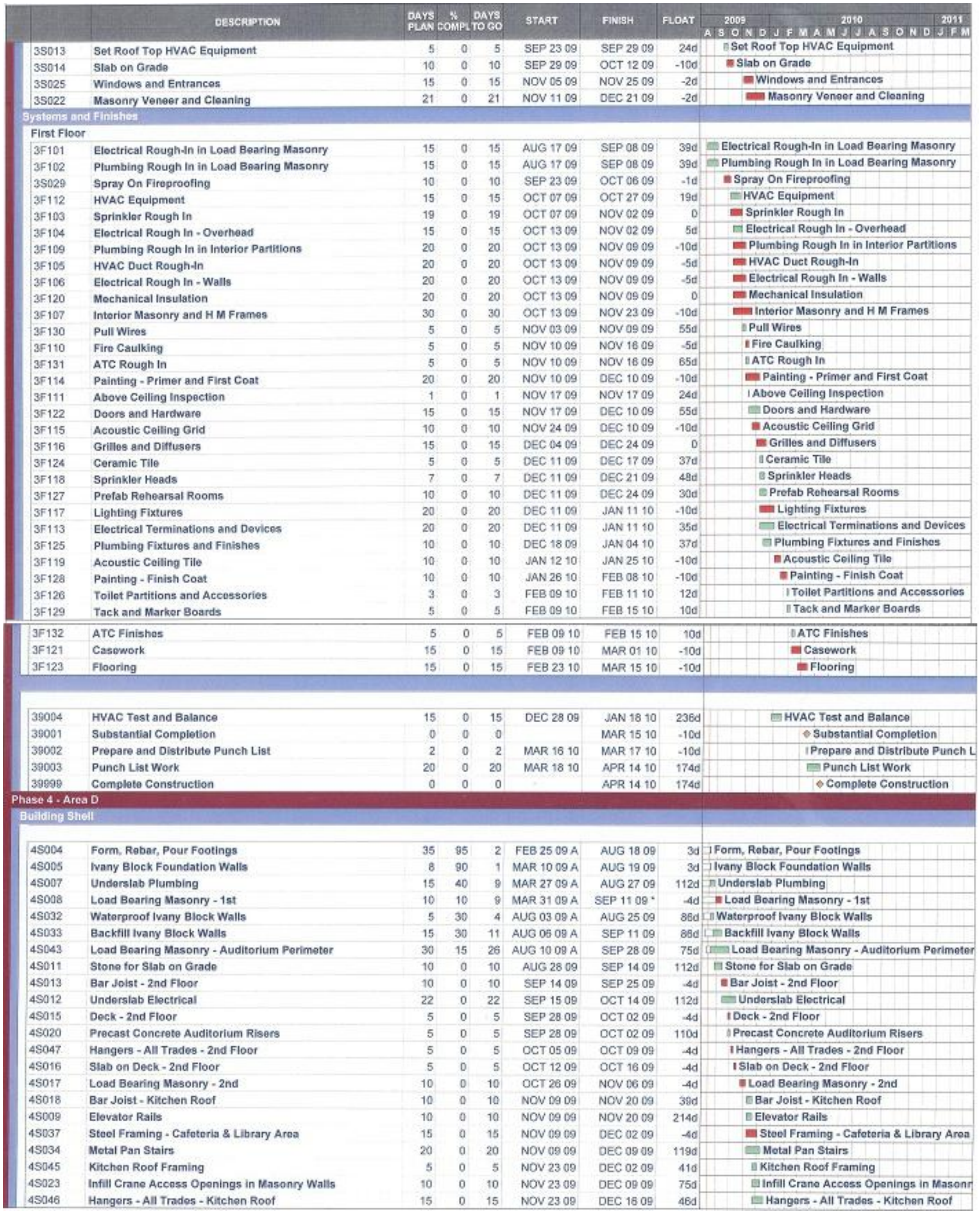


	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
1F329	Painting - Finish Coat	15	0	15	APR 05 10	APR 23 10	69d
1F326	Carpet	5	0	5	APR 12 10	APR 16 10	109d
1F306	Toilet Partitions and Accessories	5	0	5	APR 26 10	APR 30 10	99d
1F327	ATC Finishes	5	0	5	APR 26 10	APR 30 10	99d
1F330	Tack and Marker Boards	10	0	10	APR 26 10	MAY 07 10	94d
1F331	Lockers	15	0	15	APR 26 10	MAY 14 10	89d
1F323	Casework	20	0	20	APR 26 10	MAY 21 10	69d
1F325	Resilient Flooring	25	0	25	MAY 10 10	JUN 14 10	69d
Penthouse							
1FP06	Spray On Fireproofing	10	0	10	NOV 02 09	NOV 13 09	75d
1FP04	HVAC Duct Rough-In	30	0	30	NOV 16 09	DEC 31 09	75d
1FP03	HVAC Pipe Rough-In	30	0	30	NOV 23 09	JAN 08 10	75d
1FP05	Plumbing Rough-In	20	0	20	DEC 03 09	DEC 31 09	139d
1FP01	Sprinkler Rough In	5	0	5	DEC 10 09	DEC 16 09	139d
1FP21	Sprinkler Heads	2	0	2	DEC 17 09	DEC 18 09	192d
1FP02	Electrical Rough-In, Conduit	20	0	20	DEC 17 09	JAN 15 10	139d
1FP16	Plumbing Fixtures and Trim	5	0	5	JAN 04 10	JAN 08 10	179d
1FP13	HVAC Pipe Test	1	0	1	JAN 11 10	JAN 11 10	128d
1FP10	Interior Drywall	15	0	15	JAN 11 10	JAN 29 10	144d
1FP09	HVAC Equipment	30	0	30	JAN 11 10	FEB 19 10	129d
1FP11	Mechanical Insulation	20	0	20	JAN 12 10	FEB 08 10	128d
1FP07	Fire Caulking	5	0	5	JAN 18 10	JAN 22 10	159d
1FP08	Pull Wires	20	0	20	JAN 18 10	FEB 12 10	139d
1FP12	Painting - Primer and First Coat	10	0	10	FEB 09 10	FEB 22 10	128d
1FP20	Light Fixtures	10	0	10	FEB 15 10	FEB 26 10	144d
1FP15	Grilles and Diffusers	10	0	10	FEB 22 10	MAR 05 10	129d
1FP19	Interior Doors and Hardware	10	0	10	FEB 23 10	MAR 08 10	128d
1FP22	Electrical Terminations and Trim Out	15	0	15	FEB 23 10	MAR 15 10	133d
1FP24	Painting - Finish Coat	10	0	10	MAR 09 10	MAR 22 10	128d
19004	HVAC Test and Balance	15	0	15	JUN 01 10	JUN 21 10	127d
19001	Substantial Completion	0	0	0		JUL 20 10	44d
19002	Prepare and Distribute Punch List	2	0	2	JUL 21 10	JUL 22 10	44d
19003	Punch List Work	20	0	20	JUL 23 10	AUG 19 10	85d
19999	Complete Construction	0	0	0		AUG 19 10	85d
Phase 2 - Area A							
Building Shell							
2S007	Underground Electrical	15	80	3	APR 07 09 A	AUG 21 09	92d
2S008	Steel - Decking and Studs	15	90	2	JUN 11 09 A	AUG 18 09	95d
2S041	Hangers - All Trades	15	75	4	JUN 17 09 A	AUG 24 09	101d
2S017	CMU Backup, Elevator & Stair Tower Masonry - 2nd	6	10	5	AUG 05 09 A	SEP 23 09	82d
2S006	Stone for Slab on Grade	5	40	3	AUG 11 09 A	AUG 19 09	92d
2S025	Light Gauge Roof Framing and Decking	10	60	4	AUG 13 09 A	AUG 24 09	131d
2S024	Metal Stud Parapet and Soffit Framing	15	10	14	AUG 14 09 A	OCT 21 09	96d
2S009	Slab on Grade	10	0	10	AUG 24 09	SEP 08 09	92d
2S031	Penthouse Slab on Deck	5	0	5	SEP 09 09	SEP 15 09	112d
2S012	CMU Backup, Elevator & Stair Tower Masonry - 1st	6	0	6	SEP 09 09	SEP 16 09	82d
2S032	Penthouse Metal Stud Backup	10	0	10	SEP 16 09	SEP 29 09	112d
2S023	CMU Backup, Elevator & Stair Tower Masonry - 3rd	6	0	6	SEP 24 09	OCT 01 09	82d
2S026	Metal Roof, Insulation and Sheathing	15	0	15	SEP 28 09	OCT 16 09	109d
2S033	Penthouse Metal Siding	10	0	10	SEP 30 09	OCT 13 09	112d
2S036	Elevator Rails	10	0	10	OCT 02 09	OCT 15 09	246d
2S013	Metal Pan Stairs	15	0	15	OCT 02 09	OCT 22 09	186d
2S010	Membrane Roofing	10	0	10	OCT 22 09	NOV 04 09	79d
2S016	Dry In	0	0	0		NOV 04 09	96d
2S020	Set Roof Top HVAC Equipment	5	0	5	NOV 05 09	NOV 11 09	121d
2S038	Elevator Doors	10	0	10	NOV 05 09	NOV 18 09	202d
2S019	Masonry Veneer and Cleaning	34	0	34	NOV 11 09	JAN 15 10	82d
2S022	Metal Studs and EIFS Panels	15	0	15	JAN 18 10	FEB 05 10	135d
2S028	Roof Copings, Soffit and Trim	30	0	30	JAN 18 10	FEB 26 10	115d
2S029	Windows and Entrances	60	0	60	JAN 18 10	APR 09 10	90d
2S037	Elevator Machinery and Cab	30	0	30	APR 06 10	MAY 17 10	129d
Systems and Finishes							
First Floor							
2F103	Sprinkler Rough In	23	0	23	NOV 16 09	DEC 21 09	130d
2F135	ATC Rough In	5	0	5	NOV 23 09	DEC 02 09	140d
2F101	Electrical Rough-In, Conduit	30	0	30	NOV 23 09	JAN 08 10	130d
2F104	HVAC Duct Rough-In	30	0	30	DEC 17 09	JAN 29 10	69d

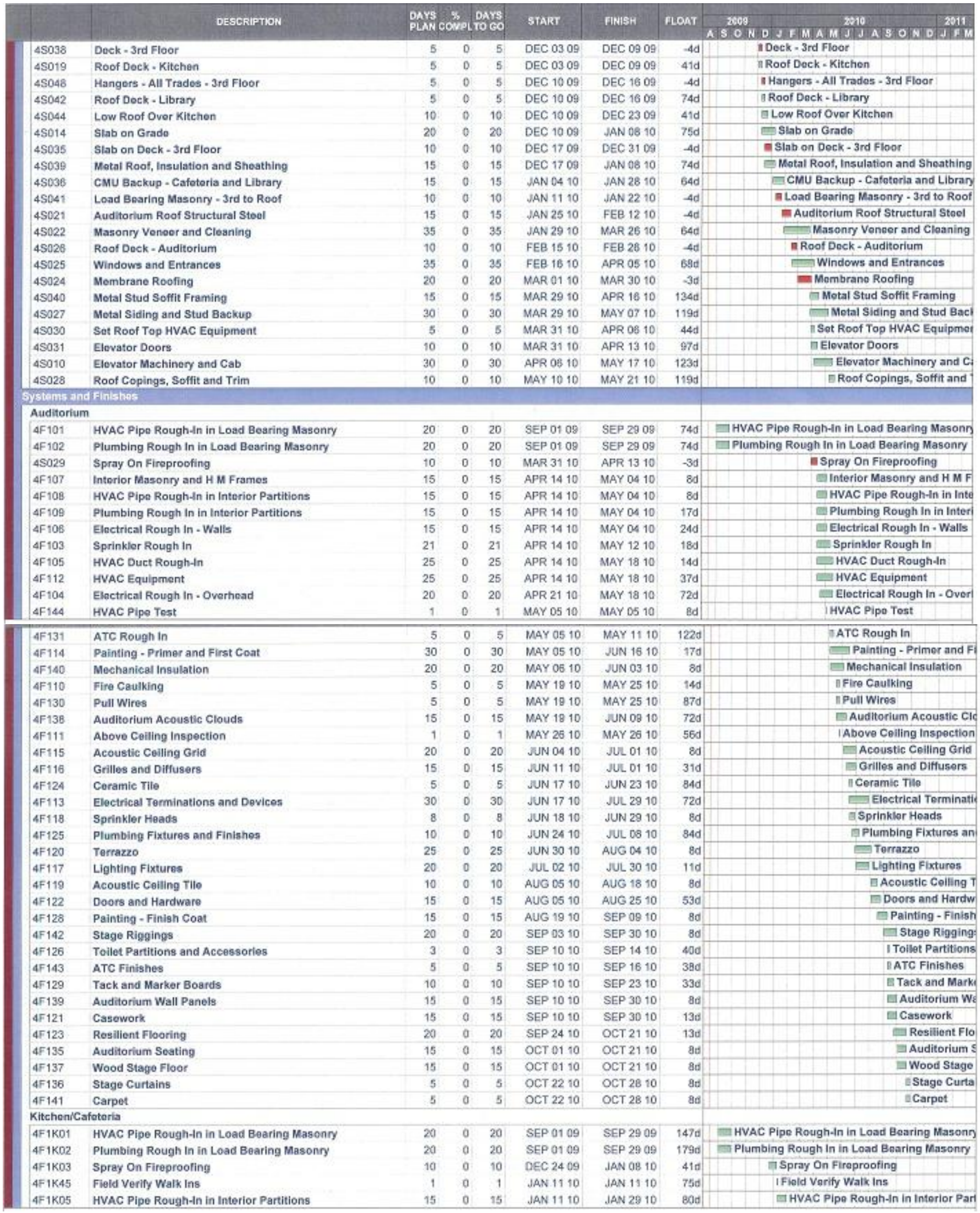


	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
2F102	HVAC Pipe Rough-In	15	0	15	DEC 24 09	JAN 15 10	69d
2F105	Plumbing Rough-In	20	0	20	JAN 04 10	JAN 29 10	130d
2F107	Pull Wires	20	0	20	JAN 11 10	FEB 05 10	130d
2F137	HVAC Pipe Test	1	0	1	JAN 18 10	JAN 18 10	119d
2F108	HVAC Equipment	10	0	10	JAN 18 10	JAN 29 10	145d
2F112	Fire Caulking	5	0	5	FEB 01 10	FEB 05 10	149d
2F132	Mechanical Insulation	20	0	20	FEB 01 10	FEB 26 10	110d
2F115	Above Ceiling Inspection	1	0	1	FEB 08 10	FEB 08 10	149d
2F106	Interior Masonry and H M Frames	25	0	25	FEB 09 10	MAR 15 10	64d
2F133	Concrete Locker Bases	6	0	6	MAR 16 10	MAR 23 10	153d
2F131	Set and Connect Switchgear	15	0	15	MAR 16 10	APR 05 10	119d
2F109	Interior Drywall	30	0	30	MAR 16 10	APR 26 10	69d
2F134	Install Service Cable	5	0	5	APR 06 10	APR 12 10	119d
2F114	Painting - Primer and First Coat	20	0	20	APR 20 10	MAY 17 10	64d
2F113	Ceramic Tile	10	0	10	APR 27 10	MAY 10 10	69d
2F116	Acoustic Ceiling Grid	15	0	15	MAY 04 10	MAY 24 10	64d
2F117	Grilles and Diffusers	15	0	15	MAY 04 10	MAY 24 10	79d
2F118	Plumbing Fixtures and Trim	15	0	15	MAY 11 10	JUN 01 10	114d
2F124	Ceiling Light Fixtures	20	0	20	MAY 11 10	JUN 08 10	64d
2F121	Sprinkler Heads	8	0	8	MAY 18 10	MAY 27 10	106d
2F110	Terrazzo	10	0	10	MAY 18 10	JUN 01 10	69d
2F122	Electrical Terminations and Trim Out	30	0	30	MAY 25 10	JUL 07 10	89d
2F119	Interior Doors and Hardware	15	0	15	JUN 02 10	JUN 22 10	99d
2F120	Acoustic Ceiling Tile	10	0	10	JUN 09 10	JUN 22 10	64d
2F127	Painting - Finish Coat	15	0	15	JUN 23 10	JUL 14 10	64d
2F126	Carpet	5	0	5	JUL 08 10	JUL 14 10	89d
2F129	Toilet Partitions and Accessories	5	0	5	JUL 15 10	JUL 21 10	84d
2F136	ATC Finishes	5	0	5	JUL 15 10	JUL 21 10	84d
2F128	Tack and Marker Boards	10	0	10	JUL 15 10	JUL 28 10	79d
2F130	Lockers	15	0	15	JUL 15 10	AUG 04 10	74d
2F123	Casework	20	0	20	JUL 15 10	AUG 11 10	64d
2F125	Resilient Flooring	15	0	15	JUL 29 10	AUG 18 10	64d
Second Floor							
2F203	HVAC Duct Rough-In	30	0	30	JAN 04 10	FEB 12 10	75d
2F202	HVAC Pipe Rough-In	15	0	15	JAN 11 10	JAN 29 10	90d
2F205	Plumbing Rough-In	20	0	20	JAN 18 10	FEB 12 10	110d
2F204	Sprinkler Rough In	22	0	22	JAN 18 10	FEB 16 10	80d
2F227	ATC Rough In	5	0	5	JAN 25 10	JAN 29 10	200d
2F201	Electrical Rough-In, Conduit	30	0	30	JAN 25 10	MAR 05 10	80d
2F232	HVAC Pipe Test	1	0	1	FEB 01 10	FEB 01 10	99d
2F208	HVAC Equipment	20	0	20	FEB 01 10	FEB 26 10	115d
2F213	Ceramic Tile	10	0	10	FEB 15 10	FEB 26 10	110d
2F210	Mechanical Insulation	20	0	20	FEB 15 10	MAR 12 10	90d
2F218	Plumbing Fixtures and Trim	15	0	15	MAR 01 10	MAR 19 10	165d
2F212	Fire Caulking	5	0	5	MAR 08 10	MAR 12 10	114d
2F207	Pull Wires	20	0	20	MAR 08 10	APR 02 10	80d
2F214	Painting - Primer and First Coat	20	0	20	MAR 08 10	APR 02 10	85d
2F215	Above Ceiling Inspection	1	0	1	MAR 15 10	MAR 15 10	114d
2S027	Interior Masonry and H M Frames	25	0	25	MAR 16 10	APR 19 10	64d
2F216	Acoustic Ceiling Grid	15	0	15	MAR 22 10	APR 09 10	85d
2F217	Grilles and Diffusers	15	0	15	MAR 22 10	APR 09 10	100d
2F221	Sprinkler Heads	8	0	8	APR 05 10	APR 14 10	127d
2F219	Interior Doors and Hardware	15	0	15	APR 05 10	APR 23 10	140d
2F224	Ceiling Light Fixtures	20	0	20	APR 05 10	APR 30 10	80d
2F222	Electrical Terminations and Trim Out	30	0	30	APR 12 10	MAY 21 10	120d
2S039	Concrete Locker Bases	6	0	6	APR 20 10	APR 27 10	128d
2F220	Acoustic Ceiling Tile	10	0	10	MAY 03 10	MAY 14 10	80d
2F229	Painting - Finish Coat	15	0	15	MAY 17 10	JUN 07 10	80d
2F226	Carpet	5	0	5	MAY 24 10	MAY 28 10	120d
2F206	Toilet Partitions and Accessories	5	0	5	JUN 08 10	JUN 14 10	110d
2F228	ATC Finishes	5	0	5	JUN 08 10	JUN 14 10	110d
2F230	Tack and Marker Boards	10	0	10	JUN 08 10	JUN 21 10	105d
2F231	Lockers	15	0	15	JUN 08 10	JUN 28 10	100d
2F223	Casework	40	0	40	JUN 08 10	AUG 03 10	80d
2F225	Resilient Flooring	25	0	25	JUN 22 10	JUL 27 10	80d
Third Floor							
2F311	Spray On Fireproofing	10	0	10	NOV 16 09	DEC 02 09	94d
2F304	Sprinkler Rough In	18	0	18	DEC 03 09	DEC 29 09	100d
2F303	HVAC Duct Rough-In	30	0	30	DEC 03 09	JAN 15 10	94d
2F301	Electrical Rough-In, Conduit	30	0	30	DEC 10 09	JAN 22 10	100d

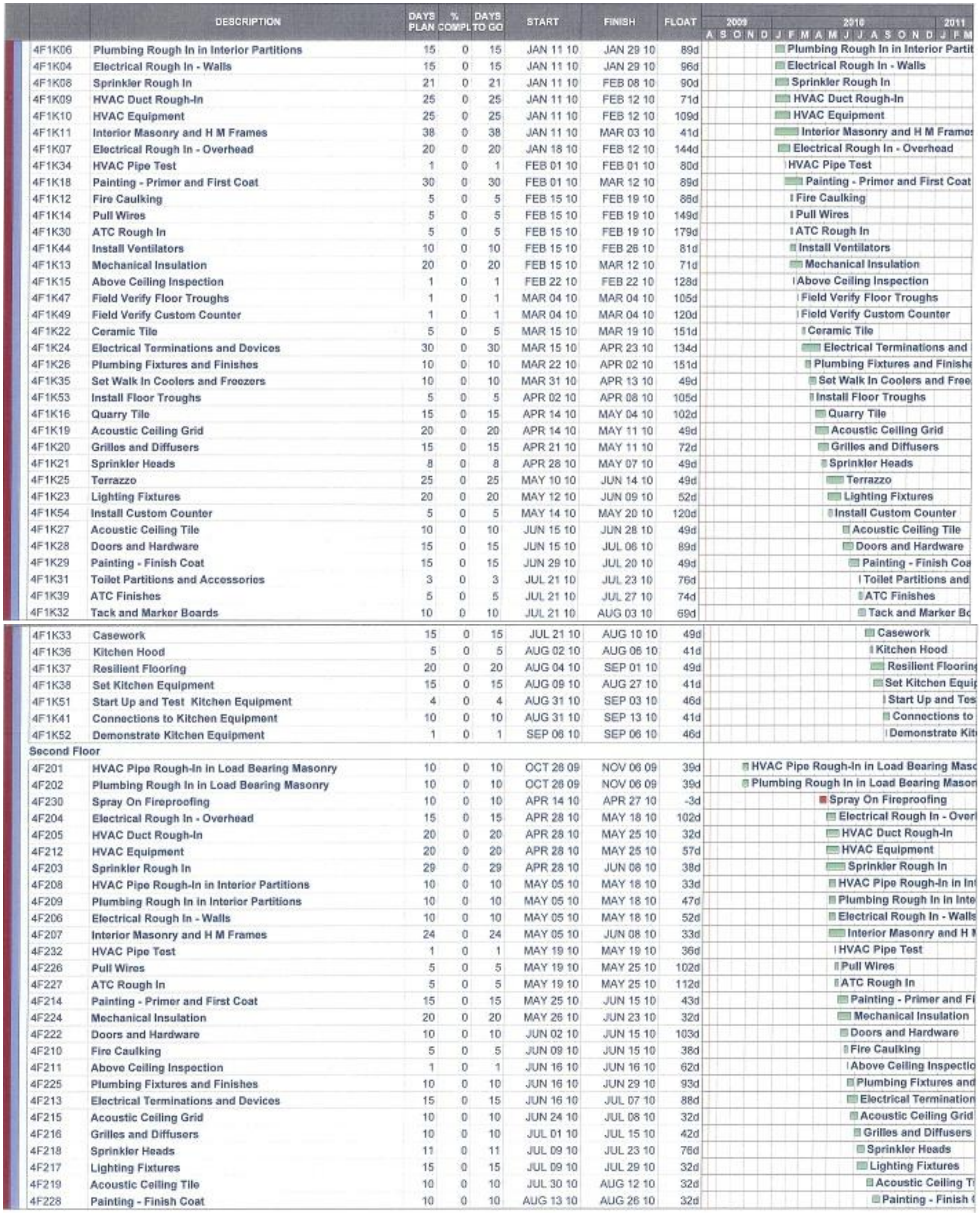
	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
2F302	HVAC Pipe Rough-In	30	0	30	JAN 18 10	FEB 26 10	69d
2F327	ATC Rough In	5	0	5	JAN 25 10	JAN 29 10	200d
2F305	Plumbing Rough-In	20	0	20	JAN 25 10	FEB 19 10	100d
2F307	Pull Wires	20	0	20	JAN 25 10	FEB 19 10	100d
2F313	Ceramic Tile	10	0	10	FEB 22 10	MAR 05 10	100d
2F332	HVAC Pipe Test	1	0	1	MAR 01 10	MAR 01 10	69d
2F312	Fire Caulking	5	0	5	MAR 01 10	MAR 05 10	119d
2F308	HVAC Equipment	20	0	20	MAR 01 10	MAR 26 10	95d
2F314	Painting - Primer and First Coat	25	0	25	MAR 01 10	APR 02 10	80d
2F310	Mechanical Insulation	20	0	20	MAR 02 10	MAR 29 10	69d
2F315	Above Ceiling Inspection	1	0	1	MAR 08 10	MAR 08 10	119d
2F318	Plumbing Fixtures and Trim	15	0	15	MAR 08 10	MAR 26 10	160d
2F316	Acoustic Ceiling Grid	20	0	20	MAR 30 10	APR 26 10	69d
2F319	Interior Doors and Hardware	15	0	15	APR 05 10	APR 23 10	140d
2F317	Grilles and Diffusers	15	0	15	APR 06 10	APR 26 10	89d
2F324	Ceiling Light Fixtures	30	0	30	APR 06 10	MAY 17 10	69d
2F321	Sprinkler Heads	6	0	6	APR 13 10	APR 20 10	123d
2S030	Interior Masonry and H M Frames	26	0	26	APR 20 10	MAY 25 10	102d
2F322	Electrical Terminations and Trim Out	30	0	30	APR 27 10	JUN 08 10	109d
2F320	Acoustic Ceiling Tile	10	0	10	MAY 18 10	JUN 01 10	69d
2S040	Concrete Locker Bases	6	0	6	MAY 26 10	JUN 03 10	102d
2F329	Painting - Finish Coat	15	0	15	JUN 02 10	JUN 22 10	69d
2F326	Carpet	5	0	5	JUN 09 10	JUN 15 10	109d
2F306	Toilet Partitions and Accessories	5	0	5	JUN 23 10	JUN 29 10	99d
2F328	ATC Finishes	5	0	5	JUN 23 10	JUN 29 10	99d
2F330	Tack and Marker Boards	10	0	10	JUN 23 10	JUL 07 10	94d
2F331	Lockers	15	0	15	JUN 23 10	JUL 14 10	89d
2F323	Casework	20	0	20	JUN 23 10	JUL 21 10	69d
2F325	Resilient Flooring	25	0	25	JUL 08 10	AUG 11 10	69d
Penthouse							
2FP06	Spray On Fireproofing	10	0	10	DEC 03 09	DEC 16 09	115d
2FP04	HVAC Duct Rough-In	30	0	30	FEB 15 10	MAR 26 10	75d
2FP03	HVAC Pipe Rough-In	30	0	30	FEB 22 10	APR 02 10	75d
2FP05	Plumbing Rough-In	20	0	20	MAR 01 10	MAR 26 10	120d
2FP01	Sprinkler Rough In	6	0	6	MAR 08 10	MAR 15 10	120d
2FP02	Electrical Rough-In, Conduit	20	0	20	MAR 15 10	APR 09 10	120d
2FP21	Sprinkler Heads	2	0	2	MAR 16 10	MAR 17 10	172d
2FP16	Plumbing Fixtures and Trim	5	0	5	MAR 29 10	APR 02 10	160d
2FP13	HVAC Pipe Test	1	0	1	APR 05 10	APR 05 10	109d
2FP09	HVAC Equipment	20	0	20	APR 05 10	APR 30 10	120d
2FP11	Mechanical Insulation	20	0	20	APR 06 10	MAY 03 10	109d
2FP07	Fire Caulking	5	0	5	APR 12 10	APR 16 10	140d
2FP08	Pull Wires	20	0	20	APR 12 10	MAY 07 10	120d
2FP15	Grilles and Diffusers	10	0	10	MAY 03 10	MAY 14 10	120d
2FP12	Painting - Primer and First Coat	10	0	10	MAY 04 10	MAY 17 10	109d
2FP20	Light Fixtures	10	0	10	MAY 10 10	MAY 21 10	125d
2FP19	Interior Doors and Hardware	10	0	10	MAY 18 10	JUN 01 10	109d
2FP22	Electrical Terminations and Trim Out	15	0	15	MAY 18 10	JUN 08 10	114d
2FP24	Painting - Finish Coat	10	0	10	JUN 02 10	JUN 15 10	109d
29004	HVAC Test and Balance	15	0	15	JUN 23 10	JUL 14 10	111d
29001	Substantial Completion	0	0	0		AUG 18 10	68d
29002	Prepare and Distribute Punch List	2	0	2	AUG 19 10	AUG 20 10	64d
29003	Punch List Work	20	0	20	AUG 23 10	SEP 20 10	64d
29999	Complete Construction	0	0	0		SEP 20 10	64d
Phase 3 - Area E							
Building Shell							
3S008	Load Bearing Masonry	19	75	5	MAR 25 09 A	AUG 21 09	1d
3S007	Underslab Plumbing	15	40	9	APR 09 09 A	AUG 27 09	-10d
3S009	Waterproof Ivany Block Walls	5	50	3	AUG 04 09 A	AUG 19 09	177d
3S010	Backfill Ivany Block Walls	10	50	5	AUG 05 09 A	SEP 15 09	165d
3S018	Bar Joist - Roof	5	0	5	AUG 24 09 *	AUG 28 09	-1d
3S011	Stone for Slab on Grade	5	0	5	AUG 28 09	SEP 04 09	-10d
3S019	Roof Deck	5	0	5	SEP 01 09	SEP 08 09	-1d
3S020	Hangers - All Trades	15	0	15	SEP 01 09	SEP 22 09	-1d
3S012	Underslab Electrical	15	0	15	SEP 08 09	SEP 28 09	-10d
3S002	Metal Pan Stairs	5	0	5	SEP 09 09	SEP 15 09	29d
3S024	Membrane Roofing	10	0	10	SEP 09 09	SEP 22 09	-1d



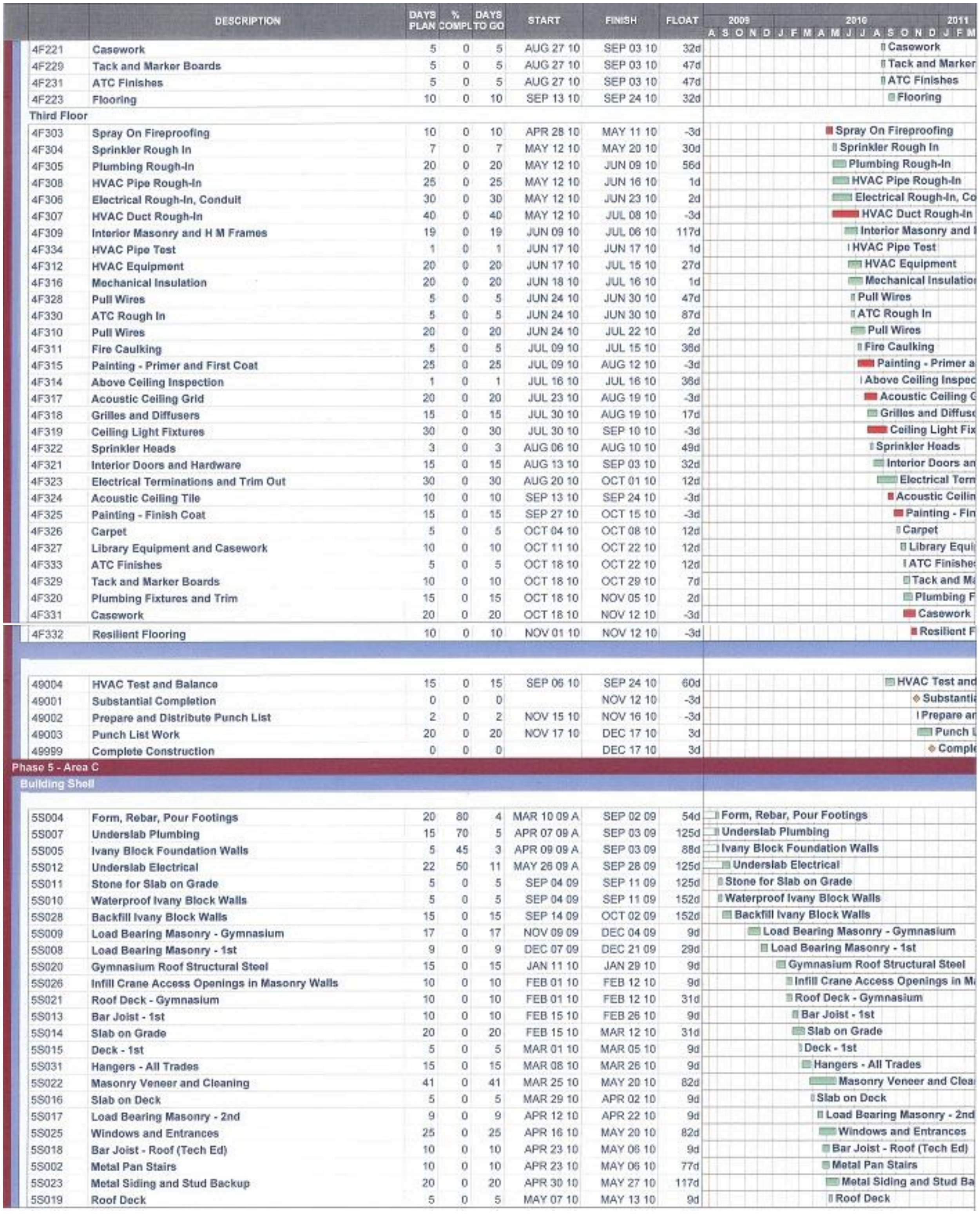
	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
3S013	Set Roof Top HVAC Equipment	5	0	5	SEP 23 09	SEP 29 09	24d
3S014	Slab on Grade	10	0	10	SEP 29 09	OCT 12 09	-10d
3S025	Windows and Entrances	15	0	15	NOV 05 09	NOV 25 09	-2d
3S022	Masonry Veneer and Cleaning	21	0	21	NOV 11 09	DEC 21 09	-2d
Systems and Finishes							
First Floor							
3F101	Electrical Rough-In in Load Bearing Masonry	15	0	15	AUG 17 09	SEP 08 09	39d
3F102	Plumbing Rough In in Load Bearing Masonry	15	0	15	AUG 17 09	SEP 08 09	39d
3S029	Spray On Fireproofing	10	0	10	SEP 23 09	OCT 06 09	-1d
3F112	HVAC Equipment	15	0	15	OCT 07 09	OCT 27 09	19d
3F103	Sprinkler Rough In	19	0	19	OCT 07 09	NOV 02 09	0
3F104	Electrical Rough In - Overhead	15	0	15	OCT 13 09	NOV 02 09	5d
3F109	Plumbing Rough In in Interior Partitions	20	0	20	OCT 13 09	NOV 09 09	-10d
3F105	HVAC Duct Rough-In	20	0	20	OCT 13 09	NOV 09 09	-5d
3F106	Electrical Rough In - Walls	20	0	20	OCT 13 09	NOV 09 09	-5d
3F120	Mechanical Insulation	20	0	20	OCT 13 09	NOV 09 09	0
3F107	Interior Masonry and H M Frames	30	0	30	OCT 13 09	NOV 23 09	-10d
3F130	Pull Wires	5	0	5	NOV 03 09	NOV 09 09	55d
3F110	Fire Caulking	5	0	5	NOV 10 09	NOV 16 09	-5d
3F131	ATC Rough In	5	0	5	NOV 10 09	NOV 16 09	65d
3F114	Painting - Primer and First Coat	20	0	20	NOV 10 09	DEC 10 09	-10d
3F111	Above Ceiling Inspection	1	0	1	NOV 17 09	NOV 17 09	24d
3F122	Doors and Hardware	15	0	15	NOV 17 09	DEC 10 09	55d
3F115	Acoustic Ceiling Grid	10	0	10	NOV 24 09	DEC 10 09	-10d
3F116	Grilles and Diffusers	15	0	15	DEC 04 09	DEC 24 09	0
3F124	Ceramic Tile	5	0	5	DEC 11 09	DEC 17 09	37d
3F118	Sprinkler Heads	7	0	7	DEC 11 09	DEC 21 09	48d
3F127	Prefab Rehearsal Rooms	10	0	10	DEC 11 09	DEC 24 09	30d
3F117	Lighting Fixtures	20	0	20	DEC 11 09	JAN 11 10	-10d
3F113	Electrical Terminations and Devices	20	0	20	DEC 11 09	JAN 11 10	35d
3F125	Plumbing Fixtures and Finishes	10	0	10	DEC 18 09	JAN 04 10	37d
3F119	Acoustic Ceiling Tile	10	0	10	JAN 12 10	JAN 25 10	-10d
3F128	Painting - Finish Coat	10	0	10	JAN 26 10	FEB 08 10	-10d
3F126	Toilet Partitions and Accessories	3	0	3	FEB 09 10	FEB 11 10	12d
3F129	Tack and Marker Boards	5	0	5	FEB 09 10	FEB 15 10	10d
3F132	ATC Finishes	5	0	5	FEB 09 10	FEB 15 10	10d
3F121	Casework	15	0	15	FEB 09 10	MAR 01 10	-10d
3F123	Flooring	15	0	15	FEB 23 10	MAR 15 10	-10d
39004	HVAC Test and Balance	15	0	15	DEC 28 09	JAN 18 10	236d
39001	Substantial Completion	0	0	0		MAR 15 10	-10d
39002	Prepare and Distribute Punch List	2	0	2	MAR 16 10	MAR 17 10	-10d
39003	Punch List Work	20	0	20	MAR 18 10	APR 14 10	174d
39999	Complete Construction	0	0	0		APR 14 10	174d
Phase 4 - Area D							
Building Shell							
4S004	Form, Rebar, Pour Footings	35	95	2	FEB 25 09 A	AUG 18 09	3d
4S005	Ivany Block Foundation Walls	8	90	1	MAR 10 09 A	AUG 19 09	3d
4S007	Underslab Plumbing	15	40	9	MAR 27 09 A	AUG 27 09	112d
4S008	Load Bearing Masonry - 1st	10	10	9	MAR 31 09 A	SEP 11 09 *	-4d
4S032	Waterproof Ivany Block Walls	5	30	4	AUG 03 09 A	AUG 25 09	86d
4S033	Backfill Ivany Block Walls	15	30	11	AUG 06 09 A	SEP 11 09	86d
4S043	Load Bearing Masonry - Auditorium Perimeter	30	15	26	AUG 10 09 A	SEP 28 09	75d
4S011	Stone for Slab on Grade	10	0	10	AUG 28 09	SEP 14 09	112d
4S013	Bar Joist - 2nd Floor	10	0	10	SEP 14 09	SEP 25 09	-4d
4S012	Underslab Electrical	22	0	22	SEP 15 09	OCT 14 09	112d
4S015	Deck - 2nd Floor	5	0	5	SEP 28 09	OCT 02 09	-4d
4S020	Precast Concrete Auditorium Risers	5	0	5	SEP 28 09	OCT 02 09	110d
4S047	Hangers - All Trades - 2nd Floor	5	0	5	OCT 05 09	OCT 09 09	-4d
4S016	Slab on Deck - 2nd Floor	5	0	5	OCT 12 09	OCT 16 09	-4d
4S017	Load Bearing Masonry - 2nd	10	0	10	OCT 26 09	NOV 06 09	-4d
4S018	Bar Joist - Kitchen Roof	10	0	10	NOV 09 09	NOV 20 09	39d
4S009	Elevator Rails	10	0	10	NOV 09 09	NOV 20 09	214d
4S037	Steel Framing - Cafeteria & Library Area	15	0	15	NOV 09 09	DEC 02 09	-4d
4S034	Metal Pan Stairs	20	0	20	NOV 09 09	DEC 09 09	119d
4S045	Kitchen Roof Framing	5	0	5	NOV 23 09	DEC 02 09	41d
4S023	Infill Crane Access Openings in Masonry Walls	10	0	10	NOV 23 09	DEC 09 09	75d
4S046	Hangers - All Trades - Kitchen Roof	15	0	15	NOV 23 09	DEC 16 09	46d



	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
4S038	Deck - 3rd Floor	5	0	5	DEC 03 09	DEC 09 09	-4d
4S019	Roof Deck - Kitchen	5	0	5	DEC 03 09	DEC 09 09	41d
4S048	Hangers - All Trades - 3rd Floor	5	0	5	DEC 10 09	DEC 16 09	-4d
4S042	Roof Deck - Library	5	0	5	DEC 10 09	DEC 16 09	74d
4S044	Low Roof Over Kitchen	10	0	10	DEC 10 09	DEC 23 09	41d
4S014	Slab on Grade	20	0	20	DEC 10 09	JAN 08 10	75d
4S035	Slab on Deck - 3rd Floor	10	0	10	DEC 17 09	DEC 31 09	-4d
4S039	Metal Roof, Insulation and Sheathing	15	0	15	DEC 17 09	JAN 08 10	74d
4S036	CMU Backup - Cafeteria and Library	15	0	15	JAN 04 10	JAN 28 10	64d
4S041	Load Bearing Masonry - 3rd to Roof	10	0	10	JAN 11 10	JAN 22 10	-4d
4S021	Auditorium Roof Structural Steel	15	0	15	JAN 25 10	FEB 12 10	-4d
4S022	Masonry Veneer and Cleaning	35	0	35	JAN 29 10	MAR 26 10	64d
4S026	Roof Deck - Auditorium	10	0	10	FEB 15 10	FEB 26 10	-4d
4S025	Windows and Entrances	35	0	35	FEB 16 10	APR 05 10	68d
4S024	Membrane Roofing	20	0	20	MAR 01 10	MAR 30 10	-3d
4S040	Metal Stud Soffit Framing	15	0	15	MAR 29 10	APR 16 10	134d
4S027	Metal Siding and Stud Backup	30	0	30	MAR 29 10	MAY 07 10	119d
4S030	Set Roof Top HVAC Equipment	5	0	5	MAR 31 10	APR 06 10	44d
4S031	Elevator Doors	10	0	10	MAR 31 10	APR 13 10	97d
4S010	Elevator Machinery and Cab	30	0	30	APR 06 10	MAY 17 10	123d
4S028	Roof Copings, Soffit and Trim	10	0	10	MAY 10 10	MAY 21 10	119d
Systems and Finishes							
Auditorium							
4F101	HVAC Pipe Rough-In in Load Bearing Masonry	20	0	20	SEP 01 09	SEP 29 09	74d
4F102	Plumbing Rough In in Load Bearing Masonry	20	0	20	SEP 01 09	SEP 29 09	74d
4S029	Spray On Fireproofing	10	0	10	MAR 31 10	APR 13 10	-3d
4F107	Interior Masonry and H M Frames	15	0	15	APR 14 10	MAY 04 10	8d
4F108	HVAC Pipe Rough-In in Interior Partitions	15	0	15	APR 14 10	MAY 04 10	8d
4F109	Plumbing Rough In in Interior Partitions	15	0	15	APR 14 10	MAY 04 10	17d
4F106	Electrical Rough In - Walls	15	0	15	APR 14 10	MAY 04 10	24d
4F103	Sprinkler Rough In	21	0	21	APR 14 10	MAY 12 10	18d
4F105	HVAC Duct Rough-In	25	0	25	APR 14 10	MAY 18 10	14d
4F112	HVAC Equipment	25	0	25	APR 14 10	MAY 18 10	37d
4F104	Electrical Rough In - Overhead	20	0	20	APR 21 10	MAY 18 10	72d
4F144	HVAC Pipe Test	1	0	1	MAY 05 10	MAY 05 10	8d
4F131	ATC Rough In	5	0	5	MAY 05 10	MAY 11 10	122d
4F114	Painting - Primer and First Coat	30	0	30	MAY 05 10	JUN 16 10	17d
4F140	Mechanical Insulation	20	0	20	MAY 06 10	JUN 03 10	8d
4F110	Fire Caulking	5	0	5	MAY 19 10	MAY 25 10	14d
4F130	Pull Wires	5	0	5	MAY 19 10	MAY 25 10	87d
4F138	Auditorium Acoustic Clouds	15	0	15	MAY 19 10	JUN 09 10	72d
4F111	Above Ceiling Inspection	1	0	1	MAY 26 10	MAY 26 10	56d
4F115	Acoustic Ceiling Grid	20	0	20	JUN 04 10	JUL 01 10	8d
4F116	Grilles and Diffusers	15	0	15	JUN 11 10	JUL 01 10	31d
4F124	Ceramic Tile	5	0	5	JUN 17 10	JUN 23 10	84d
4F113	Electrical Terminations and Devices	30	0	30	JUN 17 10	JUL 29 10	72d
4F118	Sprinkler Heads	8	0	8	JUN 18 10	JUN 29 10	8d
4F125	Plumbing Fixtures and Finishes	10	0	10	JUN 24 10	JUL 08 10	84d
4F120	Terrazzo	25	0	25	JUN 30 10	AUG 04 10	8d
4F117	Lighting Fixtures	20	0	20	JUL 02 10	JUL 30 10	11d
4F119	Acoustic Ceiling Tile	10	0	10	AUG 05 10	AUG 18 10	8d
4F122	Doors and Hardware	15	0	15	AUG 05 10	AUG 25 10	53d
4F128	Painting - Finish Coat	15	0	15	AUG 19 10	SEP 09 10	8d
4F142	Stage Riggings	20	0	20	SEP 03 10	SEP 30 10	8d
4F126	Toilet Partitions and Accessories	3	0	3	SEP 10 10	SEP 14 10	40d
4F143	ATC Finishes	5	0	5	SEP 10 10	SEP 16 10	38d
4F129	Tack and Marker Boards	10	0	10	SEP 10 10	SEP 23 10	33d
4F139	Auditorium Wall Panels	15	0	15	SEP 10 10	SEP 30 10	8d
4F121	Casework	15	0	15	SEP 10 10	SEP 30 10	13d
4F123	Resilient Flooring	20	0	20	SEP 24 10	OCT 21 10	13d
4F135	Auditorium Seating	15	0	15	OCT 01 10	OCT 21 10	8d
4F137	Wood Stage Floor	15	0	15	OCT 01 10	OCT 21 10	8d
4F136	Stage Curtains	5	0	5	OCT 22 10	OCT 28 10	8d
4F141	Carpet	5	0	5	OCT 22 10	OCT 28 10	8d
Kitchen/Cafeteria							
4F1K01	HVAC Pipe Rough-In in Load Bearing Masonry	20	0	20	SEP 01 09	SEP 29 09	147d
4F1K02	Plumbing Rough In in Load Bearing Masonry	20	0	20	SEP 01 09	SEP 29 09	179d
4F1K03	Spray On Fireproofing	10	0	10	DEC 24 09	JAN 08 10	41d
4F1K45	Field Verify Walk Ins	1	0	1	JAN 11 10	JAN 11 10	75d
4F1K05	HVAC Pipe Rough-In in Interior Partitions	15	0	15	JAN 11 10	JAN 29 10	80d

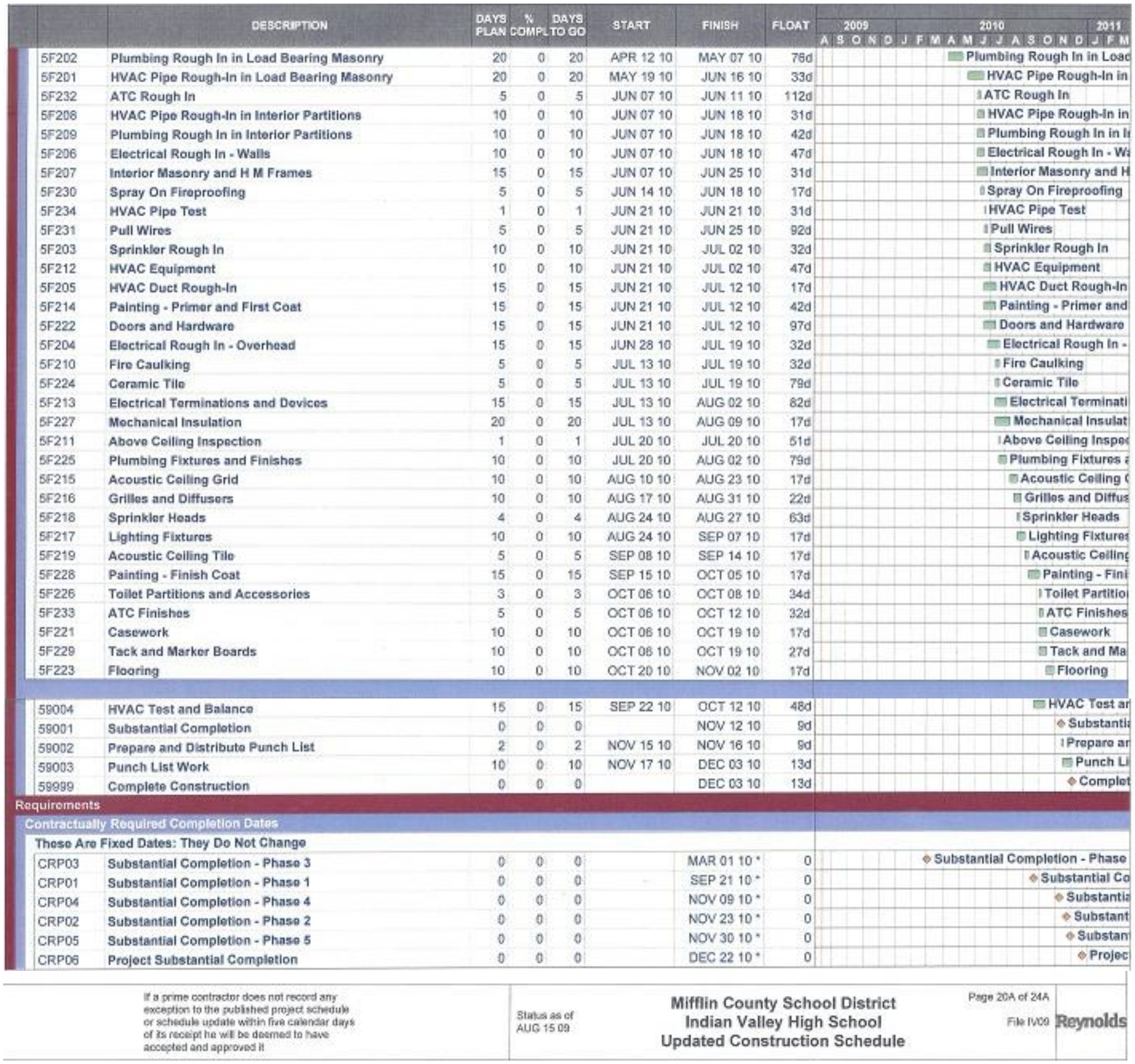


	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
4F1K06	Plumbing Rough In in Interior Partitions	15	0	15	JAN 11 10	JAN 29 10	89d
4F1K04	Electrical Rough In - Walls	15	0	15	JAN 11 10	JAN 29 10	96d
4F1K08	Sprinkler Rough In	21	0	21	JAN 11 10	FEB 08 10	90d
4F1K09	HVAC Duct Rough-In	25	0	25	JAN 11 10	FEB 12 10	71d
4F1K10	HVAC Equipment	25	0	25	JAN 11 10	FEB 12 10	109d
4F1K11	Interior Masonry and H M Frames	38	0	38	JAN 11 10	MAR 03 10	41d
4F1K07	Electrical Rough In - Overhead	20	0	20	JAN 18 10	FEB 12 10	144d
4F1K34	HVAC Pipe Test	1	0	1	FEB 01 10	FEB 01 10	80d
4F1K18	Painting - Primer and First Coat	30	0	30	FEB 01 10	MAR 12 10	89d
4F1K12	Fire Caulking	5	0	5	FEB 15 10	FEB 19 10	86d
4F1K14	Pull Wires	5	0	5	FEB 15 10	FEB 19 10	149d
4F1K30	ATC Rough In	5	0	5	FEB 15 10	FEB 19 10	179d
4F1K44	Install Ventilators	10	0	10	FEB 15 10	FEB 26 10	81d
4F1K13	Mechanical Insulation	20	0	20	FEB 15 10	MAR 12 10	71d
4F1K15	Above Ceiling Inspection	1	0	1	FEB 22 10	FEB 22 10	128d
4F1K47	Field Verify Floor Troughs	1	0	1	MAR 04 10	MAR 04 10	105d
4F1K49	Field Verify Custom Counter	1	0	1	MAR 04 10	MAR 04 10	120d
4F1K22	Ceramic Tile	5	0	5	MAR 15 10	MAR 19 10	151d
4F1K24	Electrical Terminations and Devices	30	0	30	MAR 15 10	APR 23 10	134d
4F1K26	Plumbing Fixtures and Finishes	10	0	10	MAR 22 10	APR 02 10	151d
4F1K35	Set Walk In Coolers and Freezers	10	0	10	MAR 31 10	APR 13 10	49d
4F1K53	Install Floor Troughs	5	0	5	APR 02 10	APR 08 10	105d
4F1K16	Quarry Tile	15	0	15	APR 14 10	MAY 04 10	102d
4F1K19	Acoustic Ceiling Grid	20	0	20	APR 14 10	MAY 11 10	49d
4F1K20	Grilles and Diffusers	15	0	15	APR 21 10	MAY 11 10	72d
4F1K21	Sprinkler Heads	8	0	8	APR 28 10	MAY 07 10	49d
4F1K25	Terrazzo	25	0	25	MAY 10 10	JUN 14 10	49d
4F1K23	Lighting Fixtures	20	0	20	MAY 12 10	JUN 09 10	52d
4F1K54	Install Custom Counter	5	0	5	MAY 14 10	MAY 20 10	120d
4F1K27	Acoustic Ceiling Tile	10	0	10	JUN 15 10	JUN 28 10	49d
4F1K28	Doors and Hardware	15	0	15	JUN 15 10	JUL 06 10	89d
4F1K29	Painting - Finish Coat	15	0	15	JUN 29 10	JUL 20 10	49d
4F1K31	Toilet Partitions and Accessories	3	0	3	JUL 21 10	JUL 23 10	76d
4F1K39	ATC Finishes	5	0	5	JUL 21 10	JUL 27 10	74d
4F1K32	Tack and Marker Boards	10	0	10	JUL 21 10	AUG 03 10	69d
4F1K33	Casework	15	0	15	JUL 21 10	AUG 10 10	49d
4F1K36	Kitchen Hood	5	0	5	AUG 02 10	AUG 06 10	41d
4F1K37	Resilient Flooring	20	0	20	AUG 04 10	SEP 01 10	49d
4F1K38	Set Kitchen Equipment	15	0	15	AUG 09 10	AUG 27 10	41d
4F1K51	Start Up and Test Kitchen Equipment	4	0	4	AUG 31 10	SEP 03 10	46d
4F1K41	Connections to Kitchen Equipment	10	0	10	AUG 31 10	SEP 13 10	41d
4F1K52	Demonstrate Kitchen Equipment	1	0	1	SEP 06 10	SEP 06 10	46d
Second Floor							
4F201	HVAC Pipe Rough-In in Load Bearing Masonry	10	0	10	OCT 26 09	NOV 06 09	39d
4F202	Plumbing Rough In in Load Bearing Masonry	10	0	10	OCT 26 09	NOV 06 09	39d
4F230	Spray On Fireproofing	10	0	10	APR 14 10	APR 27 10	-3d
4F204	Electrical Rough In - Overhead	15	0	15	APR 28 10	MAY 18 10	102d
4F205	HVAC Duct Rough-In	20	0	20	APR 28 10	MAY 25 10	32d
4F212	HVAC Equipment	20	0	20	APR 28 10	MAY 25 10	57d
4F203	Sprinkler Rough In	29	0	29	APR 28 10	JUN 08 10	38d
4F208	HVAC Pipe Rough-In in Interior Partitions	10	0	10	MAY 05 10	MAY 18 10	33d
4F209	Plumbing Rough In in Interior Partitions	10	0	10	MAY 05 10	MAY 18 10	47d
4F206	Electrical Rough In - Walls	10	0	10	MAY 05 10	MAY 18 10	52d
4F207	Interior Masonry and H M Frames	24	0	24	MAY 05 10	JUN 08 10	33d
4F232	HVAC Pipe Test	1	0	1	MAY 19 10	MAY 19 10	36d
4F226	Pull Wires	5	0	5	MAY 19 10	MAY 25 10	102d
4F227	ATC Rough In	5	0	5	MAY 19 10	MAY 25 10	112d
4F214	Painting - Primer and First Coat	15	0	15	MAY 25 10	JUN 15 10	43d
4F224	Mechanical Insulation	20	0	20	MAY 26 10	JUN 23 10	32d
4F222	Doors and Hardware	10	0	10	JUN 02 10	JUN 15 10	103d
4F210	Fire Caulking	5	0	5	JUN 09 10	JUN 15 10	38d
4F211	Above Ceiling Inspection	1	0	1	JUN 16 10	JUN 16 10	62d
4F225	Plumbing Fixtures and Finishes	10	0	10	JUN 16 10	JUN 29 10	93d
4F213	Electrical Terminations and Devices	15	0	15	JUN 16 10	JUL 07 10	88d
4F215	Acoustic Ceiling Grid	10	0	10	JUN 24 10	JUL 08 10	32d
4F216	Grilles and Diffusers	10	0	10	JUL 01 10	JUL 15 10	42d
4F218	Sprinkler Heads	11	0	11	JUL 09 10	JUL 23 10	76d
4F217	Lighting Fixtures	15	0	15	JUL 09 10	JUL 29 10	32d
4F219	Acoustic Ceiling Tile	10	0	10	JUL 30 10	AUG 12 10	32d
4F228	Painting - Finish Coat	10	0	10	AUG 13 10	AUG 26 10	32d



	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
4F221	Casework	5	0	5	AUG 27 10	SEP 03 10	32d
4F229	Tack and Marker Boards	5	0	5	AUG 27 10	SEP 03 10	47d
4F231	ATC Finishes	5	0	5	AUG 27 10	SEP 03 10	47d
4F223	Flooring	10	0	10	SEP 13 10	SEP 24 10	32d
Third Floor							
4F303	Spray On Fireproofing	10	0	10	APR 28 10	MAY 11 10	-3d
4F304	Sprinkler Rough In	7	0	7	MAY 12 10	MAY 20 10	30d
4F305	Plumbing Rough-In	20	0	20	MAY 12 10	JUN 09 10	56d
4F308	HVAC Pipe Rough-In	25	0	25	MAY 12 10	JUN 16 10	1d
4F306	Electrical Rough-In, Conduit	30	0	30	MAY 12 10	JUN 23 10	2d
4F307	HVAC Duct Rough-In	40	0	40	MAY 12 10	JUL 08 10	-3d
4F309	Interior Masonry and H M Frames	19	0	19	JUN 09 10	JUL 06 10	117d
4F334	HVAC Pipe Test	1	0	1	JUN 17 10	JUN 17 10	1d
4F312	HVAC Equipment	20	0	20	JUN 17 10	JUL 15 10	27d
4F316	Mechanical Insulation	20	0	20	JUN 18 10	JUL 16 10	1d
4F328	Pull Wires	5	0	5	JUN 24 10	JUN 30 10	47d
4F330	ATC Rough In	5	0	5	JUN 24 10	JUN 30 10	87d
4F310	Pull Wires	20	0	20	JUN 24 10	JUL 22 10	2d
4F311	Fire Caulking	5	0	5	JUL 09 10	JUL 15 10	36d
4F315	Painting - Primer and First Coat	25	0	25	JUL 09 10	AUG 12 10	-3d
4F314	Above Ceiling Inspection	1	0	1	JUL 16 10	JUL 16 10	36d
4F317	Acoustic Ceiling Grid	20	0	20	JUL 23 10	AUG 19 10	-3d
4F318	Grilles and Diffusers	15	0	15	JUL 30 10	AUG 19 10	17d
4F319	Ceiling Light Fixtures	30	0	30	JUL 30 10	SEP 10 10	-3d
4F322	Sprinkler Heads	3	0	3	AUG 06 10	AUG 10 10	49d
4F321	Interior Doors and Hardware	15	0	15	AUG 13 10	SEP 03 10	32d
4F323	Electrical Terminations and Trim Out	30	0	30	AUG 20 10	OCT 01 10	12d
4F324	Acoustic Ceiling Tile	10	0	10	SEP 13 10	SEP 24 10	-3d
4F325	Painting - Finish Coat	15	0	15	SEP 27 10	OCT 15 10	-3d
4F326	Carpet	5	0	5	OCT 04 10	OCT 08 10	12d
4F327	Library Equipment and Casework	10	0	10	OCT 11 10	OCT 22 10	12d
4F333	ATC Finishes	5	0	5	OCT 18 10	OCT 22 10	12d
4F329	Tack and Marker Boards	10	0	10	OCT 18 10	OCT 29 10	7d
4F320	Plumbing Fixtures and Trim	15	0	15	OCT 18 10	NOV 05 10	2d
4F331	Casework	20	0	20	OCT 18 10	NOV 12 10	-3d
4F332	Resilient Flooring	10	0	10	NOV 01 10	NOV 12 10	-3d
49004	HVAC Test and Balance	15	0	15	SEP 06 10	SEP 24 10	60d
49001	Substantial Completion	0	0	0		NOV 12 10	-3d
49002	Prepare and Distribute Punch List	2	0	2	NOV 15 10	NOV 16 10	-3d
49003	Punch List Work	20	0	20	NOV 17 10	DEC 17 10	3d
49999	Complete Construction	0	0	0		DEC 17 10	3d
Phase 5 - Area C							
Building Shell							
5S004	Form, Rebar, Pour Footings	20	80	4	MAR 10 09 A	SEP 02 09	54d
5S007	Underslab Plumbing	15	70	5	APR 07 09 A	SEP 03 09	125d
5S005	Ivany Block Foundation Walls	5	45	3	APR 09 09 A	SEP 03 09	88d
5S012	Underslab Electrical	22	50	11	MAY 26 09 A	SEP 28 09	125d
5S011	Stone for Slab on Grade	5	0	5	SEP 04 09	SEP 11 09	125d
5S010	Waterproof Ivany Block Walls	5	0	5	SEP 04 09	SEP 11 09	152d
5S028	Backfill Ivany Block Walls	15	0	15	SEP 14 09	OCT 02 09	152d
5S009	Load Bearing Masonry - Gymnasium	17	0	17	NOV 09 09	DEC 04 09	9d
5S008	Load Bearing Masonry - 1st	9	0	9	DEC 07 09	DEC 21 09	29d
5S020	Gymnasium Roof Structural Steel	15	0	15	JAN 11 10	JAN 29 10	9d
5S026	Infill Crane Access Openings in Masonry Walls	10	0	10	FEB 01 10	FEB 12 10	9d
5S021	Roof Deck - Gymnasium	10	0	10	FEB 01 10	FEB 12 10	31d
5S013	Bar Joist - 1st	10	0	10	FEB 15 10	FEB 26 10	9d
5S014	Slab on Grade	20	0	20	FEB 15 10	MAR 12 10	31d
5S015	Deck - 1st	5	0	5	MAR 01 10	MAR 05 10	9d
5S031	Hangers - All Trades	15	0	15	MAR 08 10	MAR 26 10	9d
5S022	Masonry Veneer and Cleaning	41	0	41	MAR 25 10	MAY 20 10	82d
5S016	Slab on Deck	5	0	5	MAR 29 10	APR 02 10	9d
5S017	Load Bearing Masonry - 2nd	9	0	9	APR 12 10	APR 22 10	9d
5S025	Windows and Entrances	25	0	25	APR 16 10	MAY 20 10	82d
5S018	Bar Joist - Roof (Tech Ed)	10	0	10	APR 23 10	MAY 06 10	9d
5S002	Metal Pan Stairs	10	0	10	APR 23 10	MAY 06 10	77d
5S023	Metal Siding and Stud Backup	20	0	20	APR 30 10	MAY 27 10	117d
5S019	Roof Deck	5	0	5	MAY 07 10	MAY 13 10	9d

	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
5S024	Membrane Roofing	20	0	20	MAY 14 10	JUN 11 10	9d
5S030	Set Roof Top HVAC Equipment	5	0	5	JUN 14 10	JUN 18 10	32d
5S027	Roof Copings and Trim	10	0	10	JUN 14 10	JUN 25 10	107d
Systems and Finishes							
Gymnasiums							
5FG01	HVAC Pipe Rough-In in Load Bearing Masonry	40	0	40	NOV 09 09	JAN 08 10	9d
5FG02	Plumbing Rough In in Load Bearing Masonry	40	0	40	NOV 09 09	JAN 08 10	9d
5FG18	ATC Rough In	5	0	5	MAR 15 10	MAR 19 10	171d
5FG05	HVAC Pipe Rough-In in Interior Partitions	10	0	10	MAR 15 10	MAR 26 10	77d
5FG06	Plumbing Rough In in Interior Partitions	10	0	10	MAR 15 10	MAR 26 10	98d
5FG03	Electrical Rough In - Walls	20	0	20	MAR 15 10	APR 09 10	88d
5FG04	Interior Masonry and H M Frames	44	0	44	MAR 15 10	MAY 13 10	31d
5FG23	HVAC Pipe Test	1	0	1	MAR 29 10	MAR 29 10	77d
5FG11	HVAC Equipment	10	0	10	JUN 14 10	JUN 25 10	54d
5FG10	HVAC Duct Rough-In	15	0	15	JUN 14 10	JUL 02 10	9d
5FG08	Sprinkler Rough In	24	0	24	JUN 28 10	JUL 30 10	10d
5FG09	Electrical Rough In - Overhead	15	0	15	JUL 06 10	JUL 26 10	14d
5FG15	Mechanical Insulation	20	0	20	JUL 06 10	AUG 02 10	9d
5FG17	Pull Wires	5	0	5	JUL 27 10	AUG 02 10	29d
5FG14	Fire Caulking	5	0	5	AUG 02 10	AUG 06 10	25d
5FG12	Painting - Primer and First Coat	20	0	20	AUG 03 10	AUG 31 10	9d
5FG13	Doors and Hardware	15	0	15	AUG 10 10	AUG 31 10	62d
5FG22	Sprinkler Heads	9	0	9	SEP 01 10	SEP 13 10	15d
5FG16	Athletic Equipment	10	0	10	SEP 01 10	SEP 14 10	14d
5FG19	Electrical Terminations and Devices	15	0	15	SEP 01 10	SEP 21 10	9d
5FG20	Grilles and Diffusers	15	0	15	SEP 01 10	SEP 21 10	9d
5FG21	Lighting Fixtures	15	0	15	SEP 01 10	SEP 21 10	9d
5FG25	Painting - Finish Coat	15	0	15	SEP 01 10	SEP 21 10	9d
5FG30	ATC Finishes	5	0	5	SEP 22 10	SEP 28 10	42d
5FG29	Rubber Athletic Flooring	18	0	18	SEP 22 10	OCT 15 10	24d
5FG31	Wood Gymnasium Floor	23	0	23	SEP 22 10	OCT 22 10	9d
5FG33	Wall Pads	5	0	5	OCT 25 10	OCT 29 10	19d
5FG34	Bleachers	15	0	15	OCT 25 10	NOV 12 10	9d
First Floor Locker Rooms and Fitness							
5F101	HVAC Pipe Rough-In in Load Bearing Masonry	20	0	20	DEC 07 09	JAN 05 10	37d
5F102	Plumbing Rough In in Load Bearing Masonry	20	0	20	DEC 07 09	JAN 05 10	37d
5S032	ATC Rough In	5	0	5	MAY 14 10	MAY 20 10	127d
5F107	Interior Masonry and H M Frames	15	0	15	MAY 14 10	JUN 04 10	31d
5F108	HVAC Pipe Rough-In in Interior Partitions	15	0	15	MAY 14 10	JUN 04 10	46d
5F109	Plumbing Rough In in Interior Partitions	15	0	15	MAY 14 10	JUN 04 10	57d
5F106	Electrical Rough In - Walls	15	0	15	MAY 14 10	JUN 04 10	62d
5F134	HVAC Pipe Test	1	0	1	JUN 07 10	JUN 07 10	46d
5S029	Spray On Fireproofing	5	0	5	JUN 14 10	JUN 18 10	22d
5F112	HVAC Equipment	10	0	10	JUN 21 10	JUL 02 10	52d
5F105	HVAC Duct Rough-In	15	0	15	JUN 21 10	JUL 12 10	22d
5F114	Painting - Primer and First Coat	15	0	15	JUN 21 10	JUL 12 10	47d
5F122	Doors and Hardware	15	0	15	JUN 21 10	JUL 12 10	97d
5F103	Sprinkler Rough In	19	0	19	JUN 21 10	JUL 16 10	33d
5F104	Electrical Rough In - Overhead	15	0	15	JUN 28 10	JUL 19 10	37d
5F124	Ceramic Tile	15	0	15	JUL 13 10	AUG 02 10	69d
5F127	Mechanical Insulation	20	0	20	JUL 13 10	AUG 09 10	22d
5F110	Fire Caulking	5	0	5	JUL 19 10	JUL 23 10	33d
5F130	Pull Wires	5	0	5	JUL 20 10	JUL 26 10	72d
5F111	Above Ceiling Inspection	1	0	1	JUL 26 10	JUL 26 10	52d
5F113	Electrical Terminations and Devices	15	0	15	JUL 27 10	AUG 16 10	72d
5F125	Plumbing Fixtures and Finishes	10	0	10	AUG 03 10	AUG 16 10	69d
5F115	Acoustic Ceiling Grid	10	0	10	AUG 10 10	AUG 23 10	22d
5F116	Grilles and Diffusers	15	0	15	AUG 17 10	SEP 07 10	22d
5F118	Sprinkler Heads	7	0	7	AUG 24 10	SEP 02 10	60d
5F117	Lighting Fixtures	10	0	10	AUG 24 10	SEP 07 10	22d
5F119	Acoustic Ceiling Tile	5	0	5	SEP 08 10	SEP 14 10	22d
5F128	Painting - Finish Coat	10	0	10	SEP 15 10	SEP 28 10	22d
5F126	Toilet Partitions and Accessories	3	0	3	SEP 29 10	OCT 01 10	39d
5F131	ATC Finishes	5	0	5	SEP 29 10	OCT 05 10	37d
5F121	Casework	10	0	10	SEP 29 10	OCT 12 10	22d
5F129	Tack and Marker Boards	10	0	10	SEP 29 10	OCT 12 10	32d
5F133	Lockers	10	0	10	SEP 29 10	OCT 12 10	32d
5F132	Rubber Athletic Flooring	15	0	15	SEP 29 10	OCT 19 10	27d
5F123	Flooring	10	0	10	OCT 13 10	OCT 26 10	22d



	DESCRIPTION	DAYS PLAN	% COMPL	DAYS TO GO	START	FINISH	FLOAT
5F202	Plumbing Rough In in Load Bearing Masonry	20	0	20	APR 12 10	MAY 07 10	76d
5F201	HVAC Pipe Rough-In in Load Bearing Masonry	20	0	20	MAY 19 10	JUN 16 10	33d
5F232	ATC Rough In	5	0	5	JUN 07 10	JUN 11 10	112d
5F208	HVAC Pipe Rough-In in Interior Partitions	10	0	10	JUN 07 10	JUN 18 10	31d
5F209	Plumbing Rough In in Interior Partitions	10	0	10	JUN 07 10	JUN 18 10	42d
5F206	Electrical Rough In - Walls	10	0	10	JUN 07 10	JUN 18 10	47d
5F207	Interior Masonry and H M Frames	15	0	15	JUN 07 10	JUN 25 10	31d
5F230	Spray On Fireproofing	5	0	5	JUN 14 10	JUN 18 10	17d
5F234	HVAC Pipe Test	1	0	1	JUN 21 10	JUN 21 10	31d
5F231	Pull Wires	5	0	5	JUN 21 10	JUN 25 10	92d
5F203	Sprinkler Rough In	10	0	10	JUN 21 10	JUL 02 10	32d
5F212	HVAC Equipment	10	0	10	JUN 21 10	JUL 02 10	47d
5F205	HVAC Duct Rough-In	15	0	15	JUN 21 10	JUL 12 10	17d
5F214	Painting - Primer and First Coat	15	0	15	JUN 21 10	JUL 12 10	42d
5F222	Doors and Hardware	15	0	15	JUN 21 10	JUL 12 10	97d
5F204	Electrical Rough In - Overhead	15	0	15	JUN 28 10	JUL 19 10	32d
5F210	Fire Caulking	5	0	5	JUL 13 10	JUL 19 10	32d
5F224	Ceramic Tile	5	0	5	JUL 13 10	JUL 19 10	79d
5F213	Electrical Terminations and Devices	15	0	15	JUL 13 10	AUG 02 10	82d
5F227	Mechanical Insulation	20	0	20	JUL 13 10	AUG 09 10	17d
5F211	Above Ceiling Inspection	1	0	1	JUL 20 10	JUL 20 10	51d
5F225	Plumbing Fixtures and Finishes	10	0	10	JUL 20 10	AUG 02 10	79d
5F215	Acoustic Ceiling Grid	10	0	10	AUG 10 10	AUG 23 10	17d
5F216	Grilles and Diffusers	10	0	10	AUG 17 10	AUG 31 10	22d
5F218	Sprinkler Heads	4	0	4	AUG 24 10	AUG 27 10	63d
5F217	Lighting Fixtures	10	0	10	AUG 24 10	SEP 07 10	17d
5F219	Acoustic Ceiling Tile	5	0	5	SEP 08 10	SEP 14 10	17d
5F228	Painting - Finish Coat	15	0	15	SEP 15 10	OCT 05 10	17d
5F226	Toilet Partitions and Accessories	3	0	3	OCT 06 10	OCT 08 10	34d
5F233	ATC Finishes	5	0	5	OCT 06 10	OCT 12 10	32d
5F221	Casework	10	0	10	OCT 06 10	OCT 19 10	17d
5F229	Tack and Marker Boards	10	0	10	OCT 06 10	OCT 19 10	27d
5F223	Flooring	10	0	10	OCT 20 10	NOV 02 10	17d
59004	HVAC Test and Balance	15	0	15	SEP 22 10	OCT 12 10	48d
59001	Substantial Completion	0	0	0		NOV 12 10	9d
59002	Prepare and Distribute Punch List	2	0	2	NOV 15 10	NOV 16 10	9d
59003	Punch List Work	10	0	10	NOV 17 10	DEC 03 10	13d
59999	Complete Construction	0	0	0		DEC 03 10	13d
Requirements							
Contractually Required Completion Dates							
These Are Fixed Dates: They Do Not Change							
CRP03	Substantial Completion - Phase 3	0	0	0		MAR 01 10 *	0
CRP01	Substantial Completion - Phase 1	0	0	0		SEP 21 10 *	0
CRP04	Substantial Completion - Phase 4	0	0	0		NOV 09 10 *	0
CRP02	Substantial Completion - Phase 2	0	0	0		NOV 23 10 *	0
CRP05	Substantial Completion - Phase 5	0	0	0		NOV 30 10 *	0
CRP06	Project Substantial Completion	0	0	0		DEC 22 10 *	0

If a prime contractor does not record any exception to the published project schedule or schedule update within five calendar days of its receipt he will be deemed to have accepted and approved it

Status as of AUG 15 09

Mifflin County School District
Indian Valley High School
Updated Construction Schedule

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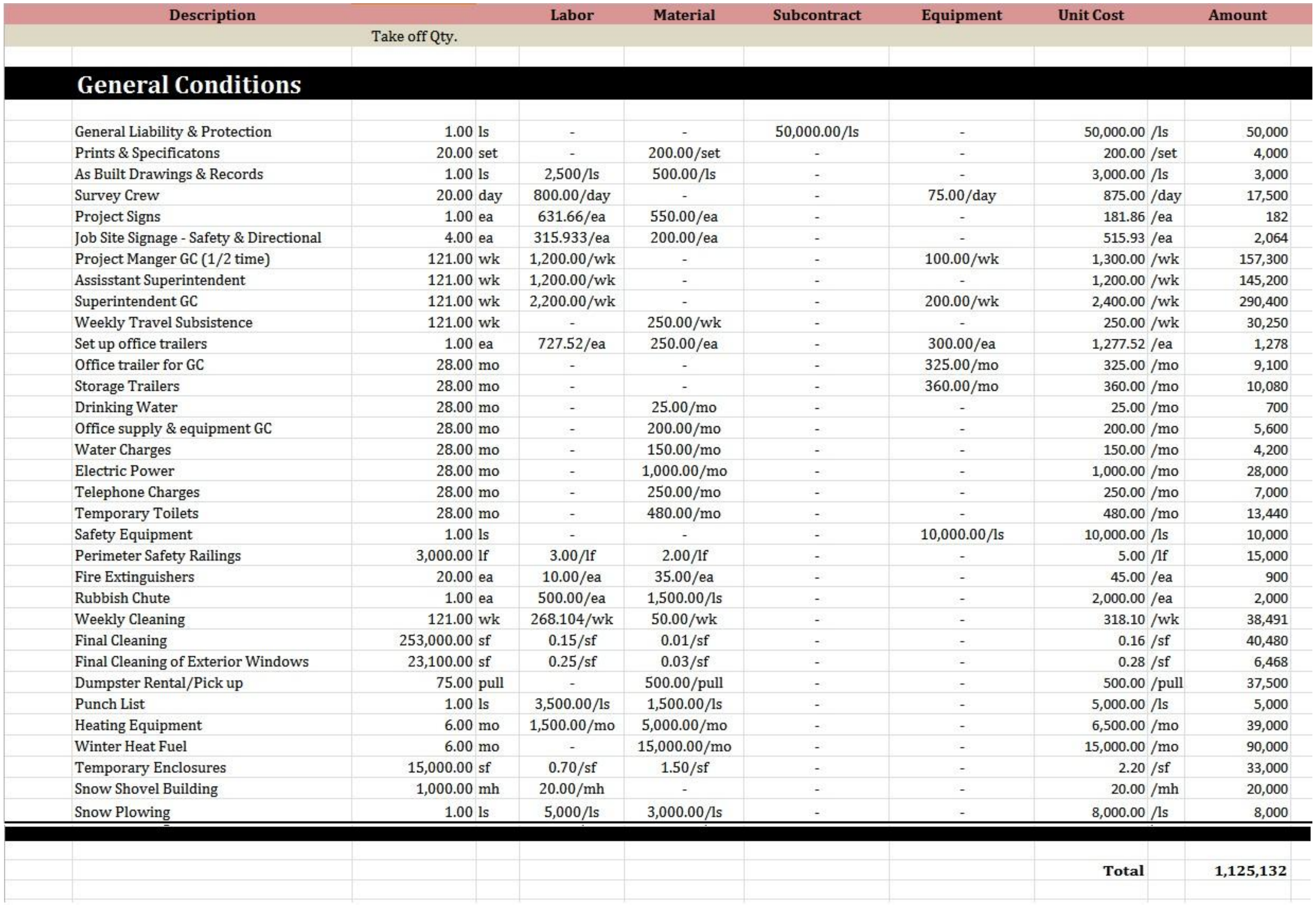
File IV09

Reynolds

APPENDIX D: General Conditions Estimate



Description	Take off Qty.	Labor	Material	Subcontract	Equipment	Unit Cost	Amount
General Conditions							
General Liability & Protection	1.00 ls	-	-	50,000.00/ls	-	50,000.00 /ls	50,000
Prints & Specificatons	20.00 set	-	200.00/set	-	-	200.00 /set	4,000
As Built Drawings & Records	1.00 ls	2,500/ls	500.00/ls	-	-	3,000.00 /ls	3,000
Survey Crew	20.00 day	800.00/day	-	-	75.00/day	875.00 /day	17,500
Project Signs	1.00 ea	631.66/ea	550.00/ea	-	-	181.86 /ea	182
Job Site Signage - Safety & Directional	4.00 ea	315.933/ea	200.00/ea	-	-	515.93 /ea	2,064
Project Manger GC (1/2 time)	121.00 wk	1,200.00/wk	-	-	100.00/wk	1,300.00 /wk	157,300
Assistant Superintendent	121.00 wk	1,200.00/wk	-	-	-	1,200.00 /wk	145,200
Superintendent GC	121.00 wk	2,200.00/wk	-	-	200.00/wk	2,400.00 /wk	290,400
Weekly Travel Subsistence	121.00 wk	-	250.00/wk	-	-	250.00 /wk	30,250
Set up office trailers	1.00 ea	727.52/ea	250.00/ea	-	300.00/ea	1,277.52 /ea	1,278
Office trailer for GC	28.00 mo	-	-	-	325.00/mo	325.00 /mo	9,100
Storage Trailers	28.00 mo	-	-	-	360.00/mo	360.00 /mo	10,080
Drinking Water	28.00 mo	-	25.00/mo	-	-	25.00 /mo	700
Office supply & equipment GC	28.00 mo	-	200.00/mo	-	-	200.00 /mo	5,600
Water Charges	28.00 mo	-	150.00/mo	-	-	150.00 /mo	4,200
Electric Power	28.00 mo	-	1,000.00/mo	-	-	1,000.00 /mo	28,000
Telephone Charges	28.00 mo	-	250.00/mo	-	-	250.00 /mo	7,000
Temporary Toilets	28.00 mo	-	480.00/mo	-	-	480.00 /mo	13,440
Safety Equipment	1.00 ls	-	-	-	10,000.00/ls	10,000.00 /ls	10,000
Perimeter Safety Railings	3,000.00 lf	3.00/lf	2.00/lf	-	-	5.00 /lf	15,000
Fire Extinguishers	20.00 ea	10.00/ea	35.00/ea	-	-	45.00 /ea	900
Rubbish Chute	1.00 ea	500.00/ea	1,500.00/ls	-	-	2,000.00 /ea	2,000
Weekly Cleaning	121.00 wk	268.104/wk	50.00/wk	-	-	318.10 /wk	38,491
Final Cleaning	253,000.00 sf	0.15/sf	0.01/sf	-	-	0.16 /sf	40,480
Final Cleaning of Exterior Windows	23,100.00 sf	0.25/sf	0.03/sf	-	-	0.28 /sf	6,468
Dumpster Rental/Pick up	75.00 pull	-	500.00/pull	-	-	500.00 /pull	37,500
Punch List	1.00 ls	3,500.00/ls	1,500.00/ls	-	-	5,000.00 /ls	5,000
Heating Equipment	6.00 mo	1,500.00/mo	5,000.00/mo	-	-	6,500.00 /mo	39,000
Winter Heat Fuel	6.00 mo	-	15,000.00/mo	-	-	15,000.00 /mo	90,000
Temporary Enclosures	15,000.00 sf	0.70/sf	1.50/sf	-	-	2.20 /sf	33,000
Snow Shovel Building	1,000.00 mh	20.00/mh	-	-	-	20.00 /mh	20,000
Snow Plowing	1.00 ls	5,000/ls	3,000.00/ls	-	-	8,000.00 /ls	8,000
						Total	**1,125,132**

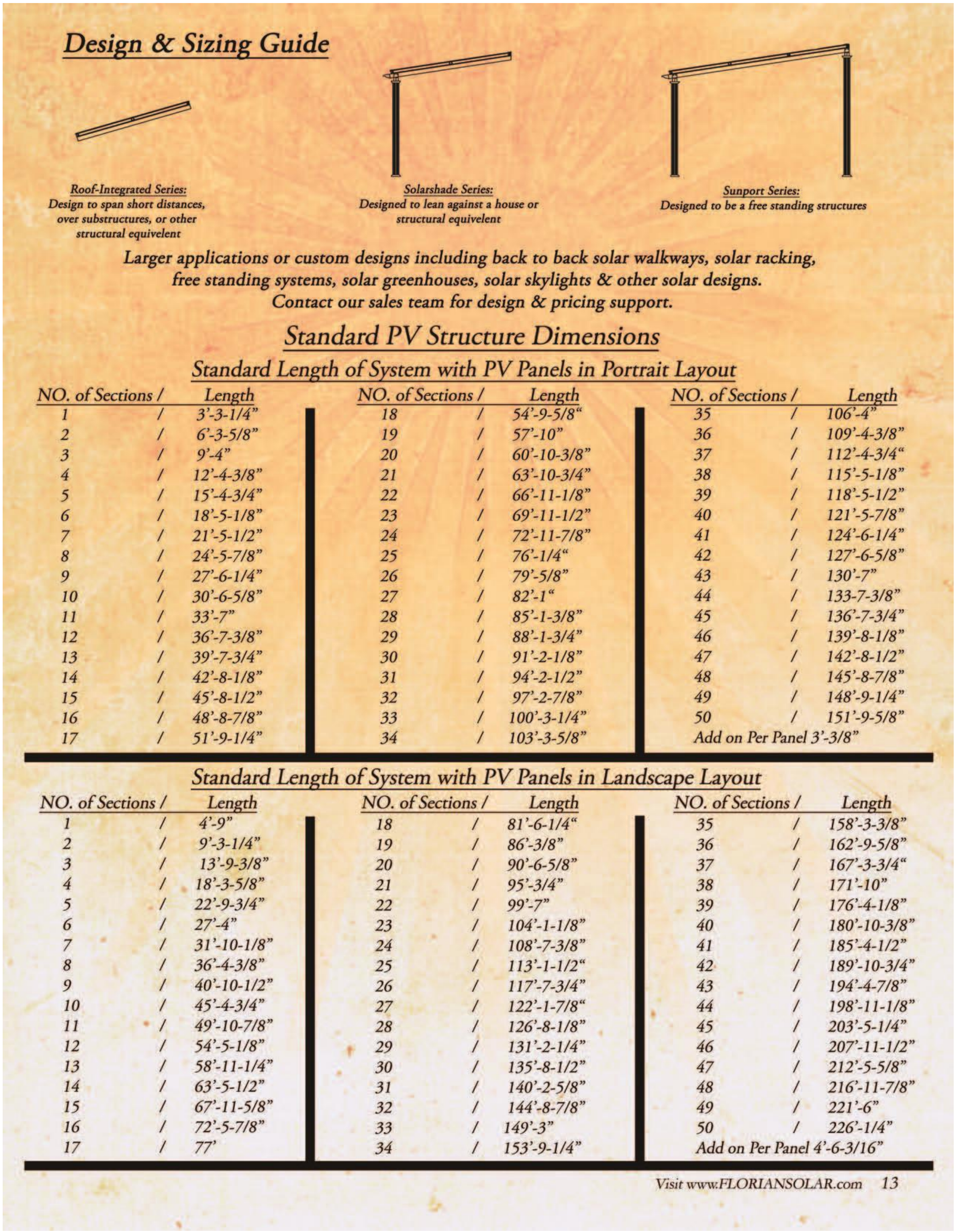
APPENDIX E: Pennsylvania Incentives/Rebates

Summary of Solar & Wind Incentives and Rebates currently stored and available:

Show Solar & Wind Incentives for: PA » Go

State/Region/Utility	Solar/Wind Technology	Solar/Wind Incentive or Rebate Description
US (US) Applies to: Residential & Business	Solar Electric (PV) Solar Water Heating Wind Turbine	Federal Tax Credit (30% of Gross Cost at Installation) » link
Pennsylvania (PA) Applies to: Residential & Business	Solar Electric (PV) Wind Turbine	Pennsylvania SREC Market (assumes $ 300 per MWh for 10 years) » link
US (US) Applies to: Residential	Energy Efficiency	Federal Residential Energy Efficiency Tax Credit » link
US (US) Applies to: Residential & Business	Solar Electric (PV) Solar Water Heating Wind Turbine	Federal Tax Credit (30% of Net Cost at Installation) » link
Pennsylvania (PA) Applies to: Business	Solar Electric (PV)	PA State SunShine Rebate (Commercial - Step 4) » link
Pennsylvania (PA) Applies to: Business	Solar Water Heating	PA State SunShine Rebate (Commercial) 35% of Gross Cost » link
Pennsylvania (PA) Applies to: Residential	Solar Water Heating	PA State SunShine Rebate (Residential) 35% of Gross Cost » link
Pennsylvania (PA) Applies to: Residential	Solar Electric (PV)	PA State SunShine Rebate (Residential Tier 4: $ 0.75 per watt) » link
Pennsylvania (PA) Utility: **Duquesne Light Co** Applies to: Residential	Solar Water Heating	Duquesne Light Company - Residential Solar Water Heating Program » link
Pennsylvania (PA) Utility: **PPL Electric Utilities Corp** Applies to: Residential	Solar Electric (PV)	PPL Electric Utilities - Solar Rebate Program (Residential) » link
Pennsylvania (PA) Utility: **The Energy Coop** Applies to: Residential & Business	Solar Electric (PV)	The Energy Coop Solar Power Purchase Program: $ 0.20 per kWH ten years » link

APPENDIX F: Solar Module Sizing Charts



Design & Sizing Guide

Roof-Integrated Series:
Design to span short distances, over substructures, or other structural equivelent

Solarshade Series:
Designed to lean against a house or structural equivelent

Sunport Series:
Designed to be a free standing structures

Larger applications or custom designs including back to back solar walkways, solar racking, free standing systems, solar greenhouses, solar skylights & other solar designs.
Contact our sales team for design & pricing support.

Standard PV Structure Dimensions

Standard Length of System with PV Panels in Portrait Layout

NO. of Sections /	Length	NO. of Sections /	Length	NO. of Sections /	Length
1	3’-3-1/4”	18	54’-9-5/8“	35	106’-4”
2	6’-3-5/8”	19	57’-10”	36	109’-4-3/8”
3	9’-4”	20	60’-10-3/8”	37	112’-4-3/4“
4	12’-4-3/8”	21	63’-10-3/4”	38	115’-5-1/8”
5	15’-4-3/4”	22	66’-11-1/8”	39	118’-5-1/2”
6	18’-5-1/8”	23	69’-11-1/2”	40	121’-5-7/8”
7	21’-5-1/2”	24	72’-11-7/8”	41	124’-6-1/4”
8	24’-5-7/8”	25	76’-1/4“	42	127’-6-5/8”
9	27’-6-1/4”	26	79’-5/8”	43	130’-7”
10	30’-6-5/8”	27	82’-1“	44	133-7-3/8”
11	33’-7”	28	85’-1-3/8”	45	136’-7-3/4”
12	36’-7-3/8”	29	88’-1-3/4”	46	139’-8-1/8”
13	39’-7-3/4”	30	91’-2-1/8”	47	142’-8-1/2”
14	42’-8-1/8”	31	94’-2-1/2”	48	145’-8-7/8”
15	45’-8-1/2”	32	97’-2-7/8”	49	148’-9-1/4”
16	48’-8-7/8”	33	100’-3-1/4”	50	151’-9-5/8”
17	51’-9-1/4”	34	103’-3-5/8”	Add on Per Panel 3’-3/8”	

Standard Length of System with PV Panels in Landscape Layout

NO. of Sections /	Length	NO. of Sections /	Length	NO. of Sections /	Length
1	4’-9”	18	81’-6-1/4“	35	158’-3-3/8”
2	9’-3-1/4”	19	86’-3/8”	36	162’-9-5/8”
3	13’-9-3/8”	20	90’-6-5/8”	37	167’-3-3/4“
4	18’-3-5/8”	21	95’-3/4”	38	171’-10”
5	22’-9-3/4”	22	99’-7”	39	176’-4-1/8”
6	27’-4”	23	104’-1-1/8”	40	180’-10-3/8”
7	31’-10-1/8”	24	108’-7-3/8”	41	185’-4-1/2”
8	36’-4-3/8”	25	113’-1-1/2“	42	189’-10-3/4”
9	40’-10-1/2”	26	117’-7-3/4”	43	194’-4-7/8”
10	45’-4-3/4”	27	122’-1-7/8“	44	198’-11-1/8”
11	49’-10-7/8”	28	126’-8-1/8”	45	203’-5-1/4”
12	54’-5-1/8”	29	131’-2-1/4”	46	207’-11-1/2”
13	58’-11-1/4”	30	135’-8-1/2”	47	212’-5-5/8”
14	63’-5-1/2”	31	140’-2-5/8”	48	216’-11-7/8”
15	67’-11-5/8”	32	144’-8-7/8”	49	221’-6”
16	72’-5-7/8”	33	149’-3”	50	226’-1/4”
17	77’	34	153’-9-1/4”	Add on Per Panel 4’-6-3/16”	

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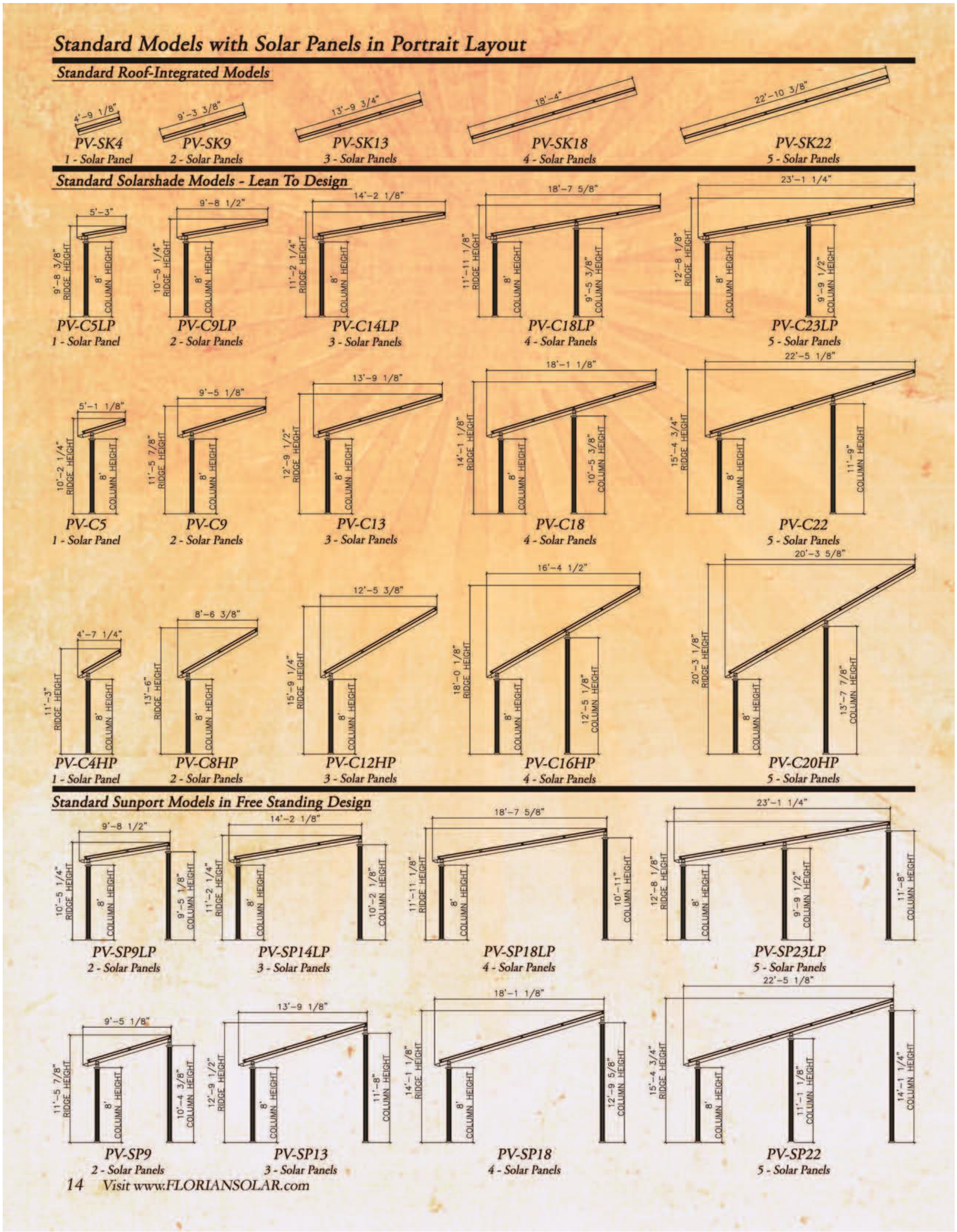

Standard Models with Solar Panels in Portrait Layout

Standard Roof-Integrated Models

PV-SK4
1 - Solar Panel

PV-SK9
2 - Solar Panels

PV-SK13
3 - Solar Panels

PV-SK18
4 - Solar Panels

PV-SK22
5 - Solar Panels

Standard Solarshade Models - Lean To Design

PV-C5LP
1 - Solar Panel

PV-C9LP
2 - Solar Panels

PV-C14LP
3 - Solar Panels

PV-C18LP
4 - Solar Panels

PV-C23LP
5 - Solar Panels

PV-C5
1 - Solar Panel

PV-C9
2 - Solar Panels

PV-C13
3 - Solar Panels

PV-C18
4 - Solar Panels

PV-C22
5 - Solar Panels

PV-C4HP
1 - Solar Panel

PV-C8HP
2 - Solar Panels

PV-C12HP
3 - Solar Panels

PV-C16HP
4 - Solar Panels

PV-C20HP
5 - Solar Panels

Standard Sunport Models in Free Standing Design

PV-SP9LP
2 - Solar Panels

PV-SP14LP
3 - Solar Panels

PV-SP18LP
4 - Solar Panels

PV-SP23LP
5 - Solar Panels

PV-SP9
2 - Solar Panels

PV-SP13
3 - Solar Panels

PV-SP18
4 - Solar Panels

PV-SP22
5 - Solar Panels

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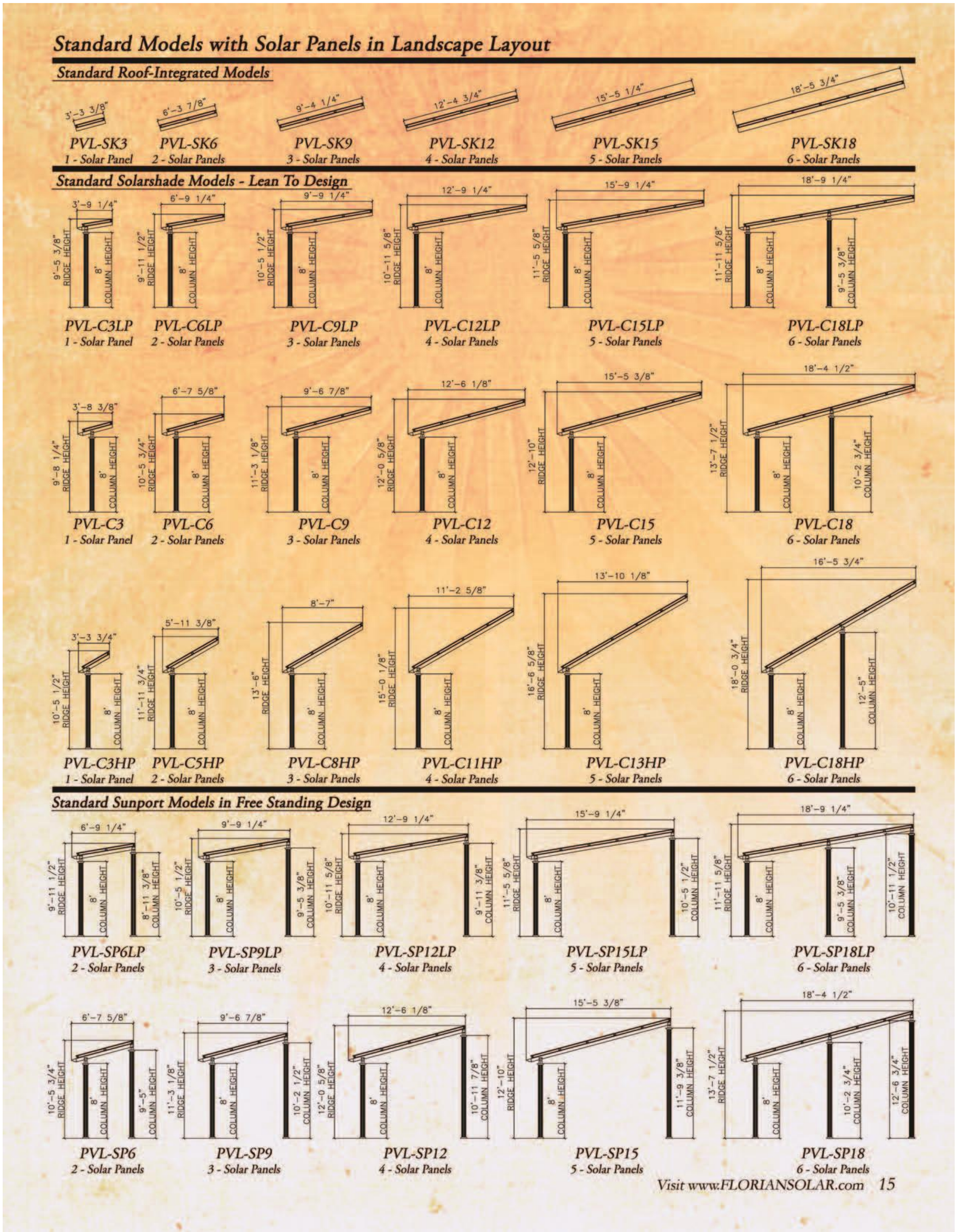

Standard Models with Solar Panels in Landscape Layout

Standard Roof-Integrated Models

PVL-SK3 1 - Solar Panel
PVL-SK6 2 - Solar Panels
PVL-SK9 3 - Solar Panels
PVL-SK12 4 - Solar Panels
PVL-SK15 5 - Solar Panels
PVL-SK18 6 - Solar Panels

Standard Solarshade Models - Lean To Design

PVL-C3LP 1 - Solar Panel
PVL-C6LP 2 - Solar Panels
PVL-C9LP 3 - Solar Panels
PVL-C12LP 4 - Solar Panels
PVL-C15LP 5 - Solar Panels
PVL-C18LP 6 - Solar Panels

PVL-C3 1 - Solar Panel
PVL-C6 2 - Solar Panels
PVL-C9 3 - Solar Panels
PVL-C12 4 - Solar Panels
PVL-C15 5 - Solar Panels
PVL-C18 6 - Solar Panels

PVL-C3HP 1 - Solar Panel
PVL-C5HP 2 - Solar Panels
PVL-C8HP 3 - Solar Panels
PVL-C11HP 4 - Solar Panels
PVL-C13HP 5 - Solar Panels
PVL-C18HP 6 - Solar Panels

Standard Sunport Models in Free Standing Design

PVL-SP6LP 2 - Solar Panels
PVL-SP9LP 3 - Solar Panels
PVL-SP12LP 4 - Solar Panels
PVL-SP15LP 5 - Solar Panels
PVL-SP18LP 6 - Solar Panels

PVL-SP6 2 - Solar Panels
PVL-SP9 3 - Solar Panels
PVL-SP12 4 - Solar Panels
PVL-SP15 5 - Solar Panels
PVL-SP18 6 - Solar Panels

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APPENDIX G: Solar Panel Data Sheets

Think GAIA
For Life and the Earth

SANYO

Bifacial Photovoltaic Module

HIT Double195

Photovoltaic Module

Power per Square Foot up to 19.1 Watts

Photo by Golden Energy, Santa Monica, CA

Phatport® - from Phat Energy, L.A., CA

High Efficiency

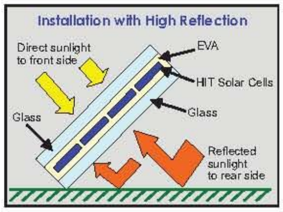
HIT® Double bifacial solar panels are the World leaders in sunlight conversion efficiency, helping customers to enjoy the maximum power per square foot from available space.

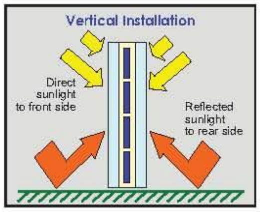
Power Guarantee

SANYO guarantees customers will receive 100% of the panel's rated power (or more) at the time of purchase, enabling owners to generate more kWh per rated watt.

Bifacial Effect

The back face of HIT Double solar panels generates electricity from ambient light reflected off surrounding surfaces, and combines with power from the front face of the panel. Dependant upon system design and site albedo, this results in up to 30% higher power generation (more kWh) per square foot.





Application Possibilities

- Architectural, Awnings, Balconies, Bus Shelters, BIPV
- Deck & Porch Coverings, Canopies, Carports, Facades
- Fences, Siding, Trellises, Tracking Systems

Proprietary Technology

HIT bifacial solar cells are hybrids of single crystalline silicon surrounded by ultra-thin amorphous silicon layers, available solely from SANYO.

High Temperature Performance

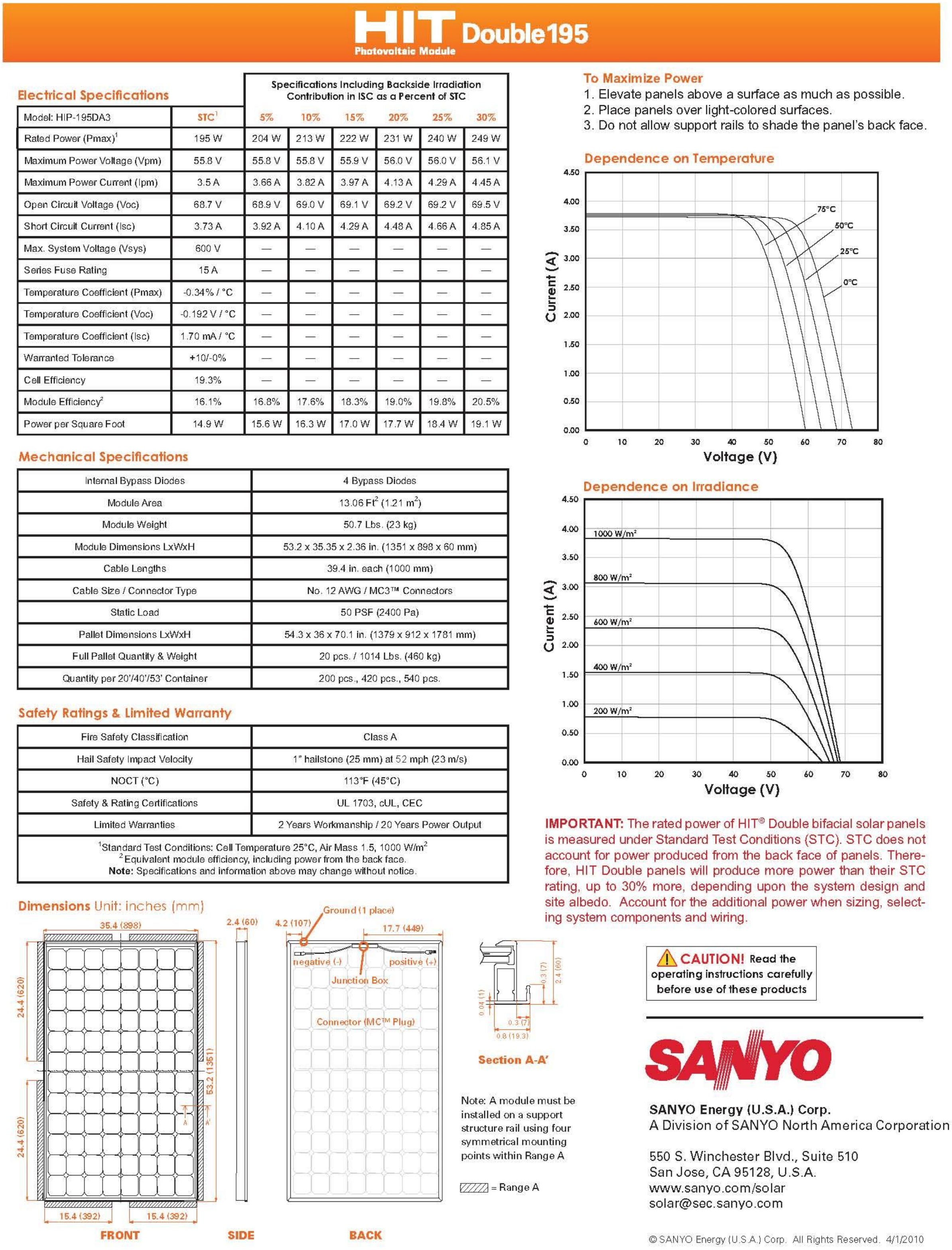
As temperatures rise, HIT Double solar panels produce more electricity than conventional solar panels at the same temperature, for good performance in high temperature sites.

Quality Products

SANYO silicon wafers are made in California USA, and assembled in Mexico at SANYO's certified factory. ISO 9001 (quality), 14001 (environment), 18001 (safety).

Valuable Features

HIT Double panels operate silently and have no moving parts. A double glass structure allows some sunlight to penetrate portions of the panel, creating brilliant light and shadows for aesthetic and architectural applications. HIT Double panels are perfect for areas with performance-based incentives and tradable energy credits.



HIT Double195

Photovoltaic Module

Electrical Specifications

		Specifications Including Backside Irradiation Contribution in ISC as a Percent of STC					
Model: HIP-195DA3	STC[1]	5%	10%	15%	20%	25%	30%
Rated Power (Pmax)[1]	195 W	204 W	213 W	222 W	231 W	240 W	249 W
Maximum Power Voltage (Vpm)	55.8 V	55.8 V	55.8 V	55.9 V	56.0 V	56.0 V	56.1 V
Maximum Power Current (Ipm)	3.5 A	3.66 A	3.82 A	3.97 A	4.13 A	4.29 A	4.45 A
Open Circuit Voltage (Voc)	68.7 V	68.9 V	69.0 V	69.1 V	69.2 V	69.2 V	69.5 V
Short Circuit Current (Isc)	3.73 A	3.92 A	4.10 A	4.29 A	4.48 A	4.66 A	4.85 A
Max. System Voltage (Vsys)	600 V	—	—	—	—	—	—
Series Fuse Rating	15 A	—	—	—	—	—	—
Temperature Coefficient (Pmax)	-0.34% / °C	—	—	—	—	—	—
Temperature Coefficient (Voc)	-0.192 V / °C	—	—	—	—	—	—
Temperature Coefficient (Isc)	1.70 mA / °C	—	—	—	—	—	—
Warranted Tolerance	+10/-0%	—	—	—	—	—	—
Cell Efficiency	19.3%	—	—	—	—	—	—
Module Efficiency[2]	16.1%	16.8%	17.6%	18.3%	19.0%	19.8%	20.5%
Power per Square Foot	14.9 W	15.6 W	16.3 W	17.0 W	17.7 W	18.4 W	19.1 W

Mechanical Specifications

Internal Bypass Diodes	4 Bypass Diodes
Module Area	13.06 Ft^2 (1.21 m^2)
Module Weight	50.7 Lbs. (23 kg)
Module Dimensions LxWxH	53.2 x 35.35 x 2.36 in. (1351 x 898 x 60 mm)
Cable Lengths	39.4 in. each (1000 mm)
Cable Size / Connector Type	No. 12 AWG / MC3™ Connectors
Static Load	50 PSF (2400 Pa)
Pallet Dimensions LxWxH	54.3 x 36 x 70.1 in. (1379 x 912 x 1781 mm)
Full Pallet Quantity & Weight	20 pcs. / 1014 Lbs. (460 kg)
Quantity per 20'/40'/53' Container	200 pcs., 420 pcs., 540 pcs.

Safety Ratings & Limited Warranty

Fire Safety Classification	Class A
Hail Safety Impact Velocity	1" hailstone (25 mm) at 52 mph (23 m/s)
NOCT (°C)	113°F (45°C)
Safety & Rating Certifications	UL 1703, cUL, CEC
Limited Warranties	2 Years Workmanship / 20 Years Power Output

[1] Standard Test Conditions: Cell Temperature 25°C, Air Mass 1.5, 1000 W/m^2

[2] Equivalent module efficiency, including power from the back face.

Note: Specifications and information above may change without notice.

Dimensions Unit: inches (mm)

Note: A module must be installed on a support structure rail using four symmetrical mounting points within Range A

▨ = Range A

To Maximize Power

1. Elevate panels above a surface as much as possible.
2. Place panels over light-colored surfaces.
3. Do not allow support rails to shade the panel's back face.

Dependence on Temperature

Dependence on Irradiance

IMPORTANT: The rated power of HIT® Double bifacial solar panels is measured under Standard Test Conditions (STC). STC does not account for power produced from the back face of panels. Therefore, HIT Double panels will produce more power than their STC rating, up to 30% more, depending upon the system design and site albedo. Account for the additional power when sizing, selecting system components and wiring.

⚠ **CAUTION!** Read the operating instructions carefully before use of these products

SANYO

SANYO Energy (U.S.A.) Corp.
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APPENDIX H: SIPS Take-Offs

First Floor

	Room Name	Room #	Floor	Base	Wall	Ceiling Type	Casework LF	Room SF	Ceiling Height (FT)
1	Business Classroom	A120	VCT	Rubber	Gypsum Wall Board	ACT	45	965	9.3333
1	Business Classroom	A119	VCT	Rubber	Gypsum Wall Board	ACT	49	954	9.3333
1	Business Classroom	A115	VCT	Rubber	Gypsum Wall Board	ACT	50	971	9.3333
1	Business Classroom	A112	VCT	Rubber	Gypsum Wall Board	ACT	45	798	9.3333
1	Business Classroom	A106	VCT	Rubber	Gypsum Wall Board	ACT	42	803	9.3333
1	IPC	A111	Carpet	Rubber	Gypsum Wall Board	ACT	20	512	8
1	Art Classroom	B113	Conc	Rubber	Gypsum Wall Board	ACT	40	713	9.3333
1	Art Classroom	B115	Conc	Rubber	Gypsum Wall Board	ACT	40	740	9.3333
1	Art Classroom	B123	Conc	Rubber	Gypsum Wall Board	ACT	45	813	9.3333
1	Child Development	B124	Linoleum	Integral	Gypsum Wall Board	ACT	20	588	9.3333
1	Food Lab	B125	Linoleum	Integral	Gypsum Wall Board	ACT	60	1095	9.3333
1	Home Econ	B122	Linoleum	Integral	Gypsum Wall Board	ACT	65	1098	9.3333
1	Media	B114	Carpet	Rubber	Gypsum Wall Board	ACT	60	1082	9.3333

Second Floor

	Room Name	Room #	Floor	Base	Wall	Ceiling Type	Casework LF	Room SF	Ceiling Height (FT)
1	General Science	A217	VCT	Rubber	Gypsum Wall Board	ACT	70	1075	9.3333
1	General Science	A216	VCT	Rubber	Gypsum Wall Board	ACT	70	1025	9.3333
1	General Science	A212	VCT	Rubber	Gypsum Wall Board	ACT	75	1138	9.3333
1	General Science	A214	VCT	Rubber	Gypsum Wall Board	ACT	75	1099	9.3333
1	Chem	A211	VCT	Rubber	Gypsum Wall Board	ACT	75	1087	9.3333
1	Chem	A208	VCT	Rubber	Gypsum Wall Board	ACT	65	1045	9.3333
1	Bio	A210	VCT	Rubber	Gypsum Wall Board	ACT	65	1025	9.3333
1	Bio	A202	VCT	Rubber	Gypsum Wall Board	ACT	65	1025	9.3333
1	Physics	A203	VCT	Rubber	Gypsum Wall Board	ACT	40	838	9.3333
1	Computer Lab	B208	VCT	Rubber	Gypsum Wall Board	ACT	40	791	9.3333
1	Office	B207	Carpet	Rubber	Gypsum Wall Board	ACT	10	184	8
1	IPC	B214	Carpet	Rubber	Gypsum Wall Board	ACT	15	423	8
1	Math	B205	VCT	Rubber	Gypsum Wall Board	ACT	35	692	9.3333
1	Math	B212	VCT	Rubber	Gypsum Wall Board	ACT	40	763	9.3333
1	Math	B209	VCT	Rubber	Gypsum Wall Board	ACT	40	799	9.3333
1	Math	B215	VCT	Rubber	Gypsum Wall Board	ACT	40	799	9.3333
1	Math	B217	VCT	Rubber	Gypsum Wall Board	ACT	35	711	9.3333
1	Math	B216	VCT	Rubber	Gypsum Wall Board	ACT	40	799	9.3333
1	Math	B222	VCT	Rubber	Gypsum Wall Board	ACT	40	799	9.3333
1	Math	B226	VCT	Rubber	Gypsum Wall Board	ACT	45	807	9.3333
1	Math	B223	VCT	Rubber	Gypsum Wall Board	ACT	40	799	9.3333
1	SG1	B211	VCT	Rubber	Gypsum Wall Board	ACT	20	415	9.3333
1	SG1	B219	VCT	Rubber	Gypsum Wall Board	ACT	20	448	9.3333

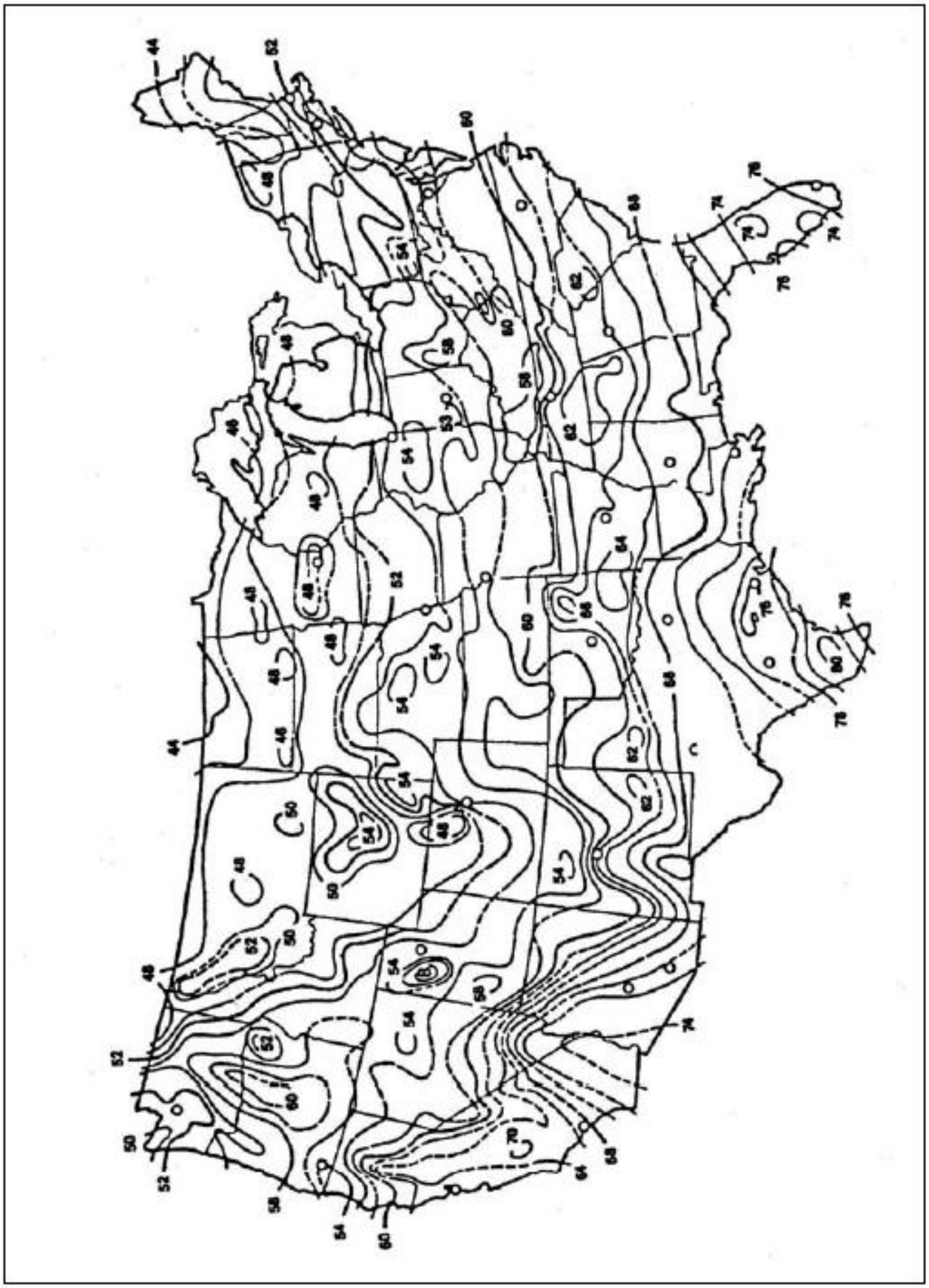
Third Floor

	Room Name	Room #	Floor	Base	Wall	Ceiling Type	Casework LF	Room SF	Ceiling Height (FT)
1	Special Ed	B312	VCT	Rubber	Gypsum Wall Board	ACT	30	599	9.3333
1	Special Ed	B318	VCT	Rubber	Gypsum Wall Board	ACT	30	660	9.3333
1	Special Ed	A323	VCT	Rubber	Gypsum Wall Board	ACT	40	754	9.3333
1	Special Ed	A302	VCT	Rubber	Gypsum Wall Board	ACT	40	771	9.3333
	English	A327	VCT	Rubber	Gypsum Wall Board	ACT	45	799	9.3333
1	English	A326	VCT	Rubber	Gypsum Wall Board	ACT	45	803	9.3333
1	English	A321	VCT	Rubber	Gypsum Wall Board	ACT	40	768	9.3333
1	English	A318	VCT	Rubber	Gypsum Wall Board	ACT	45	802	9.3333
1	English	A320	VCT	Rubber	Gypsum Wall Board	ACT	45	826	9.3333
1	English	A314	VCT	Rubber	Gypsum Wall Board	ACT	45	811	9.3333
1	English	A317	VCT	Rubber	Gypsum Wall Board	ACT	45	803	9.3333
1	English	A311	VCT	Rubber	Gypsum Wall Board	ACT	45	803	9.3333
1	Language	A313	VCT	Rubber	Gypsum Wall Board	ACT	40	767	9.3333
1	Language	A307	VCT	Rubber	Gypsum Wall Board	ACT	35	769	9.3333
1	Language	A310	VCT	Rubber	Gypsum Wall Board	ACT	40	799	9.3333
1	Language	A305	VCT	Rubber	Gypsum Wall Board	ACT	40	810	9.3333
1	IPC	A309	Carpet	Rubber	Gypsum Wall Board	ACT	35	534	9.3333
1	Social Studies	B308	VCT	Rubber	Gypsum Wall Board	ACT	45	797	9.3333
1	Social Studies	B309	VCT	Rubber	Gypsum Wall Board	ACT	45	803	9.3333
1	Social Studies	B315	VCT	Rubber	Gypsum Wall Board	ACT	45	802	9.3333
1	Social Studies	B316	VCT	Rubber	Gypsum Wall Board	ACT	45	802	9.3333
1	Social Studies	B324	VCT	Rubber	Gypsum Wall Board	ACT	40	801	9.3333
1	Social Studies	B325	VCT	Rubber	Gypsum Wall Board	ACT	40	807	9.3333
1	Social Studies	B321	VCT	Rubber	Gypsum Wall Board	ACT	45	875	9.3333
1	Social Studies	B319	VCT	Rubber	Gypsum Wall Board	ACT	45	800	9.3333
1	LG1	B306	VCT	Rubber	Gypsum Wall Board	ACT	70	1072	9.3333

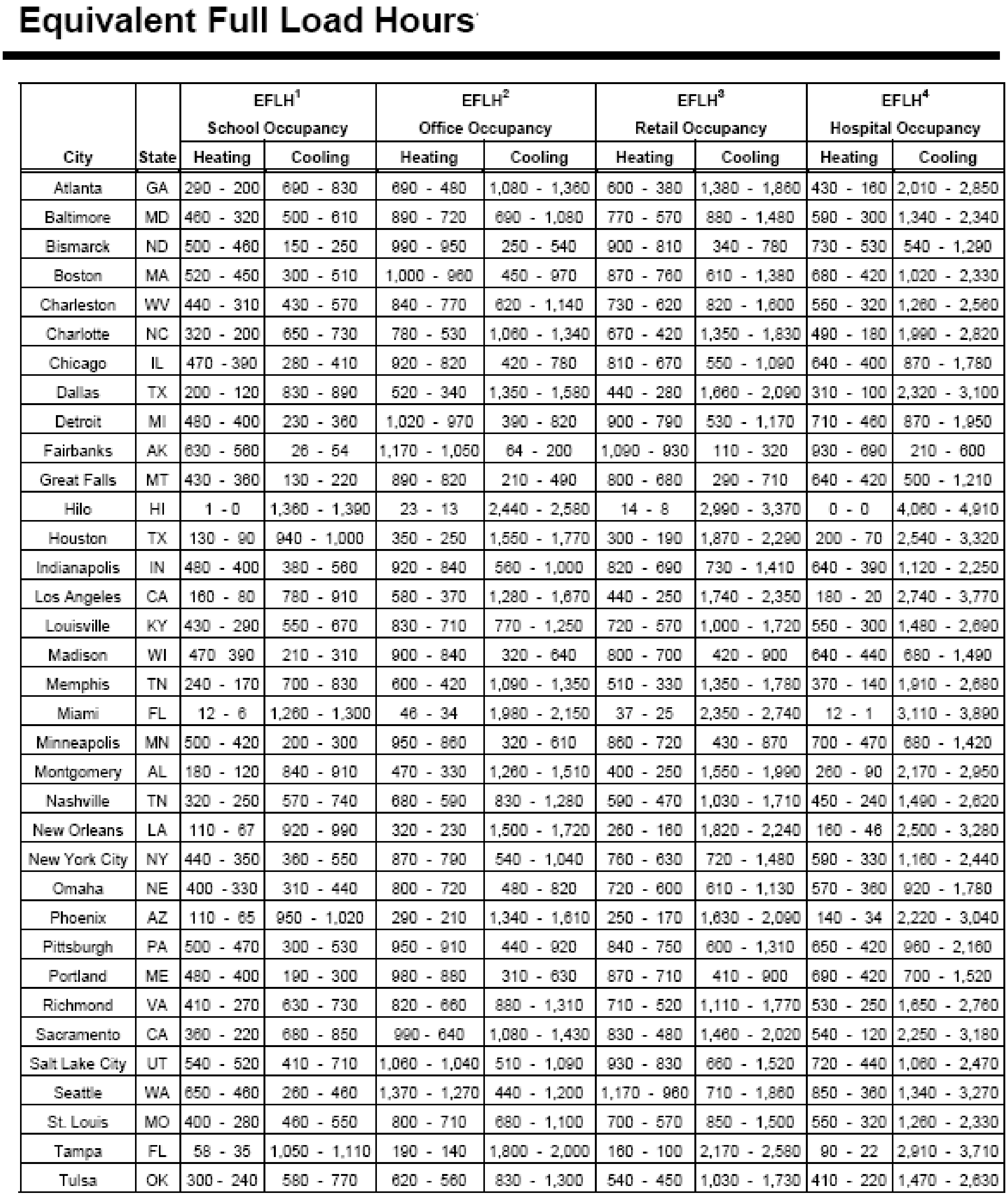
Units/Rooms	**61**
SF	**50155**
AVG per room	**822.2131148**
Height	**9.3333**
AVG wall length	**28.6**
AVG wall area	**266.93238**
AVG wall area per Roo	**1067.72952**

APPENDIX I: Average Ground Temperatures Map

Figure 9 – Approximate Ground Water Temperatures in the USA[7]



APPENDIX J: Equivalent Full Load Hours Chart



Equivalent Full Load Hours

City	State	EFLH[1] School Occupancy		EFLH[2] Office Occupancy		EFLH[3] Retail Occupancy		EFLH[4] Hospital Occupancy	
		Heating	Cooling	Heating	Cooling	Heating	Cooling	Heating	Cooling
Atlanta	GA	290 - 200	690 - 830	690 - 480	1,080 - 1,360	600 - 380	1,380 - 1,860	430 - 160	2,010 - 2,850
Baltimore	MD	460 - 320	500 - 610	890 - 720	690 - 1,080	770 - 570	880 - 1,480	590 - 300	1,340 - 2,340
Bismarck	ND	500 - 460	150 - 250	990 - 950	250 - 540	900 - 810	340 - 780	730 - 530	540 - 1,290
Boston	MA	520 - 450	300 - 510	1,000 - 960	450 - 970	870 - 760	610 - 1,380	680 - 420	1,020 - 2,330
Charleston	WV	440 - 310	430 - 570	840 - 770	620 - 1,140	730 - 620	820 - 1,600	550 - 320	1,260 - 2,560
Charlotte	NC	320 - 200	650 - 730	780 - 530	1,060 - 1,340	670 - 420	1,350 - 1,830	490 - 180	1,990 - 2,820
Chicago	IL	470 - 390	280 - 410	920 - 820	420 - 780	810 - 670	550 - 1,090	640 - 400	870 - 1,780
Dallas	TX	200 - 120	830 - 890	520 - 340	1,350 - 1,580	440 - 280	1,660 - 2,090	310 - 100	2,320 - 3,100
Detroit	MI	480 - 400	230 - 360	1,020 - 970	390 - 820	900 - 790	530 - 1,170	710 - 460	870 - 1,950
Fairbanks	AK	630 - 560	26 - 54	1,170 - 1,050	64 - 200	1,090 - 930	110 - 320	930 - 690	210 - 600
Great Falls	MT	430 - 360	130 - 220	890 - 820	210 - 490	800 - 680	290 - 710	640 - 420	500 - 1,210
Hilo	HI	1 - 0	1,360 - 1,390	23 - 13	2,440 - 2,580	14 - 8	2,990 - 3,370	0 - 0	4,060 - 4,910
Houston	TX	130 - 90	940 - 1,000	350 - 250	1,550 - 1,770	300 - 190	1,870 - 2,290	200 - 70	2,540 - 3,320
Indianapolis	IN	480 - 400	380 - 560	920 - 840	560 - 1,000	820 - 690	730 - 1,410	640 - 390	1,120 - 2,250
Los Angeles	CA	160 - 80	780 - 910	580 - 370	1,280 - 1,670	440 - 250	1,740 - 2,350	180 - 20	2,740 - 3,770
Louisville	KY	430 - 290	550 - 670	830 - 710	770 - 1,250	720 - 570	1,000 - 1,720	550 - 300	1,480 - 2,690
Madison	WI	470 390	210 - 310	900 - 840	320 - 640	800 - 700	420 - 900	640 - 440	680 - 1,490
Memphis	TN	240 - 170	700 - 830	600 - 420	1,090 - 1,350	510 - 330	1,350 - 1,780	370 - 140	1,910 - 2,680
Miami	FL	12 - 6	1,260 - 1,300	46 - 34	1,980 - 2,150	37 - 25	2,350 - 2,740	12 - 1	3,110 - 3,890
Minneapolis	MN	500 - 420	200 - 300	950 - 860	320 - 610	860 - 720	430 - 870	700 - 470	680 - 1,420
Montgomery	AL	180 - 120	840 - 910	470 - 330	1,260 - 1,510	400 - 250	1,550 - 1,990	260 - 90	2,170 - 2,950
Nashville	TN	320 - 250	570 - 740	680 - 590	830 - 1,280	590 - 470	1,030 - 1,710	450 - 240	1,490 - 2,620
New Orleans	LA	110 - 67	920 - 990	320 - 230	1,500 - 1,720	260 - 160	1,820 - 2,240	160 - 46	2,500 - 3,280
New York City	NY	440 - 350	360 - 550	870 - 790	540 - 1,040	760 - 630	720 - 1,480	590 - 330	1,160 - 2,440
Omaha	NE	400 - 330	310 - 440	800 - 720	480 - 820	720 - 600	610 - 1,130	570 - 360	920 - 1,780
Phoenix	AZ	110 - 65	950 - 1,020	290 - 210	1,340 - 1,610	250 - 170	1,630 - 2,090	140 - 34	2,220 - 3,040
Pittsburgh	PA	500 - 470	300 - 530	950 - 910	440 - 920	840 - 750	600 - 1,310	650 - 420	960 - 2,160
Portland	ME	480 - 400	190 - 300	980 - 880	310 - 630	870 - 710	410 - 900	690 - 420	700 - 1,520
Richmond	VA	410 - 270	630 - 730	820 - 660	880 - 1,310	710 - 520	1,110 - 1,770	530 - 250	1,650 - 2,760
Sacramento	CA	360 - 220	680 - 850	990 - 640	1,080 - 1,430	830 - 480	1,460 - 2,020	540 - 120	2,250 - 3,180
Salt Lake City	UT	540 - 520	410 - 710	1,060 - 1,040	510 - 1,090	930 - 830	660 - 1,520	720 - 440	1,060 - 2,470
Seattle	WA	650 - 460	260 - 460	1,370 - 1,270	440 - 1,200	1,170 - 960	710 - 1,860	850 - 360	1,340 - 3,270
St. Louis	MO	400 - 280	460 - 550	800 - 710	680 - 1,100	700 - 570	850 - 1,500	550 - 320	1,260 - 2,330
Tampa	FL	58 - 35	1,050 - 1,110	190 - 140	1,800 - 2,000	160 - 100	2,170 - 2,580	90 - 22	2,910 - 3,710
Tulsa	OK	300 - 240	580 - 770	620 - 560	830 - 1,300	540 - 450	1,030 - 1,730	410 - 220	1,470 - 2,630