Waynesburg Central High School

Thesis Final Report 2009

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Construction Management

Adviser: Dr. Riley

Waynesburg Central High School

Central Greene School District — Waynesburg, Pennsylvania

Project Team

Owner: Central Greene School District

Construction Manager: Foreman Program and Construction Managers

Architect and Engineers: Foreman Architects and Engineers

Project Overview

- **Estimated Project Cost:** $17,000,000
- **Size, Addition:** 24,000 square feet
  Renovation: 154,000 square feet
- **Number of Stories:** 2
- **Delivery Method:** CM Agency, with Multiple Primes
- **Project Dates:**

Phase 1:	10 Dec. 2007 – 24 Nov. 2008
Phase 1A:	24 Dec. 2007 – 31 Dec. 2007
Phase 2:	10 Dec. 2007 - 15 Aug. 2008
Phase 3:	15 May 2008 – 15 Sep. 2008
Phase 3A:	06 June 2008 – 22 Aug. 2008
Phase 3B:	06 June 2008 – 15 Oct. 2008
Phase 4:	15 July 2008 – 27 Aug. 2008
Phase 5:	01 Dec. 2008 – 13 Mar. 2009
Phase 6:	20 Mar. 2009 – 01 June 2009
Phase 6A:	15 May 2009 – 15 Aug. 2009
Phase 7:	15 May 2009 – 28 Aug. 2009
Phase 7A:	05 June 2009 – 28 Aug. 2009

Project Structure

- Pre-cast concrete column and beam structure
- Masonry infill with load bearing masonry walls
- Open web structural steel joists for roof structure
- Pre-cast concrete docs plank over boiler room
- Foundation comprised of grade beams and footers

Project Architecture

Additions:

- Exposed Architectural pre-cast concrete columns
- Brick veneer with a grape vine joint
- New TPO roof system on building

Renovations and Additions:

- Columns protrude with beams creating sunshades
- Consistent style maintained on additions
- Operable punch out windows
- Natural day lighting through use of skylights

Project Infrastructure

Mechanical Additions:

- 215 ton Air cooled chiller
- Prepackaged rooftop air units

Mechanical Renovations:

- 4 pipe unit ventilators (UV) replace old UV system

Electrical Service:

- **Main Service:** 277/480V, 3 Phase, 4 Wire
- **Main Breaker:** 3000A, 3 Phase
- **Secondary Service:** 208Y/120V
- 40 types of luminaires in the building

Table of Contents

Acknowledgements

FOREMAN
PROGRAM AND CONSTRUCTION MANAGERS

Central Greene School District

Executive Summary

Construction projects no matter how well orchestrated or planned, always have areas where improvements can be made. Waynesburg Central High School is no different; this report analyzes some areas in which the project may have been able to more effectively handle a task. Alternative methods that may not have been considered are also suggested.

LEED certified construction projects are ever becoming more popular; but convincing a school district to spend more money initially is not an easy task. Since no specific suggestion can be made for all schools, suggestions will be made based on regional demographics. Schools in more highly populated areas will have an easier time achieving LEED certification than the rural regions; this because many of the LEED points are based on the site accessibility to the public. I would suggest that schools with public transportation and a dense population centrally located near the school strive to obtain LEED certification. For those districts that are in very rural areas striving for LEED certification would be entirely upon the district to decide because they do not have the ability to obtain some points that are very easy for urban schools.

Lighting systems in buildings can consume a large amount of energy in a building and with recent innovations in technology to control these systems; managing energy consumption is becoming easier. Occupancy sensors are a good way to prevent energy from being wasted when the room is vacated. With the thousands of dollars that can be saved annually by installing these in every classroom and even more if installed in all rooms of the building. Occupancy sensors are definitely a product that should be installed for the lighting system to save money. Lighting sensors are also a product that should be implemented at Waynesburg Central High School though the savings are not as large as the occupancy sensors they should still be implemented.

After analyzing the information from all the different sources, results all tend to point to structural steel being a better alternative then precast concrete. There are several pieces of evidence that point to this the first of which is that steel is a more common structural system in western Pennsylvania, which will result in a more efficient construction sequence and crews that are more experienced performing the work resulting in higher quality work being completed. Constructability of the structure is not the only reason steel seems to be superior to a precast concrete structural system; cost also leads to the conclusion that a steel system would be more economical. With the cost of the structural steel system being an estimated $123,500 savings over the precast concrete system it would be strongly recommended to use the steel system. With the proposed change of the structural system it would also change some of the exterior façade and make it look more like the original building. By making the proposed change to the building it not only saves a significant amount of money but also makes the architecture of the new and old building match even more closely. Changing the structural system from precast concrete to structural steel is a change that should certainly be made.

With a lot of thought and analysis, many comparisons and research the end result came out with not to many differences then what the initial design called for. The differences in precast concrete and structural steel for Waynesburg Central High School turned out to be so miniscule that it would never be seen on a full schedule. This is why alternative schedules were created allowing for the steps of the structural steel system to be shown in more detail. Site plans were a similar scenario with not many alterations from the original designs. Five site plans were developed in an effort to help contractors understand the areas and amount of work that will be going on during a given time period.

Project Introduction

Waynesburg Central High School is located in Waynesburg, Pennsylvania. Central Greene School District is the owner of the project. Waynesburg Central High School is primarily a renovation project with two minor additions; the renovation work is about 154,000 square feet and the addition work approximately 24,000 square feet. The original school building was constructed in 1969, Central Greene School District desires to expand and gain more educational space while bringing all areas of the building to modern learning standards.

Sequencing is of particular interest to the district, because construction will last two years; all the while the school will be occupied. Waynesburg Central High School is broken up into twelve different phases. This posses concerns while creating a schedule and creates several critical activates to insure that students are able to occupy each phase of the building on time.

Figure 1: Waynesburg Central High School logo

Waynesburg Central High School is a public project and therefore requires specific protocol to be followed. In the pre-construction phase of public school projects pricing must be submitted for state approval. Pennsylvania government also sets standards on the delivery method. A multiple prime with a construction management agency will be utilized on the high school. Public school projects in Pennsylvania also require a hard bid to take place with contractors submitting a lump sum bid, the lowest bidder is then rewarded the contract.

One of the more unusual things on this construction project not often implemented on schools in western Pennsylvania is the use of precast concrete for the structural system. A series of precast concrete columns and beams comprise the primary structural system on the additions. Precast concrete buildings are not common practice requiring special attention be paid to the connections.

Renovation work on Waynesburg Central High School is only cosmetic and infrastructure related, no significant structural modifications are being made to the existing building. The project will provide Central Greene School District with a facility equipped with modern amenities such as wireless internet, new mechanical system, and completely remodeled lighting and electrical system. Construction on Waynesburg Central High School will provide the owner the desired space along with updating all systems from what was in the existing building.

Client Information

Waynesburg Central High School is owned by Central Greene School District (CGSD). Central Greene School District has a graduating class of about 190 students. CGSD has four buildings in the district Perry Elementary, Waynesburg Central Elementary, Margaret Bell Miller Middle School, and Waynesburg Central High School. CGSD has a central campus were three buildings are located one of which is Waynesburg Central High School. The other two buildings are Waynesburg Central Elementary School, and Greene County Vocational-Technical School.

Central Greene School District is renovating and adding on to Waynesburg Central High School to update the learning environment and create additional space. Waynesburg Central High School was originally built in 1969 and has not had a significant renovation since. The entire building will undergo a complete renovation of all systems except the structural. When the project is complete the building will have a modern learning atmosphere equipped with wireless internet throughout the building, along with modern mechanical and electrical systems.

Central Greene School District is interested in the entire sequencing of the project. The construction sequence is of particular interest to CGSD because the building will remain occupied through the entirety of construction. This creates potential safety issues for CGSD since areas of the building will be under construction while students attend classes. Sequencing is also important to ensure that students are able to occupy classrooms when scheduled.

Figure 2: Central Greene School District's mascot

Central Greene School District is concerned with construction related issues like cost, quality and safety as well. This is evident in the type of insurance plan required for all contractors on site; CGSD implemented an owner controlled insurance program (OCIP). A representative of OCIP is onsite on a weekly basis and gives feedback on potential safety hazards and possible violations. Since Waynesburg Central High School is a publicly funded project the budget was a point of concern through the design phase. Cost of construction and following the bid documents is a priority because all change orders must be taken to the school board for approval, which only meets once a month. This creates not only cost increases but also has the potential to create delays in construction.

Project Delivery System

Waynesburg Central High School is a public project in south west Pennsylvania, which requires that public school projects follow a certain delivery structure. The delivery structure used on this project is a multiple prime contract. Figure 3 shows the delivery method for Waynesburg Central High School, in which the owner is shown on the left side with all the contractors having a contract with the owner on the right. Contract types are color coded.

Waynesburg Central High School Organizational Chart

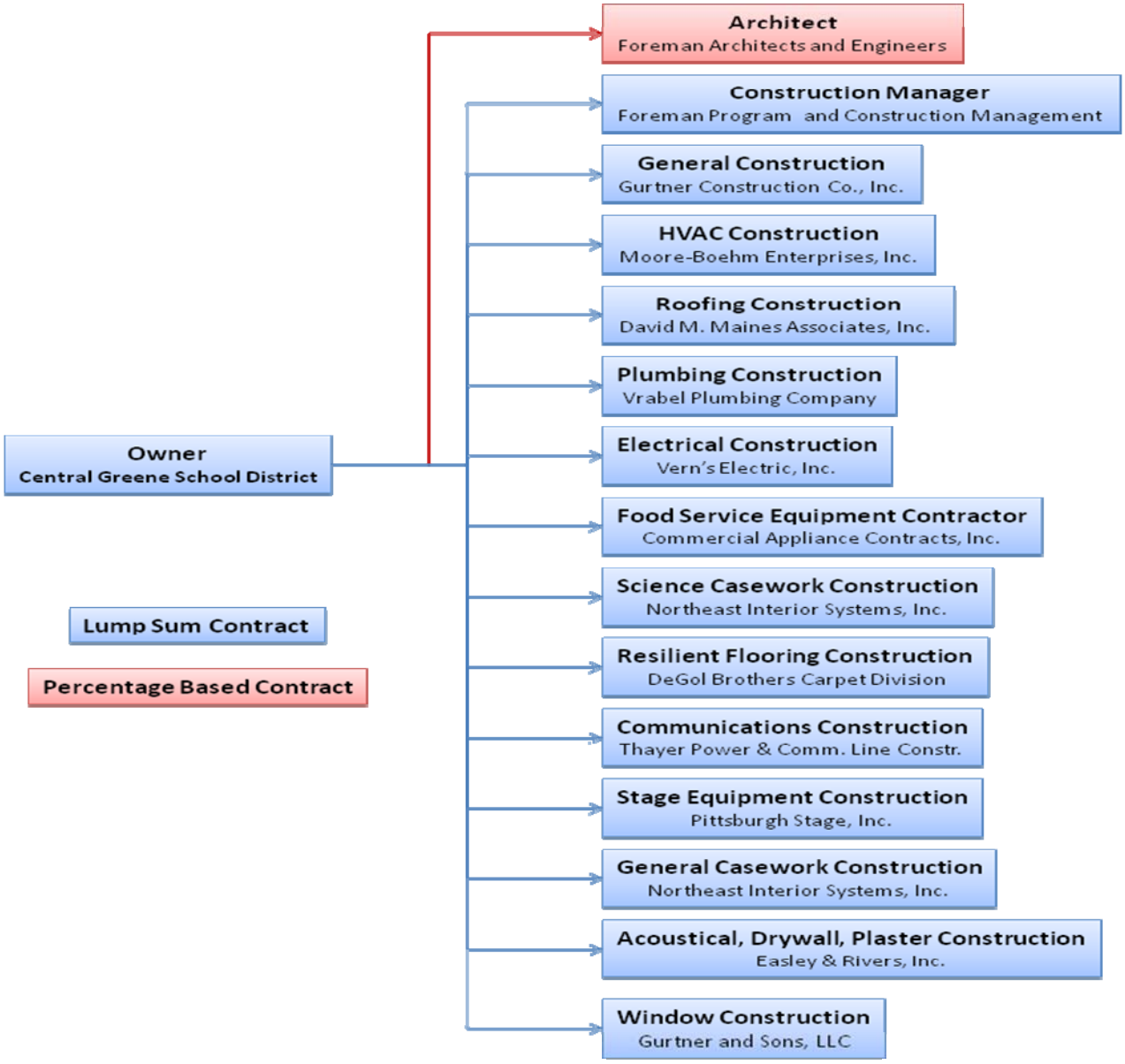


Figure 3: Organizational chart

Waynesburg Central High School is a design-bid-build construction method. Construction documents were complete before being put out for bid by contractors. Since it was chosen to be delivered in a design-bid-build construction method the construction manager was brought on during design phase. Foreman, the construction manager, then advised the owner on the best way to divide packages when placing them out for bid. The manner in which packages for contractors is broken has to be determined prior to final construction documents being complete; because the specifications of the project are dependent on the project package definitions. Waynesburg Central High School was then placed out for a competitive bid, in which the low bidder receives the contract and becomes the prime contractor for the given package.

Multiple prime contractors is a common approach for many public projects, not only public school buildings. A multiple prime contract delivery method is when the owner, in this case Central Greene School District, holds all the contracts as depicted in figure 3. Prime contractors are then only legally obligated to the owner and no other organization. In the case of Waynesburg Central High School the construction manager (Foreman Program and Construction Manager) takes the role of a construction advisor to the owner. Foreman is responsible to ensure that contractors perform work to the required specifications and notify the owner of negligence or failure to comply. Foreman does not hold any contract with the prime contractors.

Each Prime contractor is responsible to the owner for a given section of the specifications. The concept behind a multiple prime approach is driven by conceptual savings to the owner, because there are fewer markups by each prime contractor since they have less sub contractors. This is the reason why Waynesburg Central High School has 13 prime contractors, with a construction management agency, and then an architect.

Project Schedule Summary

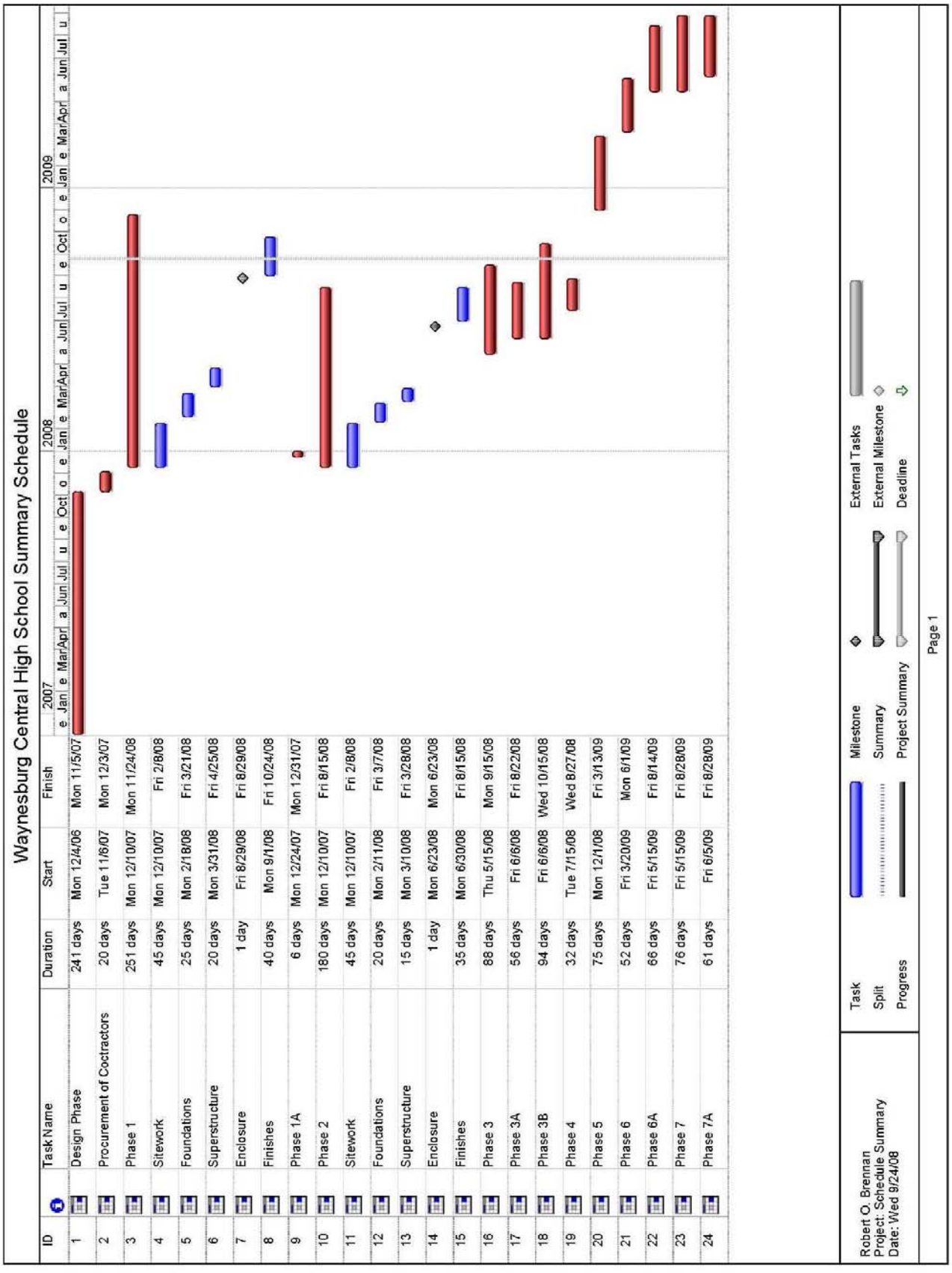
Waynesburg central High School is a facility in which the schedule is critical because the building will be occupied through the entirety of construction. The phasing sequence was carefully planned to ensure that no temporary facilities would need to be provided for students while school is in session. There are several phases where occupancy of the area will be taking place immediately following completion. Transitions into new phases are scheduled to occur over student breaks, thus alleviating much stress. The Waynesburg Central High School construction project is for the most part a renovation project. Less than a quarter of the area under construction is additions, the rest renovation work. The summary schedule on the page that follows shows time lines in which phases are scheduled to be completed.

A supplemental phasing plan has been attached on page 6, to further help understand the schedule in which areas will be occupied and taken over for renovation throughout the course of the project. The phases are labeled on the plan and color coded. There are twelve phases on this project and as many as six under construction at any given time. With this many different areas of work, all of which have different turn over dates. It is important to first understand the phasing breakdown before the schedule.

Waynesburg Central High School is a publicly funded project which means funding must be approved by several parties before construction can commence. Being a publicly funded project causes for a longer design phase; since there are more parties imputing information and reviewing the designs before sending for approval and construction. The procurement of contractors is a straight forward process that is further elaborated on in the project delivery section. Since it was a public project the bid date was set and when the bids came in the lowest contractor was selected to perform the work.

Phase 1 of Waynesburg Central High School is the main addition to the building. This new addition will house the science department immediately following completion. Soon thereafter phase 5 the old science rooms will be taken and renovated into general purpose classrooms. This sequence will follow the general progression set forth with phase 6 following phase 5 and subsequently phase 6a following phase 6.

The schedule summary on the following page only breaks out the new addition phases into subsequent sections. New addition phases are the only phases in which any site work, foundation, or structural work will being done. The phases are colored in red and the subsections of the additions are shown in blue, with building enclosure shown as a milestone.


Waynesburg Central High School Summary Schedule
ID
Task Name
Duration
Start
Finish
2007
2008
2009
1 Design Phase 241 days Mon 12/4/06 Mon 11/5/07
2 Procurement of Coctractors 20 days Tue 11/6/07 Mon 12/3/07
3 Phase 1 251 days Mon 12/10/07 Mon 11/24/08
4 Sitework 45 days Mon 12/10/07 Fri 2/8/08
5 Foundations 25 days Mon 2/18/08 Fri 3/21/08
6 Superstructure 20 days Mon 3/31/08 Fri 4/25/08
7 Enclosure 1 day Fri 8/29/08 Fri 8/29/08
8 Finishes 40 days Mon 9/1/08 Fri 10/24/08
9 Phase 1A 6 days Mon 12/24/07 Mon 12/31/07
10 Phase 2 180 days Mon 12/10/07 Fri 8/15/08
11 Sitework 45 days Mon 12/10/07 Fri 2/8/08
12 Foundations 20 days Mon 2/11/08 Fri 3/7/08
13 Superstructure 15 days Mon 3/10/08 Fri 3/28/08
14 Enclosure 1 day Mon 6/23/08 Mon 6/23/08
15 Finishes 35 days Mon 6/30/08 Fri 8/15/08
16 Phase 3 88 days Thu 5/15/08 Mon 9/15/08
17 Phase 3A 56 days Fri 6/6/08 Fri 8/22/08
18 Phase 3B 94 days Fri 6/6/08 Wed 10/15/08
19 Phase 4 32 days Tue 7/15/08 Wed 8/27/08
20 Phase 5 75 days Mon 12/1/08 Fri 3/13/09
21 Phase 6 52 days Fri 3/20/09 Mon 6/1/09
22 Phase 6A 66 days Fri 5/15/09 Fri 8/14/09
23 Phase 7 76 days Fri 5/15/09 Fri 8/28/09
24 Phase 7A 61 days Fri 6/5/09 Fri 8/28/09
Robert O. Brennan
Project: Schedule Summary
Date: Wed 9/24/08
Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline
Page 1


WAYNESBURG CENTRAL HIGH SCHOOL
CENTRAL GREENE SCHOOL DISTRICT
A051-PH
OVERALL FIRST FLOOR PHASING PLAN
KEYPLAN
PHASE 1
PHASE 5
PHASE 6A
PHASE 6
REMOVE CEILINGS - PHASE IA
PHASE 3B
PHASE 7A
PHASE 3A
PHASE 7A
PHASE 3A
PHASE 4
PHASE 7
PHASE 7A
PHASE 3
PHASE 2
PHASING SCHEDULE
PHASE I
10 DECEMBER 2007 - 24 NOVEMBER 2008
PHASE IA
24 DECEMBER - 31 DECEMBER 2007
PHASE 2
10 DECEMBER 2007 - 15 AUGUST 2008
PHASE 3
15 MAY - 15 SEPTEMBER 2008
PHASE 3A
06 JUNE - 22 AUGUST 2008
PHASE 3B
06 JUNE - 15 OCTOBER 2008
PHASE 4
15 JULY - 27 AUGUST 2008
PHASE 5
01 DECEMBER 2008 - 13 MARCH 2009
PHASE 6
20 MARCH - 01 JUNE 2009
PHASE 6A
05 JUNE - 15 AUGUST 2009
PHASE 7
15 MAY - 15 SEPTEMBER 2009
PHASE 7A
05 JUNE - 28 AUGUST 2009
CORRIDORS
24 DECEMBER 2007 - 15 AUGUST 2009
1 OVERALL FIRST FLOOR PHASING PLAN

Project Cost Summary

Cost is often a driving factor for any building, when a publicly funded project is proposed a question of what it is going to cost the public carries heavy weight. Public board meetings are held to discuss the project budget which is then sent out for public approval. Waynesburg Central High School, being a public project, followed the same pattern for funding. The project cost evaluation will analyze the cost of the project and compare it with two different estimating techniques. Actual building cost is the best way to directly compare buildings, because local area cost are minimized, by excluding land costs, site size and preparation, along with the permitting costs that vary based on geographic location. The following table displays roughly the actual cost to construct Waynesburg Central High School per the plans and specifications on bid day.

Actual Building Construction Cost	
Total Cost excluding land	$ 17,191,000.00
Cost of Site work	$ 952,000.00
Actual Building Construction Cost	**$ 16,239,000.00**

Actual Building Construction Cost per Sq. ft.	**$ 91.23**

Table 1: Actual Building Construction Cost

Waynesburg Central High School is being constructed on a school campus setting were the land is already owned by the district. With previous ownership of the land this cost is not factored in for the total building construction cost. Some additional costs are incurred over the course of construction which are subsequently accounted for in table 2. Table 2 displays the total building construction cost along with the fees for additional services not directly related to the construction, as well as the additional costs like permits and financing.

Total Building Construction Cost	
Total cost excluding land	$ 17,191,000.00
Architect and Engineer Fees	$ 1,450,000.00
Construction Manager Fees	$ 2,100,000.00
Additional related costs	$ 750,000.00
Actual Building Construction Cost	**$ 21,491,000.00**

Table 2: Total Building Construction Cost

Various systems are intricately intertwined in order to construct a building. These systems create a large majority of the construction cost and should be analyzed to assure the systems are not out of line with the common construction practices. Table 3 shows some of the building systems that were installed and the cost associated with them. The construction management fee and the architect and engineering fees have also been included since this is the area of particular interest for this report. Since this is a multiple prime contract which is further elaborated upon in the project delivery system all systems were installed by a separate prime contractor.

Building System Costs	
Mechanical system	$ 3,840,000.00
Structural system	$ 810,000.00
Electrical system	$ 2,310,000.00
Communication system	$ 399,000.00
Plumbing system	$ 1,342,000.00
Roofing system	$ 1,108,000.00
Interior Finish systems	$ 508,000.00
Construction Manager	$ 2,100,000.00
Architect and Engineer	$ 1,450,000.00

Table 3: Building Construction Cost

Cost is always a driving factor in the construction industry and must always be kept in check to make sure the project does not come in over budget. This is not the only time cost is mentioned in this report, in almost every analysis cost in mentioned and analyzed in some way. Before the cost of individual items is looked at it is best to have at least a broad understanding of the overall cost of the project as to not loose sight of the initial goal. A break down by systems is good to understand because some of these systems will be looked at as well and portions analyzed for cost, thus the overall initial cost must be kept in mind to assure that the proposed changes are still within budget. Waynesburg Central High School is a project that is publically funded meaning that the budget must be approved by the board and in several cases by the community. Since the community has a say in the matter it is important to educate them as to the benefits to not only the construction project but also to the features that are going to be put in and the effect they will have on the learning environment.

Project Systems Summary

Yes	No	Work Scope	If yes, address these questions / issues
x		Demolition Required	Extensive demolition work is necessary on this project. A variety of different materials shall be removed from the site. Asbestos was present in several areas and a specialty contractor (PSI, Inc.) was removing prior to other systems. Since the project scope contained a total renovation PSI, Inc. conducted a thorough analysis of all questionable materials in the building before any demolition occurred. Metal lockers were removed and taken to a salvage yard were the owner received compensation and did not have to pay tipping fees.
	x	Structural Steel Frame	Two column lines flanking the interior corridor in building G contain structural steel. These column lines contain less than eight columns per, and building G is a single story structure.
	x	Cast in Place Concrete	No extensive cast in place concrete is scheduled. A few slabs on grades shall be poured but no formwork is required because exterior walls are already in place and act as formwork.
x		Precast Concrete	• Precast concrete cast by Concrete Fabricators, in Wheeling, West Virginia • Concrete columns are connected to the foundation using leveling plates and anchor bolts • 45 ton mobile crane used to set all precast concrete
x		Mechanical System	• New mechanical room located in basement of building G • 215 ton air cooled chiller located outside mechanical room • 15 prepackaged air handling units • 73, 4 pipe unit ventilators replacing existing system • Fire protection system is a pre action sprinkler system
x		Electrical System	• 277/480V, 3 phase, 4 wire main service to building • 3000A, 3 phase main breaker • 208Y/120V service to receptacles and some luminaires • 150KW/180KVA, 120/208V-3 phase, 4 wire diesel emergency generator • 40 different luminaires used in the building
x		Masonry	• A combination of load bearing and non load bearing CMU walls are utilized. • The building has a brick veneer struck with a grapevine joint. • Traditional scaffolding used on this project which had a maximum height of two stories. • Masonry walls are connected to the precast concrete through a series of angle iron braces.
	x	Curtain wall	No curtain wall system implemented in construction**.**
	x	Support of Excavation	No unusual conditions existed in the excavation process. Rock was encountered before the desired footer depth allowing for a redesign and shallower footing system to be implemented.

Project Local Conditions Summary

Waynesburg Central High School in located in Waynesburg Pennsylvania. Waynesburg Pennsylvania is located 50 miles south of Pittsburgh just off of I-79. Waynesburg is also only 20 miles north of Morgantown West Virginia. Waynesburg's location makes construction convenient because of the easy access to a major interstate.

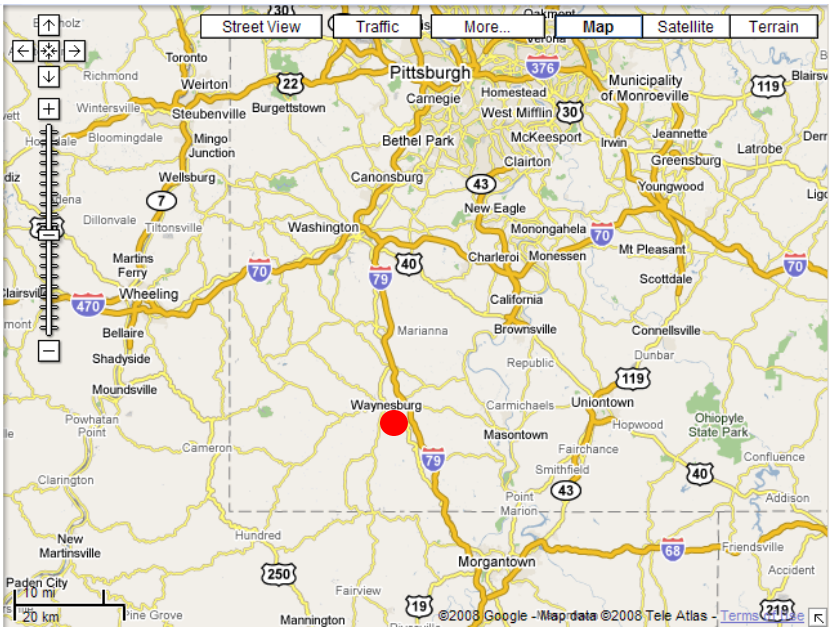


Figure 4: Waynesburg Central High School depicted by red

Contractor parking is often an issue on construction projects, but at Waynesburg the site is large enough to provide adequate space for contractors to park. Over the course of construction, designated parking areas will be changed. Contractors will be permitted to park in student parking lot located west of the school building when school is not in session. When school is in session contractors are only permitted to park in the last row of that lot and in the parking area designated on the site plan.

Tipping Fees in Pennsylvania and Neighboring States

State	Remaining Capacity (tons)	2007 Average Tipping Fee*	Per-Ton State Imposed Fees
Pennsylvania	278,704,216	$61.00	$6.25/ton to state + $1.00/ton to host municipality
Delaware	59,800,000	$61.00	No fees; facilities are state-owned
Maryland	7,947,736	$68.00	No fees
New Jersey	38,000,000	$73.00	$1.00/ton to host municipality + $0.25/ton post closure fee
New York	90,000,000	$95.00	No fees
Ohio	370,793,903	$33.00	Multiple fees vary from $1.00 to $9.00/ton
Virginia	235,094,159	$47.00	Fee assessed on waste received above approved permit level
West Virginia	107,568,455	$34.00	$8.25/ton + $0.50/ton to host municipality

Source: Solid Waste Digest, Year 17, Report No. 1. 2007 Chartwell Gate Price Progress Report.

Figure 5: Tipping fees chart for north eastern United States

Specifications do not require recycling of materials during the demolition of this project. Central Greene School District decided to contact a local salvage yard for the removal of lockers. This was suggested by the general contractor to save tipping costs; the salvage yard provided dumpsters and removed them at no charge to the owner and also paid the owner for the materials. An average price for tipping on other dumpsters in Pennsylvania is given in figure 5.

Site Conditions and unforeseen conditions are the single largest reason for changes and delays to a construction project. Soil conditions are a critical part of foreseeing possible problems and potential delays. At Waynesburg Central High School an independent consultant was hired to perform soil tests on the property. These soil tests were compiled prior to the completion of design and issued to all contractors bidding on the project. Civil & Environmental Consultants, Inc. performed the soil analysis.

Civil & Environmental Consultants, Inc. performed a series of 19 core bores were done in various locations surrounding the building. Figure 6 shows the locations in which the bores were taken. Appendix A contains two sample core bores, B4 and B7. Core bores on site vary in depth from 3.3 feet to a depth of 21.8 feet. The depth of core bore is dependent on the depth of excavation in the area. The south side of building G is the deepest excavation occurring on the site thus the core bores are the deepest. Core bores show the different types of materials encountered and the composition of the soils.

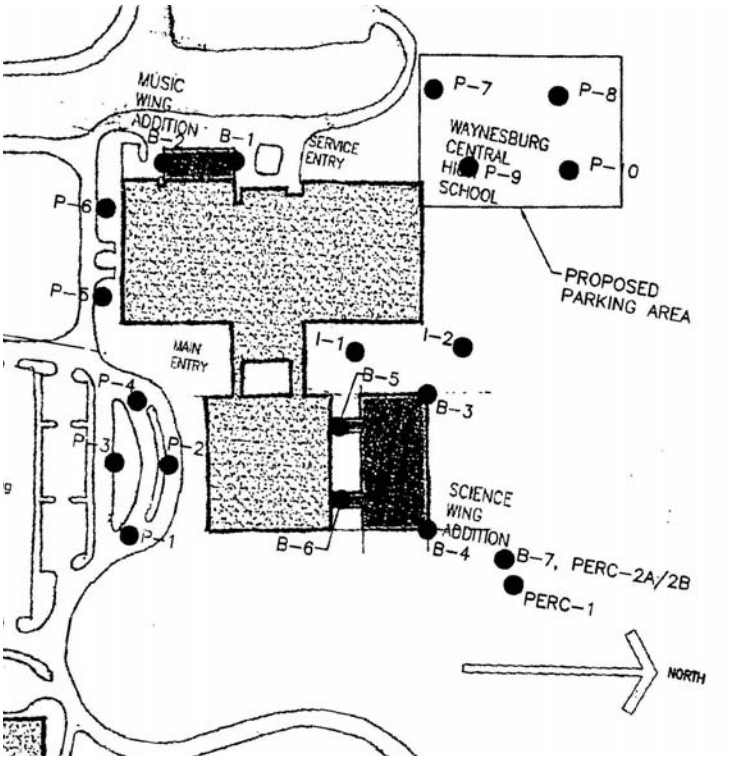


Figure 6: Core boring plan from specifications

The general soil composition on the site is a sandy clay material consistent on the surface layer, protruding downward an average depth of 4 to 6 feet. Many core bores encountered some form of sandstone following the sandy clay classified as medium hard to hard. This layer of sandstone required hammering to take place during the excavation process and was necessary to be foreseen therefore not delay the scheduled construction. Water levels on the site varied from 2 to 8 feet in depth when encountered, several core bores never encountered water. Water levels were not an issue and did not require any special techniques to handle the water.

Analysis 1: LEED Certification

Problem:

Public high schools often have a hard time deciding whether or not it is worthwhile to pursue LEED certification.

Public high schools are publicly funded projects and as a result must be approved by the state and the taxpayers in the district. LEED certification today is often viewed as a bragging right in today's public education system, but it can also be used to help educate the general public of some simple cost effective ways to be more energy efficient. In any LEED certified project there are some simple steps that can greatly reduce the life cycle cost of a product, should a public school facility be constructed in a manner like this it allows for students that are attending the facility the opportunity to see the difference first hand and possibly study some of these techniques in science class. The most effective way to change the amount of energy consumption the country is using is not to change regulations, but to educate the next generation on the cost effective ways they can reduce energy consumption and ultimately save themselves some money.

Goal:

Create a guide for school districts in western Pennsylvania that would help them decide if LEED certification is worth pursuing.

Resources:

United States Green Building Council
LEED Design for Schools 2007
Surveys to Industry Members and School Districts
Various other LEED websites

Methodology:

The LEED analysis was handled in a two step process the first of which was to retrieve information from industry professionals. Information was attained through a survey that was sent out to industry professionals in western Pennsylvania and Ohio. The survey that was sent out to construction managers and school districts is on the pages to follow, this was dispersed through email as a word document attachment so individuals could simply fill in their information and reply to the email. The second step in of this analysis was to analyze the surveys that were returned and determine some of the common points that were attained. When this information was processed it was then transferred into a spread sheet for the LEED certification checklist reflecting the areas that would have best fit Waynesburg Central High School.

Survey:

Interview Questionnaire

Name:

Company:

Position:

1) How many LEED certified construction projects have you worked on?

2) How many of these projects were school buildings in the western Pennsylvania area?

3) What levels of LEED certification did these projects receive?

4) What was the largest challenge on the LEED projects?

5) How cooperative were contractors in participating with LEED certification? If there was any resistance to participation how was it handled?

6) Was there any sort of incentive program to encourage contractor participation?

7) What was the easiest LEED point to obtain? Why?

8) In western Pennsylvania were there any difficulties in attaining points for recycling and waste management? If so please describe them.

9) Which area was the hardest to attain points in for LEED certification? What made this section more difficult to attain points?

10) Have you ever worked on a LEED certified project not in western Pennsylvania? If so were there any points that were easier to attain in western Pennsylvania then other regions?

11) Choose a LEED accredited project in Western Pennsylvania. Please describe 3 LEED points were issues arose in the process, also describe how the problem was resolved and if the point was attained in the end.

Project Name:

LEED Certification Level:

1.

2.

3.

12) How much harder was it to manage a LEED project compared to a traditional construction project? Describe a few areas that made the project more difficult.

13) Do you think it is worth it to the school district to do a LEED certified project?

Survey Results:

The survey was sent out to numerous industry professional with varying fields of background, all of which had experience with a LEED project in some way. Some had experience on the ownership side others had experience being construction managers. This gave a good array of information that would not have a bias toward one side of construction or to the owner. The results that are stated in the following section do not reflect the view of all individuals that responded to the survey. The results simply reflect the view of the majority.

LEED is not common in western Pennsylvania on school projects; this was seen as a result of the survey since most of the individuals responding had only worked on one LEED certified project. The majority of the projects worked on only strived to attain LEED certification. I also sent the survey to practitioners in Ohio. These surveys were informative to the fact that the state of Ohio had recently required that all construction on schools in the state meet or exceed a LEED silver rating in order to receive funding from the state. I was informed of several of these projects that are underway and striving for the LEED silver rating and as a result surveys received from participants in the state of Ohio reflected the fact that the choices were made based on the requirement of state funding. For the most part individuals in Ohio had also only been a part of one LEED project as well. This all leads to the conclusion that LEED is not as common in the industry as scholastics make it seem, though it does appear to be becoming more common.

There were several LEED points that came up on a consistent basis as being hard to obtain, many of these had to do with the sustainable sites section of LEED certification. This is probably a result of the individuals that were surveyed and the general environment of western Pennsylvania and Ohio. After receiving and reviewing the results of the surveys the sustainable site concerns were a general trend, so the location of schools sent the survey was then analyzed. Most of the schools that were responded about were located in rural areas, which would explain why the alternative transportation and the urban redevelopment points were cited as being impossible to attain. Another common point that was cited as being a hard to attain was the site selection, this was often a response from the owner's side. The reasoning for this being a hard one to attain was based on the fact that school districts already own large portions of land around a central campus and are adding facilities to this property. These were some of the most common responses to the most challenging LEED points to attain.

In the survey there was a question asked pertaining to how much more challenging a LEED certified project was to manage then other projects. This question was geared more toward the construction manager's side to see if they felt it was worth the extra work required or even if there was extra work required. The general consensus on this question was that a LEED project only required a minimal amount of extra work but required a substantial amount of extra paperwork. This idea of extra paperwork caused by striving for LEED certification required that construction managers be more demanding of the subcontractors to fill out the correct paperwork. This was often said to be the toughest challenge on the entire LEED project and in several cases was accredited to the fact that many of the subcontractors are not organized enough to effectively handle such a task. It was also accredited to LEED not being very prevalent in the area and many of the subcontractors have never worked on a LEED project before and thus causing them at least initially to have a lack of understanding of the required paperwork.

Solution:

Waynesburg Central High School chose not to strive for LEED certification of any type, with the research done for this analysis the goal was to determine the LEED points that were feasible and common to the western Pennsylvania area in which Waynesburg Central High School is located. After receiving the feedback from the surveys and the information obtained through research of the United States Green Building Councils website a spreadsheet was made to show more simply the areas that would be relatively easy for the school to attain along with those that may be possible and also the line items that area just not possible for Waynesburg Central High School whether it be because of location or site conditions or various other reasons. A filled out sample for Waynesburg Central High School of the "Registered Project Checklist" from the United States Green Building Councils website is shown on the following four pages. This table is simply a summary of the findings of my research applied to Waynesburg Central High School, this chart in no way reflects that Waynesburg Central High School would be guarantied the points that are marked as yes, because this is simply the checklist to guide industry professionals in the correct direction, all points are then submitted to the council to ensure that all aspects of the point were completed satisfactorily before awarding the LEED point.

As the LEED for schools checklist on the following pages indicates, LEED Certification should be possible and it would depend upon the level of commitment by all parties associated on whether or not a higher accreditation could be attained, with a maximum level of gold being possible with the items noted as yes and maybe. With the potential of achieving each point being determined by the responses of industry professionals, some of the maybes were placed as such because the professionals responded that a significant cost was associated with the point. Becoming a LEED certified school would have been attainable for Waynesburg Central High School but the option was forgone and the building was constructed utilizing traditional construction techniques.

Cost is often the leading deterrent from striving for LEED certification and one that was cited by some of those involved at Waynesburg Central High School. Research was done to further understand the true cost implications of constructing a LEED certified project, the results were startling. According to research conducted of 30 green schools the results yield that a typical LEED rated school can save over $100,000 per year on energy costs, this according to Greening Americas Schools. LEED rated schools typically cost on average 2% more than conventional schools, this translates to approximately $3 per square foot of building area increase. The financial savings of having a green school is estimated to be approximately $74 per square foot. This means that in the end, the net financial benefits of constructing a green school is going to be about $71 per square foot. A summary of these findings are displayed in table 4, which was taken from the Greening America's School: Cost and Benefits report. When all the data is analyzed the concerns of individuals who are worried a LEED certified project costing more to construct are confirmed. This is not the end of the story though individuals responsible for making these decisions need to analyze the cost of construction over the life of the project and not simply look at initial cost; they would then see that a LEED certified building though having a higher initial cost in the long run would result in tremendous savings.

Table A: Financial Benefits of Green Schools ($/ft^2)	
Energy	$9
Emissions	$1
Water and Wastewater	$1
Increased Earnings	$49
Asthma Reduction	$3
Cold and Flu Reduction	$5
Teacher Retention	$4
Employment Impact	$2
TOTAL	$74
COST OF GREENING	($3)
NET FINANCIAL BENEFITS	$71

Table 4: Financial benefits of green schools

LEED for Schools 2007
Registered Project Checklist

Project Name: Waynesburg Central High School

Project Address: _____

Yes	?	No		
31	23	25	**Project Totals** (Pre-Certification Estimates)	79 Points
CERTIFIED			**Certified**: 29-36 points **Silver**: 37-43 points **Gold**: 44-57 points **Platinum**: 58-79 points	

Yes	?	No			
6	4	6	**Sustainable Sites**		16 Points
Yes			Prereq 1	**Construction Activity Pollution Prevention**	Required
Yes			Prereq 2	**Environmental Site Assessment**	Required
	1		Credit 1	**Site Selection**	1
		1	Credit 2	**Development Density & Community Connectivity**	1
		1	Credit 3	**Brownfield Redevelopment**	1
		1	Credit 4.1	**Alternative Transportation**, Public Transportation	1
		1	Credit 4.2	**Alternative Transportation**, Bicycle Use	1
		1	Credit 4.3	**Alternative Transportation**, Low-Emitting & Fuel Efficient Vehicles	1
	1		Credit 4.4	**Alternative Transportation**, Parking Capacity	1
1			Credit 5.1	**Site Development**, Protect or Restore Habitat	1
1			Credit 5.2	**Site Development**, Maximize Open Space	1
1			Credit 6.1	**Stormwater Design**, Quantity Control	1
	1		Credit 6.2	**Stormwater Design**, Quality Control	1
		1	Credit 7.1	**Heat Island Effect**, Non-Roof	1
1			Credit 7.2	**Heat Island Effect**, Roof	1
1			Credit 8	**Light Pollution Reduction**	1
	1		Credit 9	**Site Master Plan**	1
1			Credit 10	**Joint Use of Facilities**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
3	2	2	**Water Efficiency**		7 Points
1			Credit 1.1	**Water Efficient Landscaping**, Reduce by 50%	1
1			Credit 1.2	**Water Efficient Landscaping**, No Potable Use or No Irrigation	1
		1	Credit 2	**Innovative Wastewater Technologies**	1
1	1	1	Credit 3	**Water Use Reduction**	1 to 3
			--> Credit 3.1	20% Reduction	1
			Credit 3.2	30% Reduction	2
			Credit 3.3	40% Reduction	3
	1		Credit 4	**Process Water Use Reduction**, 20% Reduction	1

Yes	?	No			
5	2	10	**Energy & Atmosphere**		17 Points
Yes			Prereq 1	**Fundamental Commissioning of the Building Energy Systems**	Required
Yes			Prereq 2	**Minimum Energy Performance**	Required
Yes			Prereq 3	**Fundamental Refrigerant Management**	Required

***Note for EAc1:** All LEED for Schools projects registered after June 26, 2007 are required to achieve at least two (2) points.

5		5	Credit 1	**Optimize Energy Performance**	2 to 10
			Credit 1.2	14% New Buildings / 7% Existing Building Renovations	2
			Credit 1.3	17.5% New Buildings / 10.5% Existing Building Renovations	3
			Credit 1.4	21% New Buildings / 14% Existing Building Renovations	4
			--> Credit 1.5	24.5% New Buildings / 17.5% Existing Building Renovations	5
			Credit 1.6	28% New Buildings / 21% Existing Building Renovations	6
			Credit 1.7	31.5% New Buildings / 24.5% Existing Building Renovations	7
			Credit 1.8	35% New Buildings / 28% Existing Building Renovations	8
			Credit 1.9	38.5% New Buildings / 31.5% Existing Building Renovations	9
			Credit 1.10	42% New Buildings / 35% Existing Building Renovations	10
		3	Credit 2	**On-Site Renewable Energy**	1 to 3
			Credit 2.1	2.5% Renewable Energy	1
			Credit 2.2	7.5% Renewable Energy	2
			Credit 2.3	12.5% Renewable Energy	3
	1		Credit 3	**Enhanced Commissioning**	1
	1		Credit 4	**Enhanced Refrigerant Management**	1
		1	Credit 5	**Measurement & Verification**	1
		1	Credit 6	**Green Power**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
6	7		**Materials & Resources**		**13 Points**
Yes			Prereq 1	**Storage & Collection of Recyclables**	Required
1			Credit 1.1	**Building Reuse,** Maintain 75% of Existing Walls, Floors & Roof	1
	1		Credit 1.2	**Building Reuse,** Maintain 95% of Existing Walls, Floors & Roof	1
	1		Credit 1.3	**Building Reuse,** Maintain 50% of Interior Non-Structural Elements	1
1			Credit 2.1	**Construction Waste Management**, Divert 50% from Disposal	1
	1		Credit 2.2	**Construction Waste Management**, Divert 75% from Disposal	1
1			Credit 3.1	**Materials Reuse**, 5%	1
	1		Credit 3.2	**Materials Reuse**, 10%	1
1			Credit 4.1	**Recycled Content**, 10% (post-consumer + 1/2 pre-consumer)	1
	1		Credit 4.2	**Recycled Content**, 20% (post-consumer + 1/2 pre-consumer)	1
1			Credit 5.1	**Regional Materials**, 10% Extracted, Processed & Manufactured	1
	1		Credit 5.2	**Regional Materials**, 20% Extracted, Processed & Manufactured	1
	1		Credit 6	**Rapidly Renewable Materials**	1
1			Credit 7	**Certified Wood**	1

LEED for Schools 2007
Registered Project Checklist

Yes	?	No			
9	8	3	**Indoor Environmental Quality**		20 Points
Yes			Prereq 1	**Minimum IAQ Performance**	Required
Yes			Prereq 2	**Environmental Tobacco Smoke (ETS) Control**	Required
Yes			Prereq 3	**Minimum Acoustical Performance**	Required
1			Credit 1	**Outdoor Air Delivery Monitoring**	1
	1		Credit 2	**Increased Ventilation**	1
1			Credit 3.1	**Construction IAQ Management Plan,** During Construction	1
1			Credit 3.2	**Construction IAQ Management Plan,** Before Occupancy	1
3	1		Credit 4	**Low-Emitting Materials**	1 to 4
	1		Credit 5	**Indoor Chemical & Pollutant Source Control**	1
	1		Credit 6.1	**Controllability of Systems,** Lighting	1
1			Credit 6.2	**Controllability of Systems,** Thermal Comfort	1
	1		Credit 7.1	**Thermal Comfort,** Design	1
	1		Credit 7.2	**Thermal Comfort,** Verification	1
2	1		Credit 8.1	**Daylight & Views,** Daylight 75% of Spaces	1 to 3
			-->	75% of classrooms (Required for either points below)	1
			-->	90% of classrooms	2
				75% of other spaces	3
		1	Credit 8.2	**Daylight & Views,** Views for 90% of Spaces	1
	1		Credit 9	**Enhanced Acoustical Performance,** 40 dBA / RC level of 32	1
		1		**Enhanced Acoustical Performance,** 35 dBA / RC level of 27	1
		1	Credit 10	**Mold Prevention**	1

Yes	?	No			
2	0	4	**Innovation & Design Process**		6 Points
	0	1	Credit 1.1	**Innovation in Design:** Provide Specific Title	1
		1	Credit 1.2	**Innovation in Design:** Provide Specific Title	1
		1	Credit 1.3	**Innovation in Design:** Provide Specific Title	1
		1	Credit 1.4	**Innovation in Design:** Provide Specific Title	1
1			Credit 2	**LEED® Accredited Professional**	1
1			Credit 3	**School as a Teaching Tool**	1

Conclusion:

After analyzing all the data that has been attained it is hard to make a broad suggestion relating to all schools seeking to do a construction project in western Pennsylvania. Since no specific suggestion can be made for all schools suggestions will be made based on regional demographics. Schools in more highly populated areas will have an easier time achieving LEED certification than the rural regions; this because many of the LEED points are based on the site accessibility to the public. I would suggest that schools with public transportation and a dense population centrally located near the school strive to obtain LEED certification. For those districts that are in very rural areas striving for LEED certification would be entirely upon the district to decide because they do not have the ability to obtain some points that are very easy for urban schools. No matter where the school is located the district has to make the choice if it is worth spending the few percent more upfront in order to save over the life of building.

Analysis 1.1: Recycling and Waste Management

Problem:

Construction projects produce large quantities of waste.

Construction projects today produce large quantities of waste that could be mitigated with the proper precautionary steps. Waynesburg Central High School currently has no recycling plan in place, and as a result all was is placed in the same dumpster and removed from the site. LEED projects often implement a multiple dumpster system where debris of the same nature is placed in the corresponding dumpster. Waynesburg Central High School is a rural location in south western Pennsylvania which may cause for recycling to be more challenging to do then other locations where the practice is more common. In this region recycling companies may not be a readily available as in most regions.

Goal:

Implement a waste management plan that promotes recycling resulting in waste reduction.

Methodology:

Start by analyzing the current plan for waste removal and seeing ways in which the site can maintain a cleaner working environment by the strategic placement of small dumpsters throughout the building. Create waste stations throughout the building to minimize the amount of travel distance to remove construction waste. Research local waste management facilities to determine what materials will be kept separate. After determining the materials that will be separated place a small dumpster at each waste station for every individual material that is being discarded. Waste stations will be emptied into the larger recycling center on an as needed basis. The final steps for this analysis will be to determined the expected time between tips in order to derive an estimated cost for the waste management plan.

Research Results:

Plan:

Waste management is a place when striving to attain LEED certification were points are often gained. There are a possible four points directly associeated with waste management and recycling. One point is gained if 50 percent of the waiste is diverted from a land fill and two points are gained if 75 percent of the construction waste is diverted from a landfill. There are also two points directly related to the amount of materials reused in the building, 5 percent gains the project a point and another point is awarded should the project reutalize 10 percent of the material.

Waste management is an area that was focused on for this analysis in an effort to obtain one of the two possible LEED points associated with waste management. Since the building has multiple phases an attempt was made to determine a central location that would not need to be moved often to set up a small waste management station that would have small dumpsters like the blue dumpster shown in figure 7. Each of the small dumpsters would be labeled for the material permitted to be discarded in it.

Figure 7: Small dumpsters for waste management

Two stations were determined in the building that these dumpsters would be located at, the idea behind placing small waste management stations is to encourage contractors to keep a clean work space as they are performing their work by allowing for minimal travel time to discard waste. Since the dumpsters are small they will have to be emptied on a regular basis and this is why the depicted dumpsters were chosen. The chosen dumpster as shown in figure 7 are easily moved either by a manual forklift or by one on a piece of machinery. When the smaller dumpsters are full they will be removed from the building and taken to the large waste management center on site which is located in the lower staging area. The large waste management center will contain a series of dumpsters like depicted in figure 8, again each dumpster will contain labels to ensure that material again make it in the proper location. With these steps being taken it should ensure that at least 50 percent of material is able to be diverted from landfills allowing the project to gain one LEED point.

Figure 8: Large waste management area photo

Since Waynesburg Central High School is a renovation project there is a substantial amount of material that is being removed from the building. With the large quantity of material being removed combined with the fact that most of the materials in the building are original dating them about fourty years, it will be a great challenge to reuse 10 percent of these materials. The project will however strive to reuse 5 percent of the material which will gain them another LEED point. In most renovation projects one of the systems that is rarely changes is the structure, Waynesburg Central High School is no different, there are almost no alterations being made to the structure of the existing building. LEED points are awarded for this kind of reuse in fact Waynesburg Central High School has the opportunity to attain three LEED points in this area, because not only is the entire exterior being reused but the majority of the interior is remaining in the building. The renovation work that is being done is primarily to bring the building up to modern standards by updating then comunications, heating ventelating and air conditioning, along with the electrical system. Other then these system the other materials in the building are not being altered. With these things in mind Waynesburg Central High School should be able to attain another four LEED points in this area.

Waynesburg Central High School is a project located in south west Pennsylvania and in order to perform a thurough analysis it is not enough to simply impliment a plan for the waste on site, the process needs to be looked at through the full disposal. This is where the company Waste Management comes in, who is the leading provider of comprehensive waste and environmental services in North America. With 25 percent of all material being a byproduct of construction or demolition, Waste Management is a company that helps the customers maximize the materials value chain, optimize the reuse of debris, and earn points for LEED certification. Less than 5 percent of construction and demolition debris in North America is recycled, most of it goes directly to landfills. By partnering with a company like Waste Management which has helped more then 500 project earn LEED point, it will create an opportunity for the individuals working on the Waynesburg site to have an experienced company to ask questions in order to produce the best possible solution. Waste Management has a

facility in the Pittsburgh region allowing the opportunity to utalize Waste Management's expertise in the field and to also achieve the initial goal of achieving the LEED point.

Cost:

With the new plan for waste management being installed there will be an additional cost because there will be more dumpsters required and a few more tips then initially planned. For this reason representatives working on Waynesburg Central High School were contacted to see the rate at which dumpsters needed to be tipped. This was not a straight forward answer because the project is a multiple phase project were construction on the school is not consistent throughout the duration of the project. Since the school is not highly occupied during the summer months this is when the bulk of the work is done and at this stage of the project an extra dumpster was brought in to handle the waste. With three dumpsters on site for the summer and each being tipped on a weekly basis this comes out to an average of three per week over the summer. During the school year however there are only two dumpsters on site and with the reduced work they are only tipped on a biweekly basis meaning about one per week. With the new waste management plan the cost analysis was done based on a very similar amount of waste being removed from the building, the difference being that the waste will now be separated into the materials specific dumpster either to be recycled or disposed of.

For the cost analysis the numbers attained above were averaged for the duration of the construction project and combined with numbers found from other research to create an estimated cost for the waste management plan. Figure 5 contains the rates per state in the north east region, the numbers used for this analysis were taken from this information. Calculation had to be done to come up with the expected weight of material being removed from the site. Some research was done along with much averaging to come up with the average weight of construction debris per cubic yard. The Number used in this calculation for the weight per cubic yard was 250 pounds, this number was then translated into total tonnage for the project by determining dumpster size and the tipping rate. The results of this process are shown in table 5.

Waste Management Cost Analysis				
	Quantity	Units	Cost / Unit	Cost
Tipping Rate for Pennsylvania	156	Tip	$ 61.00	$ 9,516.00
Per Ton State Imposed Fees	936	Ton	$ 7.25	$ 6,786.00
Total Estimated Cost for Recycling:				**$16,302.00**

Table 5: Waste management cost sheet

Conclusion:

Waste Management is not something that should only be done when striving for LEED certification but on any project as it is more environmentally friendly and is not an excessive amount of extra effort. This analysis was done to go more into depth on the stratagy in which Waynesburg Central High School could go about attaining the LEED point for recycling. It is certainly possible for Waynesburg Central High School to achieve this LEED point with a little extra effort. The real suggestion at the end of this analysis, is that there is an obrsorbanent amount of waste being produced by the construction industry today. So whether a project is striving for LEED certification or not, the project managers should make the responsible choice that only 5 percent of construction projects do and help protect the environment by implimenting a waste management and recycling plan for their site.

Analysis 2: Energy Savings Analysis

(Lighting/Electrical Breadth)

Problem:

Energy consumption in a building is a large cost and lighting fixtures and their controls are often easy ways to lower energy consumption.

LEED certification focuses on a few main areas of a building in order to achieve certification; one of the emphasized areas is energy consumption. With energy consumption being emphasized as an area of focus in the LEED certification process this is an area that needs to still be further looked at on most projects. Though manufacturers are becoming more consistent and there is less deviation in the performance of products, some products still perform better than others do in terms of energy consumption. Lighting systems is not the only system that should be analyzed on a construction project for energy efficiency; mechanical systems are often the largest single consumer of energy in a building. This analysis will analyze the lighting system chosen at Waynesburg Central High School because this system is more visible and can be used more easily as an educational tool.

Goal:

Analyze potential energy saving from control systems such as motion sensors and light sensors. Perform research on common luminaires to determine if there is a more efficient one available, and do a comprehensive cost analysis on the revised lighting system for a single classroom. Extrapolate the findings to create an estimated cost savings for Waynesburg Central High School as a whole.

Resources:

Finelite website
Leviton website
Various other lighting websites

Methodology:

Before any cost saving analyses can be done the proper luminaire selection must be made, meaning that the research for luminaires is the first step in the process. After the luminaire selection is made a model of the typical classroom lighting plan must be made showing the controls. The next step for this analysis is to find possible solutions for automated lighting controls that could result in energy savings. Finally all the information must be compiled into an estimated total cost savings and then eventually into an explanation of the steps taken and the findings.

Research Results:

Luminaires are about a dime a dozen and with so many options to choose from it is hard to know if the most efficient one is being selected. When doing this analysis the objective was to keep the same power density or if anything decrease it slightly. Another objective was to not totally change the interior look for the classroom, meaning since a direct indirect fixture was chosen initially the goal is to keep the same type of fixture. When reviewing the prescribed fixtures specifications which are attached

in appendix B, the lighting distribution and efficiency where determined. These pieces of information are important because they are the first thing that will be compared to the proposed fixture so as not to change the appearance of the room.

Researching to find a fixture with lamps that were more efficient then the selected fixture was a challenge; many manufacturers' websites were visited. Manufacturers such as Lithonia, Finelite, Cooper, Metalumen and many others were searched to find a fixture with similar specifications to the prescribe Finelite fixture, but none were found to be superior in both lighting distribution and power usage. Since a fixture was chosen that is already very efficient this analysis concept had to be modified slightly, it was decided to focus more on the controls for a classroom to see if any energy savings could come about from that.

Controls for a classroom are often very simple, only performing one task but with the advances of technology in classrooms today the lighting controls should be advancing as well. One of the options analyzed to see if any energy savings could be made was the installation of occupancy sensors. By installing an occupancy sensor if the lights are left on when no one is in the room the sensor will detect that and shut off the lights after a given amount of time. Research was done to find an occupancy sensor that could be installed at Waynesburg Central High School, a good option for an occupancy sensor is the Leviton OSC4-IOW shown in figure 9. The Leviton OSC4-IOW is a high density with a scanning radius of 12 feet, with this width it will allow for only one to be needed for classroom. The occupancy sensor will be placed toward the front of the classroom and closer to the side with the door, in order to sense the teacher's motion on the board as well as students in the front rows and those entering the classroom. Since the Leviton OSC4-IOW is ideal for the low ceiling places in the building and not all spaces are like that another occupancy sensor was chosen for rooms like the gymnasium and natatorium. Since the ceilings in these spaces are high a Leviton OSFHU sensor was chosen, which is a high bay occupancy sensor. Specifications for both occupancy sensors included in appendix C.

Figure 9: Image of Leviton OSC4-IOW

A second option for energy savings would be the implementation of a light sensor in each room to ensure that lights are not on when sufficient light is being provided naturally. Utilizing a light sensor is not only effective in regions that have more sunny days then not but also in climates like Pittsburgh were there were only 145 sunny days last year. The way a light detector works is to measure the number of lumens in the region and then adjust the lights accordingly. An example of how this works is shown in figure 10 which was taken from the Leviton ODCOP Photocell specifications sheet located in appendix D. The

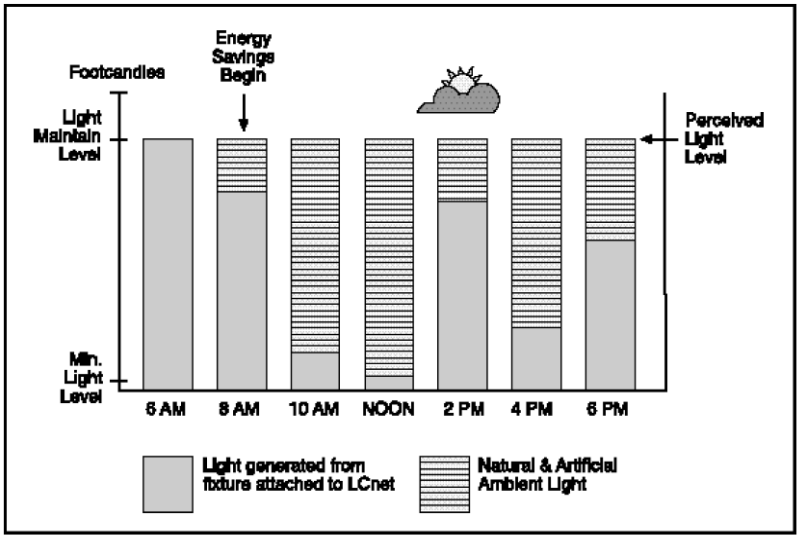


Figure 10: Depicting the way the Leviton ODCOP functions

Leviton ODCOP Photocell was chosen to run the analysis on to determine the potential savings that could be generated be implementing a system like this.

After finding products that fit the need a cost analysis needed to be ran to determine if implementing these devices would save Waynesburg Central High School money. A few pieces of information needed to be attained before running the analysis, the first of which was the average daily usage of classrooms at Waynesburg Central High School. This number was attained by calling the district and asking a few questions, the number they estimate is 85 percent of the time this is only an estimate because with the new additions and the school still under construction no schedule for all classrooms has been made. The second piece of information pertained to the cost of electricity; figure 11 shows the current average cost of electricity by state per kilowatt hour.

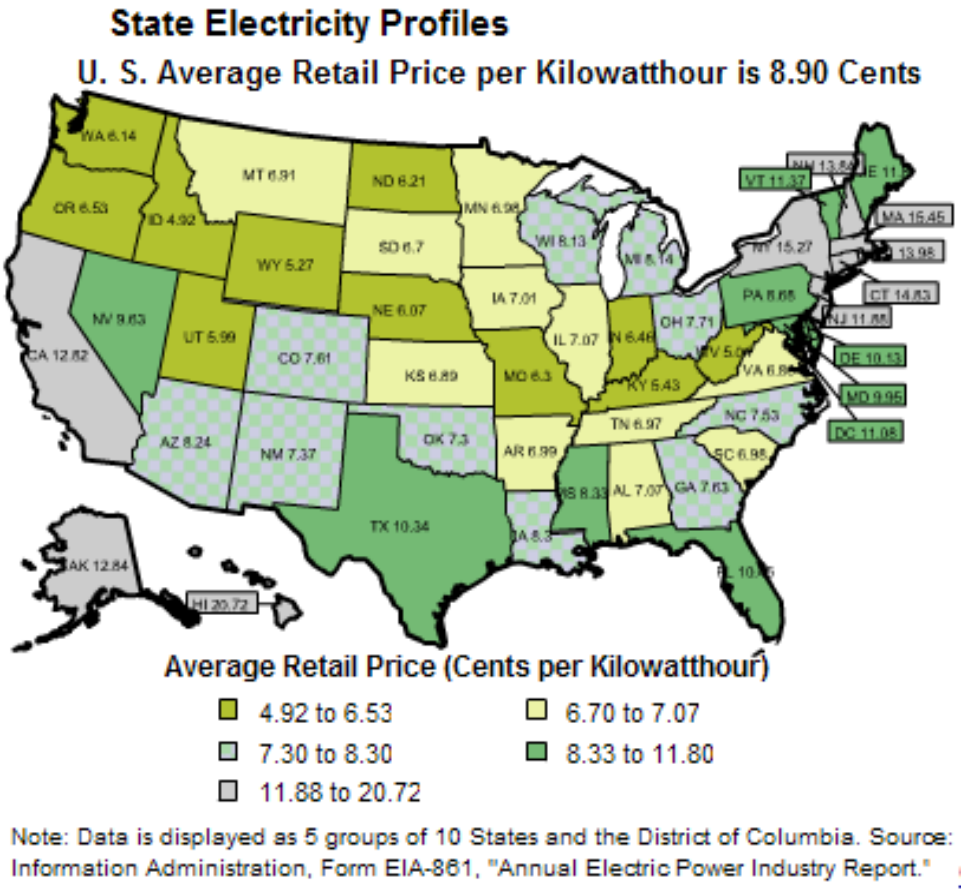


Figure 11: Depicting the way the Leviton ODCOP functions

After all information was attained the cost analysis could finally be completed. Table 6 is the summary of the calculations performed. The numbers shown in this chart reflect only the best estimate that could be attained using the data that was recovered during the research process. The estimated savings for the occupancy sensor states that an annual savings of $24,110.13 will be saved by installing occupancy sensors in each classroom. This estimate is an over estimate because it was based on the assumption that lights will be shut off immediately after the room is vacated. When in reality each sensor is programmed to shut off after a preset amount of time when no motion is observed. This assumption is also based upon the notion that teachers never turn lights off when they leave the room.

It also assumes that teachers are not in the classroom when there is not class being taught. With all these assumptions made, this is how the estimate for savings produced by the occupancy sensor was derived. On the other hand the estimate for the light sensor savings is on the low side. The assumption that a row of lights either had to be on or off was made when in reality the sensor works in a way that lights can be partially dimmed depending upon the given demand. Another assumption was made to determine the number of hours during the school year the light sensor would be used. Since there are only 145 sunny days in Pittsburgh it was assumed that these are the only days the light sensor would be used. To further that assumption only a percentage of these days could be assumed to occur while school is in session. Though the assumption in and of itself is fine the reality is that with the way the sensor works even on many partly cloudy to cloudy days potions of the fixtures will be dimmed or shut off altogether. However no table was able to be obtained with the number of days Pittsburgh experiences in a given lumen range, this information would allow for much more precise number analysis.

Expected Energy Savings

	Fixtures / Row	Watts / Fixture	Watts / Row	# of Classrooms	Watts / Room
Lighting Fixtures	7	54	378	36	40824

	cents / kWh
Electricity Cost	8.68

	Days / Year	Hours / Year	School Hours / Year
Sunlight for Pittsburgh	145	1015	500.55

Occupancy Sensor Analysis

	Saved				Cost
Time vacated Classroom	Watts / Day	kW /day	kW / Year	Total class usage	Annual Savings
1.05	42865.2	42.87	7715.74	277766.50	**$ 24,110.13**

Light Sensor Analysis

	Watts / room	kW / room	kW / Year	Total kW / Year	Annual Savings
One row off	378	0.378	13.608	6811.46	**$ 591.23**
Two rows off	756	0.756	27.216	13622.91	**$ 1,182.47**

Table 6: Depicting the way the Leviton ODCOP functions

Revised Lighting Plans:

Once the research and cost analysis was completed the expected implimentation had to be shown on drawings. A drawing of the original lighting plan is included in figure 12 so a direct comparison can be made to show that minimal changes were made to the lighting layout as to not effect the aesthetic apearance of the room. Figure 14 shows the revised lighting plan with the new sensors and the additional switch to optimize the teachers control.

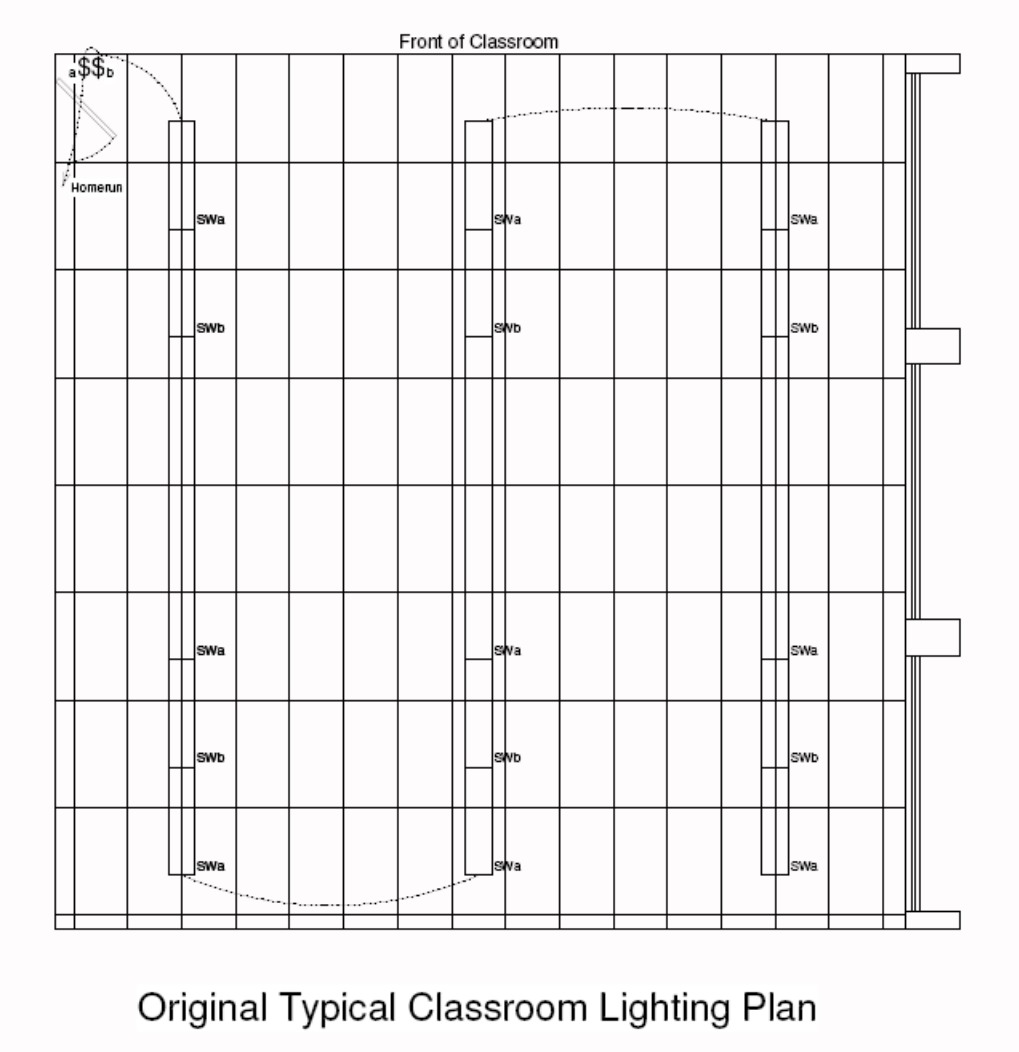


Figure 12: Original Classroom layout

A redesigned typical classroom lighting plan was developed with specific criteria to ensure that the system will operate optimally. The first thing that was changed was adding a third switch in each classroom, giving the teacher even more control. As seen in the floor plan the third switch controls the front row of fixture giving the teacher the option to turn these off should the teacher be using an overhead or a projector. The second switch for the classroom allows for the second row of lights as well as the second to last row to be shut off should the first row not allow the students to see well enough. Occupancy sensors are designated by the symbol OS with a circle around it. These are placed in the front corner of the class room in order to pick up people entring the classroom, the teacher lecturing and as well as students in the first few rows. Since the sensing patern has a radius of twelve feet which is shown in figure 13, the occupancy sensor was placed 12 feet from the door and about 8 feet from the front wall to pick up more of the

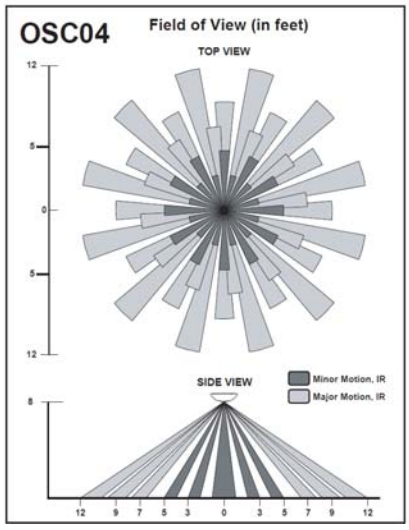


Figure 13: Sensor image for OSC04

teachers movement. The other item shown on the redesigned typicall classroom lighting plan is a lighting sensor. The lighting sensor was placed in between the second and third row from the door and not between the third row and the lights to ensure that it is not reading more light is in the room then there actually is. If the sensor were placed btweeen the third row and the windows it could result in the lights being dimmed or shut off even when the room does not have sufficient lighting. The lighting sensor will control all rows of lights dimming or shutting them off as is needed. These are a few of the changes that are done in an effort to minimize energy consumption at Waynesburg Central High School. These are some of the steps that will be taken to obtain the maximum possible number of LEED points for energy performance. This analysis was not taken as far as necessary to show the overall amount of energy saved compared to the perscribed.

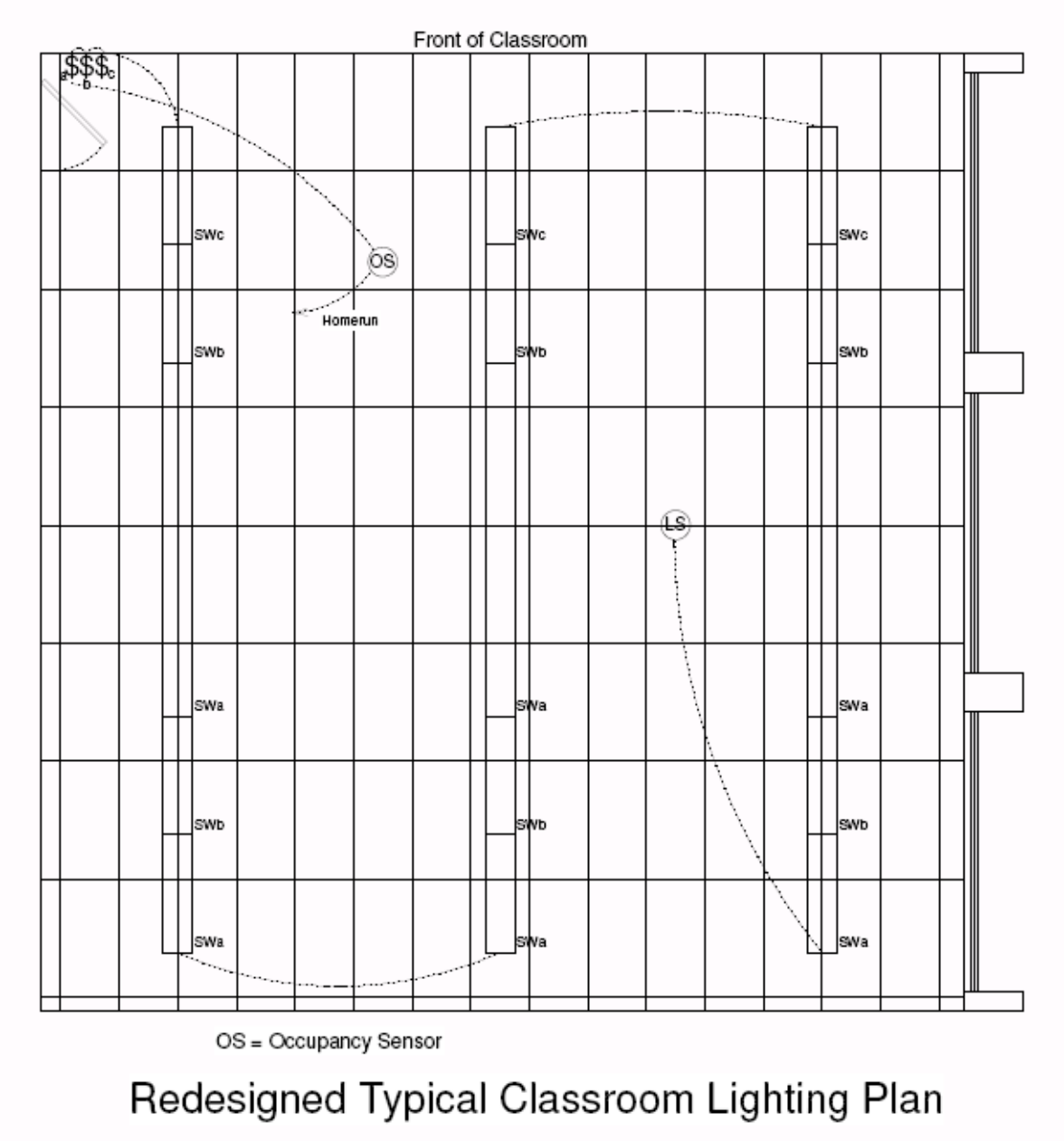


Figure 14: Redesigned classroom lighting layout

Conclusion:

Lighting systems in buildings can consume a large amount of energy in a building and with recent innovations in technology to control these systems; managing energy consumption is becoming easier. Occupancy sensors are a good way to prevent energy from being wasted when the room is vacated. With the thousands of dollars that can be saved annually by installing these in every classroom and even more if installed in all rooms of the building. Occupancy sensors are definitely a product that should be installed for the lighting system to save money. Lighting sensors are also a product that should be implemented at Waynesburg Central High School though the savings are not as large as the occupancy sensors they should still be implemented.

Analysis 3: Structural Redesign

(Structural Breadth)

Problem:

Precast concrete was chosen as a structural system and caused several constructability issues.

Precast concrete is a structural system that is not common practice in Western Pennsylvania. Waynesburg Central High School was designed with a precast concrete structural system which caused for several problems during the construction project. The primary construction method in western Pennsylvania is a structural steel system with a block infill. As a result of contractors not being familiar with the unique construction techniques required for precast concrete erection, many of the columns were set incorrectly.

Goal:

Analyze and compare a structural steel system to the implemented precast concrete system, to determine the constructability issues associated with both as well as determining the most economic system, based on both the constructability challenges and construction cost.

Resources:

RAM Structural System
American Society of Civil Engineers standard 7
RS Means 2009 Edition
Various websites for structural systems

Methodology:

Structural redesign analysis was the majority of the analysis that was done for the thesis project this was known before work even began. Starting the analysis the first thing that was looked at was what other areas of the study this might affect. For the most part the structural redesign was planned as the basis for the construction scheduling portion of this thesis, where rather than creating one long analysis it would be broken into two with the second part also incorporating what was found as a result of the LEED analysis. Once it was determined that this analysis would directly effect the following analysis it had to be done first. To start this analysis the first thing to actually be completed needed to be the redesign itself. Following the redesign could then come; the cost analysis along with the structural summary. The structural summary is an overview of the differences in construction method between structural steel and precast concrete. After both the structural summary and the cost summary were completed the schedule impacts summary then had to be completed.

Structural Summary:

With the original structural system chosen as precast concrete the intent of this analysis is to determine if choosing a structural steel system may have been a more economical choice. The first step in achieving this analysis was to model the building in a structural design program and perform an analysis. RAM structural system was the software that was chosen to model the analysis in, a sample of

this work can be seen in figure 15. Since the structural system was already designed to a specific standard in order to do a fair comparison between the two the same standards had to be used for both analyses. Loads for the initial analysis were given on the prints, which were then used to complete the analysis using RAM. Assumptions were made in order to do this analysis. Since the previously designed structural system incorporated concrete masonry walls between the precast concrete members the same had to be done for the structural steel analysis. The reinforced concrete masonry walls act as the lateral bracing for the structural system meaning that none of the steel frames need to be moment frames or resist any significant lateral load. This allows for the cost and constructability on both the steel and precast concrete systems to be lower and easier to erect.

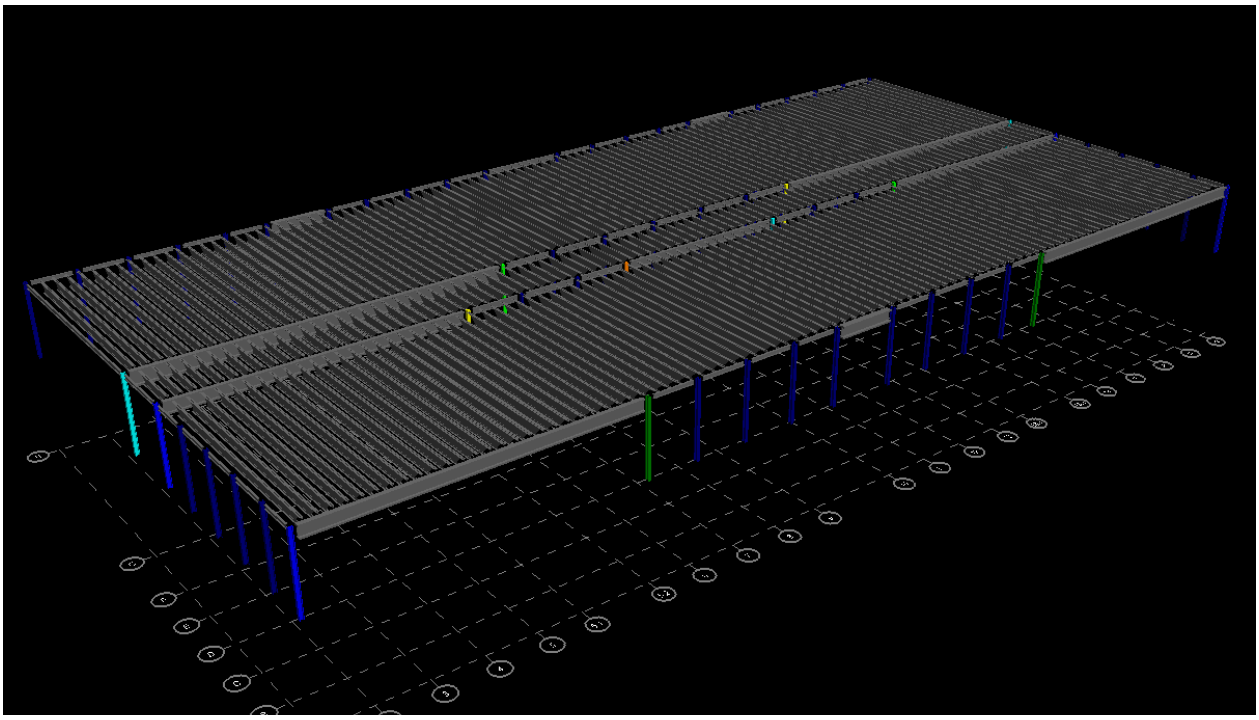


Figure 15: 3D model of structural system from RAM

A RAM model was done for building G which is the science wing addition onto Waynesburg Central High School to determine sizes of the structural members. The location of each column was kept in the same location to not disturb the aesthetic appeal that the architect was trying to achieve. With the use of precast concrete columns and concrete beams across the top acting as a lintel the architect was creating a similar aesthetic as what already exists on the original building with the concrete lintels, but added to this look by adding in the precast concrete columns giving the additions their own distinct look yet keeping a similar feel to the original building. The pictures below depict the original style of column supporting the concrete lintel in figure 16, compared to the precast concrete column with the concrete lintel in figure 17. This look was important to keep and not disrupt when choosing to analyze a possible alternative for the structural system.

Figure 16 and 17: Original above, additions below

Not all the required loads to do the calculations were given directly on the plan and had to be obtained elsewhere. Some materials that needed to be taken into account for the analysis were called out in the specifications which then had to be matched to a particular product. One case of such was with the metal roof decking, the specifications called for a 1 ½" wide rib, 20 gauge steel deck. A deck matching these specifications was found in the Vulcraft catalog on page 7 which is attached in appendix E. The product chosen was a 1.5 B, 20 gauge steel roof deck which weighs 2.14 pounds per square foot. A load that needed to be estimated was the dead load from members that were not part of the structural system like the lights, mechanical ductwork and similar systems. A value of 20 pounds per square foot was assigned for an additional dead load in addition to the self weights of the designated structural members.

The first step to doing this analysis was to set up a grid from which to place columns and insert beams. Once this step was complete the columns and beams were then placed in the grid, however not all columns were at intersections on the grid which made placing them more challenging. Since the structure is being changed from precast concrete to structural steel types of columns needed to be chosen, and since this analysis is being done primarily to make the project more constructible, the most common shape, wide flange, was chosen for all exterior columns. After all of this was determined the predetermined loads were input into the RAM model and the analysis was then completed. Figure 18 shows the completed beam analysis, shown with beam sizes

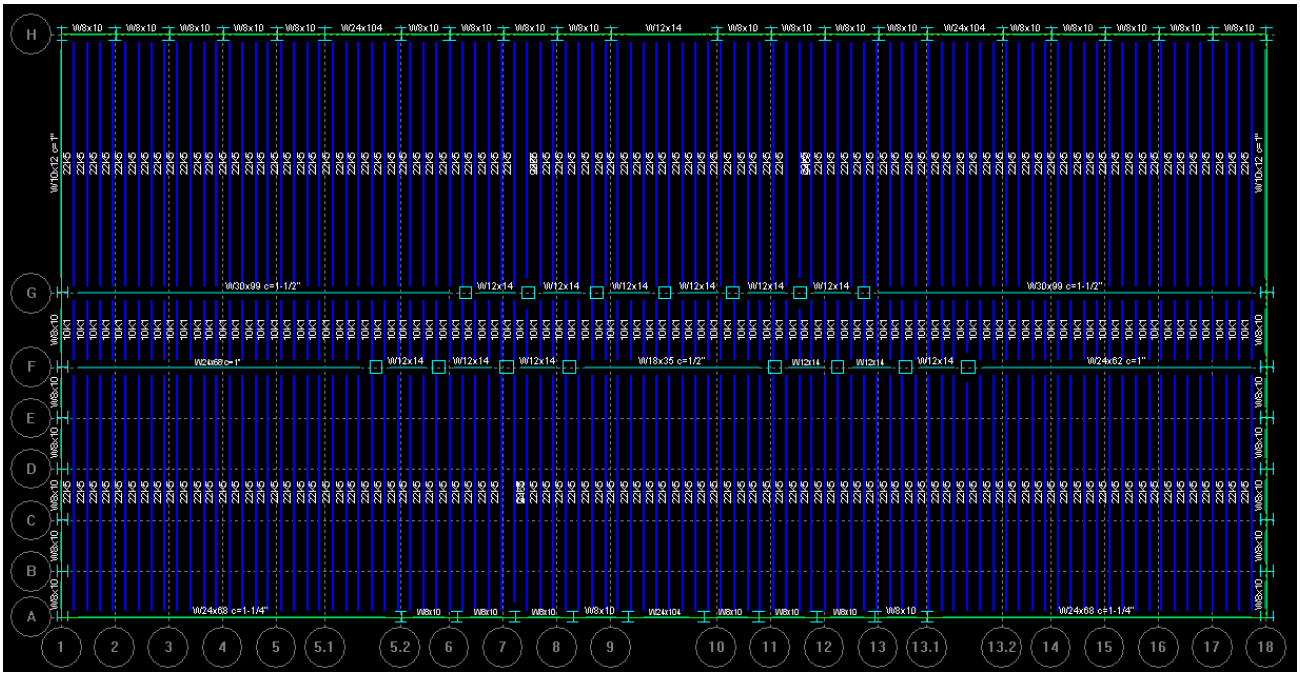


Figure 18: Beam analysis derived from RAM

Cost Summary:

It is not simply enough to come to a conclusion that one system is superior to another based solely on the fact that it is more commonly used than another system, this is why a cost analysis must be

completed. An original structural estimate was already completed based on the precast concrete structural system that was actually installed for Waynesburg Central High School. Since this analysis was already completed many of the numbers remained the same, even after changing the structural system to steel, some of the areas that would often be included in a structural systems estimate are not included. One of the items that were left out of the comparison for this part of the project was the foundations. Since the intent is to keep the same exterior façade there will be no change to the foundation size simply changes made to the spacing of the anchor bolts for each column. Since Waynesburg Central High School is a single story building there is very little variance in the load distribution resulting in beams and columns that are all very similar in size, and also not very large in size.

In doing a cost analysis for the redesigned structural steel system RS means 2009 was used in the same manor it was for the previous structural analysis to ensure a fair comparison between the two systems. When the redesign of the structural steel system was complete all the single story columns were designed as W8x24. Only four columns were determined to be a different size and those were the columns that vertically spanned from the basement to the roof which is about thirty feet, the analysis yielded that W8x31 would be sufficient. A similar scenario occurred when the program designed the steel beams, since all beams are very small spans all beams were determined to be the same size of W8x10. With the structural design complete the lengths and sizes were then placed in a series of tables which can be seen in appendix F. These tables were used to determine a final construction cost of each individual structural system; a summary of these findings is shown for the redesigned structural steel system in table 7, and the original structural system estimate is shown in table 9. Both tables are given to allow for an easier comparison between the two. With further analysis it is seen that by in large the numbers remained the same there were only a few new column sizes added and some additional lineal footage of W8x10 beam added.

Redesigned Structural System Cost

Structural Steel Construction Costs							
Description	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Price/Unit**	**Cost**
Columns Structural, structural tubing, 6x4x5/16x12	18	Ea	375.00	45.00	32.00	452.00	8136.00
Columns Structural, structural tubing, 10x6x3/8x14	4	Ea	880.00	49.00	35.00	964.00	3856.00
Columns Structural, structural tubing, 12x8x1/2x16	15	Ea	1625.00	51.00	36.50	1712.50	25687.50
Columns Structural, W Shape, A992 Steel, 2 tier, W10 x 45	133	LF	74.50	2.36	1.69	78.55	10447.15
Columns Structural, W Shape, A992 Steel, 2 tier, W8 x 24	432	LF	39.50	2.26	1.61	43.37	18736.71
Columns Structural, W Shape, A992 Steel, 2 tier, W8 x 31	119	LF	51.00	2.26	1.61	54.87	6529.53
Structural steel members, W10x49	66	LF	81.00	4.43	3.17	88.60	5847.60
Structural steel members, W16x50	74	LF	82.50	3.05	2.18	87.73	6492.02
Structural steel members, W8x15	86	LF	25.00	4.06	2.90	31.96	2748.56
Structural steel members, W12x35	11	LF	58.00	3.01	2.15	63.16	694.76
Structural steel members, W8x21	361	LF	34.50	4.06	2.90	41.46	14967.06
Structural steel members, W12x26	12	LF	43.00	2.77	1.98	47.75	573.00
Structural steel members, W16x31	36	LF	51.00	2.71	1.93	55.64	2003.04

Structural steel members, W8x10	649	LF	16.50	4.06	2.90	23.46	15225.54
Structural steel members, W8x48	9	LF	79.00	4.43	3.17	86.60	779.40
Structural steel members, W12x16	142	LF	26.50	2.77	1.98	31.25	4437.50
Structural steel members, structural tubing, 10x6x3/8x14	7	Ea	880.00	49.00	35.00	964.00	6748.00
Lintels, Steel Angles, 3 ½x3, ¼" thick, 4'6" long	102	Ea	29.00	12.45		41.45	4227.90
			Total Cost of Structural Steel:				$ 138,137.27

Structural Roofing System Construction Costs							
Description	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Price/Unit**	**Cost**
Open Web Joists, 10CS2, 7.5 lb/lf	1210	LF	7.85	2.94	1.67	12.46	15076.60
Open Web Joists, 22CS4, 16.5 lb/lf	6930	LF	17.25	1.76	1.00	20.01	138669.30
Open Web Joists, 24CS4, 16.5 lb/lf	798	LF	17.25	1.60	0.91	19.76	15768.48
Open Web Joists, 26CS4, 16.5 lb/lf	968	LF	17.25	1.60	0.91	19.76	19127.68
Roof decking, open type, 1 ½" d wide rib, 20 gauge, 50-500 sq.	24405	SF	2.42	0.35	0.03	2.80	68334.00
			Total Cost of Structural Roofing System:				$ 256,976.06

Total Cost of Structural System:	**$ 395,113.33**
Adjusted Total Cost of Structural System:	**$ 383,259.93**

Table 7: Redesigned structural steel cost summary

Table 7 shows only the structural cost associated with the redesign of the structural steel system for Waynesburg Central High School. Since the original intent of using precast concrete columns and beams was to achieve a desire aesthetic the cost comparison can not be made directly between these two without adding additional cost to the redesigned structural steel system in order maintain the desired look. Though it is possible to obtain precast concrete panels that would create the same exterior façade, this was not analyzed as part of this study. Since the rest of the original building has brick surrounding steel columns as the supporting steel structure this is what is analyzed in table 8, which follows.

Brick Pier Cost w/ Total Redesigned Cost

Architectural Brick Construction Costs							
Description	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Price/Unit**	**Cost**
Standard, sel. Common, 4x2-2/3x8	2096	SF	3.60	6.45		10.05	21064.80
			Total Cost of Structural System:				**$ 21,064.80**

Adjusted Total Cost of Structural System:	**$ 20,432.86**
Adjusted Total Cost of Redesigned Structural System w/ Brick Piers:	**$ 403,692.78**

Table 8: Estimated brick façade for columns cost

Original Structural System Cost

Precast Concrete Construction Costs							
Description	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Price/Unit**	**Cost**
Precast Beams, rectangular 20' span, 24" x 44"	18.0	Ea	2000.00	131.00	79.00	2210.00	39780.00
Precast Beams, rectangular 40' span, 24" x 52"	3.0	Ea	4850.00	263.00	158.00	5271.00	15813.00
Precast Beams, rectangular 20' span, 18" x 36"	6.0	Ea	1475.00	131.00	79.00	1685.00	10110.00
Precast Columns, rectangular to 24' high, large columns	568.5	LF	184.00	22.00	13.15	219.15	124591.16
			Total Cost of Precast Concrete:				$ 190,294.16

Structural Steel Construction Costs							
Description	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Price/Unit**	**Cost**
Columns Structural, structural tubing, 6x4x5/16x12	18	Ea	375.00	45.00	32.00	452.00	8192.50
Columns Structural, structural tubing, 10x6x3/8x14	4	Ea	880.00	49.00	35.00	964.00	3615.00
Columns Structural, structural tubing, 12x8x1/2x16	15	Ea	1625.00	51.00	36.50	1712.50	25687.50
Columns Structural, W Shape, A992 Steel, 2 tier, W10 x 45	133	LF	74.50	2.36	1.69	78.55	10447.15
Structural steel members, W10x49	66	LF	81.00	4.43	3.17	88.60	5847.60
Structural steel members, W16x50	74	LF	82.50	3.05	2.18	87.73	6492.02
Structural steel members, W8x15	86	LF	25.00	4.06	2.90	31.96	2748.56
Structural steel members, W12x35	11	LF	58.00	3.01	2.15	63.16	694.76
Structural steel members, W8x21	361	LF	34.50	4.06	2.90	41.46	14967.06
Structural steel members, W12x26	12	LF	43.00	2.77	1.98	47.75	573.00
Structural steel members, W16x31	36	LF	51.00	2.71	1.93	55.64	2003.04
Structural steel members, W8x10	84	LF	16.50	4.06	2.90	23.46	1970.64
Structural steel members, W8x48	9	LF	79.00	4.43	3.17	86.60	779.40
Structural steel members, W12x16	142	LF	26.50	2.77	1.98	31.25	4437.50
Structural steel members, structural tubing, 10x6x3/8x14	7	Ea	880.00	49.00	35.00	964.00	7023.43
Lintels, Steel Angles, 3 1/2x3, 1/4" thick, 4'6" long	23	Ea	29.00	12.45		41.45	939.53
			Total Cost of Structural Steel:				$ 96,418.69

Structural Roofing System Construction Costs							
Description	**Quantity**	**Units**	**Material**	**Labor**	**Equipment**	**Price/Unit**	**Cost**
Open Web Joists, 10CS2, 7.5 lb/lf	1210	LF	7.85	2.94	1.67	12.46	15076.60
Open Web Joists, 22CS4, 16.5 lb/lf	6930	LF	17.25	1.76	1.00	20.01	138669.30
Open Web Joists, 24CS4, 16.5 lb/lf	798	LF	17.25	1.60	0.91	19.76	15768.48
Open Web Joists, 26CS4, 16.5 lb/lf	968	LF	17.25	1.60	0.91	19.76	19127.68
Roof decking, open type, 1 1/2" d wide rib, 20 gauge, 50-500 sq.	24405	SF	2.42	0.35	0.03	2.80	68334.00

Total Cost of Structural Roofing System:	$ 256,976.06
Total Cost of Structural System:	**$ 543,688.91**
Adjusted Total Cost of Structural System:	**$ 527,378.24**

Table 9: Original structural system estimate

Schedule Impacts:

One area that was initially thought to result in several changes to the schedule was the change from precast concrete to structural steel. Upon further analysis it was found that there is actually minimal difference in the scheduling of precast concrete buildings compared to structural steel buildings. Much of this analysis consisted of conversations with a few members in the industry to try to understand the differences between the scheduling of the two systems, then once the differences are known to apply them to Waynesburg Central High School. After speeking with a few of the industry members it was determined that there are almost no schedule impacts from switching structural systems.

Figure 19: Column anchor system to foundation

Though the two systems are very different in the nature of the structure the only part being analized in this section is the schedule differences, and in terms of scheduling a one story building like Waynesburg Central High School they are almost the same. Both precast concrete and structural steel have very similay lead times required for procurement. Both system will be trucked on site and simply need to be lifted by a crane and set. The orriginal schedule for the precast concrete erection had the precast columns and beams being delivered and erected on the same day. No change is required for the structural steel system since they as well will be delivered by truck and can be picked and set straight from there just as the precast concrete columns were, thus saving time by not lifting the members multiple times. This process does require a greater amount of planning from the plant on delivery but can be done for both systems and was infact done for the precast concrete system.

Figure 20: Precast columns on base plate anchored to foundation

One of the major concerns in scheduling is the duration of each activity, and with different systems even though they have the same sequence of activities some may take longer to complete for one then the other. In this case the comparison is between the setting of precast concrete and the setting of structural steel. At Waynesburg Central High School the precast concrete columns were set on a foundation that had preset bolts pertruding that the columns slid over and then washers and nuts were placed to make a secure connection. The foundation with preset bolts is shown in figure 19. The system shown in figure 19 is almost the same connection that is commonly done for structural steel erection, the only difference being the spacing of the pertruding bolts. Since there is a base plate on the bottom of each precast concrete column, as shown in figure 20, the same as what is used on the base of structural steel columns. The connections for the precast concrete system and the structural steel system will take the same ammount of time to make. With the connections being so similar in nature the end result is that a structural steel system at Waynesburg Central High School will result in almost no changes to the original schedule for a precast concrete structural system. When all the similarities in construction method are taken into consideration and put into the original schedule there is very little that changes between the two schedules.

Conclusion:

After analyzing the information from all the different sources, results all tend to point to structural steel being a better alternative then precast concrete. There are several pieces of evidence that point to this the first of which is that steel is a more common structural system in western Pennsylvania, which will result in a more efficient construction sequence and crews that are more experienced performing the work resulting in higher quality work being completed. Constructability of the structure is not the only reason steel seems to be superior to a precast concrete structural system; cost also leads to the conclusion that a steel system would be more economical. With the cost of the structural steel system being an estimated $123,500 savings over the precast concrete system it would be strongly recommended to use the steel system. With the proposed change of the structural system it would also change some of the exterior façade and make it look more like the original building. By making the proposed change to the building it not only saves a significant amount of money but also makes the architecture of the new and old building match even more closely. Changing the structural system from precast concrete to structural steel is a change that should certainly be made.

Analysis 4: Construction Scheduling

Problem:

Multiple Phase construction projects create a need for elaborate schedules, resulting in congested work sites.

Waynesburg Central High School is a multiple phase construction project having 12 separate phases. On a construction project that has several areas under construction at the same time the lay down area is a large point of concern, because multiple contractors will have items being delivered for different phases of the project. Deliveries for each of the contractors need to be kept separate and accessible at all times as to not impede the construction process. LEED construction projects are no different from a traditional multi phase construction project there is simply more lead time necessary for several of the items.

Goal:

To compare the site plans and phasing sequence that exist with what is necessary for a LEED certified project, and create a modified schedule and series of site plans.

Methodology:

Start by analyzing the original site plans, and schedule to compare the logistics in order to make sure there would be no complications for LEED certification, as well as analyze any differences that may need to be made in order to switch to a structural steel system. Compare the recent findings to the original schedule and make adjustments according to the finding both for the structural system and the LEED certification. Create new site plans for Waynesburg Central High School incorporating new findings from both the LEED analysis and the Structural steel analysis. Create a write up describing the findings and a summary of the work done.

Schedule Impacts:

Time is money is an old phrase that proves true in the construction world because every day a project is delivered late someone is paying a penalty for it. Schedule impacts often come as a result of an issue that is unforeseen the object of creating a good schedule is to foresee issues that may arise and have a plan in place to handle it. In the case of Waynesburg Central High School having a manageable schedule is very important due to the complex nature of the sequencing. Waynesburg Central High School is a twelve phase project with almost as many different start dates and similarly with completion dates. To ensure that each phase is handed over for occupancy on time the schedule must be correct and must be executed as precisely as possible. LEED certification is one of the other analyses done for this report and is to be considered for the resulting schedule impacts. Impacts in the schedule created by the redesign from precast concrete to a structural steel system are described in the section titled Analysis 2: Structural Redesign.

LEED certification if done correctly does not have to make the schedule duration any longer then a traditional schedule. Some items for LEED may require some extra lead time to procure and others like wood products it is simply a matter of doing the leg work to find the appropriate supplier. No schedule changes are reflected in the detailed schedule for phases 1 and 2 because it does not necessarily have to result in that. There are so many different alternatives that can be taken in attaining LEED certification

that producing a schedule for one of these scenarios would not be effective. In the end the points chosen to be attained are often left up to the owner, which in this case is Central Greene School District who did not choose to pursue LEED certification. As a result of the varying alternatives in the pursuit of LEED certification schedules have to be made in cooperation with the owners to ensure that all dates are being met as well as the intended LEED points are being achieved.

Structural steel has a very similar erection procedure to that of precast concrete resulting in very little change to the overall schedule. The schedule for phases 1 and 2, contained in appendix G, reflects the place in the construction schedule were steel erection will occur. Since there was so little difference between precast concrete and structural steel an additional schedule was constructed, also in appendix G, showing the detailed erection schedule for building G and building F. The erection process was broken down further by dividing building G into two parts this is shown in figure 21. This separation is also shown in the schedule by the labels 1 and 2 after each of the tasks.

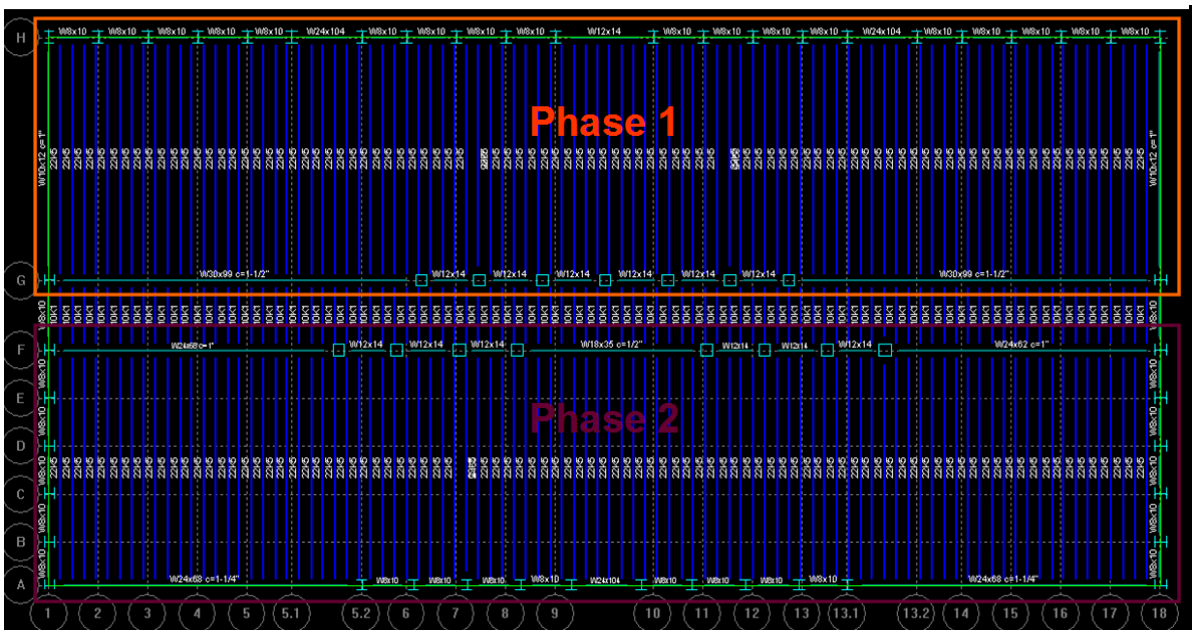


Figure 21: Erection sequencing for building G

Revised Site Plans:

LEED analysis had the greatest impact on the revised site plans resulting in a few minor changes. Initially the site plan had a few dumpsters spread across the site meaning that though dumpsters at times were closer to the working area there was no seperation of materials. With the new implimented scheme there are two lacations for smaller dumpsters throughout the duration of construction. With the small waste management centers stationed throughout these are going to need to be monitored more closely then what large dumpsters would. The waste management plan is shown on the site plan because it would be a good idea to impliment even if the project is not striving for LEED certification. Since the other LEED items are ultimately for the owner to decide these were not inculed on any of the site plans. Every revised site plan shows the location of the two small waste management sations as well as the location in which the small dumpsters will be taken and dumped int larger dumpsters for removal from the site.

Five site plans were created for this analysis to further show the progression through the construction process these plans can be seen in appendix H. Summer on a school construction project is always the bussiest time because the building is not heavily occupied. The site plans reflect this with the number of areas being renovated each summer. The spring of 2009 site plan that was added shows the takeover of the first phase of classroom for renovation. Two more areas will be taken over later to be renovated one just before school lets out for the summer and the other just after school is out for the summer.

Summer 2008 Site Plan attached in appendix H shows the site plan as it will be during the summer of 2008. Since this project is a school and students will still be in attendance the majority of work is done over the summer. As a result of this the summer of 2008 site plan has the most phases under construction at any given time. Excavation is basically complete by this point in the construction project, allowing for a fence to be placed around the main construction area. The site plan depicts the path of the crane in purple. The crane will only be present at a few select times, primarily when the structural steel is being installed as well as the roofing members.

Summer 2009 site plan shows the phases that will be under construction at that time as well as the critical paths and facilities. One of the major differences between the 2008 and the 2009 summer plan is the amount of contractors that will be staffing the site on a full time basis. Much of the work will be closing out this summer meaning that contractors such as the mason and the excavator will not be present. This is why the reduced number of trailers is depicted as well as the topsoil storage pile no longer represented. Construction parking, material staging and the other critical areas do not move from one summer to the next.

Conclusion:

With a lot of thought and analysis, many comparisons and research the end result came out with not to many differences then what the initial design called for. The differences in precast concrete and structural steel for Waynesburg Central High School turned out to be so miniscule that it would never be seen on a full schedule. This is why alternative schedules were created allowing for the steps of the structural steel system to be shown in more detail. Site plans were a similar scenario with not many alterations from the original designs. Five site plans were developed in an effort to help contractors understand the areas and amount of work that will be going on during a given time period.

Appendix A:

Soil Samples

Civil & Environmental Consultants, Inc.
333 Baldwin Road
Pittsburgh, PA 15205

BORING NUMBER B-7

CLIENT Foreman Architects Engineers
PROJECT NAME Additions to Waynesburg Central High School
PROJECT NUMBER 061-577
PROJECT LOCATION Waynesburg, Greene County, Pennsylvania
DATE STARTED 4/5/07 COMPLETED 4/5/07
GROUND ELEVATION 988 ft BACKFILL Cuttings
DRILLING CONTRACTOR Test Boring Services, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger
BEFORE CORING NA
CEC REP ALT CHECKED BY EMJ
AT END OF DRILLING Dry
NOTES Automatic hammer
AFTER DRILLING Immediately Backfilled

ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)
		Brown and orange sandy CLAY, trace mica, moist, medium stiff to very stiff, (RESIDUAL SOIL)	0	SS 1	100	0-3-3 (6)	
985				SS 2	100	5-8-9 (17)	
			5				
		Tan and orangey brown fine SAND, and clay, moist, medium dense, (RESIDUAL SOIL)		SS 3	100	5-8-11 (19)	
980							
		Wet Spoon at 9.0 ft	10	SS 4	100	4-6-6 (12)	
		Gray decomposed SHALE, trace sand, trace mica, dry to moist, stiff to hard, (RESIDUAL SOIL)		SS 5	100	4-6-5 (11)	
975			15				
				SS 6	100	10-17-50/0.3	
		Bottom of hole at 16.3 feet.					

▲ SPT N VALUE ▲
20 40 60 80
PL MC LL
20 40 60 80
☐ FINES CONTENT (%) ☐
20 40 60 80

50/0.3

CEC CUSTOM LOG 061-57-1.GPJ CEC.GDT 5/22/07

2005116

Civil & Environmental Consultants, Inc.
333 Baldwin Road
Pittsburgh, PA 15205

BORING NUMBER B-4

CLIENT Foreman Architects Engineers
PROJECT NAME Additions to Waynesburg Central High School
PROJECT NUMBER 061-577
PROJECT LOCATION Waynesburg, Greene County, Pennsylvania
DATE STARTED 4/3/07 COMPLETED 4/3/07
GROUND ELEVATION 1021 ft BACKFILL Cuttings
DRILLING CONTRACTOR Test Boring Services, Inc.
GROUND WATER LEVELS:
DRILLING METHOD Hollow Stem Auger & NQ Core
BEFORE CORING Dry
CEC REP EMJ CHECKED BY JFB
AT END OF DRILLING 2.3 ft / Elev 1018.7 ft
NOTES Automatic hammer
24hrs AFTER DRILLING 3.3 ft / Elev 1017.7 ft

ELEVATION (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)
			0				
1020		Topsoil - 0.2 ft, (TOPSOIL) Brown and orange sandy CLAY, some rock fragments, trace mica, moist, very soft to hard, (RESIDUAL SOIL)		SS 1	93	1-1-1 (2)	
				SS 2	100	14-50/0.4	
		Tan and gray MICACEOUS SANDSTONE, moderately weathered to slightly weathered, very broken to broken, medium hard to hard, orange staining, inclined fractures @ 30 degrees.	5	NX 1	100 (0)		
1015							
		Tan and gray SANDSTONE, moderately weathered to slightly weathered, very broken to broken, medium hard to hard, trace mica.	10	NX 2	48 (0)		
1010							
		Shaley gray sandstone at 15.0 ft	15	NX 3	74 (8)		
1005							
		Bottom of hole at 18.9 feet.					

▲ SPT N VALUE ▲
20 40 60 80
PL MC LL
20 40 60 80
☐ FINES CONTENT (%) ☐
20 40 60 80

50/0.4

CEC CUSTOM LOG 061-57-1.GPJ CEC.GDT 5/22/07

2005116

Appendix B:

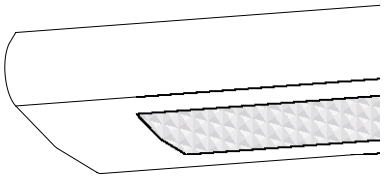
Specified Fixture Specifications

SERIES 10

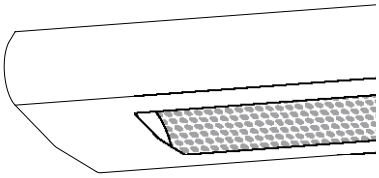
5 DOWNLIGHT SHIELDING OPTIONS

Series 10 meets every need with shieldings that are easily changed. Choose from:

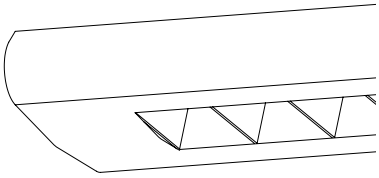
A12 DIFFUSER



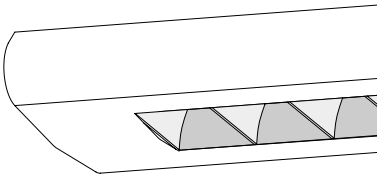
PERF SHIELD



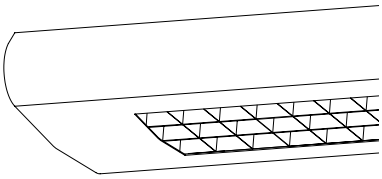
WHITE CROSS BLADE



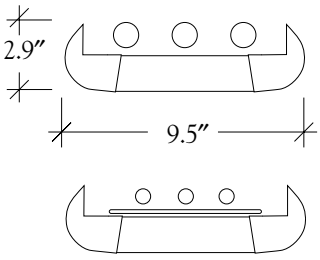
PARABOLIC LOUVER



1.5" PARACUBE



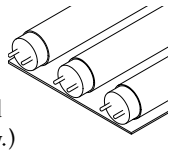
2 LAMP/BALLAST SYSTEMS



All standard ballast systems are available: 1, 2, or 3 lamp T8 or T5HO. (Diffuser included with T5HO lamps.)

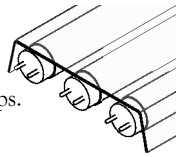
OPTIONAL ACCESSORIES

Lamp Guard



Clear acrylic, fits between lamps and shielding. (T8 only.)

Dust Cover

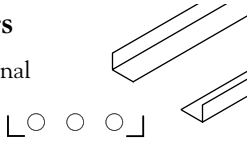


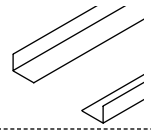
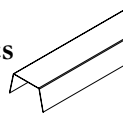
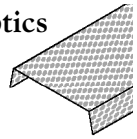
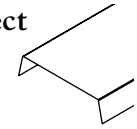
Fits on top of lamps. Clear acrylic.

8 UPLIGHT CONTROL OPTIONS

Standard 91W or Optional EP Side Reflectors

Choose between standard 91W (white side reflectors) or optional Extended Performance (EP - specular side reflectors) and pair them with one of the uplight choices below.



with	**"Open"** 	The "Open" option comes with side reflectors and no special optical control above the lamps.
or	**Controlled Center Optics** 	**Three fixtures in one!** Use dual switching for bi-directional control. Turn side lamps off for tightly controlled centered downlight 5/95. Side lamps on and center off directs light 75/25. All 3 lamps on 55/45. Especially suitable for classrooms.
or	**Soft Top Optics** 	Use the **Soft Top Optics** above the lamps to diffuse and soften uplight and direct downlight where needed. Useful in applications where less light is desired on the ceiling. 30/70
or	**Totally Direct Optics** 	Series 10 fixtures can easily be converted to 100% downlight by adding **Totally Direct Optics** above the lamps. 0/100

Form 3060.06/01

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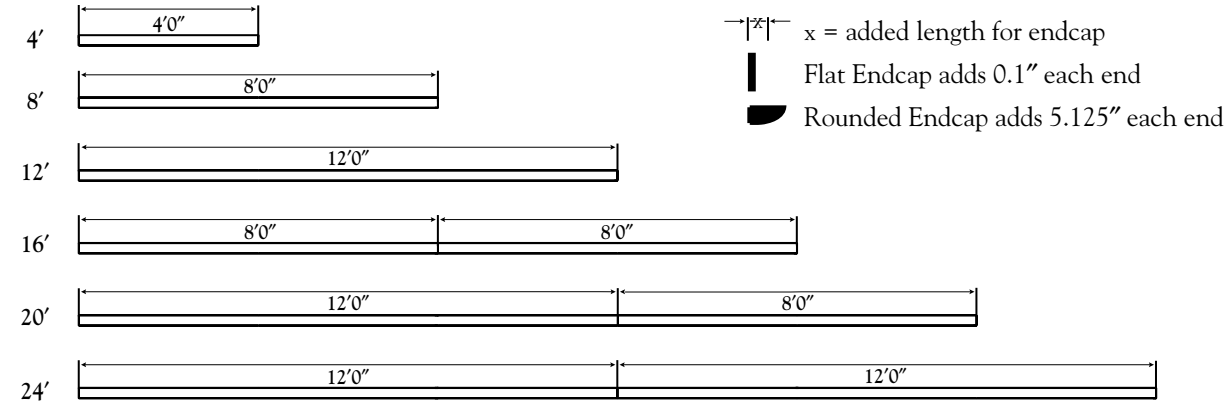
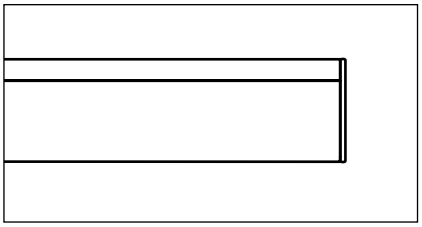
LENGTHS Fixture lengths align easily with standard grid ceiling systems.

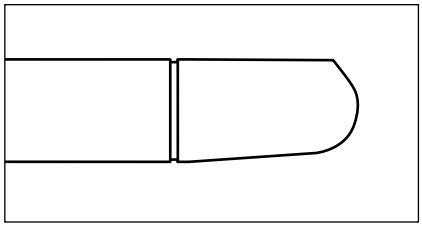


> 24′ Additional **4′**, **8′**, or **12′** segments can be added to create runs as long as required.

ENDCAPS

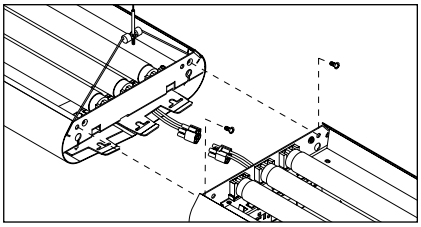


Standard flat endcap extends 0.1″ from each end of the fixture.



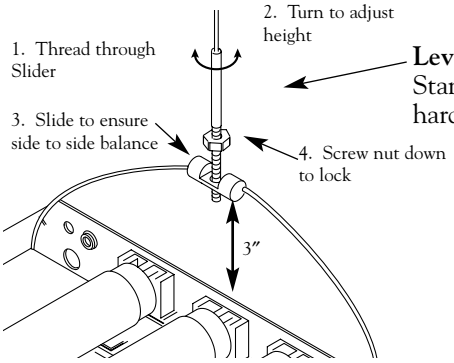
Optional rounded endcap with 0.100″ reveal extends 5.125” from each end of the fixture.

JOINING



Plug-together wiring and die-formed interlocking joiners are standard on all fixtures. Two screws secure the joint.

STANDARD FIXTURE SUPPORT

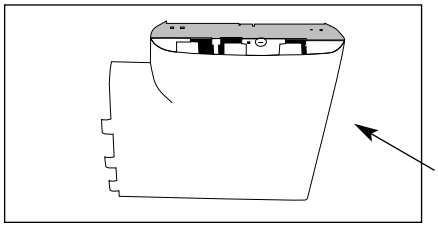


Level & Lock Assembly™ with Standard Semi-Adjustable hanging hardware.

Standard Level and Lock™ feature allows fixture to be leveled from side to side. Insert threaded end of Semi-Adjustable hardware into slider. Screw the nut down to secure the cable to the slider.

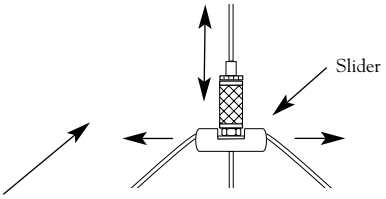
NOTE: Level and Lock™ assembly is 3″ above fixture top.

OPTIONAL 90° CORNER



Optional 90° corner joins fixtures into unique patterns.

OPTIONAL FULLY ADJUSTABLE CABLE SUPPORT



Level & Lock Assembly™ with Optional Fully Adjustable hanging hardware.

Optional Fully Adjustable aircraft cable with Safety Stop simplifies installations on variable ceiling heights. Cable length can vary from 6″ to 150″. Depress the head of the fitting to allow continuous adjustment of the cable length, then level side to side and rotate nut down to tighten securely.

Finelite, Inc. ◇ 30500 Whipple Road ◇ Union City, CA 94587-1530 ◇ 510 / 441-1100 ◇ FAX: 510 / 441-1510 ◇ www.finelite.com

COMBINATION GUIDE FOR T8 AND T5HO

SHIELDING	OPTICS			
	91W or EP Optics Order Code: 91W Order Code: EP	**Controlled Center Optics** Order Code: CCO	**Soft Top Optics** Order Code: STO	**Totally Direct Optics** Order Code: TDO
Affordable Brightness **A12 Diffuser** Acrylic Lens Order Code: A12	UP/DN 85/15 85/15 80/20			
Subtle Brightness **Perf Shield** White Order Code: PS	UP/DN 90/10 90/10 90/10			
Excellent General Purpose **White Cross Blade Baffle** White Order Code: WCB	UP/DN 70/30 75/25 70/30	UP/DN Lamps ON 10/90 1 70/30 2 55/45 3	UP/DN 30/70 35/65 30/70	UP/DN 0/100 0/100 0/100
VDT Compatible **Parabolic Louver** Semi-Specular Order Code: PLV	UP/DN 70/30 75/25 70/30	UP/DN Lamps ON 5/95 1 75/25 2 55/45 3	UP/DN 30/70 35/65 35/65	UP/DN 0/100 0/100 0/100
Tight Control **1.5" Paracube** Semi-Specular Order Code: CUB	UP/DN 75/25 80/20 75/25		UP/DN 40/60	UP/DN 0/100

FINELITE

Series 10

S10 Ordering Key

OPTICS \ SHIELDING	A12 A12 Diffuser	PS Perf Shield	WCB White Cross Blade	PLV Parabolic Louver	CUB Paracube
OPEN (91W or EP)	1/2/3 T8 1/2/3 T5HO	1/2/3 T8 1/2/3 T5HO	1/2/3 T8 1/2/3 T5HO	1/2/3 T8 1/2/3 T5HO	1/2/3 T8 1/2/3 T5HO
CCO* Controlled Center Optics			3 T8 3 T5HO	3 T8 3 T5HO	
STO Soft Top Optics			1/2/3 T8 1/2/3 T5HO	1/2/3 T8 1/2/3 T5HO	3 T8 3 T5HO
TDO Totally Direct Optics			1/2/3 T8 1/2/3 T5HO	1/2/3 T8 1/2/3 T5HO	3 T8 3 T5HO

* order dual circuit

SPECIFICATIONS

CONSTRUCTION: 20 gauge die-formed steel body with 14 gauge die-formed internal joiner system, plug-together wiring standard. All components hard tooled to tolerances of 0.005″.

ENDCAPS: Flat Endcap (FE) standard, 20 gauge die-formed steel endcaps, adds 0.1″ at each end. *Optional: Rounded Endcap (RE), injection molded sculpted endcap with 0.100″ reveal. No exposed fasteners, holes or knockouts. Rounded Endcap adds 5.125″ at each end.*

REFLECTORS: Standard 91% reflective white (91W) side reflectors. *Optional: Extended Performance specular (EP) side reflectors.*

UPLIGHT OPTICAL OPTIONS:

- **Open** No uplight optical control.
- **CCO** *Controlled Center Optics, covers center lamp, 100% downlight (center only);*
- **STO** *Soft Top Optics, 0.063″ perforations cover the top surface;*
- **TDO** *Totally Direct Optics, solid top above lamps, 0/100.*

DOWNLIGHT SHIELDING OPTIONS:

- **A12** A12 Diffuser lens, acrylic UV stabilized, 0.100″ thick;
- **PS** Perf Shield, white, curved shield with 0.063″ perforations covering the surface;
- **WCB** White Cross Blade Baffle, white cross blades 3.0″ apart;
- **PLV** Parabolic Louver, semi-specular louvers 3.0″ apart;
- **CUB** 1.5″ Paracube, semi-specular.

ACCESSORIES: *Optional Lamp Guard, 063 clear acrylic, UV stabilized; Optional Dust Cover, clear acrylic. NOTE: Will significantly impact light level performance.*

ELECTRICAL: 120 or 277 volt prewired. Fixture and electrical components UL/C-UL listed and fixture will bear UL/C-UL labels. *Optional Adders: 347 volt prewired, dual circuit, emergency circuits, emergency battery packs.*

LAMPING: 1, 2, or 3 lamp cross sections with T8 or T5HO lamps. Lamp diffuser included with T5HO lamps. For T5 lamps contact factory.

BALLAST: Electronic instant start ballast <20% THD standard. *Optional Adders: Rapid Start, High Output T8, High Output T5, Full Size Battery Backup Units, Dimming Ballast (controls by others).*

MOUNTING: Standard semi-adjustable aircraft cable (AC) (± 0.5″) in lengths of 12″, 15″, 18″, 21″, 24″, 27″, 30″, 36″. Mounting connects to fixture with factory installed **Level and Lock Assembly™** which allows side to side fixture leveling and locks it into place. **NOTE:** Level and Lock™ assembly is 3″ above top of fixture.

Optional: Fully adjustable aircraft cable (FA) with Safety Stop in lengths up to 150″.

SUPPORT CABLES: Stainless steel with plated hardware.

FEED: 18 gauge straight cord. 14 gauge feed cord used when fixture current exceeds 6 amps. *Optional Adders: Coil Cord Feed.*

FINISHES: Finelite White standard. 185 colors available from Tiger Drylac's RAL color chart for a nominal adder.

LENGTHS: 4′, 8′, 12′ section lengths can be combined to make longer runs.

WEIGHT: Fixture weight = 3 lb/ft.

WALL MOUNT: Complimentary wall mount available.

ORDERING INFORMATION S10 – A12 – 32′ – 3T8 – DC – 91W – CCO – 277 – AC 18″ - FE

- Finelite **Series 10**
- Shielding (A12, PS, WCB, PLV, CUB)
- Run length (4′, 8′, 12′ multiples standard)
- Number of lamps in cross section (1, 2, 3, T8 or T5-HO)
- Circuiting (SC-single circuit, DC-dual circuit)
- Reflector System (91W, EP)
- Uplight Optical Options (Open, CCO, STO, TDO)
- Voltage (120, 277, 347 Volts)
- Mounting (AC/FA)
- Endcap FE (flat), RE (rounded)

Form 3060.06/01

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FINELITE

Series 10 Photometric Reports

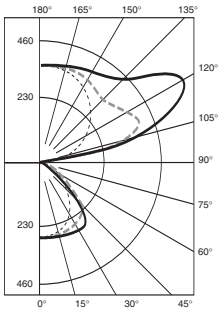
Product Photometry and ies files are also available online at www.finelite.com.
For layouts or additional photometry, contact your local representative or the factory.

S10: WCB - OPEN - 1 T8 - EP

(ITL REPORT 50843)

70% Uplight
30% Downlight

EFFICIENCY = 90.1%



CANDELA DISTRIBUTION						FLUX
	0.0	22.5	45.0	67.5	90.0	
0	281	281	281	281	281	
5	279	281	280	279	279	27
15	254	261	271	283	289	77
25	221	234	256	283	298	119
35	180	201	235	282	311	150
45	136	162	209	210	186	142
55	92	120	111	79	53	88
65	50	65	49	55	58	56
75	26	31	30	39	37	35
85	6	9	8	11	9	10
90	0	0	0	0	0	
95	18	77	86	97	87	87
105	76	200	315	352	342	278
115	142	205	410	528	550	363
125	197	236	355	501	548	327
135	248	276	328	405	437	263
145	289	308	337	363	376	211
155	320	330	347	358	364	159
165	341	343	349	355	355	99
175	349	349	349	347	348	33
180	348	348	348	348	348	

itl boulder

LEGEND:
0-deg.
45-deg.
90-deg.

ZONAL LUMEN SUMMARY

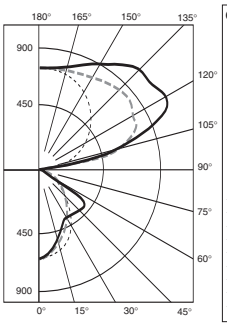
ZONE	LUMENS	%LAMP	%FIXT
0-30	222	7.9	8.8
0-40	373	13.3	14.8
0-60	602	21.5	23.9
0-90	702	25.1	27.8
90-120	729	26.0	28.9
90-130	1056	37.7	41.8
90-150	1529	54.6	60.6
90-180	1820	65.0	72.2
0-180	2523	90.1	100.0

S10: WCB - OPEN - 2 T8 - EP

(ITL REPORT 50844)

75% Uplight
25% Downlight

EFFICIENCY = 88.4%



CANDELA DISTRIBUTION						FLUX
	0.0	22.5	45.0	67.5	90.0	
0	621	621	621	621	621	
5	615	616	608	605	599	57
15	561	553	525	508	497	149
25	485	462	411	389	381	195
35	396	357	302	339	367	217
45	299	253	263	331	377	228
55	197	167	222	316	379	218
65	97	104	142	146	138	127
75	49	50	51	56	55	56
85	11	14	14	15	14	15
90	0	0	0	0	0	
95	32	127	136	154	140	140
105	147	367	535	552	537	476
115	277	484	741	936	973	682
125	398	548	815	954	1018	677
135	507	588	811	972	1032	607
145	601	642	778	898	941	485
155	673	692	730	795	830	345
165	719	724	734	745	752	208
175	740	741	736	732	734	70
180	738	738	738	738	738	

itl boulder

LEGEND:
0-deg.
45-deg.
90-deg.

ZONAL LUMEN SUMMARY

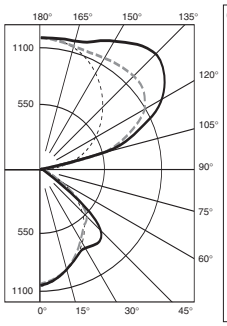
ZONE	LUMENS	%LAMP	%FIXT
0-30	401	7.2	8.1
0-40	618	11.0	12.5
0-60	1064	19.0	21.5
0-90	1262	22.5	25.5
90-120	1298	23.2	26.2
90-130	1975	35.3	39.9
90-150	3067	54.8	61.9
90-180	3690	65.9	74.5
0-180	4952	88.4	100.0

S10: WCB - OPEN - 3 T8 - EP

(ITL REPORT 50845)

70% Uplight
30% Downlight

EFFICIENCY = 88.4%



CANDELA DISTRIBUTION						FLUX
	0.0	22.5	45.0	67.5	90.0	
0	1059	1059	1059	1059	1059	
5	1049	1050	1044	1039	1034	99
15	960	956	945	945	943	268
25	835	825	807	824	839	380
35	686	669	667	761	831	447
45	518	507	583	636	670	447
55	346	349	401	442	473	357
65	178	197	216	211	195	205
75	89	94	97	108	108	105
85	19	24	23	27	26	27
90	0	0	0	0	0	
95	44	115	113	126	114	127
105	221	508	566	539	508	525
115	423	686	995	1130	1136	880
125	614	801	1152	1349	1405	962
135	788	895	1178	1395	1471	889
145	939	1002	1169	1321	1381	730
155	1058	1090	1144	1223	1265	535
165	1135	1144	1163	1178	1188	329
175	1170	1172	1167	1161	1163	111
180	1168	1168	1168	1168	1168	

itl boulder

LEGEND:
0-deg.
45-deg.
90-deg.

ZONAL LUMEN SUMMARY

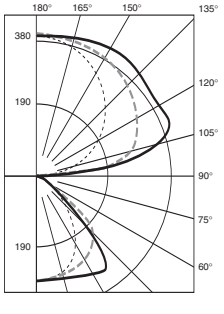
ZONE	LUMENS	%LAMP	%FIXT
0-30	746	8.9	10.1
0-40	1193	14.2	16.1
0-60	1997	23.8	26.9
0-90	2334	27.8	31.4
90-120	1532	18.2	20.6
90-130	2495	29.7	33.6
90-150	4114	49.0	55.4
90-180	5088	60.6	68.6
0-180	7422	88.4	100.0

S10: WCB - OPEN - 1 T8 - 91W

(ITL REPORT 50799)

70% Uplight
30% Downlight

EFFICIENCY = 89.4%



CANDELA DISTRIBUTION						FLUX
	0.0	22.5	45.0	67.5	90.0	
0	287	287	287	287	287	
5	285	286	285	285	284	27
15	260	266	276	287	293	78
25	226	239	261	288	304	122
35	186	205	241	288	318	154
45	141	166	215	217	196	147
55	96	124	117	82	56	92
65	54	68	52	58	65	59
75	28	32	32	40	39	36
85	6	9	8	11	9	10
90	0	0	0	0	0	
95	17	96	91	124	91	100
105	83	168	265	343	359	260
115	158	219	304	377	401	292
125	222	267	334	387	401	291
135	278	310	362	402	412	274
145	326	345	377	406	418	235
155	361	370	387	401	408	178
165	382	386	390	394	397	110
175	392	393	392	390	390	37
180	392	392	392	392	392	

itl boulder

LEGEND:
0-deg.
45-deg.
90-deg.

ZONAL LUMEN SUMMARY

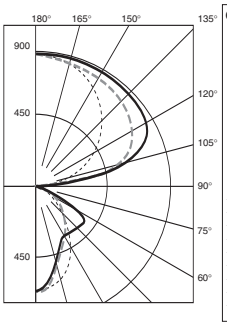
ZONE	LUMENS	%LAMP	%FIXT
0-30	227	8.1	9.1
0-40	381	13.6	15.2
0-60	619	22.1	24.7
0-90	724	25.9	28.9
90-120	652	23.3	26.0
90-130	943	33.7	37.7
90-150	1453	51.9	58.0
90-180	1779	63.5	71.1
0-180	2503	89.4	100.0

S10: WCB - OPEN - 2 T8 - 91W

(ITL REPORT 50800)

75% Uplight
25% Downlight

EFFICIENCY = 87.4%



CANDELA DISTRIBUTION						FLUX
	0.0	22.5	45.0	67.5	90.0	
0	618	618	618	618	618	
5	613	612	606	603	598	57
15	559	551	522	506	497	148
25	486	461	409	387	378	195
35	397	357	303	342	370	218
45	302	254	267	334	381	230
55	199	169	225	319	385	221
65	100	107	144	151	147	132
75	49	51	52	58	58	57
85	10	14	14	15	14	16
90	0	0	0	0	0	
95	35	131	133	147	125	138
105	172	330	491	560	555	455
115	332	452	626	765	811	596
125	474	560	700	818	858	614
135	606	667	758	844	874	583
145	718	760	811	861	881	507
155	802	825	855	878	887	393
165	857	865	877	885	893	248
175	884	884	881	877	879	84
180	882	882	882	882	882	

itl boulder

LEGEND:
0-deg.
45-deg.
90-deg.

ZONAL LUMEN SUMMARY

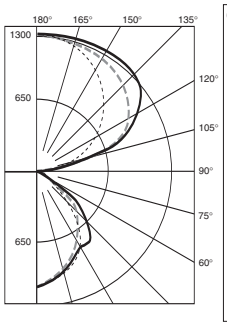
ZONE	LUMENS	%LAMP	%FIXT
0-30	400	7.1	8.2
0-40	618	11.0	12.6
0-60	1070	19.1	21.9
0-90	1275	22.8	26.1
90-120	1188	21.2	24.3
90-130	1803	32.2	36.8
90-150	2892	51.6	59.1
90-180	3617	64.6	73.9
0-180	4892	87.4	100.0

S10: WCB - OPEN - 3 T8 - 91W

(ITL REPORT 50801)

70% Uplight
30% Downlight

EFFICIENCY = 88.5%



CANDELA DISTRIBUTION						FLUX
	0.0	22.5	45.0	67.5	90.0	
0	1072	1072	1072	1072	1072	
5	1067	1064	1056	1051	1045	100
15	974	968	951	952	949	270
25	848	833	814	832	846	383
35	700	678	674	769	840	453
45	534	514	590	645	677	454
55	359	360	411	451	487	366
65	182	205	224	219	206	213
75	92	98	101	112	113	109
85	23	28	27	32	30	31
90	0	0	0	0	0	
95	47	130	123	137	120	136
105	250	465	537	559	545	515
115	482	655	875	967	980	797
125	704	825	1038	1204	1237	901
135	901	984	1143	1272	1317	871
145	1071	1119	1209	1302	1340	758
155	1199	1221	1270	1310	1327	585
165	1285	1288	1301	1315	1324	368
175	1326	1326	1318	1311	1312	126
180	1322	1322	1322	1322	1322	

itl boulder

LEGEND:
0-deg.
45-deg.
90-deg.

ZONAL LUMEN SUMMARY

ZONE	LUMENS	%LAMP	%FIXT
0-30	753	9.0	10.1
0-40	1206	14.4	16.2
0-60	2026	24.1	27.2
0-90	2379	28.3	32.0
90-120	1448	17.2	19.5
90-130	2349	28.0	31.6
90-150	3978	47.4	53.5
90-180	5057	60.2	68.0
0-180	7436	88.5	100.0

Appendix C:

Occupancy Sensor Specifications

Occupancy Sensor
Infrared Ceiling Sensor

OSC04-IOW
OSC15-IOW

The all-digital & microprocessor based OSCxx-I is the most advanced infrared ceiling sensor available. Self-calibrating sensitivity and timer allow the installer to "install & forget."

THE OSCXX-I OCCUPANCY DETECTOR

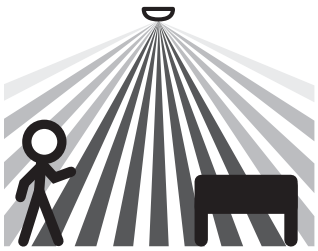
- PASSIVE INFRARED TECHNOLOGY (PIR)
- SIMPLE, FAST INSTALLATION
- SELF-ADJUSTING
- DIGITAL TECHNOLOGY, COMPLETE RELIABILITY
- PHOTOCELL CONTROL
- IMMUNITY TO AIR CURRENTS

GENERAL OPERATION

The OSCxx-IOW Infrared Ceiling Sensor is a low voltage occupancy detector that works in conjunction with the Leviton OSPxx power pack to control lighting. The detector's main function is to turn the lights on or maintain the lights on while movement is detected within the sensor's range and to turn the lights off when the space is left unoccupied.

The sensor uses a small semiconductor heat detector that resides behind a multi-zone optical lens. This Fresnel lens establishes dozens of zones of detection. The sensor is sensitive to the heat emitted by the human body. In order to trigger the sensor, the source of heat must move from one zone of sensing to another. Non-moving hot objects will not cause the lights to turn on.

At a distance close to the sensor, slight movement can be sensed. As the distance away from the sensed increases, the space between the zones of sensitivity increases, and therefore the amount of motion required to trigger the sensor increases.



FEATURES

Small Size: Installed sensor appears almost invisible.
Fast, Simple Installation: Easy ceiling mount, three wire connection (low voltage) and twist-lock sensor attachment.
Self-Adapting: An internal microprocessor continually analyzes, evaluates and adjusts settings. Performance is kept at a maximum and user complaints are eliminated.
Maximum Reliability, Low Cost: All digital circuitry uses a minimum of components.
Timer Setting: Automatic - 30s to 30 min. Manual and Automatic. Test mode - 6 sec.
Ambient Light Recognition: A photocell prevents lights from turning on when the room is adequately lit by natural light.
Non-Volatile Memory: Learned and adjusted settings saved in protected memory are not lost during power outages.

HOW THE ODC04-I AUTOMATICALLY ADAPTS

Condition	Example	Adaptive Reaction
Timer Left In Test Mode - The sensor remains in an 6 sec. test mode.	An installer accidentally leaves the sensor in the 6 sec. timer test mode and the lights may go off or on every 6 sec.	The sensor automatically resets the timer to 10 min after 15 min of test mode.
False-On -The sensor incorrectly turns the lights on.	The sensor detects movement in the corridor or hallway and the room lights turn on.	After an initial movement is sensed, if another movement is not sensed within the timer setting then the delayed off time setting is automatically reduced.
False-Off -The sensor incorrectly turns the lights off.	The sensor does not detect movement because an occupant sits virtually motionless at a desk and the lights turn off.	If motion is sensed within a short period after the lights go off, then the current delayed off-time setting is increased.

A dedicated internal microprocessor continually analyzes the room environment and adjusts itself automatically. The internal timer and infrared sensitivity are automatically adjusted. Once installed, the OSCxx does not require manual adjustment or calibration.

LEVITON SPECIFICATION SUBMITTAL

JOB NAME:		CATALOG NUMBERS:	
JOB NUMBER:			

Leviton Mfg. Co., Inc.
59-25 Little Neck Pkwy • Little Neck, NY 11362-2591 • Tech Line: 1-800-824-3005 • Fax: 1-800-832-9538
Visit our Website at: www.leviton.com

LEVITON® Building a Connected World

Product Specifications

OSC04-IOW
OSC15-IOW

PRODUCT SPECIFICATIONS

Models			
Part Number	**Lens Type**	**Coverage**	**Additional Features**
OSC04-IOW	High Density	450 sq. ft.	Photocell
OSC15-IOW	Extended Range	1500 sq. ft	Photocell

CONTROLS

PIR (Infrared Sensitivity): High to low.
Timer Adjustment (Manual): 30s - 30 min. - Factory set 10 min.
PC (Photocell Adjustment): 20 to 3,000 Lux - Factory set 3,000 Lux (Disable photocell)

DIP switch settings			
Switch	**Switch Functions**		**Switch Settings**
	Bank A	**OFF**	**ON**
A1	N/A	—	—
A2	N/A	—	—
A3	Manual Mode	Auto Adapting Enabled	Auto Adapting Disabled
A4	Walk-Thru Disable	Walk-Thru Enabled	Walk-Thru Disabled
	Bank B		
B1	Override to On	Auto Mode	Lights forced On
B2	Override to Off	Auto Mode	Lights forced Off
B3	Test Mode	OFF→ON→OFF	Enter/Exit Test Mode
B4	LED Disable	LEDS Enabled	LEDS Disabled

INDICATOR

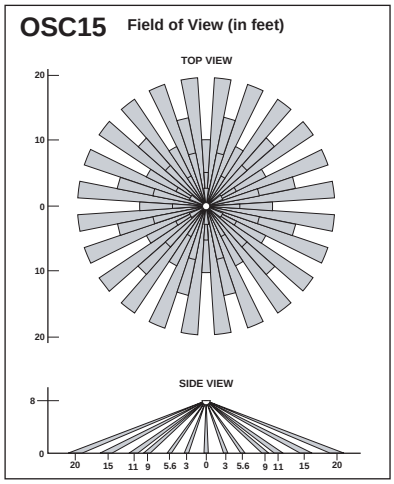
Red LED Lamp: Infrared motion.

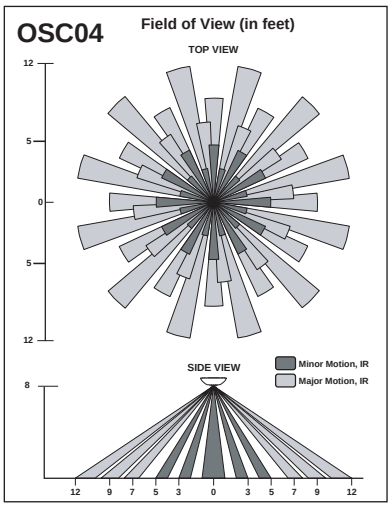
SPECIFICATIONS

Construction: Housing -- Rugged, high-impact, injection molded plastic. Color coded leads are 6" long (16.24 cm).
Size & Weight: 4.5" dia., 1.5" height; 5 oz. (114 mm dia., 38 mm height; 142 g).
Power Requirements: 24 VDC, 20mA from the OSPxx-series power pack.
Output: 24 VDC active high logic control signal with short circuit protection.
Operating Environment: 32°F to 104°F (0°C to 40°C); 0% to 95% relative humidity, non-condensing. For indoor use only.
Warranty: 5 yrs.

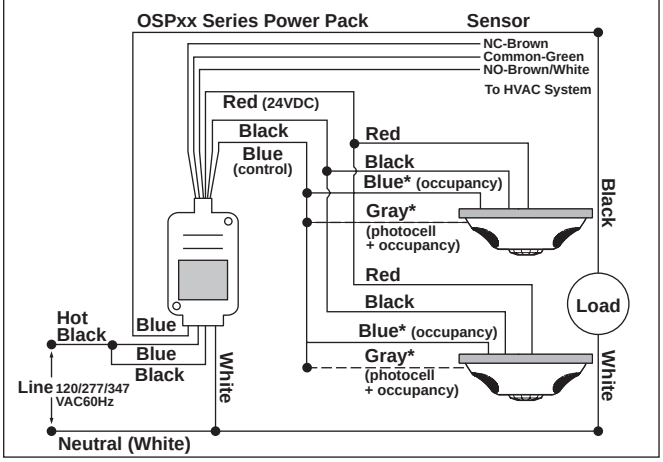
**When the photocell function is not being used, connect the Blue Occupancy Sensor lead to the Blue Power Pack lead. When using the Photocell function, connect the Gray Occupancy Sensor lead to the Blue Power pack lead–Do not use the Blue Occupancy Sensor lead for the photocell function.*

RANGES





PHYSICAL WIRING



SPECIFICATION SUBMITTAL

JOB NAME:	CATALOG NUMBERS:	
JOB NUMBER:		

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LEVITON

OSFHU Fixture-Mounted Infrared High-Bay Occupancy Sensor

The OSFHU self-contained sensor mounts directly to a luminaire or electrical box to provide local occupancy control for either general area or aisle way pattern detection using PIR technology with a microprocessor based digital architecture that minimizes false triggering. The OSFHU provides a trouble-free "install and forget" solution for high-bay lighting control.

- Passive Infrared Technology (PIR)
- Interchangeable lenses for 360° high-bay, 360° low-bay, and aisle way patterns
- Use in warehouses, manufacturing, and other high ceilings
- Cold storage application model available
- Simple, fast installation
- Mounts directly to industrial style fluorescent luminaires
- 8 ft.-40 ft. mounting heights
- 120/277/347 VAC
- 480 VAC

OSFHU

DESCRIPTION

The OSFHU high-bay occupancy sensor is specifically designed for high mounted areas such as warehouses, manufacturing and other high ceiling applications. The OSFHU installs directly to an industrial fluorescent luminaire or an electrical junction box. It is a self-contained sensor and relay that turns individual light fixtures on or off based on occupancy in the detection zone. It comes with three interchangeable lenses for use in either a 360° high-bay or 360° low-bay general area or an aisle way. The OSFHU provides reliable coverage up to 40 ft. mounting heights. The OSFHU is also available in a model for cold storage applications with temperatures as low as -40° F.

To improve the field-of-view for deep body fixtures, a separate offset adapter accessory (OSFOA-00W) can be used to position the sensor below the fixture body. The adapter simply snaps into a 1/2" knockout on the end of the industrial fixture to attach the sensor.

OPERATION

Passive Infrared Technology (PIR) is used to sense occupancy by comparing the infrared energy from an object in motion and the background space. PIR sensors minimize false ON from background environmental conditions such as air movement to provide reliable detection of line-of-sight motion.

INSTALLATION

The OSFHU installs directly to an industrial fluorescent fixture or an electrical junction box through a standard 1/2" knockout using provided lock-nut. Wiring is connected inside the fixture body. For deep body fixtures, the accessory OSFOA is a two piece plastic offset that installs into the fixture 1/2" knockout using the provided lock-nut. Then the OSFHU sensor is installed in one of three, 1/2" punch-outs positioning the OSFHU at the correct field-of-view position flush or below the fixture reflector assembly. Wiring is routed through the OSFOA to the fixture body for wiring.

FEATURES

Fast, Simple Installation: The OSFHU sensor is a self-contained, line voltage sensor that easily installs on individual fixtures using standard 1/2" knockouts. Simply make the electrical connections inside the ballast compartment, install the appropriate, adjustable lens assembly included and the sensor is ready. For deep body fixtures, the OSFOA positions the OSFHU sensor flush or below the bottom of the reflector giving the sensor full field-of-view.

Zero Crossing Circuitry: Relay uses a zero crossing circuitry to provide reliable, long-life operation.

Range and Coverage: The 360° high-bay PIR lens provides a 2:1 spacing to mounting height coverage under 25 ft. mounting and a 1.5:1 for heights up to 40 ft. mounting. The 360° low-bay lens provides 2:1 spacing to mounting height coverage for 8 ft. to 20 ft. mounting. The aisle lens is designed to provide detection of 60 ft. long by 20 ft. wide for heights up to 40 ft. mounting.

LED: Green LED indicates occupancy detection.

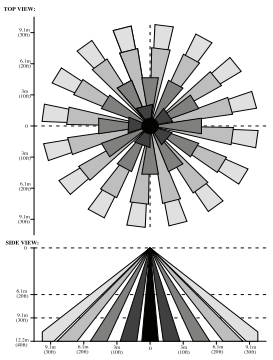
OSFHU-IxW • OSFHU-CxW • OSFOA-00W

Leviton Mfg. Co., Inc. Lighting Management Systems

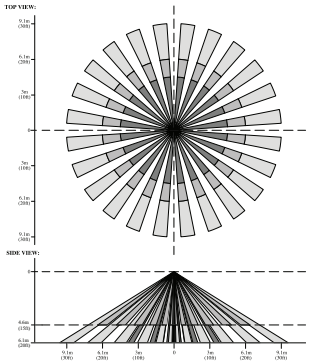
20497 SW Teton Avenue, Portland, OR 97062 1-800-736-6682 Tech Line: 1-800-959-6004 Fax: 503-404-5594 www.leviton.com/lms

LEVITON

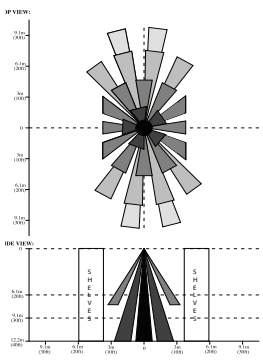
High-Bay 360° FOV



Low-Bay 360° FOV



Aisle FOV



SPECIFICATIONS

Electrical

Input Voltage: 120/277/347 VAC
Input Voltage: 480 VAC
Operational Frequencies: 50/60Hz
Wire Designation: Line-Black, Load-Red, Neutral-White
Load Rating:
Fluorescent Ballasts: 800VA @ 120 VAC
1200VA @ 277 VAC
1500VA @ 347 VAC
2000VA @ 480 VAC
Motor: 1/4 HP Load @ 120V

Environmental

Operating Temperature Range:
OSFHU-IxW: 14°F to 160°F
OSFHU-CxW: -40°F to +40°F
Storage Temperature Range: -14°F to 160°F
Relative Humidity: 20% to 90% non-condensing

Physical

OSFHU-IxW/OSFHU-CxW

Size: 3.50" H x 3.50" W x 1.25" D
Color: White
Construction: High-impact, injection molded plastic housing.
Color coded wire leads are 42" long
Listings: UL and cUL Listed

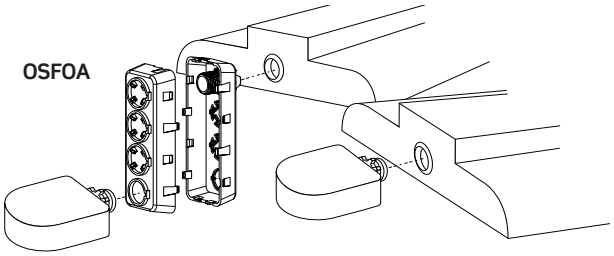
OSFOA-00W

Size: 5.50" H x 2.00" W x 2.00" D
Color: White
Construction: High-impact, injection molded plastic housing.

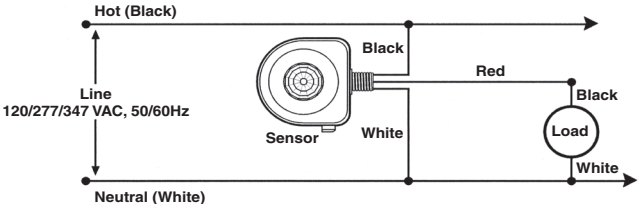
Warranty

Limited 5-Year Warranty

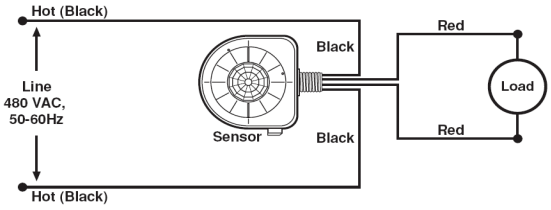
OSFOA



OSFHU Wiring Diagram



OSFHU (480V) Wiring Diagram



CONTROLS

Timer Setting: 30 seconds–20 minutes

ORDERING INFORMATION

CAT. NO.	DESCRIPTION
OSFHU-ITW	Fixture-Mounted PIR High-Bay Sensor with 3 Interchangeable Lenses, White
OSFHU-CTW	Fixture-Mounted PIR High-Bay Sensor with 3 Interchangeable Lenses for Cold Storage, White
OSFHU-I4W	Fixture-Mounted PIR High-Bay Sensor with 3 Interchangeable Lenses, 480V, No Neutral, White
OSFHU-C4W	Fixture-Mounted PIR High-Bay Sensor with 3 Interchangeable Lenses for Cold Storage, 480V, No Neutral, White
OSFOA-00W	Fixture-Mounted Offset Adapter Accessory for OSFHU, 3 Position, White

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Lago Tana 43, Mexico DF, Mexico CP 11290 • Tel. (+52) 55-5082-1040 • FAX: (+52) 5386-1797 • www.leviton.com.mx

Visit our Website at: www.leviton.com/lms

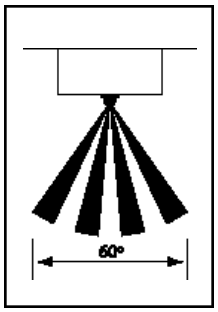
Appendix D:

Photocell Specifications

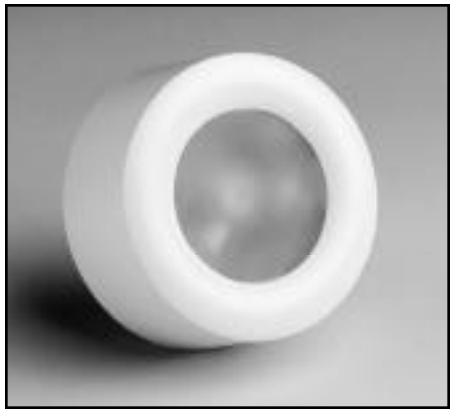
ODC0P Photocell

Application

Leviton's ODC0P Photocell is a sensor for monitoring light levels. In conjunction with other components as part of a Leviton Control Network (LCnet) lighting system, the ODC0P Photocell can be used to automatically adjust light levels to a user-defined level. The sensor is most suitable for installation in rooms with windows and in open spaces receiving substantial light from adjacent, indoor spaces.

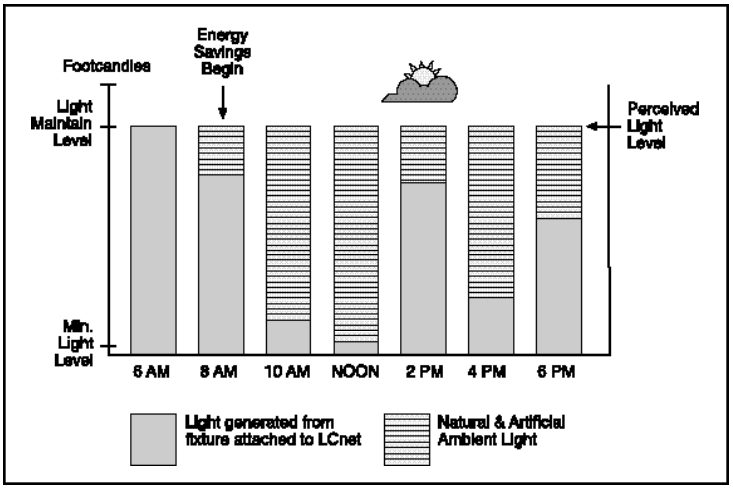


Field of View



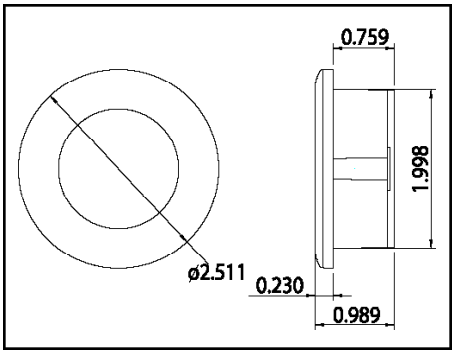
Operation

The ODC0P Photocell must be hardwired to a compatible Leviton power pack—providing the photocell with power and enabling it to contribute to a Leviton lighting control system. The ODC0P measures ambient light in a specific area and sends this data to a Dimming Power Pack that, in turn, adjusts fixtures to a constant lighting level as measured in that specific area. The Leviton Photocell makes possible a feature called Daylight Harvesting in which lights in a room (with windows or significant, artificial ambient light) will automatically brighten or dim depending on how much light the photocell detects.



Daylight Harvesting

With Daylight Harvesting, ambient (often natural) light supplements in-room, artificial light in order to keep a constant lighting level while saving electricity. This constant level, called the Light Maintain Level, is programmed into a compatible power pack via a wall-mounted controller, specialized software, or handheld remote control. Once hardwired to the photocell, the power pack will receive the photocell's comprehensive light measurement and, when necessary, adjust its own output to keep the Light Maintain Level steady within the photocell's area of detection.



Rules of Operation

Measured light level = Light Maintain Level → Output to lights remains constant
Measured light level < Light Maintain Level → Lights are brightened
Measured light level > Light Maintain Level → Lights are dimmed

LEVITON SPECIFICATIONSUBMITTAL

JOB NAME:	CATALOG NUMBERS:	
JOB NUMBER:		

Leviton Mfg. Co., Inc.
59-25 Little Neck Pkwy • Little Neck, NY 11362-2591 • Tech Line: 1-800-824-3005 • Fax: 1-800-832-9538
Visit our Website at: www.leviton.com

LEVITON LIGHTING CONTROL DIVISION
Building a Connected World

Product Specifications

ODC0P

Features and Benefits

- Constant lighting at the desired level for greater visual comfort, which contributes to improved productivity.
- Provides for ultra-convenient, hands-free lighting control.
- Lowers electric bills by reducing usage of lighting where ambient natural and/or artificial light are also present.
- Measures light from any source in the visible spectrum within a 60º cone.
- Provides continual measurements and reports back to Dimming Power Pack on LCnet. If ambient light fluctuates rapidly, power pack may average lighting adjustments over time to avoid over-frequent adjustments and provide more constant lighting.
- Mounts on ceiling.

INSTALLATION

Low Voltage Class 2 Wiring

- Connect directly to Dimming Power Pack.
- Use CAT5-type wiring

Placement

Install directly above workspace.

Specifications

Electrical

Input Voltage: 24VDC
Input Current: 10mA
Power Consumption: 1W
Light Sensitivity: 0 to 70 footcandles
Output Voltage: 0 to 10VDC
Testing/Code Compliance: UL Listed, CSA Certified, and California Title 24

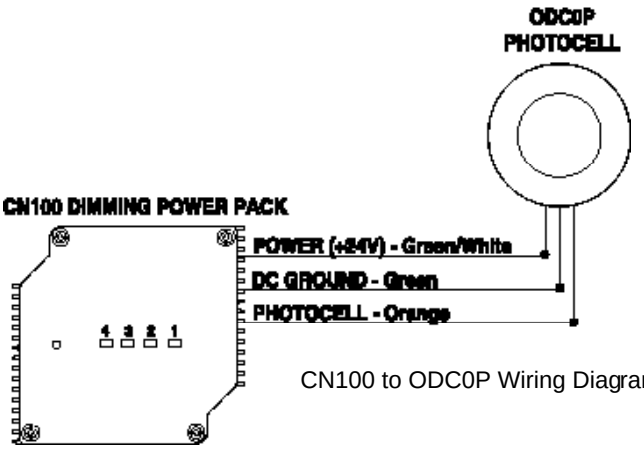
Physical

Diameter: 2.51in. (6.4cm)
Depth: 0.99in. (2.5cm)
Color: White

Environmental

Operating Temperature Range: 0ºC to +55ºC
Storage Temperature Range: -10ºC to +85ºC
Relative Humidity: 20% to 90% non-condensing

Warranty: Limited 5-Year Warranty



CN100 to ODC0P Wiring Diagram

LEVITON SPECIFICATIONSUBMITTAL

JOB NAME:	CATALOG NUMBERS:	
JOB NUMBER:		

Leviton Mfg. Co., Inc.
59-25 Little Neck Pkwy • Little Neck, NY 11362-2591 • Tech Line: 1-800-824-3005 • Fax: 1-800-832-9538

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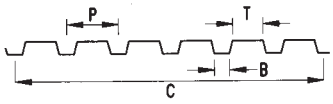
Appendix E:

Vulcraft Information Sheet

TECHNICAL PRODUCT INFORMATION



	Deck Type	Gauge	Approximate Dimensions in Inches																			
			Indiana				Nebraska				South Carolina				Texas				Alabama / New York			
			C	P	T	B	C	P	T	B	C	P	T	B	C	P	T	B	C	P	T	B
ROOF	1.5B, 1.5BI, 1.5BA, 1.5BIA	24 22 20 19 18 16	NA 36 36 36 36 36	6.00	3.50	1.75	30 36 36 36 36 36	6.00	3.50	1.75	36 36 36 36 36 36	6.00	3.50	1.75	NA 36 36 36 36 36	6.00	3.50	1.75	36 36 36 36 36 36	6.00	3.50	1.75
	1.5F	22 20 18	30	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50	36	6.00	4.25	0.50
	1.5A	22 20 18	36	6.00	5.00	0.38	36	6.00	5.00	0.38	36	6.00	5.00	0.38	NA	-	-	-	NA	-	-	-
	3N, 3NI*, 3NA, 3NIA*	22 20 18 16	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88	24	8.00	5.38	1.88
	1.0E	26 24 22 20	36	4.00	1.13	1.13	32	4.00	1.01	1.25	33	3.67	0.90	0.90	33	3.67	1.00	1.00	36	4.00	1.13	1.13
NON-COMPOSITE	0.6C and 0.6CSV**	28 26 24 22	NA 30 30 NA	2.50	0.62	0.62	NA 36 36 36	3.04	0.63	0.63	35 35 35 35	2.50	0.75	0.75	30 35 35 35	2.50	0.62	0.62	30 30 30 30	2.50	0.75	0.75
	1.0C and 1.0CSV*	26 24 22 20	36	4.00	1.13	1.13	32	4.00	1.25	1.01	33	3.67	0.90	0.90	33	3.67	1.00	1.00	36	4.00	1.13	1.13
	1.3C and 1.3CSV	26 24 22 20	NA	-	-	-	NA	-	-	-	NA	-	-	-	32	4.57	1.06	1.06	NA	-	-	-
	1.5C	24 22 20 18	NA 36 36 36	6.00	1.75	3.50	30 36 36 36	6.00	1.75	3.50	36 36 36 36	6.00	1.75	3.50	30 36 36 36	6.00	1.75	3.50	36 36 36 36	6.00	1.75	3.50
	2C	22 20 18 16	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00
	3C	22 20 18 16	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75
COMPOSITE	1.5VL and 1.5VLI	22 20 19 18 16	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.00	3.50	1.75	36	6.0	3.50	1.75
	1.5VLR	22 20 19 18 16	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.00	1.75	3.50	36	6.0	1.75	3.50
	2VLI	22 20 19 18 16	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00	36	12.0	5.00	5.00
	3VLI	22 20 19 18 16	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75	36	12.0	4.75	4.75

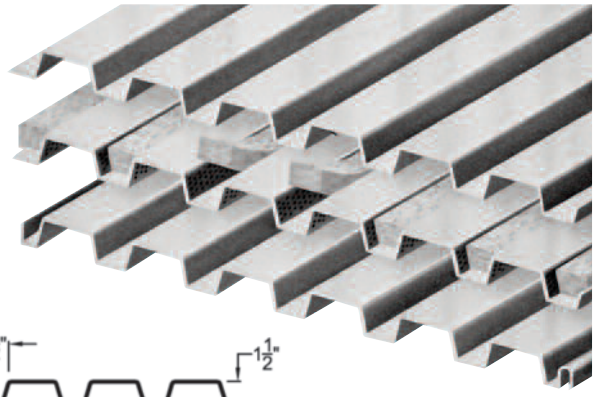
NOTES:
1. * This profile is not available from Indiana and Alabama.
2. ** This profile is not available from Nebraska and Indiana.
3. Indiana offers 16 gauge for 1.5B, 3N and 3NA only.
4. No profile in 16 gauge is available from Alabama.

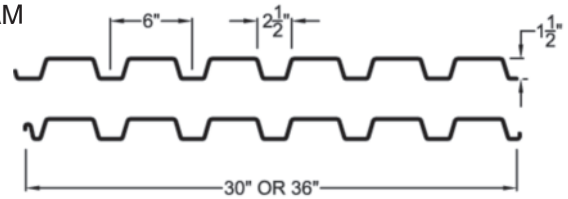
1.5 B, BI, BA, BIA

Maximum Sheet Length 42'-0
Extra charge for lengths under 6'-0
ICC ER-3415
Factory Mutual Approved*
Deck type & gauge — Max. deck span
1.5B22, 1.5BI22..... 6'-0"
1.5B20, 1.5BI20..... 6'-6"
1.5B18, 1.5BI18..... 7'-5"
FM Approvals No. 0C8A7.AM & 0G1A4.AM

1.5B16, 1.5BI16..... 9'-4"
FM Approvals No. 3029260

* Acoustical Deck is not approved by Factory Mutual





Interlocking side lap is not drawn to show actual detail.

SECTION PROPERTIES

Deck type	Design thickness in.	W psf	Section Properties				V_a lbs/ft	F_y ksi
			I_p	S_p	I_n	S_n		
			in^4/ft	in^3/ft	in^4/ft	in^3/ft		
B24	0.0239	1.46	0.107	0.120	0.135	0.131	2634	60
B22	0.0295	1.78	0.155	0.186	0.183	0.192	1818	33
B20	0.0358	2.14	0.201	0.234	0.222	0.247	2193	33
B19	0.0418	2.49	0.246	0.277	0.260	0.289	2546	33
B18	0.0474	2.82	0.289	0.318	0.295	0.327	2870	33
B16	0.0598	3.54	0.373	0.408	0.373	0.411	3578	33

ACOUSTICAL INFORMATION

Deck Type	Absorption Coefficient						Noise Reduction Coefficient[1]
	125	250	500	1000	2000	4000	
1.5BA, 1.5BIA	.11	.18	.66	1.02	0.61	0.33	0.60

[1] Source: Riverbank Acoustical Laboratories.
Test was conducted with 1.50 pcf fiberglass batts and 2 inch polyisocyanurate foam insulation for the SDI.

Type B (wide rib) deck provides excellent structural load carrying capacity per pound of steel utilized, and its nestable design eliminates the need for die-set ends.

1" or more rigid insulation is required for Type B deck.

Acoustical deck (Type BA, BIA) is particularly suitable in structures such as auditoriums, schools, and theatres where sound control is desirable. Acoustic perforations are located in the vertical webs where the load carrying properties are negligibly affected (less than 5%).

Inert, non-organic glass fiber sound absorbing batts are placed in the rib openings to absorb up to 60% of the sound striking the deck.

Batts are field installed and may require separation.

VERTICAL LOADS FOR TYPE 1.5B

No. of Spans	Deck Type	Max. SDI Const. Span	Allowable Total (PSF) / Load Causing Deflection of L/240 or 1 inch (PSF) Span (ft.-in.) ctr to ctr of supports										
			5-0	5-6	6-0	6-6	7-0	7-6	8-0	8-6	9-0	9-6	10-0
1	B24	4'-8	115 / 56	95 / 42	80 / 32	68 / 26	59 / 20	51 / 17	45 / 14	40 / 11	35 / 10	32 / 8	29 / 7
	B22	5'-7	98 / 81	81 / 61	68 / 47	58 / 37	50 / 30	44 / 24	38 / 20	34 / 17	30 / 14	27 / 12	25 / 10
	B20	6'-5	123 / 105	102 / 79	86 / 61	73 / 48	63 / 38	55 / 31	48 / 26	43 / 21	38 / 18	34 / 15	31 / 13
	B19	7'-1	146 / 129	121 / 97	101 / 75	86 / 59	74 / 47	65 / 38	57 / 31	51 / 26	45 / 22	40 / 19	36 / 16
	B18	7'-8	168 / 152	138 / 114	116 / 88	99 / 69	85 / 55	74 / 45	65 / 37	58 / 31	52 / 26	46 / 22	42 / 19
	B16	8'-8	215 / 196	178 / 147	149 / 113	127 / 89	110 / 71	96 / 58	84 / 48	74 / 40	66 / 34	60 / 29	54 / 24
2	B24	5'-10	124 / 153	103 / 115	86 / 88	74 / 70	64 / 56	56 / 45	49 / 37	43 / 31	39 / 26	35 / 22	31 / 19
	B22	6'-11	100 / 213	83 / 160	70 / 124	59 / 97	51 / 78	45 / 63	39 / 52	35 / 43	31 / 37	28 / 31	25 / 27
	B20	7'-9	128 / 267	106 / 201	89 / 155	76 / 122	66 / 97	57 / 79	51 / 65	45 / 54	40 / 46	36 / 39	32 / 33
	B19	8'-5	150 / 320	124 / 240	104 / 185	89 / 145	77 / 116	67 / 95	59 / 78	52 / 65	47 / 55	42 / 47	38 / 40
	B18	9'-1	169 / 369	140 / 277	118 / 213	101 / 168	87 / 134	76 / 109	67 / 90	59 / 75	53 / 63	48 / 54	43 / 46
	B16	10'-3	213 / 471	176 / 354	149 / 273	127 / 214	110 / 172	95 / 140	84 / 115	74 / 96	66 / 81	60 / 69	54 / 59
3	B24	5'-10	154 / 120	128 / 90	108 / 69	92 / 55	79 / 44	69 / 35	61 / 29	54 / 24	48 / 21	43 / 17	39 / 15
	B22	6'-11	124 / 167	103 / 126	87 / 97	74 / 76	64 / 61	56 / 50	49 / 41	43 / 34	39 / 29	35 / 24	31 / 21
	B20	7'-9	159 / 209	132 / 157	111 / 121	95 / 95	82 / 76	72 / 62	63 / 51	56 / 43	50 / 36	45 / 31	40 / 26
	B19	8'-5	186 / 250	154 / 188	130 / 145	111 / 114	96 / 91	84 / 74	74 / 61	65 / 51	58 / 43	52 / 37	47 / 31
	B18	9'-1	210 / 289	174 / 217	147 / 167	126 / 132	108 / 105	95 / 86	83 / 71	74 / 59	66 / 50	59 / 42	54 / 36
	B16	10'-3	264 / 369	219 / 277	185 / 214	158 / 168	136 / 135	119 / 109	105 / 90	93 / 75	83 / 63	74 / 54	67 / 46

Notes: 1. Minimum exterior bearing length required is 1.50 inches. Minimum interior bearing length required is 3.00 inches.
If these minimum lengths are not provided, web crippling must be checked.

Appendix F: Steel Cost Tables

Floor Slab				
Perimeter (LF)	**Area (SF)**	**Vol. (CF)**	**Vol. (CY)**	**SFCA**
1025	24,405	8135	301.3	341.7

Floor Slab Welded Wire Mesh	
Type	**Area (CSF)**
6x6 W2.9 x W2.9 WWF	244

Redesigned Steel Columns		
No.	**Column Size**	**Height (ft)**
C1	W8x24	18.92
C2	W8x24	18.92
C3	W8x24	18.92
C4	W8x24	18.92
C5	W8x24	18.92
C6	W8x24	18.92
C7	W8x24	12.25
C8	W8x24	12.25
C9	W8x24	12.25
C10	W8x24	12.25
C11	W8x24	12.25
C12	W8x24	12.25
C13	W8x24	12.25
C14	W8x24	12.25
C15	W8x24	12.25
C16	W8x24	12.25
C17	W8x24	12.25
C18	W8x24	12.25
C19	W8x31	29.75
C20	W8x31	29.75
C21	W8x31	29.75
C22	W8x31	29.75
C23	W8x24	12.25
C24	W8x24	12.25
C25	W8x24	12.25
C26	W8x24	12.25
C27	W8x24	12.25
C28	W8x24	12.25
C29	W8x24	12.25
C30	W8x24	12.25

C31	W8x24	12.25
C32	W8x24	12.25
C33	W8x24	12.25
C34	W8x24	12.25
C35	W8x24	12.25
C36	W8x24	12.25

Original Steel Columns		
No.	**Column Size**	**Length (ft)**
F1	HSS 8x8x1/4	22.50
F2	HSS 12x6x1/4	22.50
F3	HSS 12x6x1/4	22.50
F4	HSS 12x6x1/4	22.50
F5	HSS 12x6x1/4	22.50
F6	HSS 12x6x1/4	22.50
F7	HSS 12x6x1/4	22.50
F8	HSS 12x6x1/4	22.50
F9	HSS 12x6x1/4	22.50
F10	HSS 8x8x1/4	22.50
G1	HSS 6x6x1/4	14.50
G2	HSS 6x6x1/4	14.50
G3	HSS 6x6x1/4	14.50
G4	HSS 6x6x1/4	14.50
G5	HSS 6x6x1/4	14.50
G6	HSS 6x6x1/4	14.50
G7	HSS 6x6x1/4	14.50
G8	HSS 6x6x1/4	14.50
G9	HSS 6x6x1/4	14.50
G10	HSS 6x6x1/4	14.50
G11	HSS 6x6x1/4	14.50
G12	HSS 6x6x1/4	14.50
G13	HSS 6x6x1/4	14.50
G14	HSS 6x6x1/4	14.50
G15	HSS 6x6x1/4	14.50
G16	W 10 x 33	19.00
G17	W 10 x 33	19.00
G18	W 10 x 33	19.00
G19	W 10 x 33	19.00
G20	W 10 x 33	19.00
G21	W 10 x 33	19.00
G22	W 10 x 33	19.00

Steel Columns	
Column Size	**Length (ft)**
HSS 8x8x1/4	45.00
HSS 12x6x1/4	180.00
HSS 6x6x1/4	217.50
W 10 x 33	133.00

Steel Decking	
Type	**Area (SF)**
1 1/2" wide rib, 20 gauge	24,405

Steel Beams		
No.	**Beam Size**	**Length (ft)**
FB #1	W 10x45	66.00
FB #2	W 16x45	74.00
FB #3	W 8x15	78.00
FB #4	W 8x21	25.00
FB #5	W 12x30	11.00
FB #6	W 8x18	6.00
FB #7	W 12x26	12.00
SB #1	W 8x21	32.00
SB #2	W 8x21	32.00
SB #3	HSS 12x2x1/4	40.00
RB #1	W 8x21	204.00
RB #2	L 3x3x1/4	102.00
RB #3	W 16x31	36.00
RB #4	W 8x10	10.00
RB #5	W 8x10	42.00
RB #6	W 8x15	8.00
RB #7	W 8x10	20.00
RB #8	W 8x40	9.00
RB #1	W 12x14	142.00
RB #2	W 8x18	30.00
RB #3	W 8x21	16.00
RB #4	W 8x18	16.00
RB #5	W 8x10	12.00

Steel Beam	
Beam Size	**Length (ft)**
W 10x45	66
W 16x45	74.00
W 8x15	86.00
W 12x30	11.00
W 8x18	52.00
W 12x26	12.00
W 16x31	36.00
W 8x10	84.00
W 8x40	9.00
W 12x14	142.00
HSS 12x2x1/4	40.00
L 3x3x1/4	102.00
W 8x21	309.00

New Steel Beams	
Beam Size	**Length (ft)**
W8x10	565

Redesigned Steel Columns	
Column Size	**Length (ft)**
W8x24	432.02
W8x31	119.00

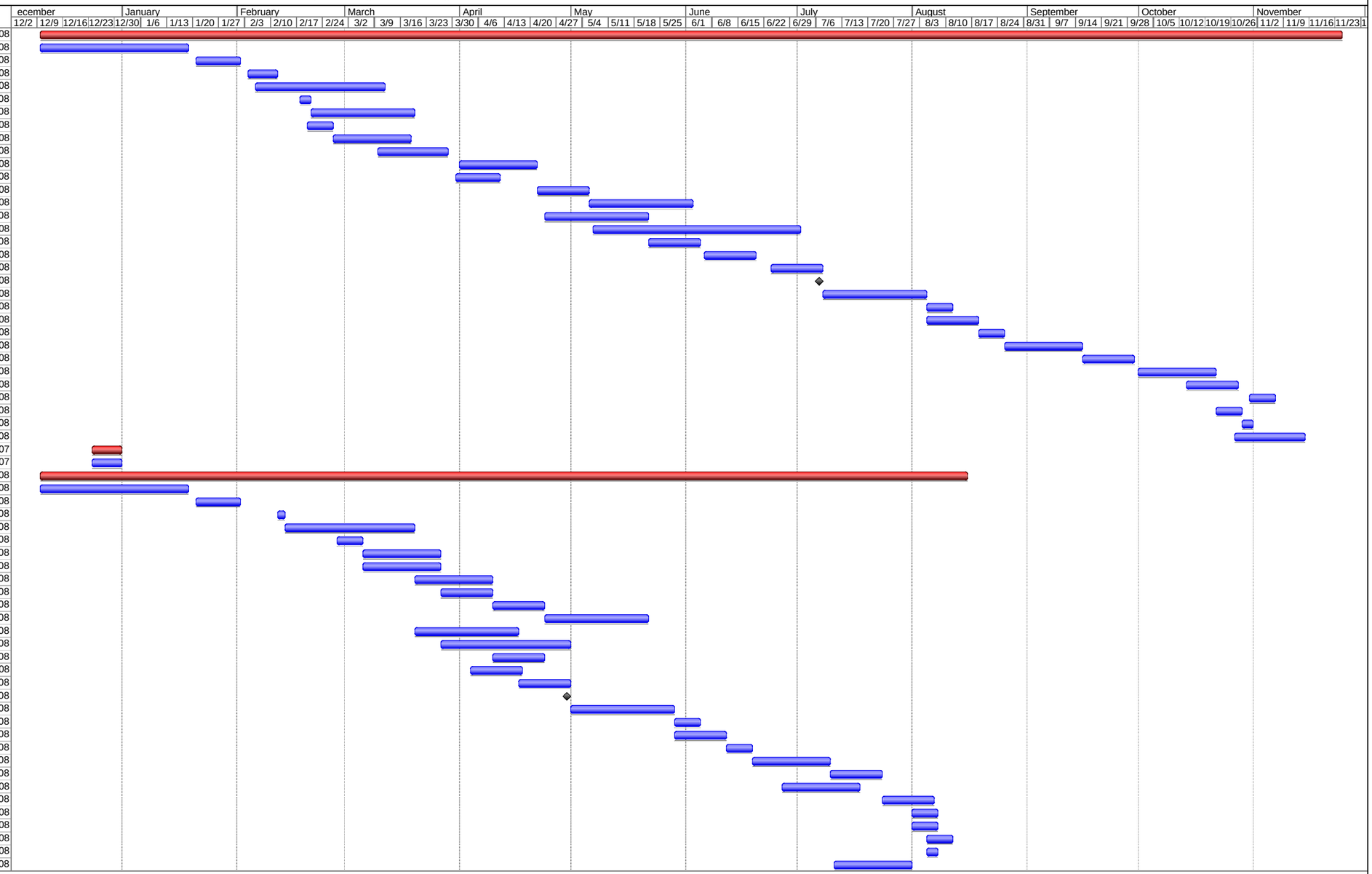
Open Web Steel Joists			
Type	**No.**	**Length per (ft)**	**Total Length (ft)**
10k1	110	11	1210
22k5	165	42	6930
24k10	19	42	798
26k8	22	44	968

Appendix G:

Revised Schedules

Waynesburg Central High School Detailed Project Schedule

ID	Task Name	Duration	Start	Finish
1	Phase 1	251 days	Mon 12/10/07	Mon 11/24/08
2	Site Excavation 1	30 days	Mon 12/10/07	Fri 1/18/08
3	FRP concrete footers 1	10 days	Mon 1/21/08	Fri 2/1/08
4	Erect Structural Steel 1	6 days	Mon 2/4/08	Mon 2/11/08
5	Install CMU's 1	25 days	Wed 2/6/08	Tue 3/11/08
6	Set Docs Plank	3 days	Mon 2/18/08	Wed 2/20/08
7	Boiler room assemblies 1	20 days	Thu 2/21/08	Wed 3/19/08
8	FRP Slab on grade 1	5 days	Wed 2/20/08	Tue 2/26/08
9	Rough in Electrical 1	15 days	Wed 2/27/08	Tue 3/18/08
10	Rough in Plumbing 1	15 days	Mon 3/10/08	Fri 3/28/08
11	Install Roofing Structure	15 days	Tue 4/1/08	Mon 4/21/08
12	Insulate Plumbing Pipes 1	10 days	Mon 3/31/08	Fri 4/11/08
13	Install Mechanical Equipment 1	10 days	Tue 4/22/08	Mon 5/5/08
14	Rough in Mechanical 1	20 days	Tue 5/6/08	Mon 6/2/08
15	Rough in Communications 1	20 days	Thu 4/24/08	Wed 5/21/08
16	Install brick veneer 1	40 days	Wed 5/7/08	Tue 7/1/08
17	Install Roofing	10 days	Thu 5/22/08	Wed 6/4/08
18	Electrical Hook ups 1	10 days	Fri 6/6/08	Thu 6/19/08
19	Install Windows 1	10 days	Tue 6/24/08	Mon 7/7/08
20	Enclosure 1	1 day	Mon 7/7/08	Mon 7/7/08
21	Painting 1	20 days	Tue 7/8/08	Mon 8/4/08
22	Install Low Voltage Fixtures 1	5 days	Tue 8/5/08	Mon 8/11/08
23	Install Ceiling Grid 1	10 days	Tue 8/5/08	Mon 8/18/08
24	Install Mechanical GRD's	5 days	Tue 8/19/08	Mon 8/25/08
25	Install Casework 1	15 days	Tue 8/26/08	Mon 9/15/08
26	Install Flooring 1	10 days	Tue 9/16/08	Mon 9/29/08
27	Install Lighting Fixtures 1	15 days	Wed 10/1/08	Tue 10/21/08
28	Install Plumbing Fixtures 1	10 days	Tue 10/14/08	Mon 10/27/08
29	Install Ceiling Tiles 1	5 days	Fri 10/31/08	Thu 11/6/08
30	Start up Mechanical System 1	5 days	Wed 10/22/08	Tue 10/28/08
31	Test Systems 1	3 days	Wed 10/29/08	Fri 10/31/08
32	Exterior Site Work Finishing 1	15 days	Mon 10/27/08	Fri 11/14/08
33	Phase 1A	6 days	Mon 12/24/07	Mon 12/31/07
34	Corridor Ceiling Demolition	6 days	Mon 12/24/07	Mon 12/31/07
35	Phase 2	180 days	Mon 12/10/07	Fri 8/15/08
36	Site Excavation 2	30 days	Mon 12/10/07	Fri 1/18/08
37	FRP concrete footers 2	10 days	Mon 1/21/08	Fri 2/1/08
38	Erect Structural Steel 2	2 days	Tue 2/12/08	Wed 2/13/08
39	Install CMU's 2	25 days	Thu 2/14/08	Wed 3/19/08
40	FRP Slab on grade 2	5 days	Thu 2/28/08	Wed 3/5/08
41	Rough in Electrical 2	15 days	Thu 3/6/08	Wed 3/26/08
42	Rough in Plumbing 2	15 days	Thu 3/6/08	Wed 3/26/08
43	Install Roofing Structure 2	15 days	Thu 3/20/08	Wed 4/9/08
44	Insulate Plumbing Pipes 2	10 days	Thu 3/27/08	Wed 4/9/08
45	Install Mechanical Equipment 2	10 days	Thu 4/10/08	Wed 4/23/08
46	Rough in Mechanical 2	20 days	Thu 4/24/08	Wed 5/21/08
47	Rough in Communications 2	20 days	Thu 3/20/08	Wed 4/16/08
48	Install brick veneer 2	25 days	Thu 3/27/08	Wed 4/30/08
49	Install Roofing 2	10 days	Thu 4/10/08	Wed 4/23/08
50	Electrical Hook ups 2	10 days	Fri 4/4/08	Thu 4/17/08
51	Install Windows 2	10 days	Thu 4/17/08	Wed 4/30/08
52	Enclosure 2	1 day	Wed 4/30/08	Wed 4/30/08
53	Painting 2	20 days	Thu 5/1/08	Wed 5/28/08
54	Install Low Voltage Fixtures 2	5 days	Thu 5/29/08	Wed 6/4/08
55	Install Ceiling Grid 2	10 days	Thu 5/29/08	Wed 6/11/08
56	Install Mechanical GRD's 2	5 days	Thu 6/12/08	Wed 6/18/08
57	Install Casework 2	15 days	Thu 6/19/08	Wed 7/9/08
58	Install Flooring 2	10 days	Thu 7/10/08	Wed 7/23/08
59	Install Lighting Fixtures 2	15 days	Fri 6/27/08	Thu 7/17/08
60	Install Plumbing Fixtures 2	10 days	Thu 7/24/08	Wed 8/6/08
61	Install Ceiling Tiles 2	5 days	Fri 8/1/08	Thu 8/7/08
62	Start up Mechanical System 2	5 days	Fri 8/1/08	Thu 8/7/08
63	Install Acoustical Panels	5 days	Tue 8/5/08	Mon 8/11/08
64	Test Systems 2	3 days	Tue 8/5/08	Thu 8/7/08
65	Exterior Site Work Finishing 2	15 days	Fri 7/11/08	Fri 8/1/08

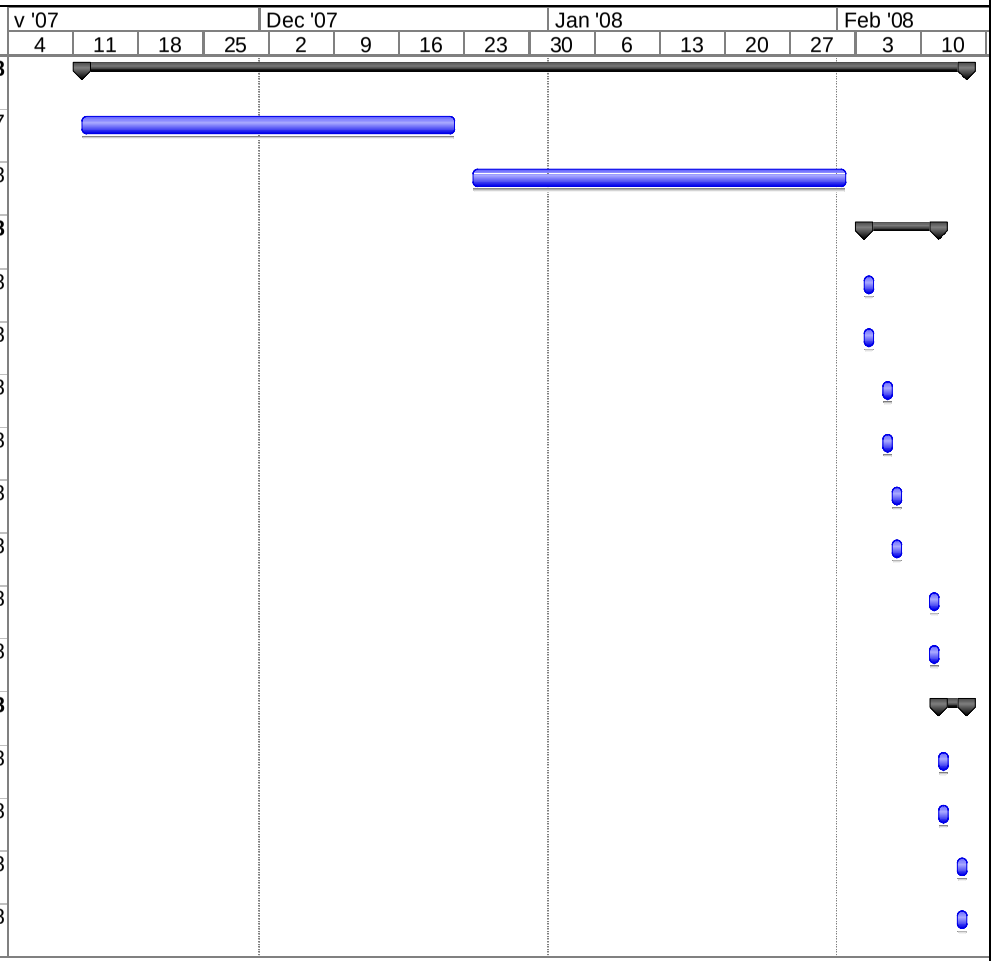


Robert O. Brennan
Project: 2 Phase
Date: Sun 4/5/09

Task — Progress — Summary — External Tasks — Deadline
Split — Milestone — Project Summary — External Milestone

Waynesburg Central High School Detailed Steel Schedule

ID	Task Name	Duration	Start	Finish
1	**Phase 1**	**69 days**	**Mon 11/12/07**	**Thu 2/14/08**
2	Steel Design	30 days	Mon 11/12/07	Fri 12/21/07
3	Steel Procurement	30 days	Mon 12/24/07	Fri 2/1/08
4	**Building G**	**6 days**	**Mon 2/4/08**	**Mon 2/11/08**
5	Erect Steel Columns 1	1 day	Mon 2/4/08	Mon 2/4/08
6	Steel Conections Columns 1	1 day	Mon 2/4/08	Mon 2/4/08
7	Thu 2/14/08	1 day	Wed 2/6/08	Wed 2/6/08
8	Steel Connections Beams 1	1 day	Wed 2/6/08	Wed 2/6/08
9	Erect Steel Columns 2	1 day	Thu 2/7/08	Thu 2/7/08
10	Steel Conections Columns 2	1 day	Thu 2/7/08	Thu 2/7/08
11	Erect Steel Beams 2	1 day	Mon 2/11/08	Mon 2/11/08
12	Steel Connections Beams 2	1 day	Mon 2/11/08	Mon 2/11/08
13	**Building F**	**3 days**	**Tue 2/12/08**	**Thu 2/14/08**
14	Erect Steel Columns F	1 day	Tue 2/12/08	Tue 2/12/08
15	Steel Conections Columns F	1 day	Tue 2/12/08	Tue 2/12/08
16	Erect Steel Beams F	1 day	Thu 2/14/08	Thu 2/14/08
17	Steel Connections Beams F	1 day	Thu 2/14/08	Thu 2/14/08

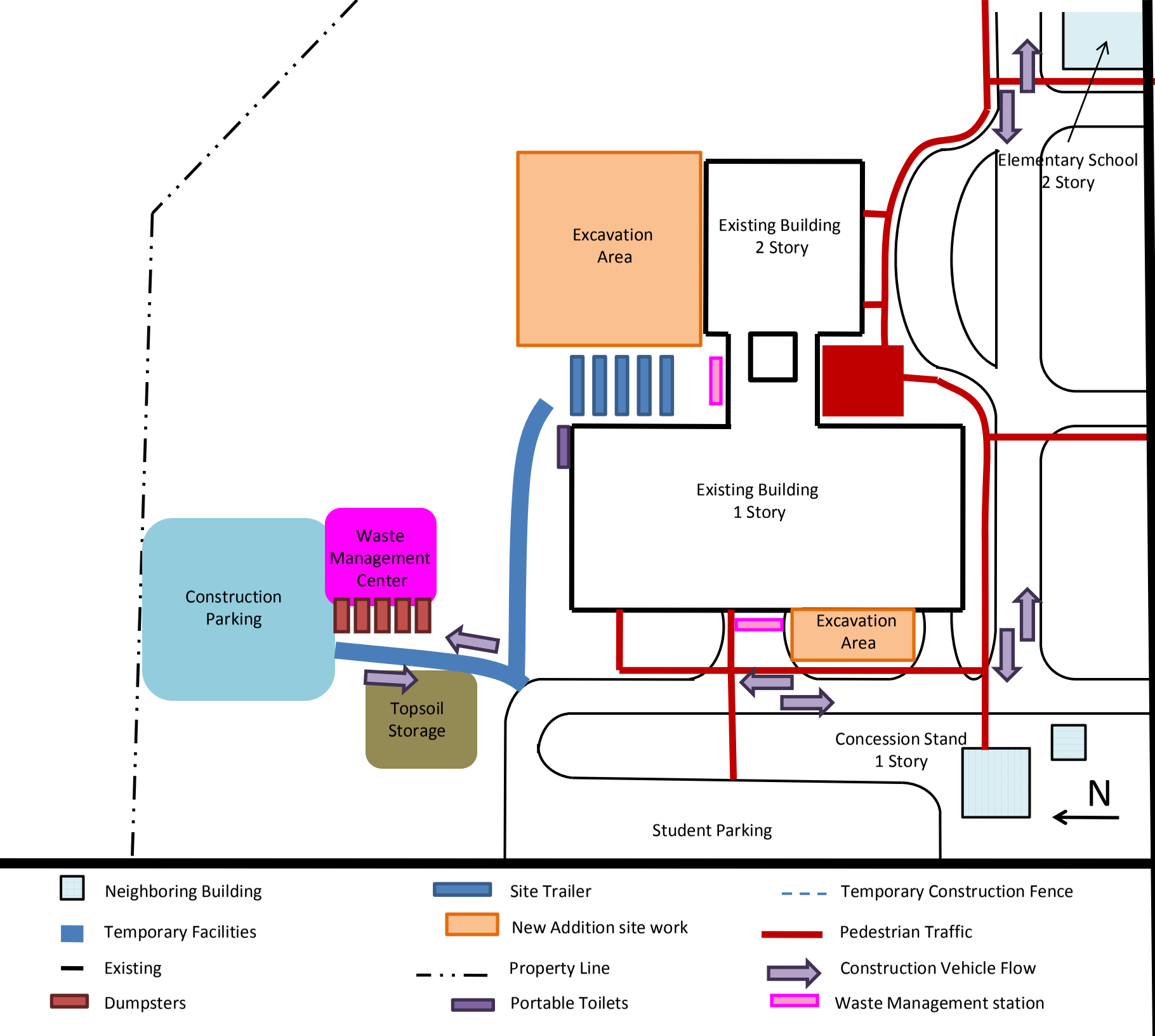


Robert O. Brennan
Project: Steel Schedule.mpp
Date: Sun 4/5/09

Task
Split
Progress
Milestone
Summary
Project Summary
External Tasks
External Milestone
Deadline

Appendix H:

Site Plans



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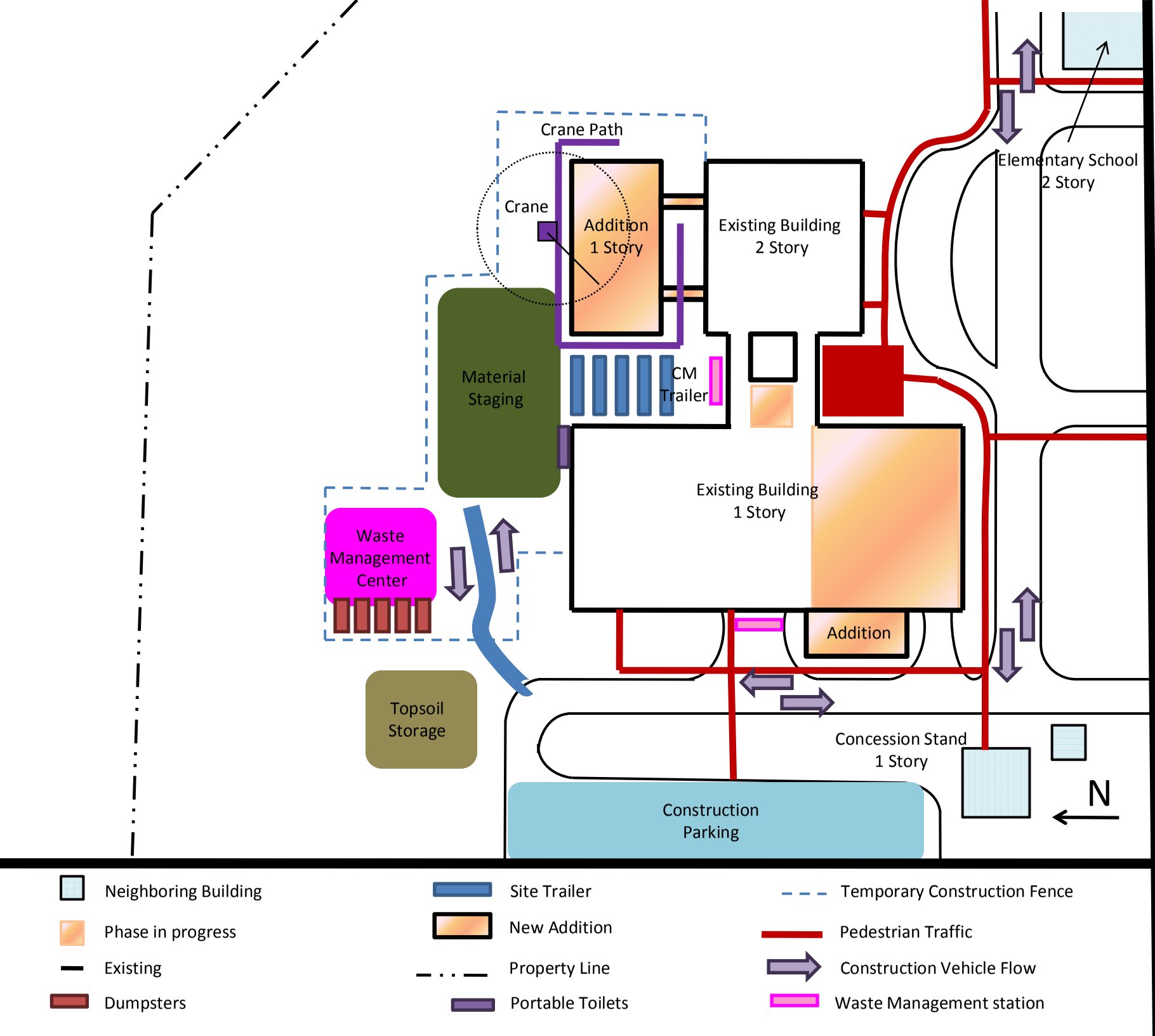
Waynesburg Central High School

Spring 2008 Site Plan

3/27/2009



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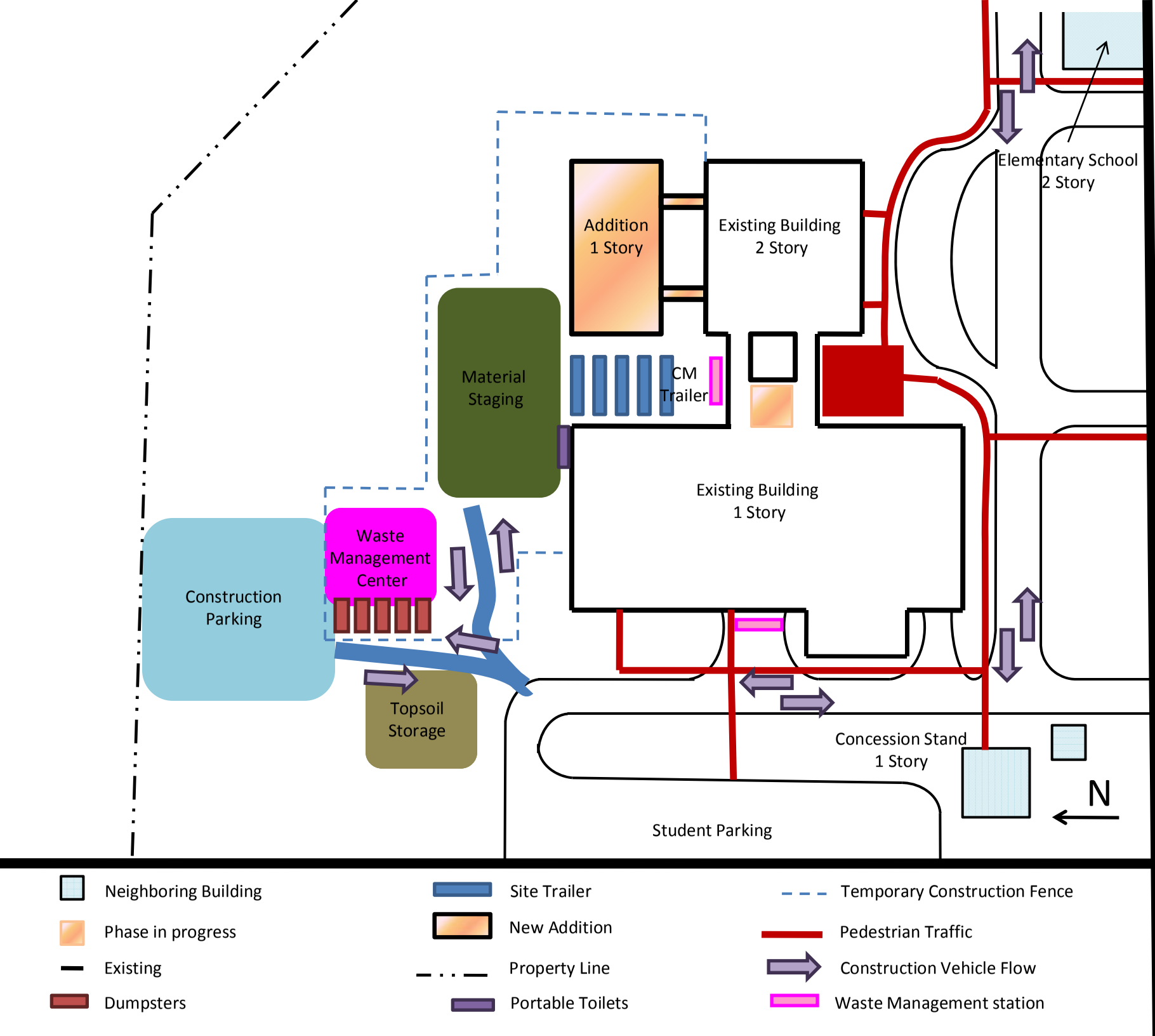
Waynesburg Central
High School

Summer 2008
Site Plan

3/27/2009



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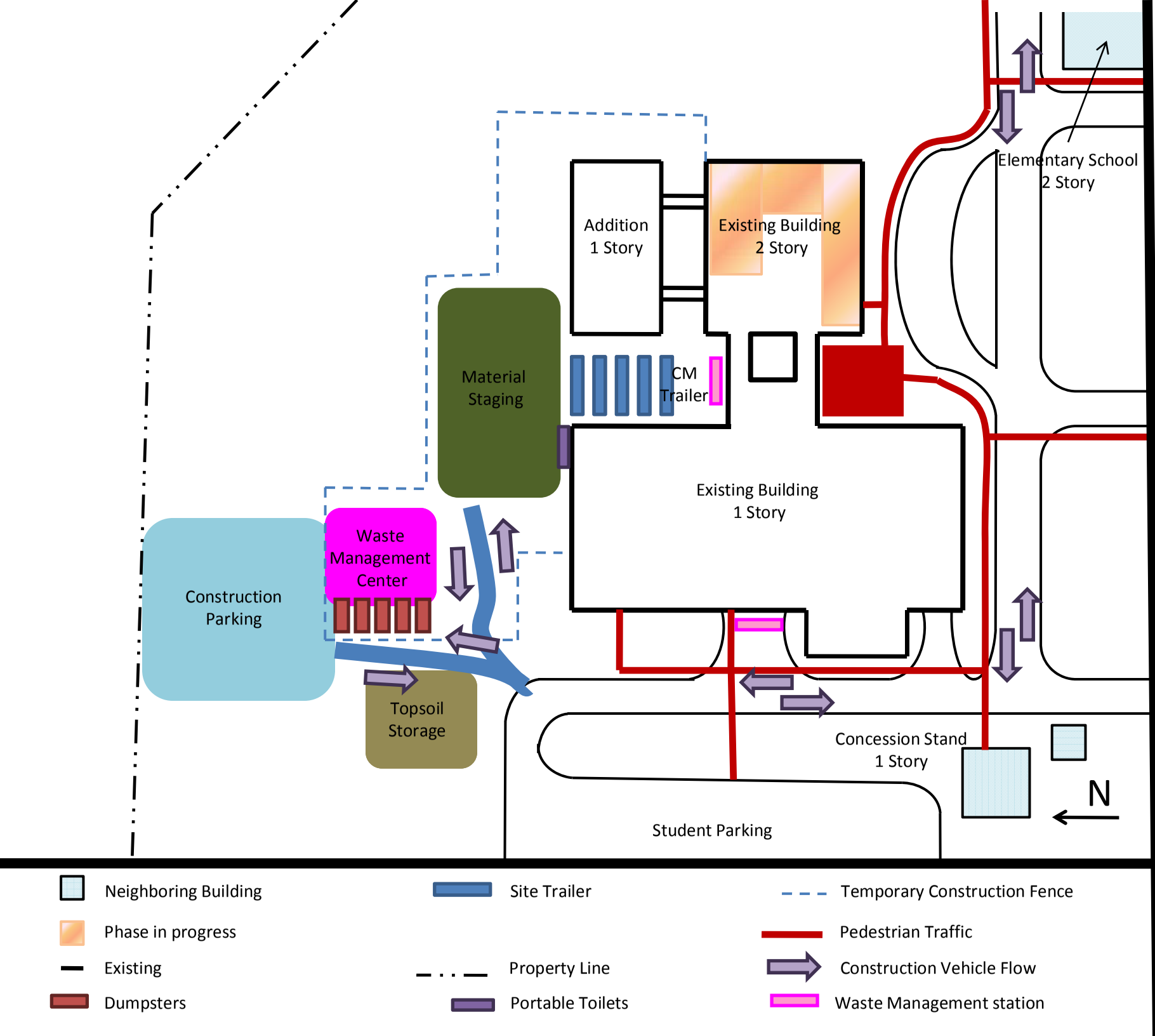
High School

Fall 2008
Site Plan

3/27/2009



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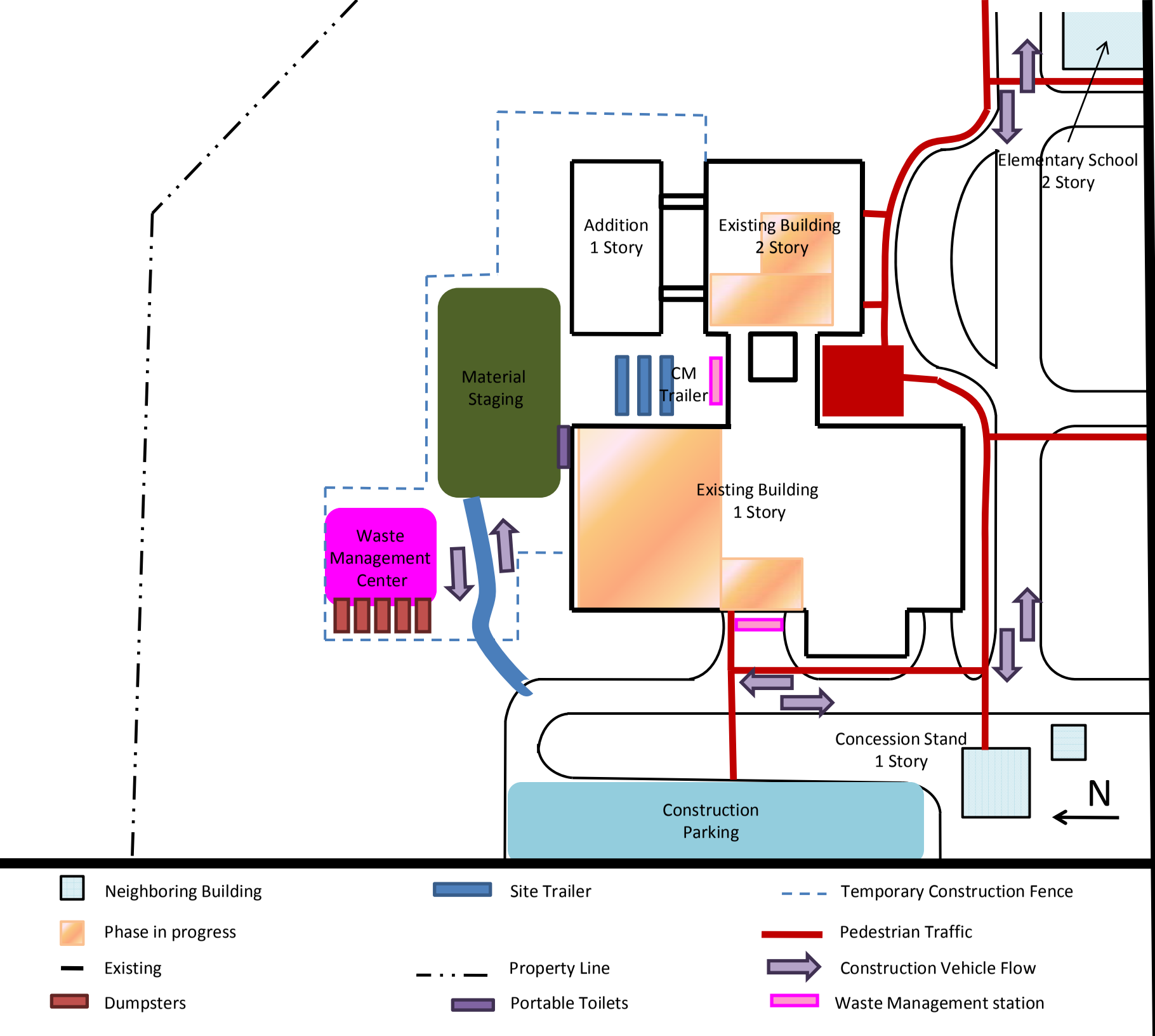
Waynesburg Central
High School

Spring 2009
Site Plan

3/27/2009



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High School

Summer 2009
Site Plan

3/27/2009