The Pennsylvania State University
Department of Architectural Engineering

Carey L. Steckler

Construction Management

Senior Thesis
April 2005

Highland Elementary School
Ambridge, Pennsylvania

Highland Elementary School

Carey L. Steckler

Construction Management Option

E-Portfolio Website: www.arche.psu.edu/thesis/2005/cls348

Overview

- New K-6 school building on site of former Highland Elementary in Ambridge, PA
- Size – 78,880 SF
- Bid Cost: $10.8 Million
- 30 classrooms, 2 computer labs, library/media center, administration suite, gymnasium, kitchen & cafeteria
- Constructed – May 2003 through August 2004

Project Team

- Owner – Ambridge Area School District
- Architect – Foreman Architects Engineers
- Construction Management – Foreman Program & Construction Managers
- General Contractor – C&M Contracting, Pittsburgh, PA
- Sixteen Prime Contractors
- Demolition – Unis Demolition, Aliquippa, PA

Architectural

Exterior
- CMU with face brick & ground face CMU, aluminum windows with insulated panels
- Brick piers reminiscent of steel mill smoke stacks once prevalent in Ohio River Valley
- Front entrance mimics a bridge, paying homage to American Bridge Co. for which Ambridge was named

Interior
- Unit A – Single-story “learning core”
- Unit B – Three-story classroom wing
- Bold, bright jewel toned finishes

Mechanical

- Mechanical room below all-purpose room
- Two hot water boilers, 3665 MBH output each
- One 191 ton chiller
- Five roof-top AHUs & nine blower coil AHUs
- One AHU for administrative suite
- UVs servicing all B-wing classrooms
- 17 spaces heated with radiant panels

Structural

- Unit A – Caissons, steel columns, grade beams along west & south exterior

- Unit B – Concrete strip footings, CMU load-bearing walls

Lighting/Electrical

- Most lighting 277/480V, receptacles 120/208V
- 3 phase, 4 wire
- Typical classroom lighting – pendant fixtures with 32W T8 fluorescent lamps
- Diesel emergency generator – 125kW/156kVA

Photographs and renderings courtesy of The Foreman Group

Table of Contents

Executive Summary

The following is a product of an eight-month Construction Management senior thesis study to meet requirements for the Bachelor's Degree of Architectural Engineering at The Pennsylvania State University. The theme of the study is public school construction issues, and the subject is the Highland Elementary School project in Ambridge, Pennsylvania. This document is organized into four parts. The first introduces the Highland Elementary project and includes the original thesis proposal submitted. The second part summarizes a Construction Management depth analysis of delivery methods for Pennsylvania public school construction. The third and fourth parts summarize breadth analyses with Lighting/Electrical and Mechanical focuses.

Highland Elementary School is a new 78,880 SF building completed in August 2004 for the Ambridge Area School District. In compliance with Pennsylvania's Separation of Contracts requirement, multiple prime contracts were released for bid—a total of sixteen. The construction management firm Foreman Program and Construction Managers managed the contracts and construction.


Rendering of New Library

Since the year 2000, Pennsylvania school districts have been allowed to apply for waivers to be excluded from the requirement of bidding at least four prime contracts, and 32 such waivers have been granted. In this thesis work, the success of this waiver program is investigated and discussed. Utilizing results of a survey, personal interviews and a literature review, conclusions are drawn about the program and about single prime construction for Pennsylvania's public schools.

Another current issue that is important to public school districts is exterior building façade design and window area. Increasing window area generally increases daylighting levels, which can positively affect learning ability, alertness and performance of building occupants such as school children. The classroom wing of Highland Elementary has 32 nearly identical classrooms, each with several windows. Increasing the window area in each of these classrooms will allow more natural light into the spaces encouraging occupants to experience the benefits of increased daylighting. The redesign proposed could also save energy costs for the school district by decreasing the amount of electric lighting necessary in the classrooms.

Finally, the effects of the alternative façade design on the mechanical system of the classrooms were analyzed. The advantages and disadvantages of unit ventilator systems were researched. Heating and cooling loads were calculated as well as airflow and ventilation requirements for both the original façade design and the proposed alternative to be assured that the effects on the mechanical equipment would not prevent the success of the alternative design.

Original Thesis Proposal

Highland Elementary School
Carey L. Steckler
10 December 2004

In my continuing thesis research, I would like to focus on three areas. As a depth analysis, I will be exploring multiple prime delivery and public school projects. I will also work on two breadth analyses in the area of daylighting. One study will address the overall effects of maximizing window area and another will address the specific effects of additional window area on the building's mechanical and electrical systems.

Analysis 1: Multiple Prime Delivery & Public School Projects

The focus of my in-depth research will be the effectiveness of multiple prime contracts in public school construction. Pennsylvania's Separation of Contracts Act requires that public school projects have least four separate contracts: (1) general; (2) plumbing; (3) heating, ventilating and air conditioning; and (4) electrical. The multiple prime system has been thought to deliver projects in a very timely and cost effective manner, a position widely disputed and rejected by many, including the Pennsylvania AIA.

Goal of Analysis

Determine specific advantages and disadvantages of the use of a multiple prime delivery method for the Highland Elementary School project.

Methodology

- Review literature & policies of other states.
- Gather information and study several projects from other states which have allowed alternative delivery methods.
- Interview/survey industry professionals experienced with multiple prime school projects. Sample survey questions:
  - Summarize your experience with PA public school K-12 projects.
  - What do you see as the benefits of multiple prime delivery… to the School District? to the Contractors?
  - What do you see as the drawbacks of multiple prime delivery… to the School District? to the Contractors?
  - What have you noticed to be specific problems with multiple prime projects?
- Apply pros/cons to Highland Elementary Project as case study.
- Draw conclusions based on information gathered, support with results of case study.

Analysis 2: Daylighting & Additional Window Area

In recent years, the positive effects of daylighting in educational spaces have been the topic of much research, and studies in favor of daylighting have been conducted by the Pennsylvania Governor's Green Government Council and the U.S. Department of Energy. It has been presented that students achieve higher test scores in classrooms that are daylit than in those that are not. Also supporting this position, daylighting has proven to significantly reduce energy consumption if used with proper electrical lighting equipment.

Goal of Analysis

Determine effects of increasing typical Highland Elementary classroom window area to achieve maximum daylighting allowable by structural constraints.

Methodology

- Determine the maximum window area that can be achieved within constraints of structural system.
- Investigate benefits of additional daylighting on learning environment through literature review.
- Identify a few schools in Pennsylvania that have similarly maximized daylighting and note the outcome(s).
- Evaluate potential schedule impact.
- Assess impact on architecture of building.

Analysis 3: Effects of Added Window Area on Mechanical/Electrical Systems

As stated earlier, daylighting has proven to significantly reduce energy consumption if used with proper electrical lighting equipment. Therefore, lighting equipment for a room with increased daylighting may be different than for the same room with less window area. Additionally, increased window area will have an affect on the mechanical system necessary to cool and heat the space.

Goal of Analysis

Determine effects of increasing window area on Mechanical & Electrical systems. As designed, a unit ventilator with heating and cooling coils services each classroom in question. Typical classroom lighting is 48 LF of pendant fixtures with 32W T8 lamps.

Methodology

Calculate/simulate additional heat and light added to typical classroom.
Determine necessary lighting and HVAC equipment changes.
Estimate cost impact.
Estimate schedule impact.

Project Overview

Background Summary

Highland Elementary School is a new 78,880 SF building housing 30 classrooms and standard elementary school facilities. It is located in Harmony Township, Ambridge, PA. The architectural design was created by a talented and experienced group of architects at Foreman Architects Engineers, Zelienople, PA. The facility was recognized in the *American School & University Architectural Portfolio 2003.* On the exterior, brick piers mimic smokestacks, reminiscent of steel mills and the American Bridge Company, namesake of the borough of Ambridge. Likewise, above the main entrance a suspension bridge-like structure is visible.

Rendering of front (north-east) facade

Ambridge Area School District (AASD) hired Foreman Program & Construction Managers (FPCM) for preconstruction and construction services. The Pennsylvania Department of Education's PlanCon process was followed and sixteen contracts were awarded (in addition to contracts for asbestos abatement and demolition of the former building on site.) Notices to Proceed were issued on 10 April 2003 and Substantial Completion was reached on 13 August 2004.

The Client

Ambridge is located north of Pittsburgh in Beaver County, Pennsylvania. Like many similar steel communities in the Pittsburgh area, Ambridge saw the departure of its main industry in the 1980s. The borough's namesake, the American Bridge Company, pulled out of town in 1983. Since then, the population in Beaver County has been declining steadily, falling 2.5% between 01 April 2000 and 01 July 2003. Crime rates are higher in Ambridge than the national average and the area can be described as economically depressed.

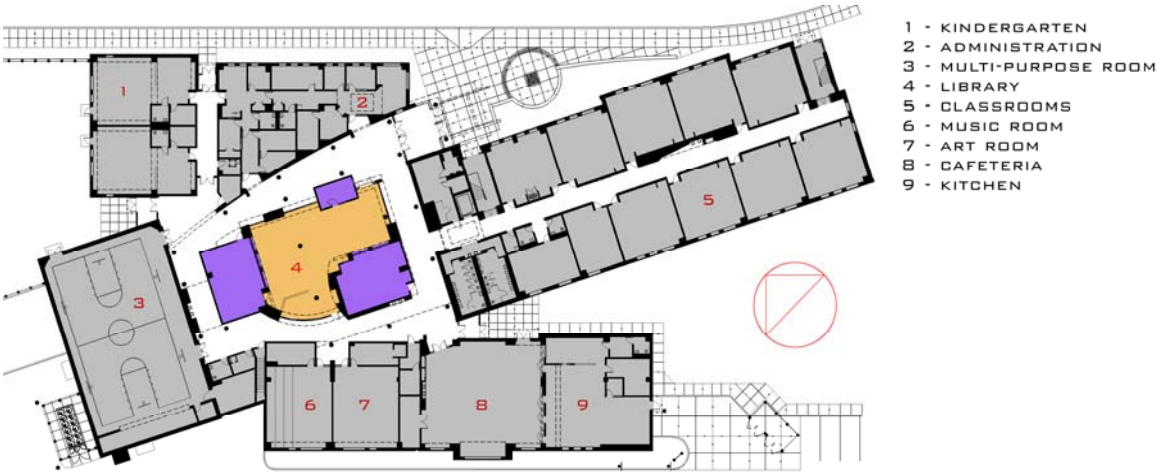
Ambridge Area School District adopted a program several years ago to consolidate from five to three elementary schools in the district. AASD also planned to replace their aging elementary buildings. This program was to result in a savings in their overall operations budget. The first phase of this program was completed in August 2002 with the opening of Economy Elementary School in Freedom, PA just a few miles north of the borough of Ambridge. Then, the former Highland Elementary was demolished in 2003 and a new building was completed in August 2004. In July 2004, the AASD school board approved plans to proceed with a new high school building.

Client Expectations

As a public school district, AASD was concerned about staying within both an inflexible budget and schedule. An amount for contingency was allowed in the budget to account for changes. Change order proposal costs were considered carefully over the course of the project as this contingency amount decreased. Delivering the project late was not a viable option as the first day of school had been established. No phasing plan was necessary.

The Owner and local authorities expected an incredibly safe site, as it is located within a dense neighborhood. The entire site was enclosed with fencing. *See site plan.* AASD held an owner-controlled insurance plan for the project; consequently, a safety inspection was conducted approximately every two weeks. Reports resulting from these inspections were sent to Foreman Program & Construction Managers personnel, who were also instrumental in maintaining a safe project.

Quality was also of importance to AASD and Superintendent Kenneth Voss. The building has a long life expectancy and early maintenance/repairs were not desirable. This is demonstrated in the selection of quality mechanical and kitchen equipment. AASD also wanted quality to be apparent to occupants and visitors, as reflected in their choices of interior finishes, i.e. the expensive, bright-hued polychromatic paint specified for interior spaces. Testing and inspection were required by the specifications for many materials and systems, from concrete to thermostat controls.



First Floor Plan

Location & Site

Months of discussion took place regarding the need for a new building and the location of this potential building. Two sites were considered in Ambridge, a new site on School Street and the site of the former Highland Elementary on Highland Avenue, the former being chosen. The new building's main axis differs approximately 30-degrees from the old building with a main entrance parallel to and facing Highland Avenue. It is located in Harmony Township, northeast of the Borough of Ambridge on a triangular site immediately bordered by small streets and surrounded by residential neighborhood.

Historical Consideration

In 1903, the American Bridge Company began operations in the area along the Ohio River formerly known as Economy Township. In 1905, the borough of Ambridge was incorporated and as American Bridge continued to prosper through much of the twentieth century, Ambridge continued to grow. The company was responsible for the production of steel for structures from suspension bridges and sports arenas to the Empire State Building and the Sears Tower.

Not unlike many similar steel communities in the Pittsburgh area, Ambridge saw the departure of its main industry and its namesake when the company pulled out of the town in 1983. Since the 1970s, the Ambridge Historic District and Historical Architectural Review Board have been active in preserving and restoring a portion of the borough east of Highland Elementary. The historical value of the former Highland Elementary building was a consideration, however, the School Board and Architect were able to conclude that the best option for a new school was to replace the current building at the existing site.

Rendering of Library

Design

Many of those involved in the project, including individuals from Foreman Architects Engineers, the Ambridge Area School Board and Ambridge Superintendent Mr. Ken Voss, strived to create a building design that would celebrate the history of the neighborhood without imposing on the landscape. The design encompassed new technology and forward-thinking by placing the library/media center and computer labs in a single story "learning core" at the center as part of the Public Wing. The more traditional three-story Classroom Wing houses the majority of the classrooms spaces. The two units are also unique structurally as the Public Wing is a steel structure with masonry backup and the Classroom Wing is a concrete block structure with steel joist and deck. The facility is 78,880 SF with a 28,860 SF footprint.

The façade of Highland Elementary is primarily concrete masonry units with face brick supported by caissons and grade beams in Unit A and by reinforced concrete footings in Unit B. Visual interest was added with two colors of face brick and several different brick patterns as well as accents of ground face CMU. Aluminum windows were specified and are often complimented by insulated metal panels or mineral fiber cement siding.

Now completed, the building is a patchwork quilt of vibrant colors on the inside and surrounded with visual interest on the exterior as Foreman Architects Engineers had promised with extensive and impressive computer renderings. Brick "columns" visible on the front façade are reminiscent of the steel mill smoke stacks once prevalent along the Ohio River Valley skyline. The cables and suspended deck at the front entrance mimic a bridge, paying homage to the American Bridge Company for which the borough of Ambridge was named. The building successfully exhibits fresh, new technology and design without losing sight of the area's history.

Building Systems

Electrical & Lighting

- 2000A main distribution panelboard
- 5 transformers in the bldg, 3 for emergency systems
- Most lighting 277/480V, receptacles 120/208V
- 3 phase, 4 wire
- One diesel emergency generator – 125kW/156kVA
- Typical classroom lighting – 32W T8 on 277/480V

Mechanical

- Various systems for different spaces:
  - UVs servicing all B-wing classrooms
  - 17 spaces heated with radiant panels
  - One AHU for administrative suite
  - Two hot water boilers, 3665 MBH output each
  - One 191 ton chiller
  - Five roof-top AHUs & nine blower coil AHUs
  - State-of-the-art controls & computer monitoring
- 2,920 SF basement mechanical room, adjacent maintenance & controls rooms
- Distribution mostly by rectangular sheet metal ductwork (interior--steel, exterior--aluminum), spiral steel ductwork used in exposed areas

Structural

- Unit A is a structural steel system
  - Bolted and welded connections
  - Crawler, lattice boom 50 ton crane
- Unit B utilizes masonry bearing walls

Project Team

Architectural: Foreman Architects Engineers – Zelienople, PA
http://www.foremangroup.com
Project Manager: Mr. John Hummel
Project Architect: Mr. Kevin Renwick

Construction Management: Foreman Program & Construction Managers – Zelienople, PA
http://www.foremangroup.com
Project Executive: Mr. John Kamer
Project Manager: Mr. Aaron Bernett
Site Manger: Mr. Dan Doyle
General Contractor: C&M Contracting – Pittsburgh, PA
Project Manager: Mr. John Cozza
Asbestos Consultants: AGX, Inc. – Wexford, PA
http://www.agxinc.com
Project Manager: Rich McVicker
Project Designer: Dan Winkle

Prime Contracts

As a public school building in Pennsylvania, Ambridge Area School District (AASD) was required to use multiple prime contractors to build the new Highland Elementary School. The Pennsylvania Department of Education specifies that school building projects have least four separate contracts: (1) general; (2) plumbing; (3) heating, ventilating and air conditioning; and (4) electrical. The PA Dept. of Education also requires a fifth prime contract for asbestos abatement.

Sixteen prime contracts were chosen for this project, in addition to asbestos abatement and demolition contracts:

1. General Construction Contact: John Cozza	C&M Contracting Pittsburgh, PA
2. Roofing Construction Contact: Jack Funovitz	Pennsylvania Roofing Systems, Inc. Bakerstown, PA
3. Aluminum Entrances/Storefronts Contact: Del Smith	Delrey Windows, Inc. Valencia, PA
4. Aluminum Windows Contact: Del Smith	Delrey Windows, Inc Valencia, PA
5. Acoustical, Drywall & Plaster Contact: Ray Dohn	J.J. Morris & Sons Pittsburgh, PA
6. Ceramic & Quarry Tile Contact: Michael Fantin	Fantin Flooring Rankin, PA
7. Resilient Flooring & Carpeting Contact: Greg DeGol	DeGol Carpet Duncansville, PA
8. Painting Contact: Greg Manesiotis	L.G. Manesiotis & Co., Inc. Ingomar, PA

9. Visual Display Boards Contact: Betty Anderson	Polyvision, Inc. Clymer, PA
10. Food Service Equipment Contact: Doug Atwell	Commercial Appliance Contracts Grove City, PA
11. General Casework Contact: Betty Anderson	Polyvision, Inc. Clymer, PA
12. Library Casework Contact: Charles Leist	Reed Associates, Inc. Harleysville, PA
13. Plumbing Contact: Al Chlystek	Wheels Mechanical Contracting Pittsburgh, PA
14. Fire Protection Contact: Time Walsh	Preferred Fire Protection Pittsburgh, PA
15. HVAC Contact: Ed Weider	Weider Services Gibsonia, PA
16. Electrical Contact: Bob Monti	Allegheny City Electric Pittsburgh, PA

To manage these contracts and provide on-site management, AASD hired a construction management agency—Foreman Program & Construction Managers (FPCM), Zelienople, PA. Applications for payment, change orders and most correspondence to/from AASD from/to the contractors were conveyed through FPCM.

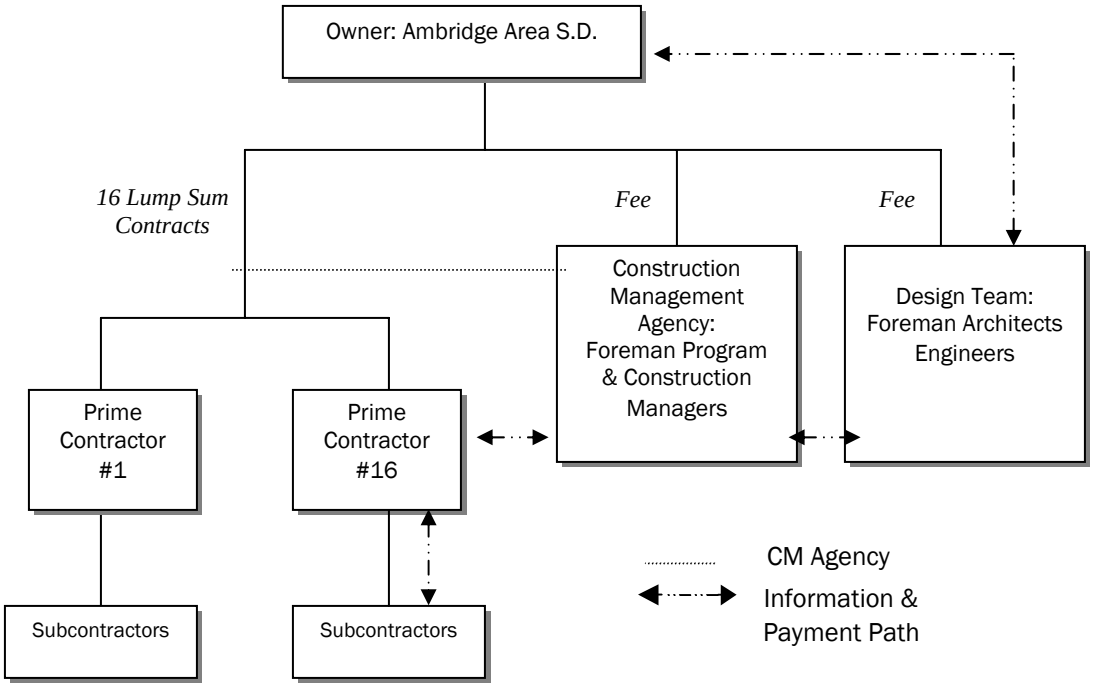
Owner Contracts

Construction Manager and Architect

The Ambridge Area School District held a contract for a set fee with the Construction Management firm, Foreman Program & Construction Managers. This contract included Preconstruction Services, such as value engineering studies and the completion of the Department of Education's PlanCon process, and Construction Services including project and site management. AASD also held a set fee contract with the Architect, Foreman Architects Engineers.

Prime Contractors

The contract for each Prime Contractor is based on AIA Document A201/CMa: General Conditions of the Contract for Construction, where the Construction Manager is not a Constructor. Some additions and deletions were made to this template document and noted as Supplementary Conditions. As a Pennsylvania public school project, it was required that Prime Contractors be selected by competitive hard bid. Low bidders were selected accordingly. An Owner Controlled Insurance Program (OCIP) was utilized covering builder's risk, workers' compensation, and commercial general liability. Contractors were responsible for commercial general (for off-site operations), automobile, aircraft, and asbestos/lead abatement liability.

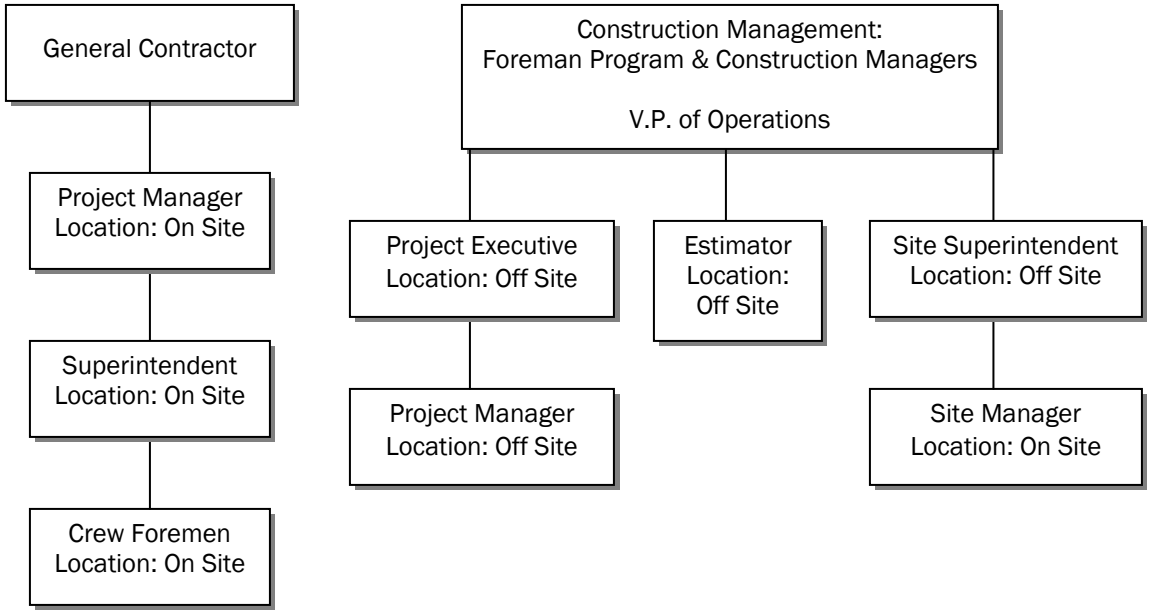


Organizational Chart

Communication

Typically, each of the Prime Contractor's personnel included an onsite crew foreman and a project manager who visited the site biweekly for the Job Conference meetings. Communication was common amongst onsite foremen and between the foremen and FPCM's site manager. Each foreman would also be in communication with his project manager, usually based in the contractor's main office with the exception of the general contractor's project manager who maintained an onsite office.

Project managers from different contractors would be likely to communicate amongst themselves as well as with the FPCM project manager. The Construction Management also had distinct lines of communication. The site and project managers were in daily contact regarding the project issues. The project manager and executive as well as site manager and superintendent also kept in contact.



Staffing Plan

Construction Coordination

Contractual Obligations

The contract of each prime contractor explains, "The Contractor shall be solely responsible for…coordinating all portions of the Work under this Contract, subject to overall coordination of the Construction Manager…" (Article 3.3.1) 3.10.2 goes on to clarify, "The Contractor shall cooperate with the Construction Manager in scheduling and performing the Contractors Work to avoid conflict, delay in or interference with the Work of other Contractors or the construction or operations of the Owner's own forces." 3.10.2.1 adds "The Contractor is financially responsible to the other prime contractors for undue delay caused by him to other prime contractors on the Project."

With regards to the Construction Management, the contract states, "The Construction Manager will provide for coordination of the activities of other Contractors and of the Owner's own forces with the Work of the Contractor, who shall cooperate with them." (Article 4.6.3) It also explains that the Construction Manager is responsible for compiling the Project Construction Schedule with the input of the Contractors' Preliminary Construction Schedules. (Article 3.10.2.1) This corresponds with Article 4.6.4 "Each Prime Contractor shall schedule and coordinate their activities with that of the other prime contractors in accord with the latest approved Project Construction Schedule."

Coordination Drawings

Specifications Section 01311: Project Coordination and Meetings
Original coordination drawings are to be furnished by the HVAC Contractor within 60 days after Execution of the Agreement or Notice to Proceed, whichever occurs first. Then, each Prime Contractor in turn has 14 days to add their particular trade items as they are agreed upon in coordination meetings.

Sequencing of drawing additions:

1. HVAC Contractor (prepares original coordination documents)
2. General Contractor
3. Plumbing Contractor
4. Fire Protection Contractor
5. Electrical Contractor
6. Food Service Equipment Contractor
7. Acoustical, Drywall, and Plaster Contractor

Once the last contractor has reviewed and approved the drawings, the HVAC Contractor must prepare and distribute a final reproducible systems coordination drawing, illustrating the work by each Prime Contractor.

Coordination: In Practice

Weekly coordination meetings or "foremen's meetings" were held at the FPCM site office trailer and facilitated by the FPCM Site Manager. A foreman or superintendent representing each onsite contractor, as well as any contractor who has work ongoing or upcoming within the next three to four weeks was required to attend. The meetings were used to discuss a two-week look-ahead schedule and any issues necessary to the group.

A set of coordination drawings was described above. These drawings in combination with the weekly coordination meetings created a coordinated MEP construction plan and minimized conflicts in the field. As a result, few minor MEP conflicts arose. Conflicts encountered between structural and MEP work were minor as well, although this could be where the greatest coordination challenges occurred. The most significant involved a conflict between the size of a load bearing CMU shaft and the duct. This issue was resolved quickly and work continued without considerable delay.

Cost Information

Bid Results (Including accepted alternates)			
Contract Number	Prime Contract	Contract Value	% of Total
401	GENERAL CONSTRUCTION	$ 4,955,200.00	46%
402	ROOFING CONSTRUCTION	$ 344,380.00	3%
403	ALUMINUM ENTRANCES & STOREFRONTS CONSTRUCTION	$ 183,700.00	2%
404	ALUMINUM WINDOWS CONSTRUCTION	$ 134,960.00	1%
405	ACOUSTICAL, DRYWALL & PLASTER CONSTRUCTION	$ 571,950.00	5%
406	CERAMIC TILE & QUARRY TILE CONSTRUCTION	$ 265,694.00	2%
407	RESILIENT FLOORING & CARPETING	$ 208,000.00	2%
408	PAINTING CONSTRUCTION	$ 94,685.00	1%
409	VISUAL DISPLAY BOARDS CONSTRUCTION	$ 74,640.00	1%
410	FOOD SERVICE EQUIPMENT CONSTRUCTION	$ 231,644.00	2%
411	GENERAL CASEWORK CONSTRUCTION	$ 264,649.00	2%
412	LIBRARY CASEWORK CONSTRUCTION	$ 66,750.00	1%
413	PLUMBING CONSTRUCTION	$ 572,500.00	5%
414	FIRE PROTECTION CONSTRUCTION	$ 110,100.00	1%
415	HVAC CONSTRUCTION	$ 1,503,638.00	14%
416	ELECTRICAL CONSTRUCTION	$ 1,176,000.00	11%
	TOTALS	$ 10,758,490.00	100%

Project Cost Evaluation

Construction Bid Cost	**$10,758,490**
- Sanitary Sewage (site cost w/in contract #413)	- 61,700
	$10,696,790
+ OCIP Cost	+ 191,369
= Construction Cost ($138.03 per SF)	**$10,888,159**
+ Architect's Fee (6% of Construction Cost)	+ 655,415
+ Moveable Fixtures & Equipment & Fee	+ 483,000
+ Architectural Printing	+ 24,950
+ Test Borings	+ 80,000
+ Site Surveys	+ 10,925
+ Site Costs	+ 70,547
+ Construction Manager Fee & Costs	+ 439,759
+ Demolition of Existing	+ 247,231
+ HVAC Balancing & Testing	+ 25,000
+ Local plan review, L&I, water tap-in	+ 89,627
+ Contingency	+ 376,000
+ Financing Costs	+ 1,166,357
+ Executed Change Orders	+ 136,980
= Total Project Costs ($186.40 per SF)	**$14,703,950**

Estimates

One estimate was created for Highland Elementary using D4Cost 2002 estimating software and the smart average feature. Four projects of new buildings similar to Highland were averaged to result in an estimate of **$8,413,873**.

Dillard Drive E.S.	83,580 SF	1 Floor	$6,463,515
Rancho Santa Fe E.S.	81,600 SF	1 Floor	$5,778,000
Rising Star E.S.	80,000 SF	1 Floor	$4,788,976
Reid Park E.S.	83,500 SF	1 Floor	$4,578,635

Square Foot Estimate

R.S. Means 2003 data was utilized to create a square foot estimate. Because of the building's three stories, a 2-3 story Jr. High School building was chosen as the model. An adjustment was made to account for 57% of the structure being CMU bearing and 43% steel. Adjustments were also made to reflect perimeter and story height differences, and a lump sum additions were also made. This resulted in a total estimated cost of **$8,959,057** or $114 per SF.

Why the difference?

Structural system: Bid cost $3,087,530; D4 $2,173,680; Means $2,647,861

Highland E.S. is unique in that it has two different structures attached to each other, the 3-story B-wing with masonry-bearing and the 1-story A-wing with steel. The coordination of these systems and complex geometry of the building could explain the low estimates.

Mech/plumbing system: Bid cost $2,076,138; D4 $1,444,882; Means $2,006,202

From the data provided about the D4 model buildings, the differences in mechanical systems between the model buildings and Highland E.S. were not apparent. One differing characteristic is that the model buildings were located in Kansas, North Carolina, and Arizona, areas with quite different climates than southwestern Pennsylvania.

Electrical system: Bid cost $1,176,000; D4 $875,300; Means $943,353

Each classroom in Highland E.S. has several data outlets, two television outlets and a public address call box and speakers. In addition, there are two computer labs and a library with data outlets, as well as a security system with motion sensors and CCTV surveillance. It appears that neither the R.S. Means nor the D4 estimates account for an electrical system of this scale.

General Conditions Estimate

An estimate for general conditions was created using R.S. Means estimating guides and actual project data. The result is a total estimate of $376,448 including approximate variable costs of $8025 per month. Also, information from the Specifications was compiled to detail the General Contractor's temporary facilities obligations. As not all of these specified items were actually utilized on the project or required by the Construction Manager/Architect, an estimate was not created for these items.

General Contractor			
Project Management	$6500 /mo	16 mos	104,000
Supervision	$6000 /mo	16 mos	96,000
Bonds	LS		48,000
Road Bond	LS		200
Site Survey	LS		2,500
Layout/Engineering	LS		3,750
Schedule	LS		5,000
Submittals	LS		7,200
Mobilize Trailers	LS		5,014
Field Offices	LS		6,000
Temporary Fence	$6 /LF	200 LF	1,200
Phone Service	$600 /mo	16 mos	9,600
Sanitary	$150 /mo	16 mos	2,400
Mobilize Excavator	LS		9,211
Silt Fence	LS		6,350
Parking, Entrance, Laydown	$1.25 /SF	42000 SF	52,500
Utilities			
Temp Electricity	$105 /mo	15 mos	1,575
Temp Heating/Ventilation	$10 /CSF	764 CSF	7,640
Temp Lighting & Outlets	$9.50 /CSF	764 CSF	7,258
Temp Water	$70 /mo	15 mos	1,050
Monthly Costs: $8025 /mo			**Total Cost: $376,448**

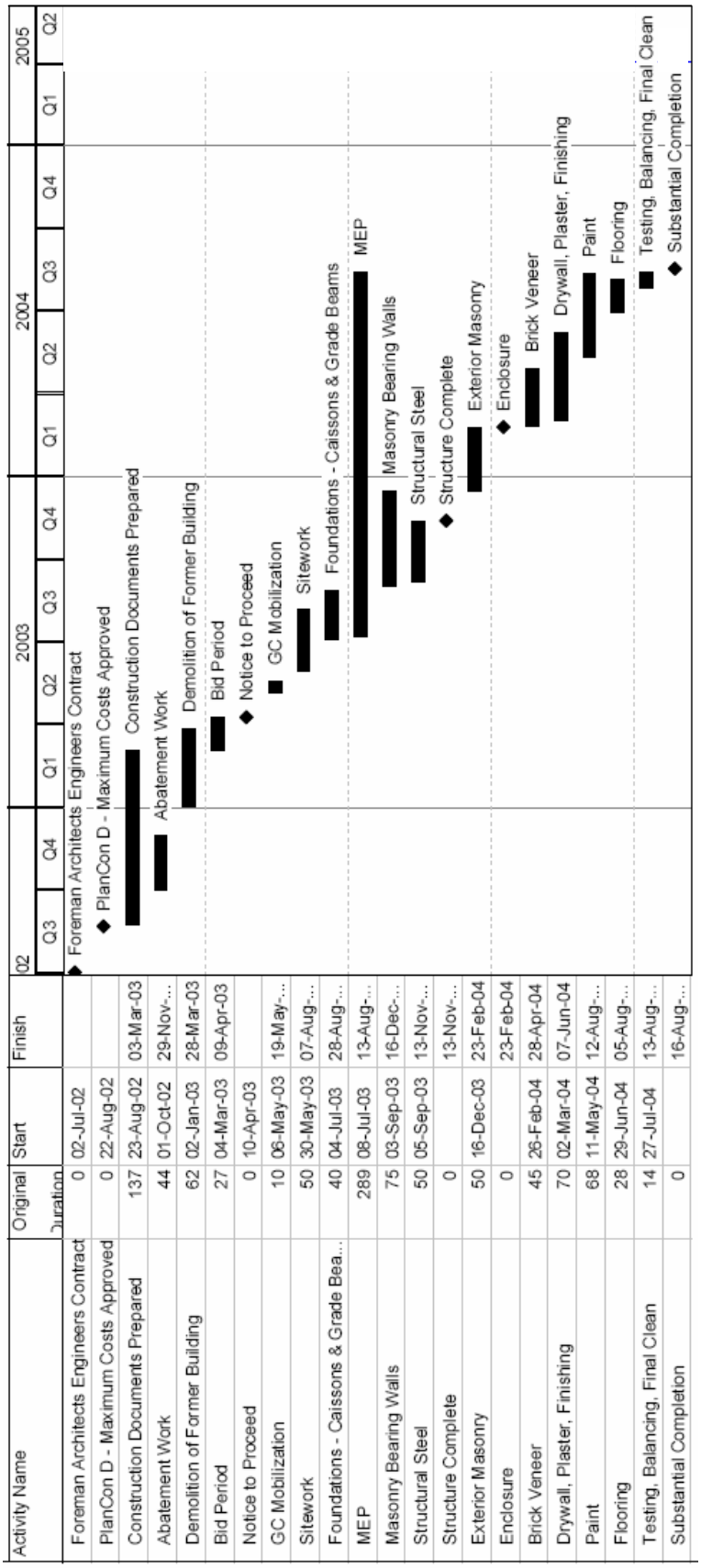
Schedule

Construction Dates: May 2003 through August 2004

Groundbreaking – May 2003
Concrete foundations – June through August 2003
Concrete masonry structure – September through December 2003
Structural steel frame erection – September & October 2003
Plumbing/HVAC/Elec. system backbone – December 2003 through March 2004
Veneer brick & windows/curtain wall – January through March 2004
Interior finishes – March through August 2004

Project Schedule Summary

See next page.

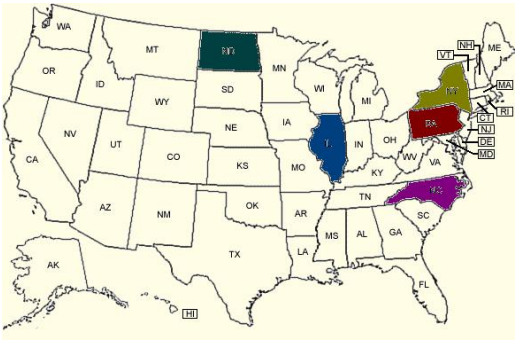


Activity Name	Original Duration	Start	Finish
Foreman Architects Engineers Contract	0	02-Jul-02	
PlanCon D - Maximum Costs Approved	0	22-Aug-02	
Construction Documents Prepared	137	23-Aug-02	03-Mar-03
Abatement Work	44	01-Oct-02	29-Nov-...
Demolition of Former Building	62	02-Jan-03	28-Mar-03
Bid Period	27	04-Mar-03	09-Apr-03
Notice to Proceed	0	10-Apr-03	
GC Mobilization	10	06-May-03	19-May-...
Sitework	50	30-May-03	07-Aug-...
Foundations - Caissons & Grade Bea...	40	04-Jul-03	28-Aug-...
MEP	289	08-Jul-03	13-Aug-...
Masonry Bearing Walls	75	03-Sep-03	16-Dec-...
Structural Steel	50	05-Sep-03	13-Nov-...
Structure Complete	0		13-Nov-...
Exterior Masonry	50	16-Dec-03	23-Feb-04
Enclosure	0		23-Feb-04
Brick Veneer	45	26-Feb-04	28-Apr-04
Drywall, Plaster, Finishing	70	02-Mar-04	07-Jun-04
Paint	68	11-May-04	12-Aug-...
Flooring	28	29-Jun-04	05-Aug-...
Testing, Balancing, Final Clean	14	27-Jul-04	13-Aug-...
Substantial Completion	0		16-Aug-...

Depth Analysis: Construction Management
Multiple Prime Contract Delivery for Pennsylvania Public Schools

School Construction Precedent

Five U.S. states currently require multiple prime contracts on public projects, including school construction: Illinois, New York, North Carolina, North Dakota, and Pennsylvania. In several of these states, if not all five, current legislation regarding single prime contracts and/or design build delivery is pending. For example, New York's Wick's Law requires multiple primes on public works projects; however, state officials have recently given New York City schools approval to proceed with single prime contracts. North Carolina and Pennsylvania have programs by which school districts can apply for waivers of multiple prime restrictions on individual projects.



States Requiring Multiple Prime Contracts

Ohio and New Jersey are two states that have recently enacting change in delivery method requirements. In 1995, Ohio approved legislation "so that a combination bid could be received and an award could go to the lowest combination bidder if the combination bid was lower than the collective multiple prime bids in the aggregate." Ohio legislators have also recently considered action to allow single prime and design-build contracts for public projects. Similarly, New Jersey now permits school districts to advertise bids as single prime, multiple prime or a combination of both and also allows design-build for public projects other than schools. The design-build method of delivery has been employed for schools in Florida under the auspices of the Florida State Division of Building and Construction, which offers expertise and experience that school districts generally lack. Design-build projects can be anticipated in states such as New Jersey as state agencies are developed to aid schools in the process.

Pennsylvania School Construction

The Pennsylvania School Code of 1949 Section 751, the "Separations Act", requires that public school projects have least four separate contracts: (1) general; (2) plumbing; (3) heating, ventilating and air conditioning; and (4) electrical. The multiple prime system has been thought to deliver projects in a very timely and cost effective manner, a position widely disputed and rejected by many, including the Pennsylvania chapter of The American Institute of Architects.

In 2000, the Mandate Waiver Program was established by Pennsylvania Act 16, the "Education Empowerment Act", as an educational reform initiative that applies to all 501 school districts in Pennsylvania. The program allows Boards of School Directors to seek waivers from compliance with certain provisions of the Public School Code in a wide range of areas, including construction and the separation of contracts requirement. As a result, any school district in anticipation of a construction project may submit an

application to the PA Department of Education detailing a plan to use less than four prime contracts for the project.

The main criterion for approval is demonstration that "the waiver will allow the school to improve its instructional program or operate in a more effective, efficient or economical manner." In regards to construction, school districts achieve this by soliciting the opinions of contractors and design professionals, which are often submitted with the applications. Drawing from these opinions, school districts generally cite five areas in which they believe they will reap benefits of single prime construction: budget, schedule, quality, safety, and litigation.

Section 751 Mandate Waivers

It appears that all Section 751 waiver applications for less than four contracts as of spring 2005 have suggested single contract arrangements as the desired alternative. The Section 751 waiver applications being considered in this thesis research were for new construction or renovation projects with project costs over three million dollars each. Projects under $3.0 million or consisting of only office space or sports facilities were not considered. Applications requesting that school district personnel or contractors already onsite be allowed to complete work were also not considered in this research.

Mandate Waiver Applications 2000-2005

Year	Total Waivers Applications	Total Section 751 Waiver Applications	751 Waivers approved that meet study criteria
2000	23	2	0
2001	161	57	7
2002	166	86	20
2003	102	28	5
2004	58	17	0
2005*	8	4	0
Total	*518*	*194*	*32*

* as of March 20, 2005

Nearly 16% of all Section 751 waiver applications approved by the Dept. of Education meet the above criteria, a total of 32—seven were approved in 2001, twenty in 2002, and five in 2003. No applications were received in 2004 or to date in 2005. It should also be noted that a few school districts (exact number unknown) received waivers and elected not to use them. *A complete table of approved applications including details about individual projects is available in Appendix A.*

Legislative and legal battles explain the recent lack of applications and why some school districts have decided not to use the waivers they have been granted. In the 2001-2002 session, the Pennsylvania House of Representatives passed House Bill 412 which, if

signed into law, would have repealed the mandate waiver option for Section 751. After months on the house floor however, the bill was vetoed by Governor Mark Schweiker in November 2002.

Why Multiple Prime?

Budget, schedule and quality are three advantages that are presented in favor of multiple prime contracting. This method is thought to provide the lowest construction bids as fewer subcontracts are necessary, eliminating the overhead and profit that a contractor would request for each subcontract. Also, with this method, each prime contractor has ample knowledge of his trade and can create an accurate cost estimate of his work. It is also argued that fewer subcontracts, in favor of more prime contracts, allow for the shortest possible project schedule. This is mostly attributed to the fact that the a contractor does not need to obtain numerous subcontractor bids before submitting a final bid himself and then further negotiate with subcontractors before entering into contracts with them. Better quality of construction is also thought to be an advantage---a result of specialty prime contractors who have thorough knowledge of their trade.

Research Goals

As proposed, the original objective of this research was to determine if multiple prime contracting was the best delivery method for the Highland Elementary School project. To achieve this goal, a study would be conducted to determine the effectiveness of multiple prime contracts. Initially, this was to be a study consisting of information collected from projects completed in states other than Pennsylvania, which allow delivery methods different than multiple prime contracting for public school projects.

However, early on, it was discovered that a change in legislation in the year 2000 has allowed Pennsylvania schools to use alternative delivery methods as well, by way of mandate waivers. And as single prime contracting has been the only utilized alternative to multiple prime contracting in Pennsylvania, this study became focused on the difference between multiple and single prime projects. It was intended that an informed decision could be made regarding the effectiveness of multiple versus single prime contracting for Pennsylvania public school construction projects. Finally, it was hoped that it could be determined whether single or multiple prime contracting was a better delivery method for the Highland Elementary School project using the categories of budget, schedule, quality, safety, and litigation.

Research Methods

To accomplish these objectives, opinions of individuals and facts will be collected to gain knowledge of this subject, as both influence public policy and legislation. Also, the Highland Elementary School project would be examined and research findings would be applied to that project's information in an effort to use this project as a case study. A literature review was necessary to learn more about relative issues and to uncover past studies in this area. A survey was created, distributed and completed by many school districts, and personnel at various schools and at the Pennsylvania Department of Education were interviewed. Additionally, the Highland Elementary School project was

researched further through personal interview and available project data. *See Appendix B for survey and Appendix C for results.*

Results

Through literature and document review and correspondence with school district personnel, a comprehensive list was created of the perceived differences between multiple and single prime contractor projects for school construction. School district personnel offering input represented districts that have recently completed one or more single prime contract projects in Pennsylvania. As single prime construction is the only available current alternative to multiple primes in Pennsylvania, it was found difficult to discern between what people perceived as disadvantages of multiple primes or as advantages of single primes. Therefore, the list was compiled simply as "differences" grouped into the five categories mentioned previously: budget, schedule, quality, safety, and litigation. It must be emphasized that these are *perceived* differences, and that often the items listed below are direct quotations from individuals.

Budget Concerns

- Change orders resulting from disputes over which trade has responsibility for portions of work. Change orders and associated cost and time.
- Processing many contracts results in legal fees for preparation, reviews and work after review of bids and bonds.
- Coordination of general conditions costs can be difficult with some items entering the bid of more than one contractor.
- Processing by district personnel of many contracts and pay applications.
- Specifications state obligation to have onsite managers, foreman, and fixed costs (phone, fax, office & storage trailers) for each prime contractor.
- School district personnel, often inexperienced, provide administrative oversight over many contractors. Professional construction management sometimes acquired.
- Each contractor must have own bond.
- Owner and architect predetermine scope of work for each contractor.

Schedule Concerns

- Difficult schedule management/coordination. Activities are not coordinated and a contractor may have to wait for another contractor's work to be completed, leading to project delays.
- Coordination and review of shop drawings, RFIs and submittals can be a timely process. Can lengthen project schedule.
- Disputes of responsibility regarding delays. No contractor assumes responsibility for delay and rectifies situation, project completion delayed.
- Multiple primes not able to coordinate well enough to accelerate a project schedule.

Quality Concerns

- Lack of quality control as school district must monitor. Lesser quality construction.
- Problems discovered during inspections and punchlisting must be pointed out to many primes and completion monitored by school district. Punchlist items not completed promptly or properly.

- Larger, more experienced quality contractors tend to avoid multi-prime projects. This is unfortunate because they have developed relationships with experienced subcontractors who have proven their capabilities.

Safety Concerns

- Overall project safety difficult for district to monitor. Possibility for unsafe work conditions.

Litigation Concerns

- Disputes of responsibility regarding scope of work and cause of delay.
- Owner at risk for claims and litigation with several contractors. Significant legal fees could ensue.

School District Post-Construction Survey

Information from seven different construction projects was received in response to the School District survey. In the opinion of the individuals surveyed, the following resulted

Area	Believed Project Benefited from Single Contract	Believed Project Did Not Benefit from Single Contract	Unsure If Project Benefited from Single Contract
Budget	5	1	1
Schedule	3	1	3
Quality	6	0	1
Safety	6	1	0
Litigation	6	0	1

Conclusion

In Pennsylvania, school districts have recently been given the opportunity to research construction delivery methods and apply for a waiver of multiple prime contract requirements. In forming their opinions to make this decision, school board members and administrators seek the advice of professionals in the industry. Through this research, it is apparent that before studying the issues thoroughly, some school districts believe single prime contracting will be most beneficial to their project. Then they solicit opinions from professionals to support their beliefs. This often includes general contractors and architects, but does not often include construction management firms or other school districts that have attempted single prime construction.

From the survey responses received, several conclusions can be drawn. Because of the small response, it is believed that this data alone is not conclusive, but the comments obtained from school district personnel were particularly useful. It appears that the majority of school districts responding believe that they benefited from using a single prime contract as compared to multiple prime contracts in the areas of budget, quality, safety and litigation. There was not a demonstration of project schedule benefiting from single prime delivery. The lack of litigation and legal costs was often the most emphasized perceived benefit of single prime delivery. Also, the overall success of the

Highland Elementary School project suggests that single prime contracting may not be the most effective delivery method for public school projects.

If school district personnel in Pennsylvania are to be allowed to continue selecting delivery methods for their construction projects, it appears that more guidance should be provided in the process. This guidance should not continue to come solely from general contractors and architects, but from an organization that more closely represents the interests of public schools. In this way, a school district and the Department of Education can both be assured that their choice of construction delivery method is the best choice for the district allowing it to operate in a more effective, efficient and economical manner.

Breadth Analysis A: Lighting/Electrical
Increased Daylighting at Highland Elementary School

To most people a good light means only much light. If we do not see a thing well enough we simply demand more light. And very often we find that it does not help because the quantity of light is not nearly as important as its quality. —Steen Rasmussen

Introduction

Daylighting and its effects on the occupants of a building space are not likely to be new concepts to individuals involved with the design of educational spaces. Several scientific studies have been conducted in this area, since the subject was raised in the 1960s. Interestingly, the problem of windowless classrooms emerged at this time as a number of new underground school structures were being built with dual purpose— as educational spaces and as fallout shelters. One of the most recent studies in this field was sponsored by the state of California Energy Commission and directed by The Heschong Mahone Group (HMG), Fair Oaks, CA.

Research Goals & Methods

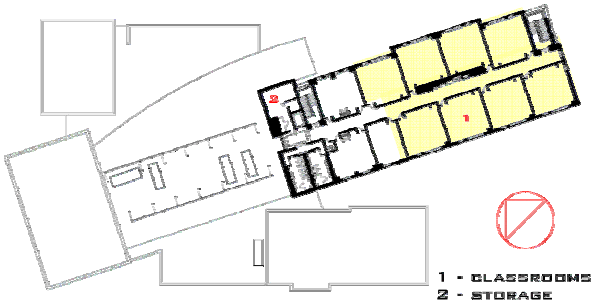
The goals of this study were to research the benefits of daylighting in educational spaces, redesign the exterior façades of the Highland Elementary School classroom wing, and determine if the building's occupants would better experience the benefits of daylighting with the redesign. AutoCAD 2005 from Autodesk, Inc. was utilized to create a three-dimensional model of part of the classroom wing. For simplicity, a curtain wall at the corner of the building was not included and north and south facades were considered to be identical.

This model was imported into AGI32, Version 1.71 Revision 11 from Lighting Analysts, Inc. After entering a number of variables such as reflectance values and textures to surfaces, light fixtures, calculation points, and building location, a daylight study was conducted. A north facing and a south facing third-story classroom of each design was analyzed at six specific points in time. The variables used are recorded in Appendix D.

Time Periods
15 April 2005 – 10:00:00 hrs & 14:00:00 hrs (Daylight Saving Time)
15 August 2005 – 10:00:00 hrs & 14:00:00 hrs (Daylight Saving Time)
15 December 2005 – 10:00:00 hrs & 14:00:00 hrs

As Built

The classroom wing of Highland Elementary School is three stories, with a total of 24 classrooms. The first and second floor classrooms (16 rooms) were designed and built with 84 sq. ft. of windows each. The third floor classrooms (8 rooms) were designed and built with 65.33 sq. ft. of windows each.

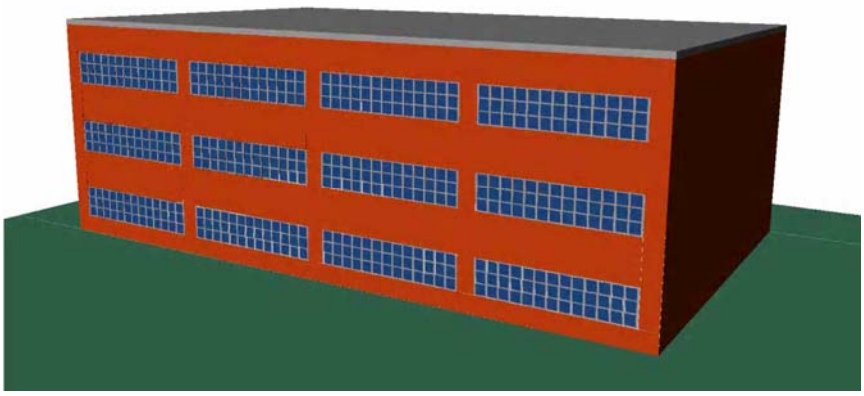


Plan of Classroom Wing As Built
(Modeled rooms highlighted)

Classroom Wing Exterior Façade As Built

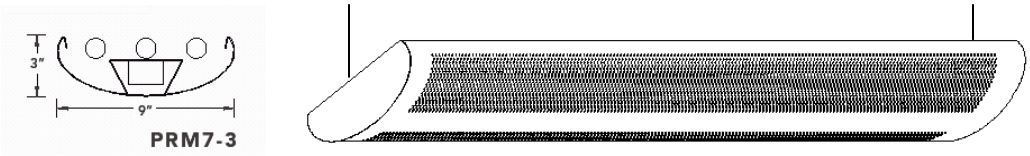
An Alternative

In the redesign, window area was increased to 26'-4" x 6'-0" (158 sq. ft.) for each of the 24 classrooms and the metal insulated panels were removed. This resulted in an 88% increase in area for each first and second floor room and a 142% increase in area for each third floor room. Neither interior finishes nor lighting fixtures (below) were modified, and window shades were not added.



Classroom Wing Exterior Façade Alternative

The light fixtures in these classroom spaces are Peerless Lighting Peerlite® pendant-mounted fixtures with three 32-watt lamps across. The fixtures have an oval silhouette and are partially perforated to allow direct and indirect lighting.



Lighting Fixture Details

Results

Maximum Average Illuminance - Clear sky, lighting **off**
Levels at Desk Height

As-Designed

North Room	South Room
August 15, 10:00AM	December 15, 2:00PM
25.44 fc	314.83 fc

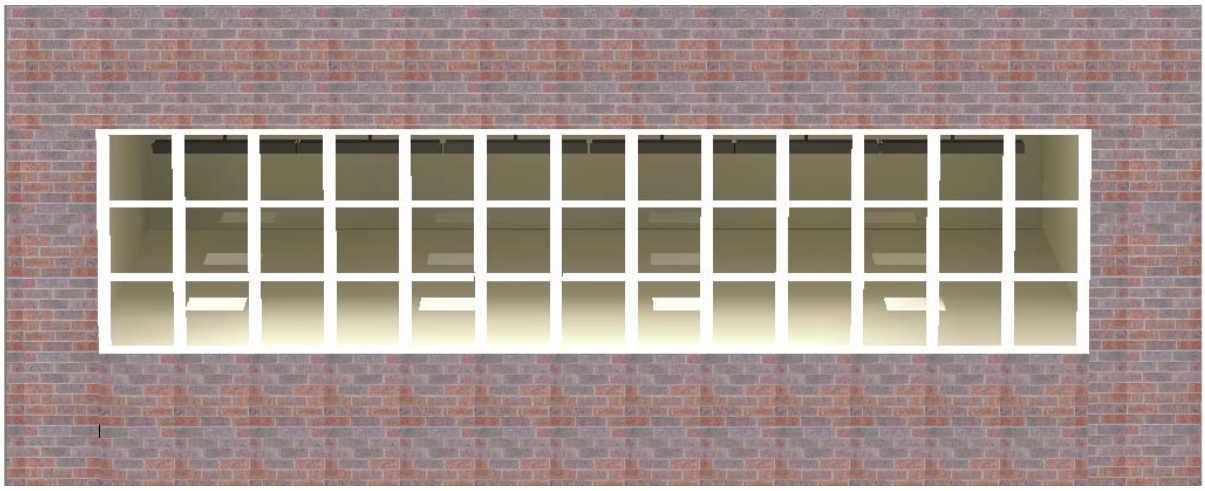
Alternative

North Room	South Room
August 15, 10:00AM	December 15, 2:00PM
57.61 fc	1855.08 fc

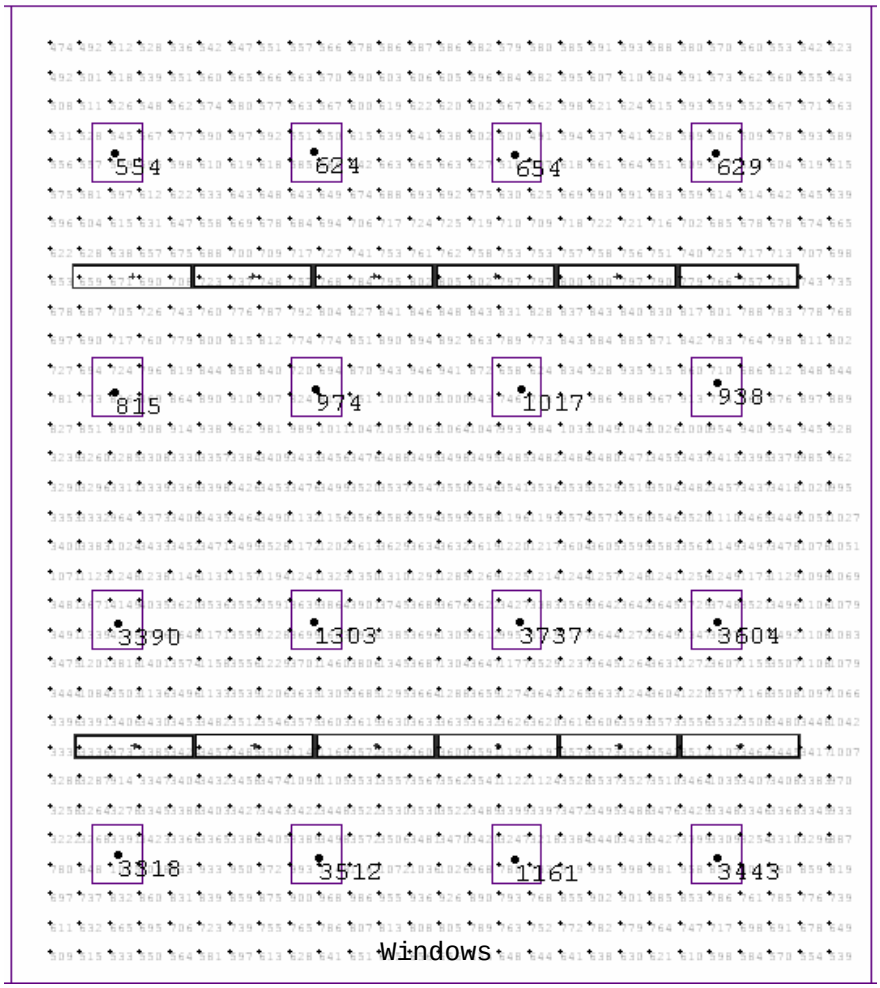
South-Facing Classroom
The above data suggest that with a clear sky, lighting levels in the south room may be acceptable without any electric lighting at some times of the year with either design. However, the light distribution across the space at desk height varies greatly, especially with the redesign:

Average nearest windows: 2858 fc
Average at far side: 615 fc

Additionally, these levels are much higher than IESNA's recommendation of 50-100 fc for classrooms, suggesting the occupants of the space will find the lighting uncomfortable. A large amount of glare is also a factor that must be considered.



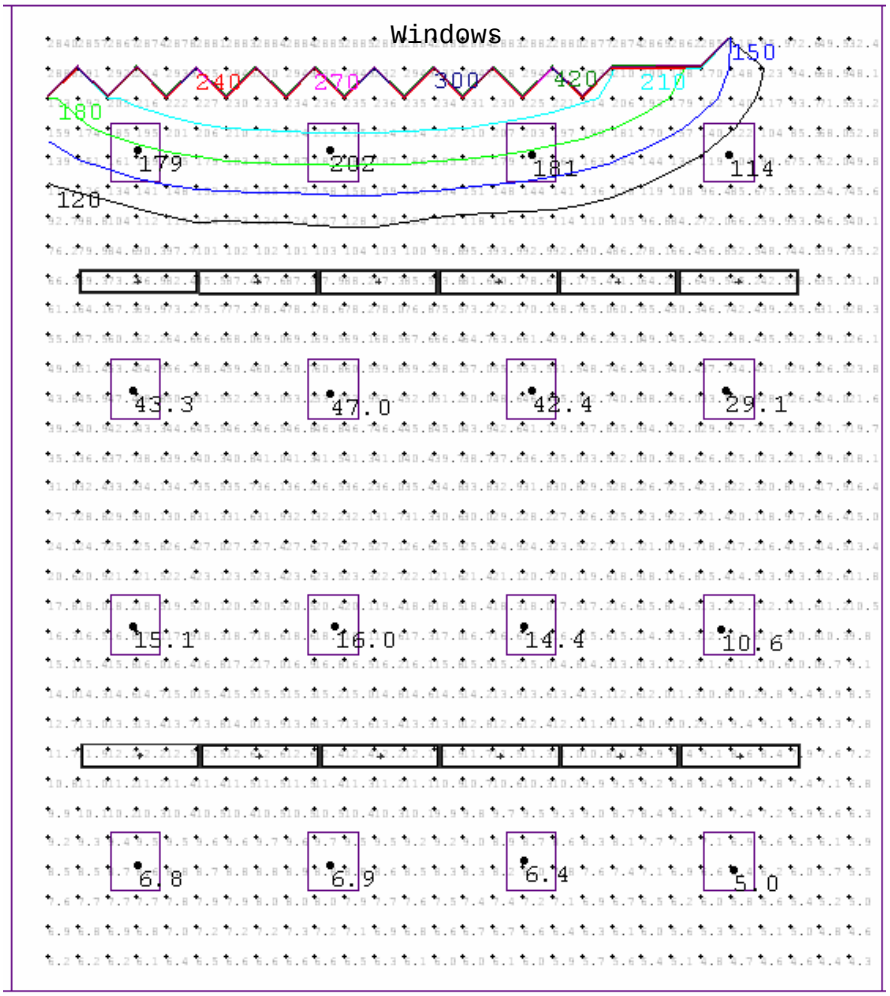
Rendering of South Room Alternative Design, 15 December 2:00PM



Illuminance Values at Calculation Points
South Room Alternative Design, 15 December 2:00PM

North-Facing Classroom

The data also suggest that the Alternative Design would allow the north room to function without electric lighting at some times of the year. Again, looking at the light distribution on 15 August, it can be seen that illuminance values vary and that the window-side of the classroom receives a concentration of light.



Illuminance Values at Calculation Points
North Room Alternative Design, 15 August 10:00AM

Energy Savings

Overall, lighting levels in the north-facing classrooms were acceptable at most times of the year if the second row of lights was not utilized. Lighting levels in the south classrooms varied more considerably and indicated different amounts of reduction at different times and conditions. The results are summarized below.

Energy Savings in a Typical South-Facing Classroom

Conditions	Avg Number of Days with Conditions+	Morning Electric Lighting Usage	Afternoon Electric Lighting Usage	Daily Energy Demand kWh	Daily Savings kWh	Period Demand Savings kWh
Aug – Clear	27 (Jul – Oct)	576W*	none	2.304	6.912	186.624
Aug – Ptly Cldy	43 (Jul – Oct)	576W	none	2.304	6.912	297.216
Aug – Overcast	53 (Jul – Oct)	576W	576W	4.608	4.608	244.224
Dec – Clear	13 (Nov – Feb)	none	none	0	9.216	119.808
Dec – Ptly Cldy	23 (Nov – Feb)	576W	none	2.304	6.912	158.976
Dec – Overcast	84 (Nov – Feb)	576W	576W	4.608	4.608	387.072
Apr – Clear	19 (Mar – Jun)	none	none	0	9.216	175.104
Apr – Ptly Cldy	36 (Mar – Jun)	576W	none	2.304	6.912	248.832
Apr – Overcast	67 (Mar – Jun)	576W	576W	4.608	4.608	308.736
					Total Demand Savings	2126.592

+ National Climatic Data Center, NOAA, 2001
* 576W = usage of one row of fixtures in typical classroom

South Rooms: 2126.592 kWh savings x 12 rooms = 25519.104 kWh
North Rooms: Half usage = 4.608kWh x 365 days x 12 rooms = 20183.04 kWh

Savings at $0.085/kWh = $3885 per year

Other Considerations

Issue	As Built	Alternative
Façade	1925 SF Brick and CMU, painted @ $17.40/SF = $33,495	1925 SF Aluminum Windows & Glazing @ $32/SF = $61,600 (Increase of $28,105)
Structure	3 Lintel pieces—(2) W8x31, (1) L8x8x1/2	One lintel piece extending beyond length of window, redesign of connections into structure, greater reinforcement of piers
Aesthetics	Façade reminiscent of steel mill stacks, interest created by insulated panels	Piers on façade nonexistent, little interest created
Energy	Electric lighting on at all times.	Lighting closest to windows often turned off. $3885 savings per year for year-round usage.
Occupants	Less daylighting, 100% usage of electric lighting.	Experience benefits of increased daylighting. Automatic dimming sensors may be necessary to decrease energy demand. May be uncomfortable without window shades.
Schedule	1925 SF Brick and CMU construction, interior painting—difference in duration negligible.	1925 SF frame and glazing installation—difference in duration negligible.
Mechanical	Discussed in Breadth Analysis B	

Conclusion

Daylighting has been proven in studies to increase learning ability, test scores, and alertness in school children. Schools and society can also benefit from daylighting in school spaces as it can reduce electric lighting demand and associated costs. At Highland Elementary, a proposed redesign of the classroom wing increased window area by 142% for third floor classrooms and 88% for first and second floor classrooms.

The study demonstrated increased lighting levels throughout the year when the alternative design was modeled. Additional cost to install more window area was estimated at $28,105. Energy savings were estimated at $3885 per year, which would negate the installation costs in a payback period of approximately seven years after construction.

While the increased window area raises lighting levels in the spaces, levels are uneven throughout the space with very high levels near the windows at certain times of year. To make this redesign comfortable for occupants, additional equipment would be necessary. Window shades as well as lighting sensor and closed-loop control systems are options that could ensure success of this alternative design. It was also discovered that sky-lighting is a more preferable daylighting option and may be a better option in the third story classrooms if future research were to be conducted.

Breadth Analysis B: Mechanical
Effects of Façade Redesign on Mechanical System at Highland Elementary School

Introduction
As part of Breadth Analysis A, a façade redesign was proposed for the classroom wing of Highland Elementary School. This redesign would add 93 SF of window area to each third floor classroom. In this analysis, the effects of this redesign on the mechanical system will be explored. The system provides heating, cooling and ventilation to each classroom by a floor-mounted vertical unit ventilator (UV). A UV is located underneath the windows on the exterior wall of each room.

Research Goals & Methods
First, this analysis was to begin with research on unit ventilator systems. The advantages and disadvantages of unit ventilator systems were to be researched to verify the appropriateness of using the systems in classroom settings. The primary objective of this analysis was to determine what affect the façade redesign would have on the mechanical system of the classrooms. This would aid in determining the feasibility of adding more window area to each room. Then, a proper mechanical system could be chosen to complement the new design.

Unit Ventilators
For several decades, one of the most widely used systems to provide heat and ventilation in classroom spaces has been the unit ventilator. This system has the basic components of a large air-handling unit contained in a package that often approximately 2 FT wide and 8 FT long with a countertop height. It is positioned on an exterior wall for access to outdoor air, which is one of the main reasons that UVs are chosen for classroom spaces. In most applications, return air enters at the front near the floor of the unit and supply air exits from the top. A variety of types of heating and cooling coils can be installed, allowing such options as steam or electric heat in different units.


As Built Typical Classroom Exterior Wall with UV

UVs are used in spaces such as classrooms and hospitals because of outdoor air needs and because of individual room zoning. Controls in each space can regulate the amount of air and temperature supplied. Also, air that may contain odor or contaminants from is not moved from adjacent spaces. There are other advantages. UVs have a relatively low first cost for both equipment and installation that is quick and easy. Maintenance staff can access the units easily, and if there is a problem with one unit it will not affect others. Another advantage of UV systems is that they do not affect lighting layouts and installation or other work above the ceiling.

There are also disadvantages to using UVs in classrooms. Sometimes the noise of fans in the units can be bothersome. Airflow is limited and concentrated around the unit. Aesthetically they can be undesirable, on the interior and exterior, as large wall openings are required to bring in outdoor air. Maintenance is not difficult, but it is regularly required on each unit to dispose of condensate and change filters. However, research does not seem to indicate that these disadvantages outweigh the positive aspects of using unit ventilators.

Selection

There are three steps in the process of selecting a UV. First, heating and cooling design loads for the space must be obtained. The software utilized for this task was the Hourly Analysis Program (HAP) by Carrier, Version 4.20a. Then, unit size must be established using requirements for total air circulation, outdoor air, and total cooling and heating capacity. Finally, appropriate coils can be selected. The units originally specified and installed were Trane model VUV-150 with chilled and hot water being supplied from equipment located in/near the basement mechanical room.

Two standard classrooms were analyzed in HAP using the following parameters:

- One room faces northeast, one faces southwest
- Calculations for a 12 month period
- 822 SF, 9'-4" ceiling height
- 270 SF exterior exposure, CMU with brick façade
- Location above conditioned space, Built-up roofing
- Medium building weight
- Free hanging lighting fixtures, 1.4 watts/SF
- Lighting demand: 10% during July, August, Holidays, Weekends & between 4PM and 6AM
- No occupants on weekends and July through August
- Otherwise, assume 30 occupants from 8AM-3PM, and single occupant 7AM-8AM and 3PM-4PM

Results

The following tables are the results of the HAP analysis for a typical north-facing and a typical south-facing classroom for both the as-designed case and the proposed façade redesign.

North Classroom Design Loads

	Design Cooling Sensible (BTU/hr)	Design Heating Sensible (BTU/hr)
North Room – As Designed	**17,466**	**13,359**
North Room – Redesign		
Window/Solar Load	+ 3,198	
Wall Transmission	- 121	- 1,815
Window Transmission	+ 26	+ 3,706
Total Redesign Load	**20,567**	**15,250**

South Classroom Design Loads

	Design Cooling Sensible (BTU/hr)	Design Heating Sensible (BTU/hr)
South Room – As Designed	**18,964**	**13,359**
South Room – Redesign		
Window/Solar Load	+ 6,742	
Wall Transmission	- 112	- 1,815
Window Transmission	+ 244	+ 3,706
Total Redesign Load	**25,838**	**15,250**

See Appendix E for comprehensive HAP analysis results and sample calculations.

Calculations continued using data from the south-facing room for two reasons: 1. the cooling design load is greater for the south-facing classroom and 2. for ease of installation and maintenance, identical units will be installed in each classroom.

Outdoor air required (15 cfm/person): 450 cfm

Air circulation required (8 air changes/hr): 1023 cfm

Cooling airflow required:
South – As Designed: 553 cfm
South – Redesign: 594 cfm

Unit Ventilators are primarily selected on the basis of airflow delivered to the space. For these classrooms, the unit supply airflow requirement is larger than the cooling airflow requirements for either design. Therefore, the supply airflow controls and a unit should be chosen to supply at least 1023 cfm. A 1500 cfm unit was originally specified. This unit is capable of meeting the 25,838 BTU/hr sensible cooling load required by the alternative design.

Conclusion

The effects of the alternative façade design on the mechanical system of the classrooms were analyzed. The advantages and disadvantages of unit ventilator systems were researched. Heating and cooling loads were calculated as well as airflow and ventilation requirements for both the original façade design and the proposed alternative. It was found that the mechanical system in place would be capable of providing appropriate cooling and that the effects on the mechanical system would not prevent the success of the redesign.

Summary and Conclusions

Public school district personnel are faced with a variety of decisions when approaching a school construction project. Administrators, school board members and staff in these situations must become educated in the construction industry itself, construction delivery methods and management options, architectural design, equipment choices, project financing, department of education procedures and the list goes on. In this thesis study, three issues were explored: delivery methods; window area and façade design; and typical classroom mechanical systems.

Rendering of Highland E.S. Corridor

In a construction management depth analysis, the multiple prime delivery system was compared to single prime delivery. The single prime contract delivery method has been allowed in many Pennsylvania school projects and a survey of these schools was conducted. It was difficult to determine how successful this method has been, although personnel from several school districts offered their praise by way of the survey conducted. The Highland Elementary School project offers a good look at multiple prime contracting with a construction management agency. This project was very successful, being delivered as scheduled and budgeted with no litigation or disputes.

Considering the survey results and in light of the Highland Elementary Project, it is difficult to conclude which delivery method is most appropriate for Pennsylvania public schools. However, recent legislation allowing waivers of the multiple prime contract requirement indicates new interest in researching issue. It is hoped that work continues in this area to explore delivery methods for public schools and that school districts become better educated such that they can make informed and appropriate decisions for their projects.

Two breadth studies were conducted in the areas of lighting and mechanical engineering. These studies focused on an alternative design for the façade of Highland Elementary School classroom wing, adding window area to each room. The design was found to be a feasible alternative, as the quality of light in the spaces were improved, daylight levels were increased, and energy demand could be decreased. The added window area had minimal effect on the design cooling loads, allowing the same unit ventilator equipment to be used in either design for heating and cooling the classrooms.

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> *We think of the effective teachers we have had over the years with a sense of recognition, but those who have touched our humanity we remember with a deep sense of gratitude.* — Anonymous student

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Linda Lewis and Brad Cordek—thanks to both of you for your assistance with those quirky little programs that CMs should simply not be permitted to touch. Maybe it's all just hooey anyways.

Image Credits:
With the exception of the renderings for Breadth Analysis A, all images are courtesy of Foreman Architects Engineers and Foreman Program & Construction Managers.

Appendix A:
Waiver Applications (Depth Analysis)

Table 1: Applications Approved for Waiver of Multiple Prime Contract Requirements

Excluded were:
- Applications for projects under $3.0 million.
- Applications for projects consisting of only office space or sports facilities.
- Applications requesting that school district personnel or contractors already onsite be allowed to complete work.

PA Dept. of Ed. ID	School District Location Telephone	Description of Project(s)	Date of Waiver Approval	Waiver used?
01-006	Tredyffrn/Easttown Berwyn 610-240-1900	Additions to Valley Forge E.S., Beaumont E.S., and Conestoga H.S. Estimated total cost $27mil.	03/19/01	
01-053	Spring-Ford Area Collegeville 610-705-6000	Upper Providence E.S., contract value $12,784,600. Middle/Intermediate School, contract value $38,806,740.	07/13/01	Y
02-018		Renovations to Spring-Ford Area M.S.	11/18/02	
02-119		New construction of E.S., Limerick Twp.	11/18/02	
01-076	Central Bucks Doylestown 267-893-2000	New H.S., E.S., and additions and Buckingham, Butler, Warwick and Cold Spring Elementary Schools. Estimated total cost $146mil.	09/12/01	
01-087	West Perry Elliottsburg 717-789-3934	Work at New Bloomfield E.S. and West Perry M.S.	10/11/01	
01-117	Great Valley Malvern 610-889-2100	Additions and renovations pf Charlestown E.S., estimated cost $10mil.	11/02/01	
02-007		Additions and renovations to Great Valley H.S., estimated cost $36mil.	03/22/02	
01-120	Pennsbury Fallsington 215-428-4100	Renovations to Quarry Hill E.S., estimated cost $5.5mil.	11/13/01	
02-117		Renovation of Manor E.S. and Penn Valley E.S.	11/15/02	
01-137	SD of the City of Jeannette Jeannette 724-523-5497	Construction and renovations of Jeannette Senior H.S.	12/14/01	

01-153	Fannett-Metal Willow Hill 717-349-7172	Addition and renovations of Fannett-Metal H.S., estimated cost $1,375,000.	01/31/02	
01-155	Owen J. Roberts Pottstown 610-469-5100	Additions and renovations of Owen J. Roberts M.S., estimated cost $1.0mil.	02/14/02	
02-023	Canon-McMillan Canonsburg 724-746-2940	Renovation of Cecil M.S., estimated cost $6,433,000 and new construction of North Strabane Intermediate School, estimated cost $6,796,000.	04/10/02	
02-029	Kiski Area Vandergrift 724-845-2022	Additions and renovations of H.S. and attached administration offices, project cost $37.5mil.	04/24/02	Y
02-051	Pennridge Perkasie 215-257-5011	Construction on H.S. and M.S. projects at Fifth Street campus.	06/18/02	
02-052	Upper Moreland Township Willow Grove 215-659-6800	Construction project to house entire K-5 program on one campus.	06/18/02	
02-069	Forest Area Tionesta 814-755-4491	Additions and renovations of West Forest Elementary-Secondary School.	08/01/02	
02-089 03-002	Lower Merion Ardmore 610-645-1800	Additions and renovations of Gladwyne, Penn Valley and Merion E.S. Same as above. Total cost of three projects $33.27mil.	09/10/02 05/02/03	
02-106	New Hope-Solebury New Hope 215-862-2552	Construction of new E.S. and additions and renovations of existing E.S. and H.S.	10/29/02	
02-108	Downingtown Area Downingtown 610-269-8460	Renovation of E.S.	11/07/02	Y
02-112	Abington Abington 215-884-4700	Demolition and reconstruction of Highland, Overlook and Roslyn E.S. Renovation of Will Hill E.S.	11/05/02	N
02-113	Mt. Lebanon Pittsburgh 412-344-2077	Renovations to Foster, Howe, Jefferson, Lincoln, Markham, Hoover and Washington E.S.	11/21/02	
02-114	West Chester Area West Chester 610-436-7000	Additions and renovations of East H.S./Fugett M.S. and B. Reed Henderson H.S. Construction of new Bayard Rustin H.S.	11/22/02	

02-124	Kennett Colsolidated Kennett Square 610-444-6600	Additions and renovations of Kennett H.S.	12/13/02	
02-128	Upper Perkiomen East Greenville 215-679-7961	New middle school.	12/02/02	
02-135	Millcreek Township Erie 814-835-5300	New elementary school.	12/18/02	
02-142	Wellsboro Area Wellsboro 570-724-3547	Additions and renovations of H.S.	01/08/03	
02-159	Neshannock Twp. New Castle 724-658-4793	Additions and renovations of Neshannock Memorial E.S.	01/17/03	
03-001	Philadelphia City Philadelphia 215-299-7000	Several new elementary and high school buildings, renovations to several existing elementary, middle and high schools.	03/03/03	
03-025	Pleasant Valley Brodheadsville 570-402-1000	Additions to elementary and high schools, total cost $8.5mil.	05/02/03	

Notes:
1. During the year 2004, no applications were received requesting waivers from the multiple prime requirements.
2. Excluded from this table are projects with estimated costs under $1 million as well as projects not containing any classroom space, such as sports facilities, arenas, and administrative office buildings.

Appendix B:
Survey Sent to School Districts (Depth Analysis)

SURVEY— SCHOOL CONSTRUCTION SINGLE PRIME CONTRACTS

Person completing survey, position: _____

School District: _____

Project(s) utilizing single prime contract: _____

Building Size: New Construction: _____ SF Renovations: _____ SF

Prime Contractor: _____

Management Type (Clerk of Works, CM Firm, etc.): _____

SCHEDULE: Date documents released for bid: ___/___/___ Date bid awarded: ___/___/___

Date of Notice to Proceed: ___/___/___ Substantial Completion: ___/___/___

In your opinion, in what way did a single prime contract (as compared to multiple primes) impact this project's schedule?

BUDGET: Prime contract value: $_____ Total project cost: $_____

Total change orders: $_____

Cost of construction management (if any): $_____

In your opinion, in what way did a single prime contract (as compared to multiple primes) impact this project's budget?

QUALITY: In your opinion, in what way did a single prime contract (as compared to multiple primes) impact the quality of construction?

SAFETY: In your opinion, in what way did a single prime contract (as compared to multiple primes) impact overall safety on this construction project?

DISPUTES: Any legal costs resulting from disputes with Contractor? Y / N $_____
Describe the nature of any disputes:

Additional Comments:

Thank you very much for your participation.
Questions may be directed to Carey at 724-372-1069.

Please return to: Carey Steckler
250 S. Burrowes St. #2
State College, PA 16801
Or email responses to: CLS348@psu.edu

Appendix C:
Survey Results (Depth Analysis)

Waiver #02-029

School District	Kiski Area
Contact Person	Kevin J. Palladino, Business Manager
Project Utilizing Single Prime	Alterations & Addition to Kiski Area H.S.
Size (SF) - New	136,000
Size (SF) - Renovations	215,000
Prime Contractor	P.J. Dick, Inc.
Management Type	In-house Project Supervisor
Date docs released for bid	1/12/2003
Date bid awarded	2/27/2003
Date of notice to proceed	4/1/2003
Substantial completion	4/1/2005
Schedule Comments	This was a very complex job with many phases. The job was originally scheduled to take 32 months. The single prime contractor was able to accelerate the work and complete the project in 24 months.
Prime Contract Value	$31,672,000
Total Project Cost	$37,446,580
Total Change Orders	$1,583,700
Construction Management Costs	0
Budget Comments	The budget for change orders was 5% of the contract which was probably low considering the complexity of the job. It appears now that the change orders will be about 3%.
Quality Comments	There is so much better control of quality when one contractor is responsible. There isn't any finger pointing or blame game.
Safety Comments	We had very few problems.
Any legal costs from dispute?	No
Dispute Comments	
Additional Comments	This last question regarding legal disputes is the biggest testament for the use of a single prime contractor. We have completed an extremely complex multi-million dollar project and we aren't in court! Need I say more!

Waiver #02-108

School District	Downingtown Area
Contact Person	Gary Musial, Contract & Construction Coordinator
Project Utilizing Single Prime	Uwchlan Hills Elementary - HVAC & Roof
Size (SF) - New	0
Size (SF) - Renovations	50,000
Prime Contractor	Centre Point Contracting
Management Type	In-house Staff
Date docs released for bid	1/12/2003
Date bid awarded	3/12/2003
Date of notice to proceed	3/12/2003
Substantial completion	10/30/2003
Schedule Comments	Kept schedule closer than using multiple primes.
Prime Contract Value	$3,300,000
Total Project Cost	$3,500,000
Total Change Orders	$115,000
Construction Management Costs	0
Budget Comments	Not much.
Quality Comments	Made communications simpler.
Safety Comments	Not much.
Any legal costs from dispute?	No
Dispute Comments	
Additional Comments	

Waiver #01-117

School District	Great Valley
Contact Person	Charles Linderman, Director of Business Affairs/Board Secretary
Project Utilizing Single Prime	Charlestown E.S.
Size (SF) - New	80,000 (combined with H.S.)
Size (SF) - Renovations	325,000 (combined with H.S.)
Prime Contractor	E.R. Steubner
Management Type	Clerk of Works (a district employee)
Date docs released for bid	3/1/2002
Date bid awarded	4/1/2002
Date of notice to proceed	5/1/2002
Substantial completion	7/1/2003
Schedule Comments	The elementary school schedule took only 14 months as compared to our last multi-prime elementary renovation which took 18 months.
Prime Contract Value	$9,900,000
Total Project Cost	$12,000,000
Total Change Orders	$300,000
Construction Management Costs	0 ($70,000 salary of district's Clerk of Works)
Budget Comments	Time was most important; money was second. We saved $900,000 in the elementary.
Quality Comments	The quality was much better because the only person responsible was the prime (no blaming other people.)
Safety Comments	Saved time in coordinating with sub-contractors and saved money.
Any legal costs from dispute?	No
Dispute Comments	The projects were a breeze.
Additional Comments	

Waiver #02-007

School District	Great Valley
Contact Person	Charles Linderman, Director of Business Affairs/Board Secretary
Project Utilizing Single Prime	Great Valley H.S.
Size (SF) - New	80,000 (combined with E.S.)
Size (SF) - Renovations	325,000 (combined with H.S.)
Prime Contractor	Ernest Bock
Management Type	Clerk of Works (a district employee)
Date docs released for bid	3/1/2003
Date bid awarded	4/1/2003
Date of notice to proceed	5/1/2003
Substantial completion	9/1/2006
Schedule Comments	

Prime Contract Value	$35,000,000
Total Project Cost	$39,000,000
Total Change Orders	$150,000
Construction Management Costs	0 ($70,000 salary of district's Clerk of Works)
Budget Comments	We estimate our savings to be $3,000,000 in the high school.

Quality Comments	The quality was much better because the only person responsible was the prime (no blaming other people.)
Safety Comments	Saved time in coordinating with sub-contractors and saved money.
Any legal costs from dispute?	No
Dispute Comments	The projects were a breeze.
Additional Comments	

Waiver #01-053

School District	Spring-Ford Area
Contact Person	Bruce W. Cooper, Director of Planning, Operations & Facilities
Project Utilizing Single Prime	Upper Providence E. S.
Size (SF) - New	93,000
Size (SF) - Renovations	0
Prime Contractor	Shoemaker Construction
Management Type	Clerk of Works
Date docs released for bid	9/18/2001
Date bid awarded	11/28/2001
Date of notice to proceed	11/29/2001
Substantial completion	1/31/2003
Schedule Comments	Scheduled project completion date 6/30/03
Prime Contract Value	$12,784,600
Total Project Cost	$13,249,252
Total Change Orders	$464,652 (Net total change orders due to structural errors & omissions by architect - $391,984 leaving total change orders in the amount of $72,669.)
Construction Management Costs	0
Budget Comments	First, it saved the architect fee which is normally 7% which turned out to be approximately 5%. Administration costs in overseeing the paperwork only to one prime contractor versus multi-prime contractors. Legal fees oversee paperwork for only one prime contractor versus multi-prime contractors. Project cost changes dealing only with one contractor versus working with multi-prime contractors. Also, receiving the project early and many other items that add up to an overall project savings.
Quality Comments	Dealing with a single-prime contractor the workmanship was greatly improved because one contractor was totally in charge and all the other contractors worked solely for that one prime contractor. The prime contractor oversaw the other contractors to make sure that there work was being installed as per plans and specifications and also oversaw all of their punch lists. If there was anything wrong with the project with the architect/owner you only had to speak to the prime contractor not to the multi-primes where everyone points fingers.
Safety Comments	The safety is greatly improved because the single prime contractor holds safety meetings which he controls and oversees the safety meetings and ensures that everyone follows there procedures. The prime contractor is held to all the OSHA rules for the entire project which means he will follow tighter procedures.
Any legal costs from dispute?	No
Dispute Comments	
Additional Comments	I highly recommend single prime contractor over a multi-prime contractor and in the past I have worked with both types of projects.

Waiver #02-018

School District	Spring-Ford Area
Contact Person	Bruce W. Cooper, Director of Planning, Operations & Facilities
Project Utilizing Single Prime	Upper Providence Middle/Intermediate School
Size (SF) - New	330,000
Size (SF) - Renovations	0
Prime Contractor	Shoemaker Construction
Management Type	Clerk of Works
Date docs released for bid	
Date bid awarded	
Date of notice to proceed	
Substantial completion	
Schedule Comments	Scheduled project completion date 7/15/04
Prime Contract Value	$38,806,740
Total Project Cost	$39,793,794
Total Change Orders	$987,054 (Net total change orders due to structural errors & omissions by architect - $886,749 leaving total change orders in the amount of $70,432.)
Construction Management Costs	0
Budget Comments	First, it saved the architect fee which is normally 7 % which turned out to be approximately 5%. Administration costs in overseeing the paperwork only to one prime contractor versus multi-prime contractors. Legal fees oversee paperwork for only one prime contractor versus multi-prime contractors. Project cost changes dealing only with one contractor versus working with multi-prime contractors. Also, receiving the project early and many other items that add up to an overall project savings.
Quality Comments	Dealing with a single-prime contractor the workmanship was greatly improved because one contractor was totally in charge and all the other contractors worked solely for that one prime contractor. The prime contractor oversaw the other contractors to make sure that there work was being installed as per plans and specifications and also oversaw all of their punch lists. If there was anything wrong with the project with the architect/owner you only had to speak to the prime contractor not to the multi-primes where everyone points fingers.
Safety Comments	The safety is greatly improved because the single prime contractor holds safety meetings which he controls and oversees the safety meetings and ensures that everyone follows there procedures. The prime contractor is held to all the OSHA rules for the entire project which means he will follow tighter procedures.
Any legal costs from dispute?	No
Dispute Comments	
Additional Comments	I highly recommend single prime contractor over a multi-prime contractor and in the past I have worked with both types of projects.

Waiver #01-076

School District	Central Bucks
Contact Person	John P. Giannini, P.E.
Project Utilizing Single Prime	Central Bucks High School South
Size (SF) - New	400000
Size (SF) - Renovations	0
Prime Contractor	Skepton Construction, Inc.
Management Type	Internal C.M. Department
Date docs released for bid	6/24/2002
Date bid awarded	8/27/2002
Date of notice to proceed	8/29/2002
Substantial completion	1/28/2005
Schedule Comments	It put control of the schedule in one contractor's hands. On this project, this resulted in delays.
Prime Contract Value	$71,153,610
Total Project Cost	$84,049,971
Total Change Orders	$41,146
Construction Management Costs	internal
Budget Comments	Lower overall construction costs. Slightly higher costs on change order work due to mark ups.
Quality Comments	Project quality was very good. Skepton is known for turning out quality work, he therefore chose major subcontractors that did similar quality work.
Safety Comments	Safety record on this project was very good. There were no major safety incidents. All major subs were made aware early on of safety requirements including appointment of safety directors, weekly safety meetings etc.
Any legal costs from dispute?	Yes, costs to be determined.
Dispute Comments	To save time the project was broken into 2 phases. First phase required preparation of site including clearing, grading, preparation of building pad, installation of utilities and parking lots. Second phase (Skepton) basically included everything else. Skepton claimed that portions of the building pad were not installed correctly.
Additional Comments	

Appendix D:
Lighting Calculations (Breadth Analysis A)

The following is a record of variables entered into two AGI32 daylight studies (one of the classroom wing as-designed and one with an alternative façade design) and the results of these daylight study calculations.

Variables

Site Name	Ambridge, PA
Site Latitude	40.589
Site Longitude	-80.225
Site Compass	117

Material Reflectances
Aluminum = 0.8 (Window frame and roof flashing)
Brick = 0.26 (Exterior, fixed 2x2 grid)
Metal Panels = 0.95 (Exterior insulated panels)
Floor = 0.95 (Warm beige floor VCT)
Ceiling = 0.86 (Acoustic tile, 2'x4' fixed grid)
Grass = 0.26 (5x5 grid)
Interior Walls = 0.95 (Sherwin Williams Medium White)
Roof = 0.22 (Gravel, 12x12 grid)
Desks = 0.95

Windows
Item #20-Transition windows, 0.99 transparency

Calculation Points
Floor = 1 foot grid spacing at 28' from z=0
One point on each desk surface at 29'-2" from z=0

Time Periods
15 April 2005 – 10:00:00hrs & 14:00:00hrs (Daylight Saving Time)
15 August 2005 – 10:00:00hrs & 14:00:00hrs (Daylight Saving Time)
15 December 2005 – 10:00:00hrs & 14:00:00hrs

Results

AS DESIGNED

1
Sky Conditions Clear
Electric Lighting On
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	139.1	204.4218	102.3215	1.36	2	N.A.	N.A.
North Room - Floor	239.65	2964.015	56.2137	4.26	52.74	N.A.	N.A.
South Room - Floor	137	182.7414	58.5384	2.34	3.12	N.A.	N.A.
South Room - Desks	148.64	191.9626	118.3492	1.26	1.62	N.A.	N.A.

2
Sky Conditions Clear
Electric Lighting On
Date 8/15/2005
Time 02:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	130.64	159.3639	103.5518	1.26	1.54	N.A.	N.A.
North Room - Floor	142.63	177.3428	57.3584	2.48	3.09	N.A.	N.A.
South Room - Floor	330.5	6840.896	58.5044	5.65	116.94	N.A.	N.A.
South Room - Desks	167.21	303.5478	124.8478	1.34	2.43	N.A.	N.A.

3
Sky Conditions Clear
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	126.42	146.0271	95.7504	1.32	1.52	N.A.	N.A.
North Room - Floor	137.3	167.8369	55.2031	2.49	3.04	N.A.	N.A.
South Room - Floor	284.07	2221.504	113.9235	2.49	19.5	N.A.	N.A.
South Room - Desks	259.48	501.0527	175.5034	1.48	2.86	N.A.	N.A.

4
Sky Conditions Clear
Electric Lighting On
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	131.83	155.5291	98.5519	1.34	1.58	N.A.	N.A.
North Room - Floor	141.82	174.5632	55.8428	2.54	3.13	N.A.	N.A.
South Room - Floor	748.01	3005.738	228.9066	3.27	13.13	N.A.	N.A.
South Room - Desks	443.58	687.8475	285.0181	1.56	2.41	N.A.	N.A.

5
Sky Conditions Clear
Electric Lighting On
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	136.83	193.0707	100.5312	1.36	1.92	N.A.	N.A.
North Room - Floor	164.65	2169.805	56.0745	2.94	38.68	N.A.	N.A.
South Room – Floor	137.52	187.4592	58.5611	2.35	3.2	N.A.	N.A.
South Room - Desks	149.33	194.4014	122.2293	1.22	1.59	N.A.	N.A.

6
Sky Conditions Clear
Electric Lighting On
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	129.86	156.8205	102.2776	1.27	1.53	N.A.	N.A.
North Room - Floor	141.5	169.7195	56.9007	2.49	2.98	N.A.	N.A.
South Room - Floor	388.71	6796.734	58.2389	6.68	116.78	N.A.	N.A.
South Room - Desks	170.63	325.7855	124.9255	1.37	2.61	N.A.	N.A.

7
Sky Conditions Clear
Electric Lighting Off
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	25.44	117.4949	1.6552	14.96	69.12	N.A.	N.A.
North Room - Floor	114.3	2894.622	1.5333	76.2	1929.73	N.A.	N.A.
South Room - Floor	17.35	105.6482	1.5889	10.84	66	N.A.	N.A.
South Room - Desks	20.49	88.8922	1.8275	11.38	49.39	N.A.	N.A.

8
Sky Conditions Clear
Electric Lighting Off
Date 8/15/2005

Time 02:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	17.04	72.3371	1.759	9.47	40.17	N.A.	N.A.
North Room - Floor	17.37	104.4294	1.679	10.22	61.41	N.A.	N.A.
South Room - Floor	210.78	6768.11	2.3638	87.83	2820.04	N.A.	N.A.
South Room - Desks	38.97	200.3956	2.8951	13.44	69.1	N.A.	N.A.

9
Sky Conditions Clear
Electric Lighting Off
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	14.39	58.4966	2.2753	6.26	25.43	N.A.	N.A.
North Room - Floor	13.57	69.2124	2.291	5.9	30.09	N.A.	N.A.
South Room - Floor	164.07	2160.005	43.389	3.78	49.77	N.A.	N.A.
South Room - Desks	130.95	424.4988	51.8058	2.53	8.2	N.A.	N.A.

10
Sky Conditions Clear
Electric Lighting Off
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	19.05	62.1587	8.1887	2.32	7.59	N.A.	N.A.
North Room - Floor	17.53	63.5754	5.2034	3.37	12.23	N.A.	N.A.
South Room - Floor	627.86	2886.921	136.7552	4.59	21.1	N.A.	N.A.
South Room - Desks	314.83	584.2645	161.6728	1.95	3.61	N.A.	N.A.

11
Sky Conditions Clear
Electric Lighting Off
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	23.24	106.0767	1.5984	14.53	66.31	N.A.	N.A.
North Room - Floor	39.32	2105.503	1.489	26.21	1403.67	N.A.	N.A.
South Room - Floor	17.92	110.3436	1.5504	11.2	68.94	N.A.	N.A.
South Room - Desks	21.18	91.354	1.8462	11.77	50.78	N.A.	N.A.

12
Sky Conditions Clear
Electric Lighting Off
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	16.63	70.0272	1.759	9.24	38.89	N.A.	N.A.
North Room - Floor	16.63	95.9223	1.6901	9.78	56.41	N.A.	N.A.
South Room - Floor	269.38	6724.167	2.5243	107.75	2689.68	N.A.	N.A.
South Room - Desks	42.79	222.8889	3.1622	13.37	69.66	N.A.	N.A.

13
Sky Conditions Partly Cloudy
Electric Lighting On
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	161.94	322.5085	122.0773	1.33	2.64	N.A.	N.A.
North Room - Floor	208.5	1395.763	60.1614	3.46	23.19	N.A.	N.A.
South Room - Floor	155.9	332.4621	61.9778	2.51	5.36	N.A.	N.A.
South Room - Desks	168.2	293.2686	125.2295	1.34	2.34	N.A.	N.A.

14
Sky Conditions Partly Cloudy

Electric Lighting On
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	154.03	276.0475	122.2574	1.26	2.26	N.A.	N.A.
North Room - Floor	171.7	415.2475	69.6891	2.46	5.96	N.A.	N.A.
South Room - Floor	298.57	4103.639	74.2167	4.02	55.3	N.A.	N.A.
South Room - Desks	222.56	596.2848	128.248	1.74	4.65	N.A.	N.A.

15
Sky Conditions Partly Cloudy
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	130.71	166.819	97.4306	1.34	1.71	N.A.	N.A.
North Room - Floor	143.4	190.3087	55.9201	2.57	3.4	N.A.	N.A.
South Room - Floor	169.62	467.2201	65.834	2.58	7.1	N.A.	N.A.
South Room - Desks	180.03	294.2458	132.1125	1.36	2.23	N.A.	N.A.

16
Sky Conditions Partly Cloudy
Electric Lighting On
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	130.99	162.0988	105.2472	1.25	1.54	N.A.	N.A.
North Room - Floor	143.9	192.7569	59.6657	2.41	3.23	N.A.	N.A.
South Room - Floor	311.99	984.549	101.8259	3.06	9.67	N.A.	N.A.
South Room - Desks	262.09	550.324	164.8988	1.59	3.34	N.A.	N.A.

17
Sky Conditions Partly Cloudy
Electric Lighting On
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	156.93	297.0686	121.4547	1.29	2.45	N.A.	N.A.
North Room - Floor	176.92	981.0333	59.5585	2.97	16.46	N.A.	N.A.
South Room - Floor	155.83	330.2797	61.583	2.53	5.36	N.A.	N.A.
South Room - Desks	168.43	293.5983	125.302	1.34	2.34	N.A.	N.A.

18
Sky Conditions Partly Cloudy
Electric Lighting On
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	150.68	260.5935	121.9075	1.24	2.14	N.A.	N.A.
North Room - Floor	167.63	382.8838	68.3539	2.45	5.6	N.A.	N.A.
South Room - Floor	325.48	3964.149	73.0338	4.46	54.3	N.A.	N.A.
South Room - Desks	226.14	618.1347	128.3871	1.76	4.81	N.A.	N.A.

19
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	48.32	235.41	2.5448	19.33	94.16	N.A.	N.A.
North Room - Floor	83.25	1323.974	2.3311	36.2	575.65	N.A.	N.A.
South Room - Floor	36.18	258.0159	1.9128	19.04	135.79	N.A.	N.A.
South Room - Desks	39.95	190.1206	2.4023	16.65	79.21	N.A.	N.A.

20
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 8/15/2005
Time 02:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	40.33	189.0236	2.6321	15.51	72.69	N.A.	N.A.
North Room - Floor	46.33	343.432	2.503	18.53	137.36	N.A.	N.A.
South Room - Floor	178.84	4030.854	4.8269	37.26	839.77	N.A.	N.A.
South Room - Desks	94.28	493.0958	5.7735	16.26	85.02	N.A.	N.A.

21
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	16.97	79.7083	1.1589	14.14	66.42	N.A.	N.A.
North Room - Floor	17.95	119.1516	1.096	16.32	108.36	N.A.	N.A.
South Room - Floor	50.26	372.3376	7.8911	6.36	47.13	N.A.	N.A.
South Room - Desks	52.14	191.6851	9.1612	5.67	20.84	N.A.	N.A.

22
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	17.41	75.0553	2.9858	5.8	25.03	N.A.	N.A.
North Room - Floor	18.68	119.7879	3.0166	6.23	39.93	N.A.	N.A.
South Room - Floor	191.9	878.2489	34.9541	5.48	25.09	N.A.	N.A.
South Room - Desks	133.46	447.2581	41.2036	3.24	10.86	N.A.	N.A.

23
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	43.3	210.1025	2.3098	18.83	91.35	N.A.	N.A.
North Room - Floor	51.63	916.76	2.1182	24.59	436.57	N.A.	N.A.
South Room - Floor	36.18	255.3811	1.887	19.04	134.42	N.A.	N.A.
South Room - Desks	40.26	190.453	2.3802	16.78	79.38	N.A.	N.A.

24
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	37.2	173.7866	2.4516	14.88	69.52	N.A.	N.A.
North Room - Floor	42.44	311.1943	2.3313	18.45	135.3	N.A.	N.A.
South Room - Floor	205.96	3891.451	5.0121	41.19	778.3	N.A.	N.A.
South Room - Desks	98.08	515.1092	6.1166	16.08	84.44	N.A.	N.A.

25
Sky Conditions Overcast
Electric Lighting On
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	129.29	166.5227	104.925	1.23	1.59	N.A.	N.A.
North Room - Floor	144.92	239.0659	58.4054	2.48	4.09	N.A.	N.A.
South Room - Floor	138.83	238.0201	55.8071	2.49	4.27	N.A.	N.A.

South Room - Desks	147.13	206.2483	106.369	1.38	1.94	N.A.	N.A.

26
Sky Conditions Overcast
Electric Lighting On
Date 8/15/2005
Time 02:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	137.98	210.1628	116.0783	1.19	1.81	N.A.	N.A.
North Room - Floor	155.83	330.0912	62.0674	2.51	5.32	N.A.	N.A.
South Room - Floor	149.34	328.9742	59.5505	2.51	5.52	N.A.	N.A.
South Room - Desks	157.52	263.0204	121.0675	1.3	2.17	N.A.	N.A.

27
Sky Conditions Overcast
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	121.67	146.2528	87.8069	1.39	1.67	N.A.	N.A.
North Room - Floor	135.45	166.9709	55.0778	2.46	3.03	N.A.	N.A.
South Room - Floor	129.66	161.7699	52.7254	2.46	3.07	N.A.	N.A.
South Room - Desks	138.08	159.5224	92.859	1.49	1.72	N.A.	N.A.

28
Sky Conditions Overcast
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	121.67	146.2528	87.8069	1.39	1.67	N.A.	N.A.
North Room - Floor	135.45	166.9709	55.0778	2.46	3.03	N.A.	N.A.
South Room - Floor	129.66	161.7699	52.7254	2.46	3.07	N.A.	N.A.
South Room - Desks	138.08	159.5224	92.859	1.49	1.72	N.A.	N.A.

29
Sky Conditions Overcast
Electric Lighting On
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	128.51	161.9887	103.4631	1.24	1.57	N.A.	N.A.
North Room - Floor	143.92	229.5961	58.06	2.48	3.95	N.A.	N.A.
South Room - Floor	137.73	228.5106	55.5156	2.48	4.12	N.A.	N.A.
South Room - Desks	146.04	200.3192	104.7796	1.39	1.91	N.A.	N.A.

30
Sky Conditions Overcast
Electric Lighting On
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	136.73	204.3835	115.3848	1.18	1.77	N.A.	N.A.
North Room - Floor	154.28	318.1871	61.4846	2.51	5.17	N.A.	N.A.
South Room - Floor	148.09	317.2342	59.0972	2.51	5.37	N.A.	N.A.
South Room - Desks	156.28	255.7097	119.9209	1.3	2.13	N.A.	N.A.

31

Sky Conditions Overcast
Electric Lighting Off
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	15.71	79.4523	.6986	22.44	113.57	N.A.	N.A.
North Room - Floor	19.67	166.0953	.6673	28.1	237.29	N.A.	N.A.
South Room - Floor	19.19	165.8432	.6627	27.41	236.86	N.A.	N.A.
South Room - Desks	18.97	103.1714	.7624	23.71	129	N.A.	N.A.

32
Sky Conditions Overcast
Electric Lighting Off
Date 8/15/2005
Time 02:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	24.36	123.1615	1.083	22.15	112	N.A.	N.A.
North Room - Floor	30.49	257.4694	1.0344	30.49	257.5	N.A.	N.A.
South Room - Floor	29.74	257.0786	1.0273	29.74	257.1	N.A.	N.A.
South Room - Desks	29.39	159.9291	1.1818	24.49	133.25	N.A.	N.A.

33
Sky Conditions Overcast
Electric Lighting Off
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	8.17	41.3061	.3632	20.43	103.25	N.A.	N.A.
North Room - Floor	10.23	86.3505	.3469	34.1	288	N.A.	N.A.
South Room - Floor	9.97	86.2194	.3445	33.23	287.33	N.A.	N.A.
South Room - Desks	9.86	53.6373	.3964	24.65	134	N.A.	N.A.

34
Sky Conditions Overcast
Electric Lighting Off
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	10.9	55.1279	.4847	21.8	110.2	N.A.	N.A.
North Room - Floor	13.65	115.2451	.463	27.3	230.4	N.A.	N.A.
South Room - Floor	13.31	115.0701	.4598	26.62	230.2	N.A.	N.A.
South Room - Desks	13.16	71.5854	.529	26.32	143.2	N.A.	N.A.

35
Sky Conditions Overcast
Electric Lighting Off
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	14.82	74.8703	.6583	21.17	107	N.A.	N.A.
North Room - Floor	18.53	156.5166	.6288	30.88	260.83	N.A.	N.A.
South Room - Floor	18.08	156.279	.6245	30.13	260.5	N.A.	N.A.
South Room - Desks	17.86	97.2215	.7184	25.51	138.86	N.A.	N.A.

36
Sky Conditions Overcast
Electric Lighting Off
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room - Desks	23.23	117.4806	1.033	23.23	117.5	N.A.	N.A.
North Room - Floor	29.09	245.5936	.9867	29.09	245.6	N.A.	N.A.
South Room - Floor	28.37	245.2208	.9799	28.37	245.2	N.A.	N.A.
South Room - Desks	28.03	152.5524	1.1273	25.48	138.73	N.A.	N.A.

REDESIGN

1
Sky Conditions Clear
Electric Lighting On
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	163.9	279.2974	111.7042	1.47	2.5	N.A.	N.A.
South Room 2 - Desks	171.41	247.8231	125.3033	1.37	1.98	N.A.	N.A.
North Room 2 - Floor	273.37	3016.983	79.2367	3.45	38.09	N.A.	N.A.
South Room 2 - Floor	155.13	231.9036	86.4467	1.8	2.68	N.A.	N.A.

2
Sky Conditions Clear
Electric Lighting On
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	145.58	192.9791	119.0723	1.22	1.62	N.A.	N.A.
South Room 2 - Desks	782.38	1320.019	409.0605	1.91	3.23	N.A.	N.A.
North Room 2 - Floor	156.16	210.2799	94.9403	1.65	2.22	N.A.	N.A.
South Room 2 - Floor	1238.51	8076.689	348.8813	3.55	23.15	N.A.	N.A.

3
Sky Conditions Clear
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	137.63	172.4105	115.0418	1.2	1.5	N.A.	N.A.
South Room 2 - Desks	534.22	2449.903	255.7292	2.09	9.58	N.A.	N.A.
North Room 2 - Floor	148.5	1858.568	71.4784	2.08	25.99	N.A.	N.A.
South Room 2 - Floor	525.19	3095.179	208.4689	2.52	14.85	N.A.	N.A.

4
Sky Conditions Clear
Electric Lighting On
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	154.09	173.3493	140.0961	1.1	1.24	N.A.	N.A.
South Room 2 - Desks	1983.48	3889.755	674.7594	2.94	5.76	N.A.	N.A.
North Room 2 - Floor	161.27	192.1012	71.1394	2.27	2.7	N.A.	N.A.
South Room 2 - Floor	1772.53	4417.638	558.3499	3.17	7.91	N.A.	N.A.

5
Sky Conditions Clear
Electric Lighting On
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	158.59	259.728	111.2315	1.43	2.34	N.A.	N.A.
South Room 2 - Desks	172.81	253.0988	125.4146	1.38	2.02	N.A.	N.A.
North Room 2 - Floor	214.44	2191.553	77.8927	2.75	28.13	N.A.	N.A.
South Room 2 - Floor	156.17	238.6056	85.7485	1.82	2.78	N.A.	N.A.

6
Sky Conditions Clear
Electric Lighting On
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	147.53	188.3991	126.0646	1.17	1.49	N.A.	N.A.
South Room 2 - Desks	741.53	1310.648	375.1066	1.98	3.49	N.A.	N.A.
North Room 2 - Floor	157.35	201.323	90.7802	1.73	2.22	N.A.	N.A.
South Room 2 - Floor	1177.68	8176.471	321.2197	3.67	25.46	N.A.	N.A.

7
Sky Conditions Clear
Electric Lighting Off
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	57.61	202.8521	4.955	11.52	40.58	N.A.	N.A.
South Room 2 - Desks	44.99	145.3043	5.5304	8.18	26.42	N.A.	N.A.
North Room 2 - Floor	155.33	2949.837	4.3153	36.12	686	N.A.	N.A.
South Room 2 - Floor	36.84	145.5603	4.5195	8.19	32.36	N.A.	N.A.

8
Sky Conditions Clear
Electric Lighting Off
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	44.21	120.6447	17.1229	2.59	7.05	N.A.	N.A.
South Room 2 - Desks	653.14	1213.926	288.0937	2.27	4.21	N.A.	N.A.
North Room 2 - Floor	42.67	140.9141	16.3674	2.6	8.59	N.A.	N.A.
South Room 2 - Floor	1117.13	8000.47	251.8961	4.43	31.76	N.A.	N.A.

9
Sky Conditions Clear
Electric Lighting Off
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	32.74	96.6002	9.4647	3.45	10.17	N.A.	N.A.
South Room 2 - Desks	410.01	2373.776	138.665	2.96	17.11	N.A.	N.A.
North Room 2 - Floor	31.76	1746.191	8.3278	3.83	210.39	N.A.	N.A.
South Room 2 - Floor	409.21	3041.054	120.1905	3.4	25.3	N.A.	N.A.

10
Sky Conditions Clear
Electric Lighting Off
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	49.53	97.6787	30.5399	1.62	3.2	N.A.	N.A.
South Room 2 - Desks	1855.08	3737.959	554.4101	3.35	6.74	N.A.	N.A.
North Room 2 - Floor	44.73	90.0829	25.995	1.72	3.47	N.A.	N.A.
South Room 2 - Floor	1652.21	4288.61	474.3051	3.48	9.04	N.A.	N.A.

11
Sky Conditions Clear
Electric Lighting Off
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	52.29	183.1992	4.7479	11.13	38.98	N.A.	N.A.
South Room 2 - Desks	46.48	151.8781	5.4501	8.45	27.62	N.A.	N.A.
North Room 2 - Floor	96.37	2132.287	4.1601	22.95	507.69	N.A.	N.A.

South Room 2 - Floor	37.97	152.6753	4.4253	8.63	34.7	N.A.	N.A.

12
Sky Conditions Clear
Electric Lighting Off
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	42.95	115.6713	17.0348	2.53	6.81	N.A.	N.A.
South Room 2 - Desks	617.87	1208.964	259.9834	2.38	4.65	N.A.	N.A.
North Room 2 - Floor	40.96	129.3031	16.5394	2.48	7.84	N.A.	N.A.
South Room 2 - Floor	1062.24	8123.541	227.8709	4.66	35.65	N.A.	N.A.

13
Sky Conditions Partly Cloudy
Electric Lighting On
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	219.26	476.7006	114.845	1.91	4.15	N.A.	N.A.
South Room 2 - Desks	218.8	416.1636	128.8188	1.7	3.23	N.A.	N.A.
North Room 2 - Floor	264.52	1498.99	112.2072	2.36	13.36	N.A.	N.A.
South Room 2 - Floor	196.62	427.3754	98.6669	1.99	4.33	N.A.	N.A.

14
Sky Conditions Partly Cloudy
Electric Lighting On
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	203.01	408.4645	120.1726	1.69	3.4	N.A.	N.A.
South Room 2 - Desks	644.23	1358.206	278.9081	2.31	4.87	N.A.	N.A.
North Room 2 - Floor	219.63	522.4171	114.684	1.91	4.55	N.A.	N.A.
South Room 2 - Floor	849.55	4814.187	235.8583	3.6	20.41	N.A.	N.A.

15
Sky Conditions Partly Cloudy
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	145.86	211.7844	111.0832	1.31	1.91	N.A.	N.A.
South Room 2 - Desks	257.23	616.8866	146.0728	1.76	4.22	N.A.	N.A.
North Room 2 - Floor	157.03	361.645	84.5792	1.86	4.27	N.A.	N.A.
South Room 2 - Floor	232.46	637.5963	113.7284	2.04	5.61	N.A.	N.A.

16
Sky Conditions Partly Cloudy
Electric Lighting On
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	147.35	205.6673	117.4768	1.25	1.75	N.A.	N.A.
South Room 2 - Desks	683.81	1318.86	259.0981	2.64	5.09	N.A.	N.A.
North Room 2 - Floor	158.99	233.5491	98.3621	1.62	2.37	N.A.	N.A.
South Room 2 - Floor	599.03	1241.155	216.24	2.77	5.74	N.A.	N.A.

17
Sky Conditions Partly Cloudy
Electric Lighting On
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	207.13	434.0025	113.8514	1.82	3.81	N.A.	N.A.

South Room 2 - Desks	219.18	417.0308	128.9	1.7	3.24	N.A.	N.A.
North Room 2 - Floor	232.6	1024.813	110.8915	2.1	9.24	N.A.	N.A.
South Room 2 - Floor	196.47	425.8931	98.6951	1.99	4.32	N.A.	N.A.

18
Sky Conditions Partly Cloudy
Electric Lighting On
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	195.84	381.2036	120.0089	1.63	3.18	N.A.	N.A.
South Room 2 - Desks	620.19	1348.748	261.5094	2.37	5.16	N.A.	N.A.
North Room 2 - Floor	211.55	480.567	113.7565	1.86	4.22	N.A.	N.A.
South Room 2 - Floor	804.73	4702.137	221.0998	3.64	21.27	N.A.	N.A.

19
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	112.76	399.9239	8.026	14.1	49.99	N.A.	N.A.
South Room 2 - Desks	92.45	315.215	7.3149	12.66	43.18	N.A.	N.A.
North Room 2 - Floor	146.37	1431.574	6.9518	20.91	204.51	N.A.	N.A.
South Room 2 - Floor	78.4	342.24	5.7945	13.52	59	N.A.	N.A.

20
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	98.38	332.4545	15.9647	6.15	20.78	N.A.	N.A.
South Room 2 - Desks	518.28	1253.378	161.935	3.2	7.74	N.A.	N.A.
North Room 2 - Floor	103.15	455.1983	14.2184	7.26	32.06	N.A.	N.A.
South Room 2 - Floor	731.68	4734.152	141.6347	5.17	33.43	N.A.	N.A.

21
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	39.19	135.0272	4.038	9.8	33.75	N.A.	N.A.
South Room 2 - Desks	131.67	538.9391	25.6009	5.14	21.05	N.A.	N.A.
North Room 2 - Floor	38.7	247.5211	3.7267	10.46	66.89	N.A.	N.A.
South Room 2 - Floor	115.07	579.8171	22.1661	5.18	26.12	N.A.	N.A.

22
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	41.69	129.5256	10.7183	3.9	12.1	N.A.	N.A.
South Room 2 - Desks	557.86	1219.198	140.0503	3.98	8.7	N.A.	N.A.
North Room 2 - Floor	41.67	159.4165	10.2668	4.05	15.48	N.A.	N.A.
South Room 2 - Floor	481.24	1134.278	120.0201	4.01	9.45	N.A.	N.A.

23
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	100.78	357.4356	7.2651	13.81	48.96	N.A.	N.A.
South Room 2 - Desks	92.81	316.8089	7.2592	12.71	43.4	N.A.	N.A.
North Room 2 - Floor	114.52	965.4793	6.2996	18.18	153.25	N.A.	N.A.
South Room 2 - Floor	78.21	340.1458	5.7271	13.72	59.67	N.A.	N.A.

24
Sky Conditions Partly Cloudy
Electric Lighting Off
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	90.54	304.9827	14.7658	6.12	20.61	N.A.	N.A.
South Room 2 - Desks	495.41	1244.995	143.6879	3.45	8.66	N.A.	N.A.
North Room 2 - Floor	94.48	412.9463	13.8279	6.85	29.92	N.A.	N.A.
South Room 2 - Floor	688.12	4630.867	126.0689	5.46	36.72	N.A.	N.A.

25
Sky Conditions Overcast
Electric Lighting On
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	145.48	222.0955	109.0964	1.33	2.04	N.A.	N.A.
South Room 2 - Desks	173.89	278.7797	121.6649	1.43	2.29	N.A.	N.A.
North Room 2 - Floor	161.19	282.5864	104.058	1.55	2.71	N.A.	N.A.
South Room 2 - Floor	161.15	294.9224	93.0801	1.73	3.17	N.A.	N.A.

26
Sky Conditions Overcast
Electric Lighting On
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	167.06	302.4217	110.355	1.51	2.74	N.A.	N.A.
South Room 2 - Desks	199.94	374.8136	123.6132	1.62	3.03	N.A.	N.A.
North Room 2 - Floor	184.97	398.1786	104.6829	1.77	3.8	N.A.	N.A.
South Room 2 - Floor	184.67	409.4886	95.3762	1.94	4.29	N.A.	N.A.

27
Sky Conditions Overcast
Electric Lighting On
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	126.69	152.1915	107.9517	1.17	1.41	N.A.	N.A.
South Room 2 - Desks	151.11	194.9489	118.7323	1.27	1.64	N.A.	N.A.
North Room 2 - Floor	140.48	183.483	77.9099	1.8	2.36	N.A.	N.A.
South Room 2 - Floor	140.6	194.9535	89.7274	1.57	2.17	N.A.	N.A.

28
Sky Conditions Overcast
Electric Lighting On
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	133.49	177.5864	108.1923	1.23	1.64	N.A.	N.A.
South Room 2 - Desks	159.34	225.3345	119.8794	1.33	1.88	N.A.	N.A.
North Room 2 - Floor	147.93	219.4428	88.3953	1.67	2.48	N.A.	N.A.
South Room 2 - Floor	148.03	231.1936	91.9475	1.61	2.52	N.A.	N.A.

29
Sky Conditions Overcast
Electric Lighting On
Date 4/15/2005

Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	143.28	213.8664	108.8946	1.32	1.96	N.A.	N.A.
South Room 2 - Desks	171.18	268.7369	121.4508	1.41	2.21	N.A.	N.A.
North Room 2 - Floor	158.73	270.7759	103.4991	1.53	2.62	N.A.	N.A.
South Room 2 - Floor	158.72	282.9506	93.016	1.71	3.04	N.A.	N.A.

30
Sky Conditions Overcast
Electric Lighting On
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	164.18	291.9079	109.7796	1.5	2.66	N.A.	N.A.
South Room 2 - Desks	196.64	362.4113	123.4981	1.59	2.93	N.A.	N.A.
North Room 2 - Floor	181.78	382.7943	104.741	1.74	3.66	N.A.	N.A.
South Room 2 - Floor	181.69	394.6714	95.1641	1.91	4.15	N.A.	N.A.

31
Sky Conditions Overcast
Electric Lighting Off
Date 8/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	39.13	145.671	2.1423	18.63	69.38	N.A.	N.A.
South Room 2 - Desks	47.52	174.6454	2.5119	19.01	69.84	N.A.	N.A.
North Room 2 - Floor	43.1	213.2148	1.9297	22.68	112.21	N.A.	N.A.
South Room 2 - Floor	42.92	212.4946	2.2088	19.51	96.59	N.A.	N.A.

32
Sky Conditions Overcast
Electric Lighting Off
Date 8/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	60.65	225.8091	3.3208	18.38	68.42	N.A.	N.A.
South Room 2 - Desks	73.69	270.7232	3.8938	18.89	69.41	N.A.	N.A.
North Room 2 - Floor	66.81	330.5108	2.9913	22.27	110.17	N.A.	N.A.
South Room 2 - Floor	66.53	329.3943	3.4239	19.57	96.88	N.A.	N.A.

33
Sky Conditions Overcast
Electric Lighting Off
Date 12/15/2005
Time 10:00:00 AM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	20.35	75.7322	1.1137	18.5	68.82	N.A.	N.A.
South Room 2 - Desks	24.72	90.7955	1.3059	19.02	69.85	N.A.	N.A.
North Room 2 - Floor	22.41	110.8472	1.0032	22.41	110.8	N.A.	N.A.
South Room 2 - Floor	22.31	110.4728	1.1483	20.28	100.45	N.A.	N.A.

34
Sky Conditions Overcast
Electric Lighting Off
Date 12/15/2005
Time 2:00:00 PM
Daylight Savings False

Label	Avg	Max	Min	Avg/Min	Max/Min	DF %Over	DF Basis
North Room 2 - Desks	27.15	101.0737	1.4864	18.1	67.4	N.A.	N.A.
South Room 2 - Desks	32.98	121.1776	1.7429	19.4	71.29	N.A.	N.A.
North Room 2 - Floor	29.9	147.9389	1.3389	23	113.77	N.A.	N.A.
South Room 2 - Floor	29.78	147.4392	1.5326	19.85	98.27	N.A.	N.A.

35
Sky Conditions Overcast

Electric Lighting Off
Date 4/15/2005
Time 10:00:00 AM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF	%Over	DF Basis
North Room 2 - Desks	36.87	137.2702	2.0187	18.44	68.65	N.A.		N.A.
South Room 2 - Desks	44.8	164.5736	2.3671	18.67	68.58	N.A.		N.A.
North Room 2 - Floor	40.61	200.9188	1.8184	22.56	111.61	N.A.		N.A.
South Room 2 - Floor	40.44	200.24	2.0814	19.26	95.33	N.A.		N.A.

36
Sky Conditions Overcast
Electric Lighting Off
Date 4/15/2005
Time 2:00:00 PM
Daylight Savings True

Label	Avg	Max	Min	Avg/Min	Max/Min	DF	%Over	DF Basis
North Room 2 - Desks	57.86	215.3936	3.1676	18.08	67.31	N.A.		N.A.
South Room 2 - Desks	70.29	258.236	3.7142	19	69.78	N.A.		N.A.
North Room 2 - Floor	63.73	315.266	2.8534	21.98	108.72	N.A.		N.A.
South Room 2 - Floor	63.46	314.201	3.266	19.23	95.21	N.A.		N.A.

Appendix E:
Mechanical Load Calculations (Breadth Analysis B)

Outdoor air required = 15 cfm/person x 30 occupants = 450 cfm
(ASHRAE Standard 62-2001)

Unit supply airflow (V_{SA}) = desired air changes per hour x room volume
= 8 AC/hr x (822 SF x 9'-4") / (60min/hr)
= 1023 cfm

Target cooling airflow = 350 to 450 cfm per ton of sensible cooling
Lower Limit = 350 cfm x sensible cooling load / (12000 BTU/hr)
Upper Limit = 450 cfm x sensible cooling load / (12000 BTU/hr)

Space Design Load Summary
North Room – As Designed

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " North Room - As Designed " IN ZONE " Zone 1 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT May 1400 COOLING OA DB / WB 79.0 °F / 66.8 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 2.0 °F / 0.3 °F OCCUPIED T-STAT 70.0 °F		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(BTU/hr)	(BTU/hr)	Details	(BTU/hr)	(BTU/hr)
Window & Skylight Solar Loads	65 ft²	2252	-	65 ft²	-	-
Wall Transmission	205 ft²	268	-	205 ft²	4009	-
Roof Transmission	822 ft²	6090	-	822 ft²	6739	-
Window Transmission	65 ft²	18	-	65 ft²	2611	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	1243 W	3818	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	30	5019	6150	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	17466	6150	-	13359	0

TABLE 1.1.B. ENVELOPE LOADS FOR SPACE " North Room - As Designed " IN ZONE " Zone 1 "						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(ft²)	(BTU/(hr-ft²-°F))	Coeff.	(BTU/hr)	(BTU/hr)	(BTU/hr)
NE EXPOSURE						
WALL	205	0.288	-	268	-	4009
WINDOW 1	65	0.588	0.811	18	2252	2611
H EXPOSURE						
ROOF	822	0.121	-	6090	-	6739

Space Design Load Summary
North Room – Redesign, 100% Lighting

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " North Room - Redesign 1 " IN ZONE " Zone 1 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT May 1400 COOLING OA DB / WB 79.0 °F / 66.8 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 2.0 °F / 0.3 °F OCCUPIED T-STAT 70.0 °F		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(BTU/hr)	(BTU/hr)	Details	(BTU/hr)	(BTU/hr)
Window & Skylight Solar Loads	158 ft²	5450	-	158 ft²	-	-
Wall Transmission	112 ft²	147	-	112 ft²	2194	-
Roof Transmission	822 ft²	6090	-	822 ft²	6739	-
Window Transmission	158 ft²	44	-	158 ft²	6317	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	1243 W	3818	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	30	5019	6150	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	20567	6150	-	15250	0

TABLE 1.1.B. ENVELOPE LOADS FOR SPACE " North Room - Redesign 1 " IN ZONE " Zone 1 "						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(ft²)	(BTU/(hr-ft²-°F))	Coeff.	(BTU/hr)	(BTU/hr)	(BTU/hr)
NE EXPOSURE						
WALL	112	0.288	-	147	-	2194
WINDOW 2	158	0.588	0.811	44	5450	6317
H EXPOSURE						
ROOF	822	0.121	-	6090	-	6739

Space Design Load Summary
North Room – Redesign, 50% Lighting

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " North Room - Redesign 2 " IN ZONE " Zone 1 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Jun 1400 COOLING OA DB / WB 85.4 °F / 69.8 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 2.0 °F / 0.3 °F OCCUPIED T-STAT 70.0 °F		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(BTU/hr)	(BTU/hr)	Details	(BTU/hr)	(BTU/hr)
Window & Skylight Solar Loads	158 ft²	5949	-	158 ft²	-	-
Wall Transmission	112 ft²	394	-	112 ft²	2194	-
Roof Transmission	822 ft²	6884	-	822 ft²	6739	-
Window Transmission	158 ft²	639	-	158 ft²	6317	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	62 W	212	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	30	5019	6150	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	19097	6150	-	15250	0

TABLE 1.1.B. ENVELOPE LOADS FOR SPACE " North Room - Redesign 2 " IN ZONE " Zone 1 "						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(ft²)	(BTU/(hr-ft²-°F))	Coeff.	(BTU/hr)	(BTU/hr)	(BTU/hr)
NE EXPOSURE						
WALL	112	0.288	-	394	-	2194
WINDOW 2	158	0.588	0.811	639	5949	6317
H EXPOSURE						
ROOF	822	0.121	-	6884	-	6739

Space Design Load Summary
South Room – As Designed

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " South Room - As Designed " IN ZONE " Zone 1 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Sep 1400 COOLING OA DB / WB 83.0 °F / 68.8 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 2.0 °F / 0.3 °F OCCUPIED T-STAT 70.0 °F		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(BTU/hr)	(BTU/hr)	Details	(BTU/hr)	(BTU/hr)
Window & Skylight Solar Loads	65 ft²	4749	-	65 ft²	-	-
Wall Transmission	205 ft²	247	-	205 ft²	4009	-
Roof Transmission	822 ft²	4960	-	822 ft²	6739	-
Window Transmission	65 ft²	172	-	65 ft²	2611	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	1243 W	3818	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	30	5019	6150	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	18964	6150	-	13359	0

TABLE 1.1.B. ENVELOPE LOADS FOR SPACE " South Room - As Designed " IN ZONE " Zone 1 "						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(ft²)	(BTU/(hr-ft²-°F))	Coeff.	(BTU/hr)	(BTU/hr)	(BTU/hr)
SW EXPOSURE						
WALL	205	0.288	-	247	-	4009
WINDOW 1	65	0.588	0.811	172	4749	2611
H EXPOSURE						
ROOF	822	0.121	-	4960	-	6739

Space Design Load Summary
South Room – Redesign, 100% Lighting

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " South Room - Redesign 1 " IN ZONE " Zone 1 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Sep 1400 COOLING OA DB / WB 83.0 °F / 68.8 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 2.0 °F / 0.3 °F OCCUPIED T-STAT 70.0 °F		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(BTU/hr)	(BTU/hr)	Details	(BTU/hr)	(BTU/hr)
Window & Skylight Solar Loads	158 ft²	11491	-	158 ft²	-	-
Wall Transmission	112 ft²	135	-	112 ft²	2194	-
Roof Transmission	822 ft²	4960	-	822 ft²	6739	-
Window Transmission	158 ft²	416	-	158 ft²	6317	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	1243 W	3818	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	30	5019	6150	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	25838	6150	-	15250	0

TABLE 1.1.B. ENVELOPE LOADS FOR SPACE " South Room - Redesign 1 " IN ZONE " Zone 1 "						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(ft²)	(BTU/(hr-ft²-°F))	Coeff.	(BTU/hr)	(BTU/hr)	(BTU/hr)
SW EXPOSURE						
WALL	112	0.288	-	135	-	2194
WINDOW 2	158	0.588	0.811	416	11491	6317
H EXPOSURE						
ROOF	822	0.121	-	4960	-	6739

Space Design Load Summary
South Room – Redesign, 50% Lighting

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " South Room - Redesign 2 " IN ZONE " Zone 1 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Sep 1400 COOLING OA DB / WB 83.0 °F / 68.8 °F OCCUPIED T-STAT 75.0 °F			HEATING DATA AT DES HTG HEATING OA DB / WB 2.0 °F / 0.3 °F OCCUPIED T-STAT 70.0 °F		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(BTU/hr)	(BTU/hr)	Details	(BTU/hr)	(BTU/hr)
Window & Skylight Solar Loads	158 ft²	11491	-	158 ft²	-	-
Wall Transmission	112 ft²	135	-	112 ft²	2194	-
Roof Transmission	822 ft²	4960	-	822 ft²	6739	-
Window Transmission	158 ft²	416	-	158 ft²	6317	-
Skylight Transmission	0 ft²	0	-	0 ft²	0	-
Door Loads	0 ft²	0	-	0 ft²	0	-
Floor Transmission	0 ft²	0	-	0 ft²	0	-
Partitions	0 ft²	0	-	0 ft²	0	-
Ceiling	0 ft²	0	-	0 ft²	0	-
Overhead Lighting	621 W	1909	-	0	0	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	0 W	0	-	0	0	-
People	30	5019	6150	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	23929	6150	-	15250	0

TABLE 1.1.B. ENVELOPE LOADS FOR SPACE " South Room - Redesign 2 " IN ZONE " Zone 1 "						
				COOLING	COOLING	HEATING
	Area	U-Value	Shade	TRANS	SOLAR	TRANS
	(ft²)	(BTU/(hr-ft²-°F))	Coeff.	(BTU/hr)	(BTU/hr)	(BTU/hr)
SW EXPOSURE						
WALL	112	0.288	-	135	-	2194
WINDOW 2	158	0.588	0.811	416	11491	6317
H EXPOSURE						
ROOF	822	0.121	-	4960	-	6739