Proposal Summary Book
Spring 2005 Senior Thesis

Bioscience Research Building

College Park, MD

Matthew Hiestand
Architectural Engineering
Construction Management Option

College of Life Sciences

Bioscience Research Building

University of Maryland

Project Team

- Owner : The University of Maryland
- CM : Barton Malow
- Architect : Ballinger
- Structural Engineers : Columbia Engineering
- Plumbing & Fire Protection : Diversified Engineering
- HVAC & Electrical : Ballinger

Structural

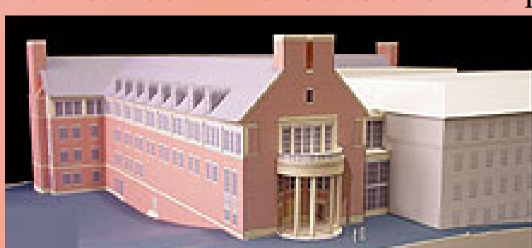
- Structural steel frame, concrete slab on metal decking
- Auger cast pile foundations
- 4 stories above grade with basement & sub-basement

Electrical

- (2) 13.8 kV 480Y/277V feeders to main switchgear
- existing 740 kW generator & addition of another identical 740 kW generator

Architectural

- Building will have a brick facade and central courtyard located between existing Bio-Psych Building
- Among unique features is a large lecture hall located on the first floor which seats over 400 people



Project Overview

- Size : 140,000 square feet
- Cost : $54 million
- Duration : 2 years
  July 2004 – July 2006
- Delivery Method : CM at Risk
- Project Includes :
  - Bioscience Research Building
  - addition to SCUB III Building

Mechanical

- Mechanical floor on top floor
- Water systems will be run from existing buildings
- 3 main air handling units, secondary AHUs in large lecture hall

Barton Malow Design/Construction Services

Matthew Hiestand – Construction Management

PennState

e-Portfolio : www.arche.psu.edu/thesis/2005/mph159

Table of Contents:

EXECUTIVE SUMMARY

Executive Summary

The purpose of this thesis is to present a few issues and proposals that may help reduce the schedule/cost of the project without sacrificing quality. The current design of the Bioscience Research Building calls for the structure on the south and east sides to be tied into the existing Biology-Psychology Building. The independent building analysis in this report entails the addition of columns and beams on this side of Bioscience Research Building to eliminate the need for it to be tied into the existing building. This analysis is proposed to reach both a schedule reduction and possibly a more cost-effective project.

The site for the Bioscience Research Building is an extremely tight sight due to its location at the University of Maryland and the surrounding buildings. An alternate proposal to the original site logistics is presented in this report. Through this alternate site logistics analysis, an attempt at a reasonable alternate was made in order to reduce the overall project schedule. Issues such as storage and hauling routes are addressed in it.

Research was conducted on asbestos and its removal on university projects such as the Bioscience Research Building at the University of Maryland. Asbestos was found to be a hazardous material around the early 1970s and many organizations were founded to protect the health of people and the environment today. This research touches on these hazards and preventions, while using resources such as industry individuals who deal with asbestos issues every day at work.

PROPOSAL LETTER

April 5, 2005

John Smith
Bioscience Research Building
College Park, MD 20742

Dear Mr. John Smith:

The following thesis was conducted to add value to the Bioscience Research Building construction project by proposing ideas to reduce the schedule and cost, while relieving site congestion. Time is an important issue on any project, especially on a university project such as this one. I felt that researching a couple ways to effectively cut down on the schedule time for this project would be in your best interest.

The current design for the Bioscience Research Building calls for it to be structurally tied into the existing Biology-Psychology Building. The whole process of this tie-in system requires weeks and weeks of taking proper measurements and samples. This requires a lot of coordination at early phases in the project. I have proposed an alternate to this that would enable the project to run smoother right from the start. The alternate system is constructing the Bioscience Research Building as an independent building, spaced away from the existing one about fourteen feet. This would still allow for the courtyard to exist between the buildings and for easy access back and forth by means of the ground floor.

The original site logistic plans for the Bioscience Research Building project require all of the work to be done in such a small area. This does not allow the necessary space for all crew members and their equipment. Included in this thesis are a few alternate ideas for the site plan. If nearby areas on campus were designated as material storage areas or areas for contractor trailers, the actual construction site would be less congested. This would make most likely improve the productivity of workers on the site, in addition to making it a safer work environment.

I have also performed research on asbestos and its current issues related to construction. Hopefully you will find this included research helpful, and consider putting extra effort into assuring safer and well-coordinated efforts in the asbestos removal parts of the project.

The following thesis will show value added to this project in more detail and I hope that you will find it useful. Relieving congestion on site, along with the potential schedule and cost savings will aid you on this project as well as construction projects you will be involved with in the future.

Sincerely,

Matthew Hiestand

PROJECT BACKGROUND

Project Background

General Information

The College of Life Sciences Bioscience Research Building will be built next to the existing Biology-Psychology Building and will offer specialized research labs and growth chambers. The Bioscience Research Building will also house the Departments of Biology and Cell Biology and Molecular Genetics. The building will be 125,600 square feet when finished and will house enough research space for up to 35 principal investigators. The project requires the installation of an independent energy generator and will cost a total of $55.8 million. The construction manager on the project is Barton Malow, and the designer is Ballinger.

Project Delivery and Contracts

PRIMARY PROJECT TEAM:

- Owner – The University of Maryland
- Construction Manager – Barton Malow Company (www.bartonmalow.com)
  - Contact: Tim Lupcho
- Architect – Ballinger (www.ballinger-ae.com)
- Engineers & Consultants –
  - Civil – Rummel, Klepper, Kahl (www.rkkengineers.com)
  - Landscape – Mahan, Rykiel (www.mahanrykiel.com)
  - Interior Design – Portnoy Levine Design Associates (www.portnoylevine.com)
  - Laboratory Equipment – Gould Architects, PA (www.gouldarchitects.com)
  - Structural Engineering – Columbia Engineering (www.columbia-eng.com)

- Plumbing & Fire Protection – Diversified Engineering (www.diversifiedengineering.net)
- Leed Consultant – Steven Winter Associates (www.swinter.com)
- Geotechnical – EBA Engineering (www.ebaengineering.com)
- Wind Wake Analysis – Rowan, Williams, Davies & Irwin (www.rwdi.com)
- Commissioning Specifications – Thos. A. Carcaterra
- Acoustic/Vibration – Cerami & Associates (www.ceramiassociates.com)
- HVAC & Electrical – Ballinger (www.ballinger-ae.com)

Barton Malow is the Construction Manager on the Bioscience Research Building project and under them are all of the subcontractors. The way that the subcontractors were selected was by a lower qualified bidder form. In this type of selection, the lowest bid wins. This type of selection was used because the University of Maryland (owner) is a state-funded university. The additional aspect for this lower qualified bidder process is that Barton Malow reviews each subcontractors bid on a one on one basis. After bid opening, they do an extensive descoping of the lowest bidders to ensure that no major aspect of the bid was missed by the subcontractor. If any of the subcontractors have missed a major aspect of the bid, then they will be asked by Barton Malow to review their bid and resubmit. Only in some instances is this change substantial enough to change the lowest bidder. Then, once everybody is comfortable with the bids that have been submitted, each contract will be awarded to the lowest bidder.

Each subcontractor is required by Barton Malow to have both a payment bond and a performance bond. These ensure that the subcontractor will complete the work and payment to Barton Malow for the project. The subcontractors also must supply their own insurance for their employees and their work. There is no OCIP or CCIP on the

Bioscience Research Building project. All parties involved are required to cover themselves. On this project, Barton Malow also carries a general liability / umbrella insurance. This insurance is used to cover any out of the ordinary situations that may arise throughout the project.

Owner's Expectations

The Owner in the Bioscience Research Building project is The University of Maryland. The university had decided that they would like to expand their College of Life Sciences by adding this new Bioscience Research Building to their campus. This will also enable them to conduct important biosciences research in a modern facility. The university is very excited about the step in building this new campus facility.

It appears that The University of Maryland would like this to be a high quality facility in that they are not trying to rush it and finish the project for the Fall of 2005, but the Fall of 2006. The schedule of the project began in July 2004 and will finish July 2006. This will give Barton Malow and the other contractors the time they need to ensure the quality work that the university is expecting. Keys for completing this project to The University of Maryland's full satisfaction are led by the importance of finishing on time. Much time has went into the planning of this project, so if the project can remain on schedule and a high quality of work is maintained, then the university will get their money's worth and will be more than satisfied.

PROJECT DESCRIPTION

Project Description

General

The Bioscience Research Building is a $55 million lab building project at the University of Maryland. Many issues must be considered by both Barton Malow and the University of Maryland to complete the project in the two year time period.

Tie-in to existing structure vs. Independent building

Since the Bioscience Research Building (BRB) project will be built on a tight site, the plan is to construct it right up against the existing Biology Psychology Building. The intentions are to not only have the BRB next to it, but to tie it into the Bio-Psych Building structurally. This process requires samples to be drilled out of the existing Biology Psychology Building, and then proper tie-in sizes are calculated before finally beginning the actual construction. This presents a lot of extra time and coordination when it comes to the scheduling aspects of the project. An alternate is proposed to this design in the following pages. The alternate design presents the Bioscience Research Building as an independent building, setting it back from the Biology Psychology Building about fourteen feet. To accomplish this, columns must be sized and added to the Bioscience Research Building on the side of the neighboring Bio-Psych Building. Beam calculations are also required because a few beams on each floor will also be necessary to add. If this new independent design is implemented properly into the schedule, time should be saved on the overall project.

Site Logistics

The site which the Bioscience Research Building is being built on is very tight. Due to several University rules and regulations, some areas around the site are off-limits to use for storage, hauling, etc. Since the construction project will span two full years, the movement of students and the use of surrounding buildings must also be considered when developing a good site logistics plan. The current plan leaves very little or no room for things such as excavation storage, equipment storage, and steel shakeout. If more area was available for use, and better truck hauling paths could be developed, then the possibility of a schedule reduction is very reasonable. Later in the report, an alternate site logistics plan is presented and shown how it could help reduce headaches and project time.

Asbestos

Since the original plans for the Bioscience Research Building were to connect it to the existing Biology Psychology Building, some demolition must be performed. There is existing asbestos in these areas which must be properly addressed before demolition and construction can be started. On projects at the University of Maryland, it is University policy that they take care of all asbestos control, rather than the project contractor. Early involvement and coordination is required by the University to achieve this, and proper training is necessary for individuals involved. These issues were researched and are addressed later in this report, as well as general facts and information about asbestos and construction.

ESTIMATE SUMMARY

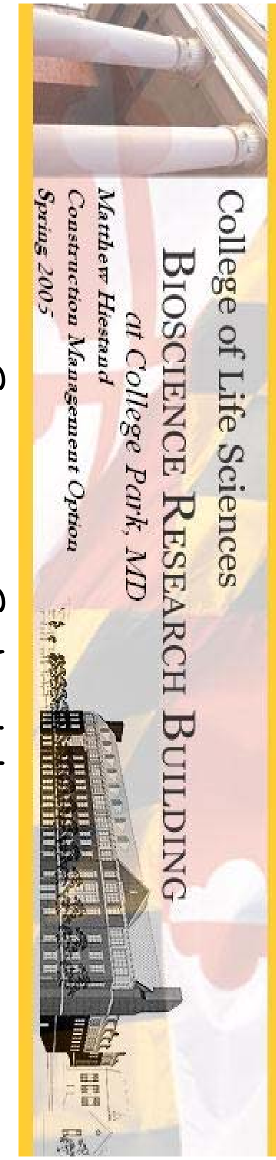
Estimate Summary

The total project cost for the proposed Bioscience Research Building (including the small addition to the SCUB III Building) is **$55 million**, while actual construction costs are about **$45 million**. The building is **140,000 square feet** and will cost about **$320 per square foot**. Major building costs on the Bioscience Research Building will be put into the actual building systems, specifically the mechanical and electrical systems. Some of the estimated system costs are as follows:

- HVAC system - $7.6 million
- Electrical system - $4.8 million
- Fire Protection – $0.9 million

- Design costs will make up approximately $2.0-2.5 million of the construction costs
- *D4 Cost 2002* Estimating software: **$28,929,511**
- R.S. Means square foot estimate: **$32,029,497**

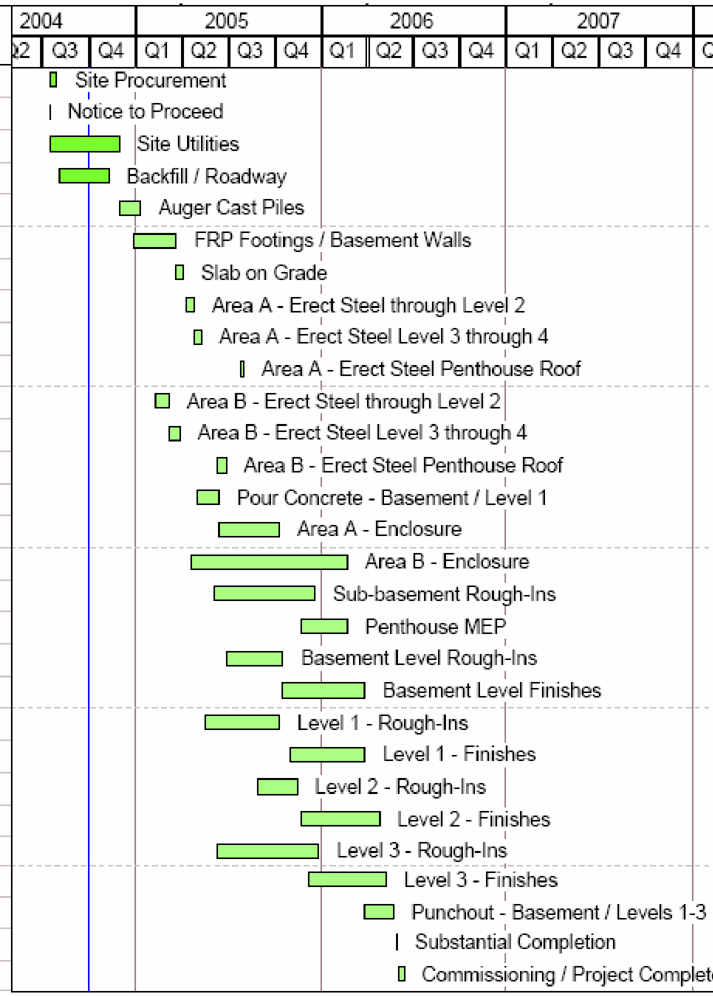
SUMMARY SCHEDULE



Summary Schedule

Bioscience Research Building — Classic Schedule Layout

Activity ID	Activity Name	Original Duration	Start	Finish
A01	Site Procurement	11	16-Jul-04*	30-Jul-04
A02	Notice to Proceed	1	16-Jul-04*	16-Jul-04
A03	Site Utilities	97	16-Jul-04*	29-Nov-04
A04	Backfill / Roadway	72	02-Aug-04*	09-Nov-04
A05	Auger Cast Piles	33	30-Nov-04*	13-Jan-05
A06	FRP Footings / Basement Walls	59	30-Dec-04*	22-Mar-05
A07	Slab on Grade	10	23-Mar-05*	05-Apr-05
A08	Area A - Erect Steel through Level 2	12	12-Apr-05*	27-Apr-05
A081	Area A - Erect Steel Level 3 through 4	10	28-Apr-05*	11-May-05
A082	Area A - Erect Steel Penthouse Roof	8	26-Jul-05*	04-Aug-05
A083	Area B - Erect Steel through Level 2	19	10-Feb-05*	08-Mar-05
A084	Area B - Erect Steel Level 3 through 4	15	09-Mar-05*	29-Mar-05
A085	Area B - Erect Steel Penthouse Roof	15	10-Jun-05*	30-Jun-05
A09	Pour Concrete - Basement / Level 1	28	05-May-05*	13-Jun-05
A10	Area A - Enclosure	87	14-Jun-05*	12-Oct-05
A101	Area B - Enclosure	222	20-Apr-05*	23-Feb-06
A11	Sub-basement Rough-Ins	143	03-Jun-05*	20-Dec-05
A12	Penthouse MEP	66	23-Nov-05*	22-Feb-06
A13	Basement Level Rough-Ins	80	28-Jun-05*	17-Oct-05
A14	Basement Level Finishes	117	18-Oct-05*	29-Mar-06
A15	Level 1 - Rough-Ins	104	18-May-05*	10-Oct-05
A151	Level 1 - Finishes	105	03-Nov-05*	29-Mar-06
A16	Level 2 - Rough-Ins	55	01-Sep-05*	16-Nov-05
A17	Level 2 - Finishes	113	21-Nov-05*	26-Apr-06
A18	Level 3 - Rough-Ins	143	10-Jun-05*	27-Dec-05
A19	Level 3 - Finishes	110	08-Dec-05*	10-May-06
A20	Punchout - Basement / Levels 1-3	40	30-Mar-06*	24-May-06
A21	Substantial Completion	1	01-Jun-06*	01-Jun-06
A22	Commissioning / Project Complete	9	02-Jun-06*	14-Jun-06



INDEPENDENT BUILDING

Original System Design

The Bioscience Research Building is 4-story (above grade) structural steel building that will be built next to the existing Biology-Psychology Building. The original design requires the Bioscience Research Building to be structurally tied into the existing building. The areas in which this tying into will occur are shown in Figure 1.1 below.

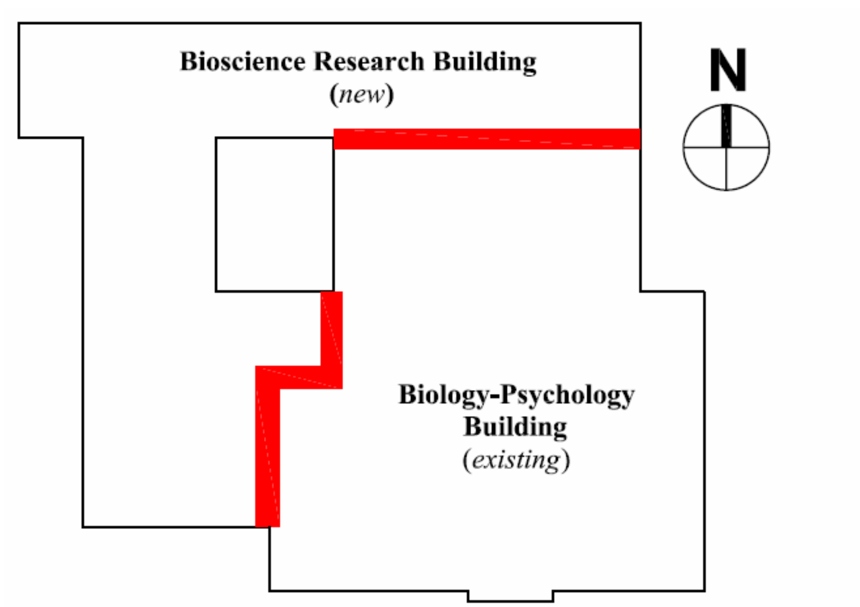


Fig 1.1 Original System Design – tie-in areas are highlighted in red

Tying the building into the existing one has some advantages such as the conservation of space and easy access to every floor of the Biology-Psychology Building. It also saves material, because less load-bearing structural members and exterior walls are necessary on these sides of the building. However, there are also disadvantages with these plans to tie into the existing structure. The biggest disadvantage is the impact this has on the project schedule. For these structural tie-ins to be done properly, samples have to be taken from the existing building early in construction phases to ensure proper installation. Once these sampling processes are completed, construction on these areas can take place according to the project schedule. The extra planning and coordination needed for the structural tie-ins has major schedule impacts.

Proposed System Design

An alternate analysis was performed on these tie-in sides of the Bioscience Research Building to see the possible effects on the schedule and cost. This alternate system would consist of additional columns and beams being placed on these sides instead of tying the new structure into the existing Biology-Psychology Building. The Bioscience Research Building would then become an independent building and support its own structure instead of sharing load with the existing building. The new building would be set back from the existing building about twelve to fourteen feet on these sides. This would allow for pedestrian travel between the buildings and the addition of a sidewalk. The courtyard space between the buildings will still be preserved and be able to serve this function, although not being completely closed off. It will not be possible to

.access every floor of the Biology-Psychology Building now, but only the first floor. Double doors will be placed at the locations shown on Figure 1.2 below. These doors are located such that stairwells and elevators are easily accessible upon entering either building.

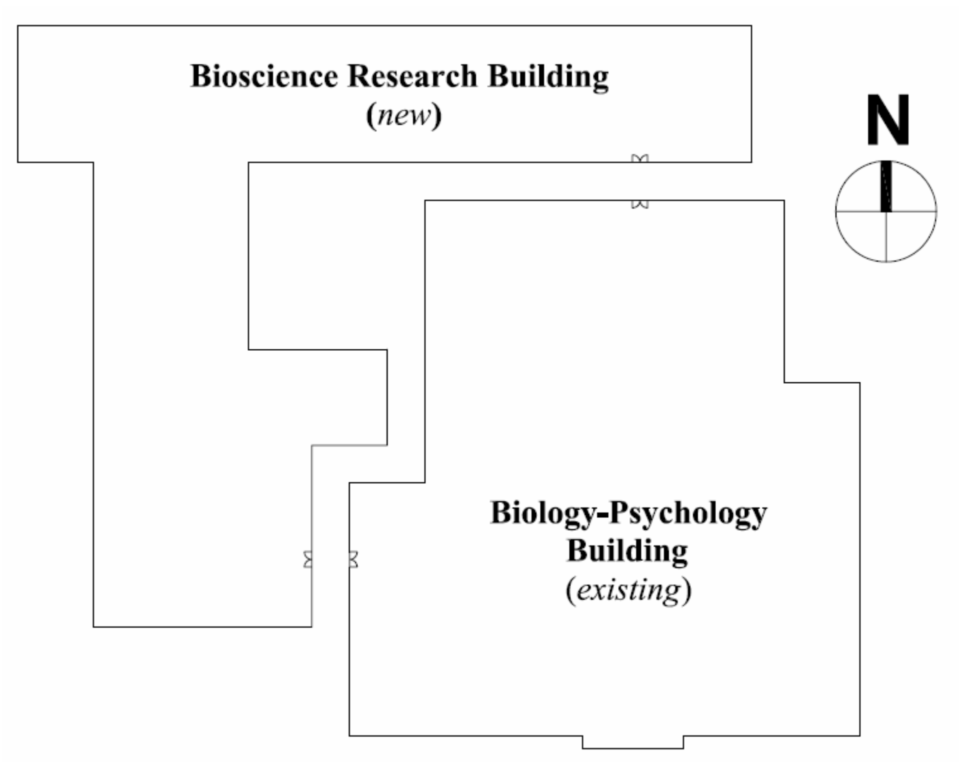


Fig 1.2 Proposed system design – buildings spaced 12-14 feet apart, with doorways shown

Schedule and Cost Impacts

The proposed system will have varying effects on the schedule and cost. Since the need for the structural tie-in process is no longer needed, this will be able to save critical time on the schedule. It will also decrease the headaches that may develop early on in the project because this coordination is no longer an issue.

However, there is new material being added on each one of these sides of the Bioscience Research Building that will cause for schedule activity durations to be modified, as well as add additional cost. Among these new materials are: steel columns and beams, foundation walls along the perimeter, exterior brick, curtain wall, and door additions. The following sections detail the analysis taken to calculate these modifications to the schedule and cost.

Sizing the new structural steel members:

In the design of these new walls being added to the Bioscience Research Building, the proper sizing of the steel columns and beams were determined. This was done by first calculating the loads that would be applied to the floors and roof. See Appendix A for the step-by-step calculation of these loads. The loadings are as follows:

	Live Load (psf)	Dead Load (psf)
Floors	150 psf	97 psf
Roof	20 psf	93.5 psf

Table 1.1 Floor and roof loads

Once these floor and roof loadings were calculated, the frames were drawn using *SAP 2000 version 8*, and the corresponding loads were assigned to each beam and column. Figures 1.3 to 1.6 show the sections of the designs for the three sides. Note the designated colors and labels in Figure 1.3 for easy association.

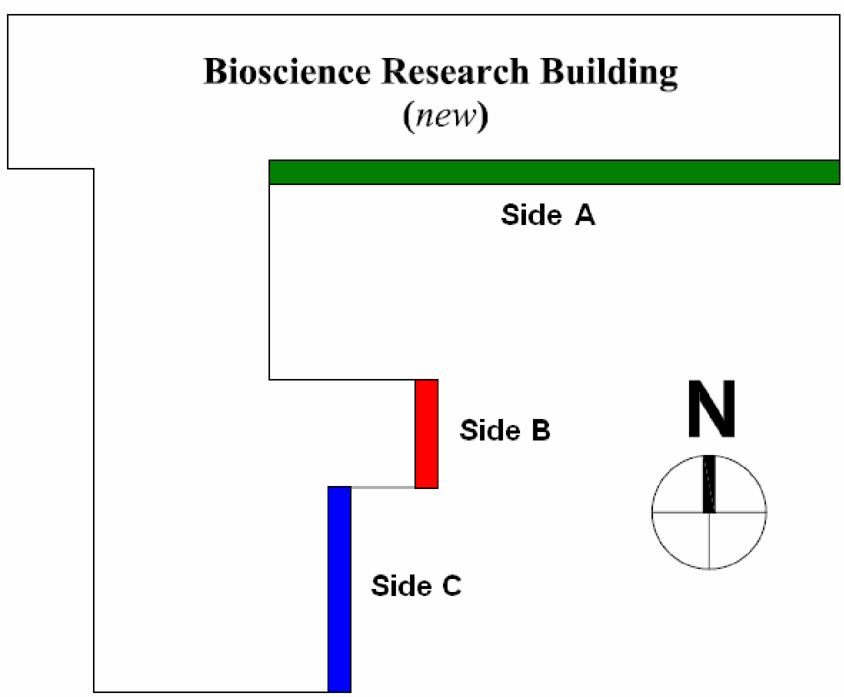


Fig 1.3 Proposed system design – buildings spaced 12 feet apart, with doorways shown

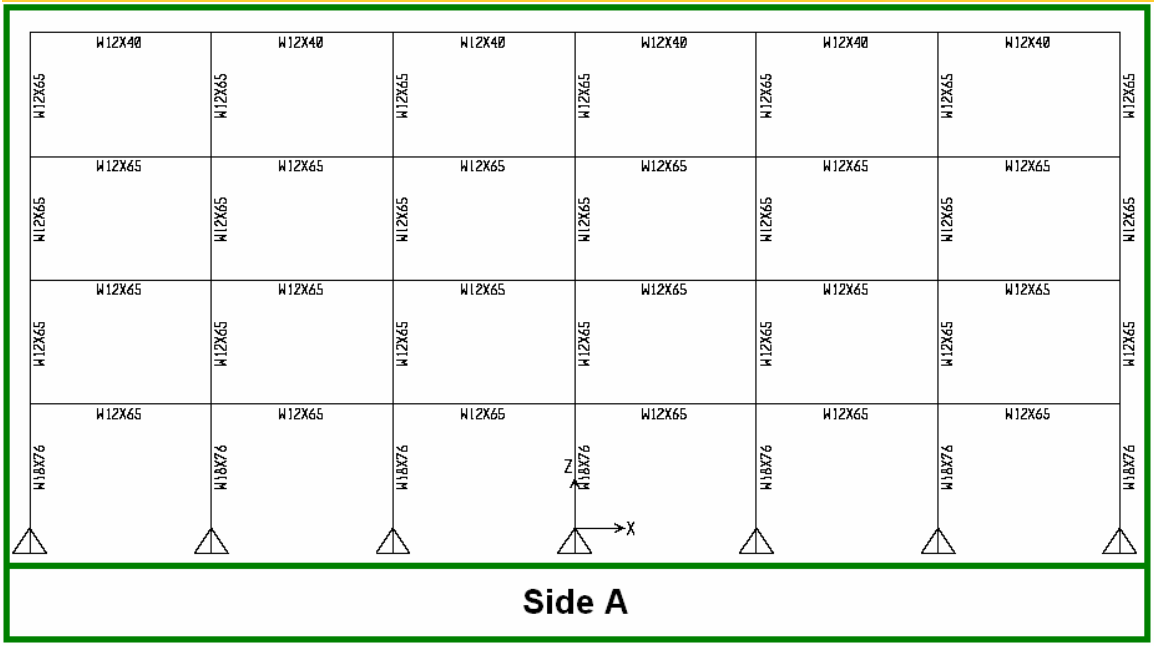


Fig 1.4

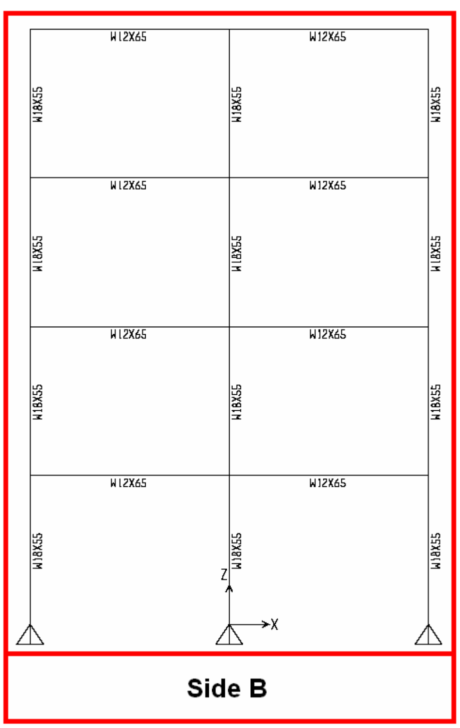


Fig 1.5

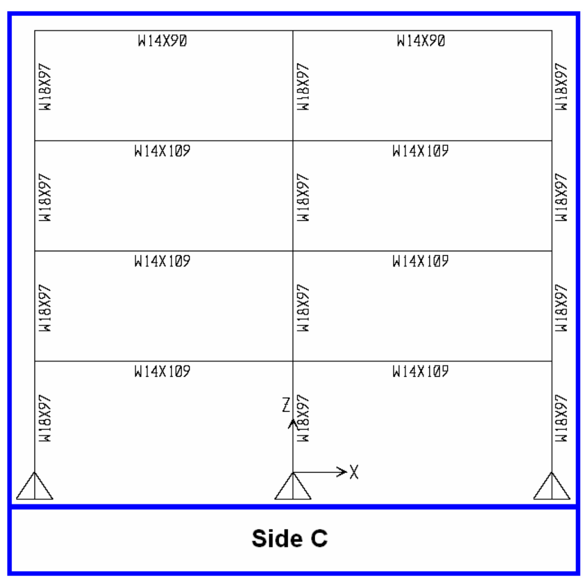


Fig 1.6

After the framing systems for each wall were developed, a material takeoff for steel was performed to determine the total tonnage and material cost. Detailed calculations of this procedure can be found in Appendix A. The calculated steel tonnage is broken down in Table 1.2 below:

	Steel (tons)	**Material Cost ($)**
Columns	21.35 tons	$12,169
Beams	40.22 tons	$22,925
Total	61.57 tons	$35,094
Average per floor	15.39 tons	$8,772

Table 1.2 Steel tonnage and cost – based on steel costs of about $570 / ton

Other material expenses:

Foundation walls, exterior wall and curtain wall, and doorways must be accounted for in the calculation of the cost and schedule adjustments. These calculations can be viewed in Appendix A. Most of these calculations were reached by using values in *RS Means 2005* and based on the total linear feet that would be necessary to add onto the building perimeter. The table below displays these calculated costs:

	Material and Labor Costs($)
Foundation walls (including excavation)	$62,234
Exterior walls (brick and curtain wall)	$177,797
Doors	$15,200
Total	$255,231

Table 1.3 Material and cost calculation results for walls

Adding the total cost from Table 1.2 with that of Table 1.3 and crane rental cost for the erection extra time, the cost for the construction of the proposed walls is approximately ***$290,000*** ***plus crane cost of $20,000 per month.***

Adjusted schedule:

Along with the cost, the adjustment for schedule impact is a critical part in the analysis of this newly proposed system. The time needed for the process of the original tie-in processes is hard to determine, but it adds several weeks onto the schedule because of the coordination and precision that is needed. The figures below show the original schedule compared to the newly adjusted schedule throughout the steel erection processes and the wall construction. The substructure, superstructure, and building enclosure schedules are analyzed separately to try and reach a conclusion on how the overall schedule will be affected. The activities having durations that are directly affected by the proposed system have been marked in red. Other durations may have changed start and finish dates due to these.

Substructure

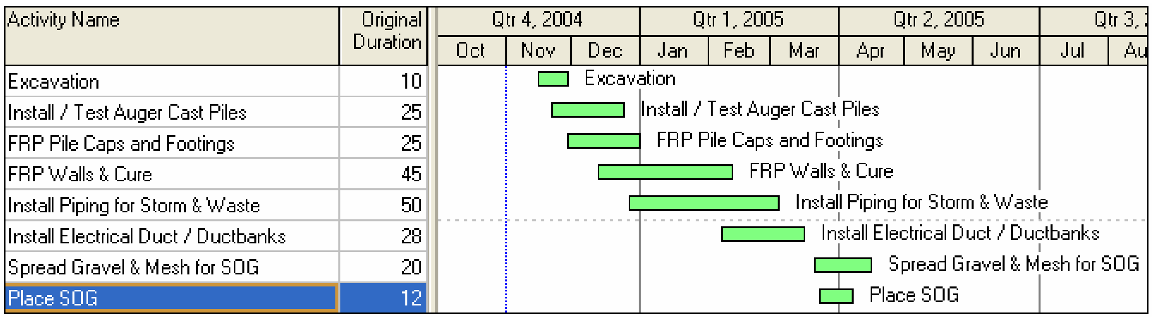


Fig 1.7 Original substructure schedule

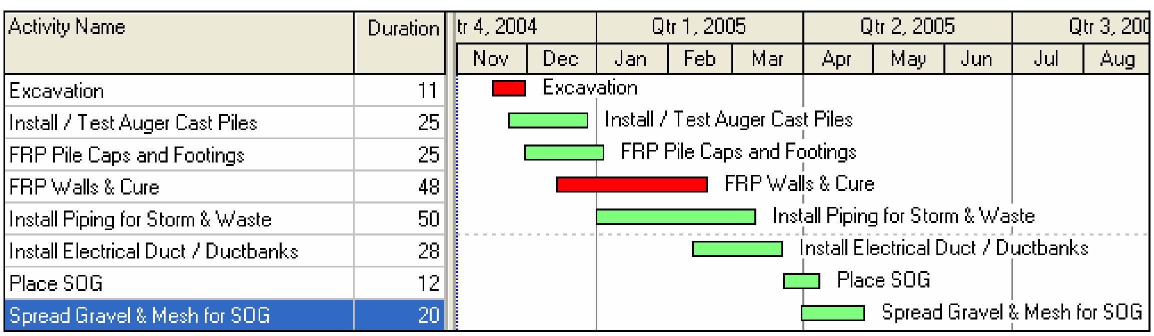
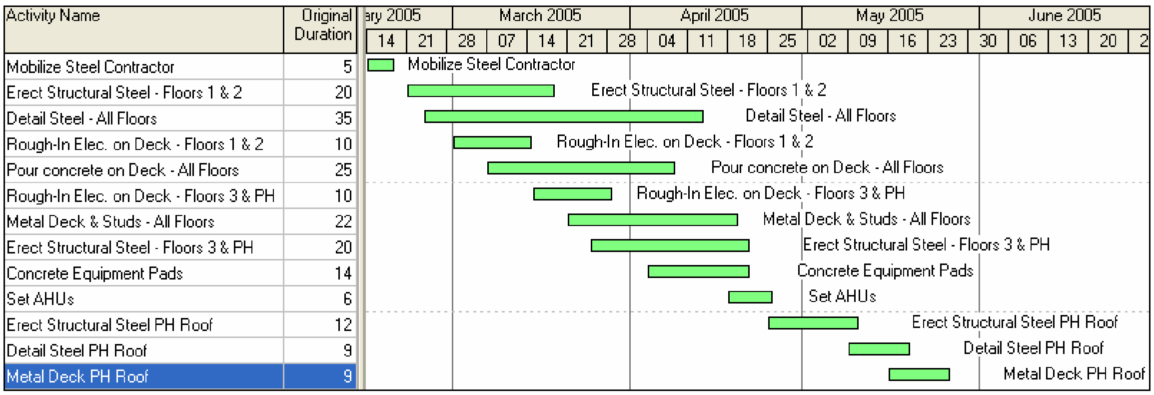


Fig 1.8 Revised substructure schedule

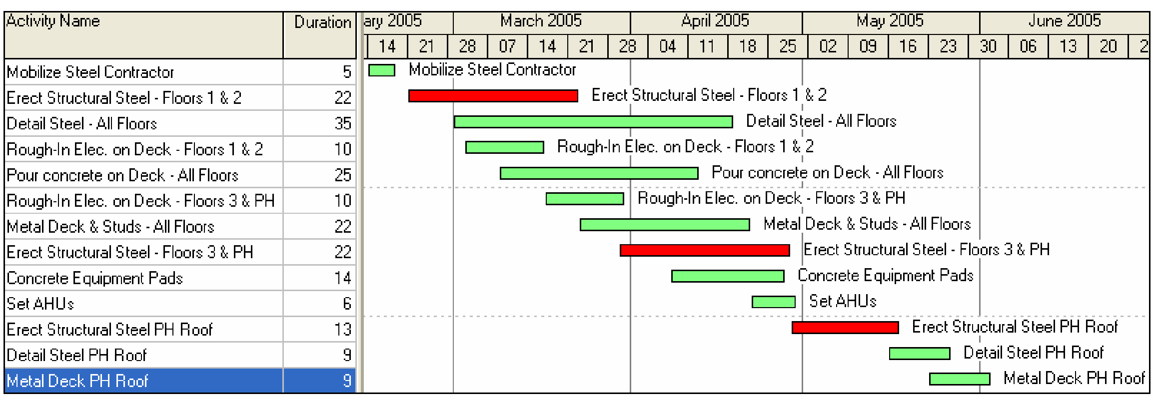
<u>Result</u>: revised substructure schedule shows delay of about three to five extra days.

Superstructure



Activity Name	Original Duration
Mobilize Steel Contractor	5
Erect Structural Steel - Floors 1 & 2	20
Detail Steel - All Floors	35
Rough-In Elec. on Deck - Floors 1 & 2	10
Pour concrete on Deck - All Floors	25
Rough-In Elec. on Deck - Floors 3 & PH	10
Metal Deck & Studs - All Floors	22
Erect Structural Steel - Floors 3 & PH	20
Concrete Equipment Pads	14
Set AHUs	6
Erect Structural Steel PH Roof	12
Detail Steel PH Roof	9
Metal Deck PH Roof	9

Fig 1.9 Original superstructure schedule

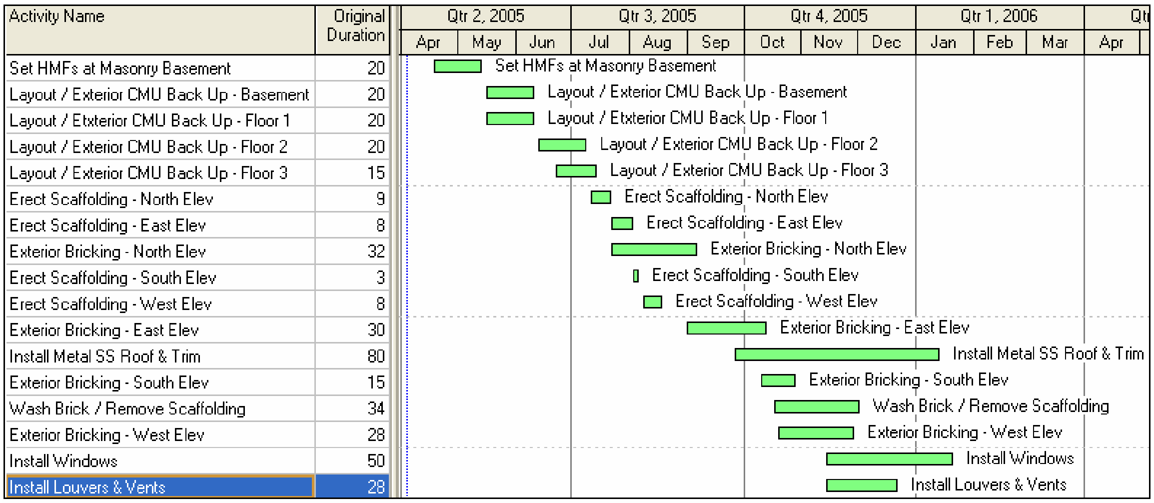


Activity Name	Duration
Mobilize Steel Contractor	5
Erect Structural Steel - Floors 1 & 2	22
Detail Steel - All Floors	35
Rough-In Elec. on Deck - Floors 1 & 2	10
Pour concrete on Deck - All Floors	25
Rough-In Elec. on Deck - Floors 3 & PH	10
Metal Deck & Studs - All Floors	22
Erect Structural Steel - Floors 3 & PH	22
Concrete Equipment Pads	14
Set AHUs	6
Erect Structural Steel PH Roof	13
Detail Steel PH Roof	9
Metal Deck PH Roof	9

Fig 1.10 Revised superstructure schedule

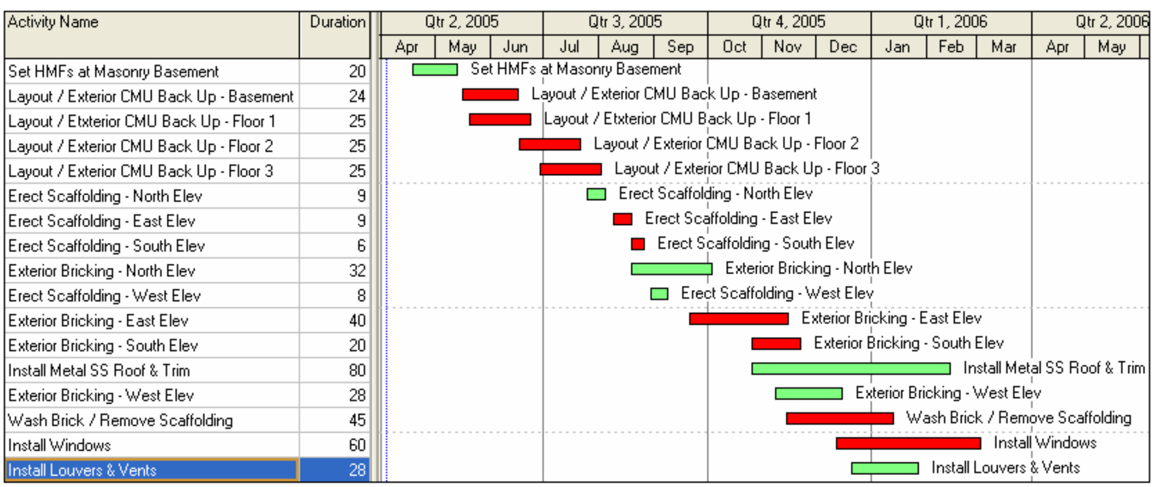
<u>Result</u>: revised superstructure schedule shows delay of approximately four to five extra days.

Building Enclosure



Activity Name	Original Duration
Set HMFs at Masonry Basement	20
Layout / Exterior CMU Back Up - Basement	20
Layout / Etxterior CMU Back Up - Floor 1	20
Layout / Exterior CMU Back Up - Floor 2	20
Layout / Exterior CMU Back Up - Floor 3	15
Erect Scaffolding - North Elev	9
Erect Scaffolding - East Elev	8
Exterior Bricking - North Elev	32
Erect Scaffolding - South Elev	3
Erect Scaffolding - West Elev	8
Exterior Bricking - East Elev	30
Install Metal SS Roof & Trim	80
Exterior Bricking - South Elev	15
Wash Brick / Remove Scaffolding	34
Exterior Bricking - West Elev	28
Install Windows	50
Install Louvers & Vents	28

Fig 1.11 Original building enclosure schedule



Activity Name	Duration
Set HMFs at Masonry Basement	20
Layout / Exterior CMU Back Up - Basement	24
Layout / Etxterior CMU Back Up - Floor 1	25
Layout / Exterior CMU Back Up - Floor 2	25
Layout / Exterior CMU Back Up - Floor 3	25
Erect Scaffolding - North Elev	9
Erect Scaffolding - East Elev	9
Erect Scaffolding - South Elev	6
Exterior Bricking - North Elev	32
Erect Scaffolding - West Elev	8
Exterior Bricking - East Elev	40
Exterior Bricking - South Elev	20
Install Metal SS Roof & Trim	80
Exterior Bricking - West Elev	28
Wash Brick / Remove Scaffolding	45
Install Windows	60
Install Louvers & Vents	28

Fig 1.12 Revised building enclosure schedule

<u>Result</u>: revised building enclosure schedule shows delay of about seven to eight weeks.

Conclusion

After comparing the original building system consisting of the structural tie-ins to the proposed independent building system, expected results were reached. Though it is hard to put the coordination and time needed for the tie-in processes on paper, a thorough analysis of the cost and time for the alternate system was achievable. The summary of the cost breakdown for the proposed system can be viewed in Tables 1.2 and 1.3. The total cost to construct these new independent walls on the South and East sides of the Bioscience Research Building is approximately **$290,000** plus $20,000 per month for crane cost. It will affect several stages of the construction schedule—substructure, steel erection, and building enclosure. These effects are visualized in figures 1.7 to 1.12, by looking at each one of these phases on an individual basis. It was determined that the overall effect on the project schedule that this alternate system will have is a total delay of about **nine to ten weeks** during these analyzed construction phases. The next analysis, *Alternate Site Logistics Plan*, will take a look at how the schedule may actually be able to be shortened from a site perspective.

SITE LOGISTICS

Site Logistics Analysis

The construction site for the Bioscience Research Building project is a fairly small area, and will be congested throughout most of the project with all of the activities that must take place at the same time. Scans of the site and the University of Maryland campus map can be found in Appendix B. It was the goal of this analysis to propose a couple ways in which the original site logistics could be modified during various phases of the project. Using these proposed alternates of things such as storage and truck hauling routes, the ultimate goal was to be able to cut back on the schedule time of the entire project. If the site is not as congested, it will allow easier movement for the workers and their equipment, and progress should move along more rapidly. The following analysis is broken down into sections which have been revised in the proposed alternate site logistics.

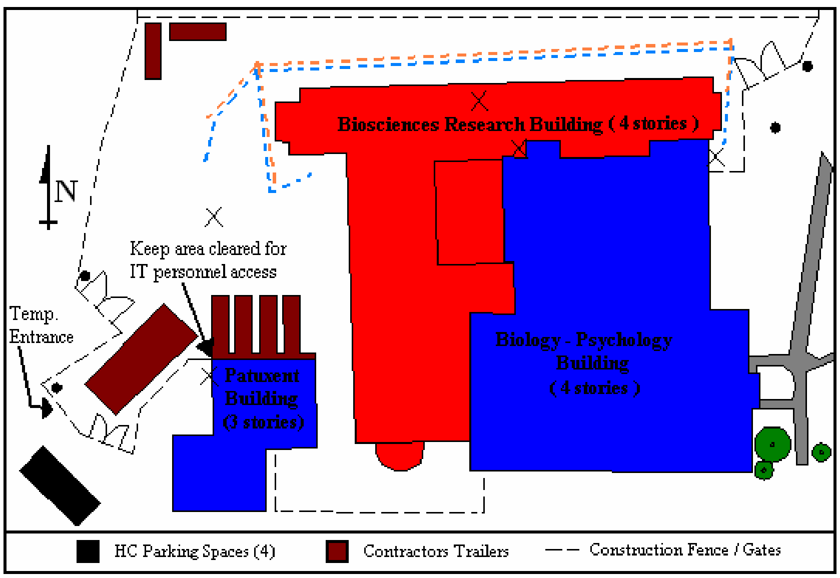


Fig 2.1 Original Site Logistics

Jobsite Trailers and Parking

Problem: In Figure 2.1 above, the location of the site trailers is shown in brown and their location may not seem to be a big problem. However, more area was needed for the trailers than is shown, and when looking at Figure 2.2 it is much more obvious that something needs to be done differently on the site. The trailers, steel shakeout, and crane are all located much too close to each other. This not only influences the project schedule, but also could be viewed as a safety hazard.

Fig 2.2

Solution: The proposed alternate to this location of the trailers is as follows. There is an area between the ICA field and Building 202 (please reference Figure 2.3 below or see the campus map in Appendix B) that is open and is nothing more than a large sidewalk to the university. A small trailer complex would be feasible in this location (designated by the red rectangle in Figure 2.3. Note also that the construction location is shown by the shaded building). This location would not be far from site and would be able to house the contractors in a more comfortable area where they do not have heavy construction going on right outside their trailer window every day. The University of Maryland has even said that if this area was proposed to them as an area to be used for contractor trailers, there is a good chance that it would have been allowed.

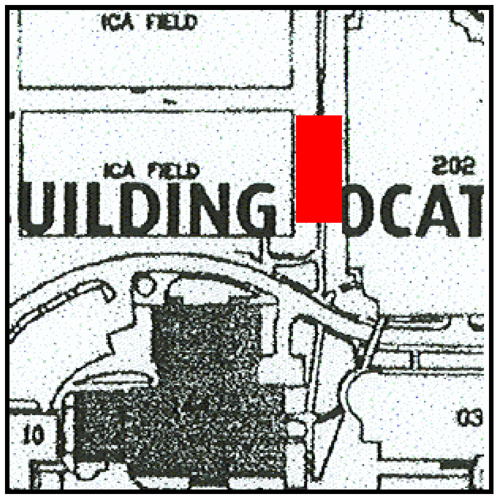


Fig 2.3 Proposed Trailer Complex

Material Storage

Problem: As seen above in Figure 2.2, there are instances where there is not appropriate room for material storage on site. Sometimes the contractors on the job have to improvise and just layout their material wherever they see fit. This is because there is no off-site area to store any kind of material and it all needs to be kept on site. Extreme emphasis has been put on getting materials delivered to site at the exact dates needed because of this. In construction, project schedules need to be reworked constantly and dates do not always stay the same. When this occurs and if a large steel shipment arrives on site a couple days earlier than needed, this material just gets laid down wherever as seen in the photograph earlier.

Solution: The proposed solution for the problem of material storage is similar to the one proposed for the trailers. Figure 2.4 shows a material storage area setup adjacent to where the jobsite trailers were proposed. This area is very close to site and is marked by the blue area on the map. This is not an area large enough for every contractor on the job to store their material there, but at least if something occurs and steel, brick, etc arrives on site earlier than expected, then it can be housed there temporarily. The problem this poses is that it may cause disputes among different contractors who all want to keep some of their material there. If this happens, then the general contractor will have to take control of the matter, but most likely it will be reserved for larger goods such as steel. Though this idea would seem to work well, it may be a little harder to get passed by the university because the area would be getting used pretty hard.

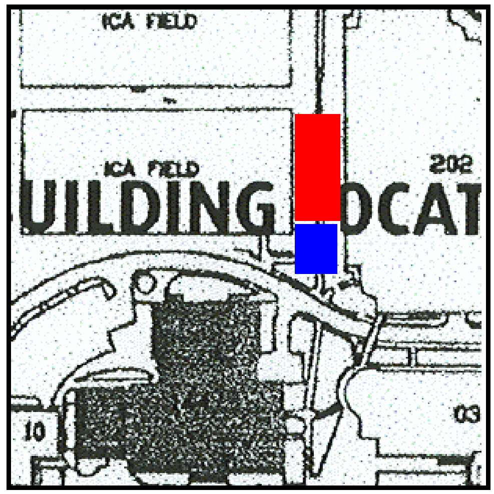


Fig 2.4 Proposed Material Storage

Cranes

Problem: The Bioscience Research Building does not have a designated site crane. This was discussed at the start of the project and was decided against. The project was on the border of being able to support the use of one site crane, but instead everyone will be bringing in their own mobile cranes as needed. The largest crane that will be used is that of the steel erectors. The crane they will be using is a 3900T model, with a maximum capacity of 155 tons.

Solution: There are advantages and disadvantages to each contractor on the project having to bring in their own mobile cranes as needed. The greatest advantage of this is that there will not be a large site crane sitting around on such a congested site for a large period of time. Also, if there are two activities taking place simultaneously on site in which a crane is needed, two contractors will not have to argue over one piece of equipment. The downside to having everyone in charge of bringing their own mobile cranes to site as needed is that this activity needs to be supervised and controlled by the general contractor. The project can only handle so much movement on site, so a schedule for crane arrivals will need to be implemented. Although there may be slight problems, the crane policy will remain the same as the original plan and there will not be a site crane.

Truck Hauling and Delivery Route

Problem: The truck hauling and delivery route can be seen in Appendix B, and a clearer diagram of it around the site has been mapped out below in Figure 2.4. The path is shown in orange and flows counter-clockwise past the site and back out to Route 193.

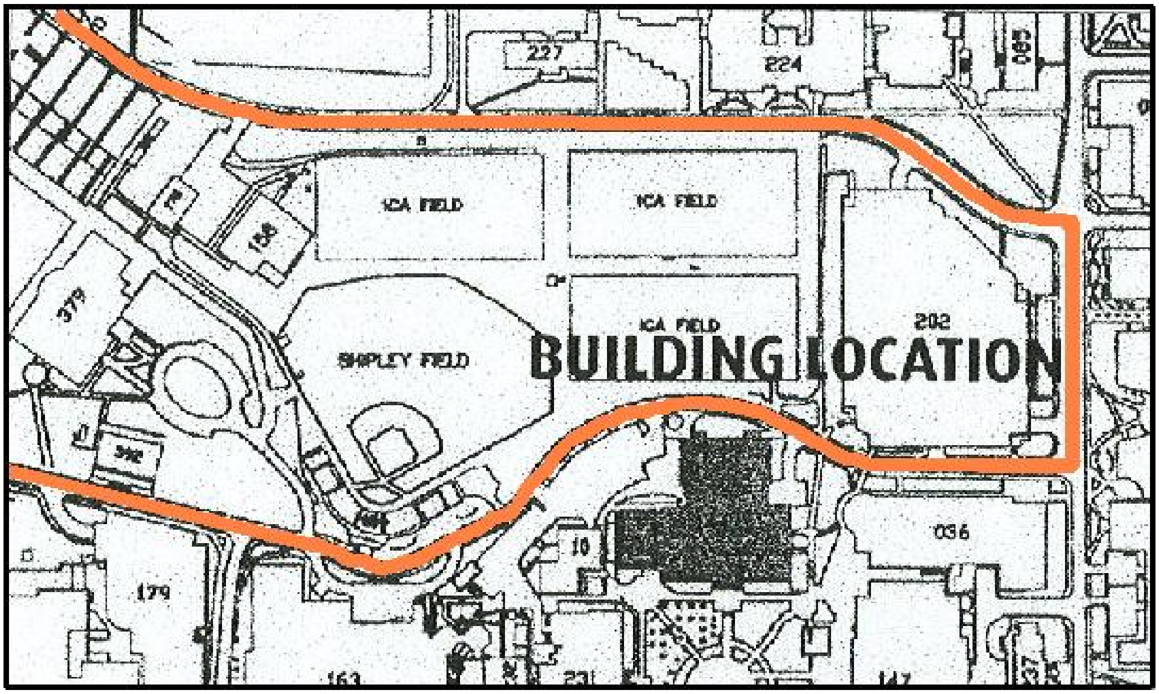


Fig 2.5 Delivery and Truck Hauling Route

This seems to be the best route for deliveries coming and going to the site, but an alternate truck hauling plan could be used. The original logistics have all excavation being hauled directly offsite, or just placed wherever is convenient on site. The problem with this falls in the temporary placement of the dirt on site. Once again, the Bioscience Research Building jobsite is about as tight as they come. Congestion is a huge problem, and there is no room to be keeping piles of dirt on site for long.

Solution: Sharing a similar approach with those of the proposed trailer complex and material storage, an area could be set up near by on campus for the storage of dirt. This area is the green box drawn on Figure 2.6. Time could be saved and site congestion could be reduced if trucks had the option of dumping at a site close by on campus. This will hopefully lessen the amount of trucks needed on site during the excavation phase as well. A short analysis of this proposed trucking approach is in the following section on schedule reduction. The delivery route for the site will remain the same.

Schedule Reduction

Each of the sections discussed above (Jobsite Trailers and Parking, Material Storage, Cranes, and Truck Hauling and Delivery Route) have compared the original plan with those proposed. They have discussed what advantages would be in the revision, and if there were any disadvantages. Though the actual results in schedule are hard to quantify, an estimate will be taken as to the impact these changes could have on the overall project schedule. A more detailed analysis on the proposed truck hauling and excavation storage that was talked about in the previous section is shown first.

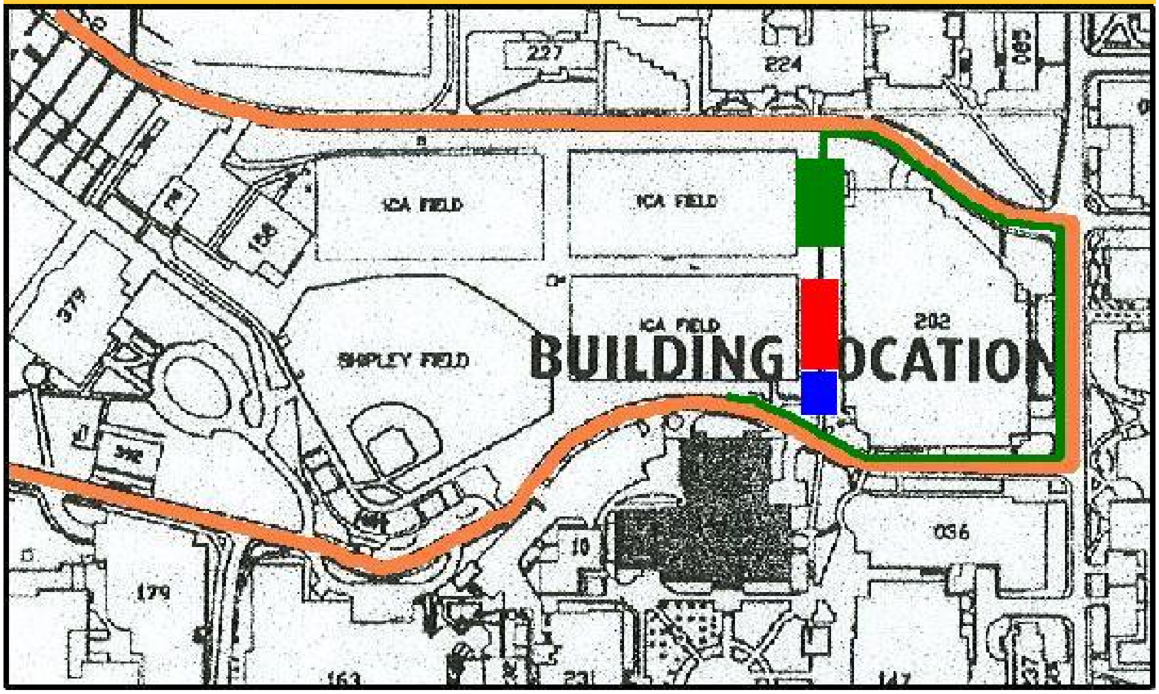


Fig 2.6 Proposed Truck Hauling Diagram (shown with trailers and material storage)

Conclusion

The results of this analysis on the proposed alternate site logistics for site trailers, material storage, cranes, deliveries, and truck hauling are summarized in Table 2.1 below.

	Schedule Reduced	Less Congestion	Feasibility	No Change
Jobsite Trailers	**YES**	**YES**	**Good**	**-**
Jobsite Parking	**YES**	**YES**	**Good**	**-**
Material Storage	**YES**	**YES**	**Fair**	**-**
Cranes	**-**	**-**	**-**	**X**
Site Deliveries	**-**	**-**	**-**	**X**
Truck Hauling	**YES**	**YES**	**Fair**	**-**

Table 2.1

The results in Table 2.1 show that many favorable outcomes could result from the proposed alternates to each of these activities. Site congestion would without question be relieved a little. The only activity whose schedule would be directly affected is the Truck Hauling. The other three activities with a ‘yes’ in the ‘schedule reduced’ column would have schedule reductions as a result of the lessening of site congestion in their respective areas. It can be concluded that favorable reductions in schedule and site congestion were able to be achieved in this analysis of site logistics.

ASBESTOS RESEARCH

Asbestos

What is asbestos?

Asbestos is a naturally occurring fibrous mineral that is mined from the earth and found in many parts of the world. Its composition is such that it can be separated into smaller and smaller fibers, which are virtually indestructible. Asbestos has several properties that caused it to become such a widely used construction material in the 1930s through the 1970s. It is resistant to chemicals and heat, and does not evaporate into the air nor dissolve in water. Asbestos is almost always combined with other materials, forming products known as asbestos-containing materials. This asbestos content in these materials can range anywhere from 1% to 100%. Unlike many other materials mined from the earth, asbestos does not break down over time. Asbestos was an acceptable material and was used in many common forms until most types of asbestos-containing materials were banned in the early 1970s. This came as a result of asbestos-related health issues being discovered.

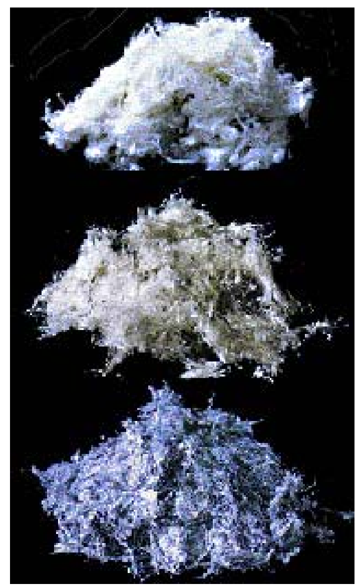


Fig 3.1

What are the different types of asbestos and where can I find it today?

Asbestos-containing materials are found in many different locations throughout the country, especially in older facilities. Three of the most common types of asbestos, shown in Figure 3.1 from top to bottom, are: chrysotile, amosite, and crocidolite. Each of these is different in color, and chrysotile is probably the most common out of the ones mentioned. These types of asbestos can be found in areas ranging from classrooms and offices to barns and farm buildings. Table 3.1 is a listing of many areas where asbestos-containing materials can be found (this list was found on the Environmental Health and Safety website: ww.ehs.psu.edu, and was adapted from US EPA Region 6 listing dated June 26th 2002)

Cement Pipes (Transite)	Elevator Brake Shoes
Cement Wallboard (Transite)	HVAC Duct Insulation
Cement Siding (Transite)(flat or corrugated)	Boiler Insulation
Asphalt Floor Tile (9"x9" and 12"x12")	Breaching/Flue Insulation
Vinyl Floor Tile (9"x9" and 12"x12")	Ductwork Flexible Fabric Connections
Vinyl Sheet Flooring	Cooling Towers (paper-like substrate or Transite)
Flooring Backing (felt-like)	Pipe Insulation (corrugated air-cell, block, etc.)
Construction Mastics (floor tile, carpet, ceiling tile, etc.)	Heating and Electrical Ducts
Acoustical Plaster	Electrical Panel Partitions
Decorative Plaster	Electrical Cloth (usually woven)
Textured Paints/Coatings	Electric Wiring Insulation (usually woven)
Ceiling Tiles and Lay-in Panels (all sizes and textures)	Chalkboards
Spray-Applied Insulation or Fireproofing	Roofing Shingles (asphalt type)
Blown-in Insulation	Roofing Felt
Fireproofing Materials	Base Flashing (tar-based, built-up)

Taping Compounds (thermal and duct joint tape)	Thermal Paper Products
Packing Materials (for wall/floor penetrations)	Fire Doors (linings)
High Temperature Gaskets	Caulking/Putties (window glazing, etc.)
Laboratory Hood Liners, Tables or Bench Tops	Adhesives
Laboratory Gloves (woven)	Wallboard
Fire Blankets (woven)	Joint Compounds
Fire Curtains (woven, usually above auditorium stages)	Vinyl Wall Coverings
Elevator Equipment Panels	Spackling Compounds

Table 3.1 Possible areas for asbestos-containing materials

Advantages and Disadvantages of Asbestos

Asbestos has advantages and disadvantages, and unfortunately the risks of asbestos use outweigh the advantages and it is now being removed from many buildings throughout the country. Asbestos is one of the best insulators known to man. It is also fairly cheap and easy to manufacture and install asbestos-containing materials for use in construction. Asbestos can be used in many different ways, as seen in the table above.

The downside of asbestos use is the health hazard which it presents. Asbestos is usually not considered harmful unless it is inhaled, and is the most dangerous when it is "friable". The term friable refers to the potential for an asbestos-containing material to be easily crumbled, resulting in the release of asbestos fibers into the air. Once these fibers in the air, they can be invisible to the naked eye and inhaled without even knowing. An example of a friable asbestos-containing material is the sprayed-on fireproofing that is often found in older buildings. Objects such as floor tiles are not considered friable asbestos-containing materials. Unless it is extremely friable, an asbestos-containing material will not usually release asbestos fibers unless it is disturbed or damaged. For this reason, all caution must be taken before things such as ceiling tiles are removed or drilled.

The health hazard for an individual who inhales asbestos fibers from the air depends on a number of factors. First off, the duration of exposure and the amount of fibers inhaled effect their likelihood of developing an asbestos related illness. The longer a person is exposed and the amount inhaled result in a greater chance of developing an asbestos related problem. This was largely a problem for industrial workers that were applying the sprayed-on fireproofing in the past, and is not as dangerous for those simply doing routine maintenance activities throughout a building. Another factor is smoking. A person smokes regularly has a greater chance of developing an asbestos related problem than an individual who does not smoke. This gives the smoker an even greater chance of developing lung cancer. Diseases which have been attributed to asbestos exposure include such diseases as asbestosis, mesothelioma and gastrointestinal cancers.

How to keep individuals today safe from asbestos exposure

To assure that both industry members and occupants of buildings today do not develop any asbestos related illnesses, everyone must be kept safe from asbestos exposure. The best way to achieve this goal is to keep everybody informed. Individuals must look out for their own safety, as well as their co-workers and others around them.

People must stay informed on common locations of asbestos containing materials, and keep away from suspect materials. On construction projects, those working around materials which may be asbestos containing materials should contact their supervisor with concerns and assume that any unknown material is asbestos unless it is verified otherwise. Taking precautions like this will assure their own safety as well as others working around them. If areas of damaged asbestos are discovered, these areas need to be blocked off, and only individuals who are licensed to deal with asbestos-containing materials should enter these zones. On the other side of things, never cut, remove, or damage any kind of material that is suspect to containing asbestos.

Organizations today

Over the past years a few organizations have been formed to deal with health and environmental issues in construction and other industries today. Some of the common ones are listed below:

- Environmental Protection Agency (EPA) – www.epa.gov
    - The Environmental Protection Agency serves as an organization to protect both human health and the environment. It was established in 1970, on the growing public demand for cleaner water, air, and land. The EPA was also assigned the task of repairing the damage already done to the

environment, as well as to establish new criteria to guide Americans in making a cleaner environment.

- U.S. Occupational Safety and Health Administrations (OSHA) – www.osha.gov
  - OHSA was formed in 1971 to assure the safety and health of America's workers by both setting and enforcing standards. They also provide training and education to encourage continual improvement in workplace safety and health.

Pennsylvania State University and University of Maryland projects

While researching asbestos and its current role in the construction process, a couple of contacts from both Pennsylvania State University and the University of Maryland were asked questions regarding their opinions and asbestos control experiences. Information below was compiled to summarize feedback obtained from these sources.

The Bioscience Research Building at College Park, MD requires small amounts of demolition and asbestos removal. The existing Biology-Psychology Building requires demolition on the north and east sides. See Figure 3.2 for a diagram of the building. Two stairwell areas and a lecture hall will be demolished and each of these areas house some asbestos containing materials. It is policy that the University of Maryland handles all asbestos control on campus projects. An issue on this project, as well as projects at most large universities, is that building use and pedestrian flow must be taken into consideration during the asbestos removal process.

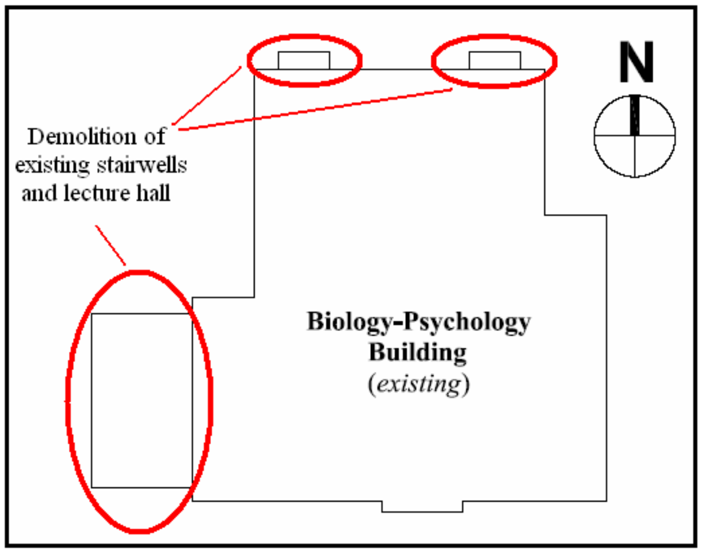


Fig 3.2 Required Demolition

Pennsylvania State University has an organization called The Department of Environmental Health and Safety (EHS) to deal with both safety and environmental issues facing the campus. EHS has three main areas of responsibility at Penn State: Environmental Protection, Occupational Health and Safety, and Radiation Protection.

The control and removal of asbestos in facilities and on building projects falls into these areas of responsibility. The current policy that the University has is that asbestos-containing materials are only disturbed or removed when absolutely necessary. When materials are found to be damaged they are removed, as well as during demolition and renovation projects. The three authorities which currently regulate the University are the EPA, the PA Department of Environmental Protection (PA DEP) and the PA Department of Labor and Industry (PA Labor and Industry). These authorities have many regulations by which the University must abide.

EHS does most of its renovations in occupied buildings, and many of their projects include some form of demolition. All of these projects add up to about 100 asbestos projects per year at Pennsylvania University campuses. For renovations, the schedule is always planned around the movement of pedestrians. This planning starts as early as the actual construction planning. Some key factors that were mentioned for a project to be completed successfully and in a timely manner are: good planning from the beginning, which includes good asbestos surveys and management programs. Asbestos must then be addressed from the beginning along with the rest of the design process. Following these guidelines ensures a good scope of work and can minimize change orders. An industry issue that affects these projects is OSHA and EPA regulations requiring all contractors to have proper training – which does not always occur.

FINAL CONCLUSIONS

Final Conclusions

Independent Building Analysis:

The proposed system required the new Bioscience Research Building to be set back from the existing Biology-Psychology Building about twelve to fourteen feet. This will leave room for walking between the neighboring buildings as well as preserve the courtyard atmosphere in the middle. Now that the building is independent and will not be structurally tied into the structure of the existing building, less need for schedule coordination is required. Time will easily be saved early in the project since samples do not need to be drilled out of the existing building for sizing of the tie-ins. Later in the project, the tie-in phase will be skipped all together and this will also cut back on the project time and cost. The proposed analysis was determined to add about nine to ten weeks onto activity durations throughout the project such as exterior bricking, pouring foundation walls, and erecting steel. A cost take-off was successfully performed for the material that will be needed in building this new wall structure and it amounted to about $290,000 plus the extra time that the crane is required to be on site, at a rate of $20,000 per month.

Site Logistics Analysis:

The site logistics of the Bioscience Research Building project were analyzed as well. Alternate ideas were proposed that would help relieve site congestion. By relieving site congestion, time and cost will decrease because work productivity will rise. This can be achieved by providing areas close by that can be used for material and equipment storage. Truck hauling was also considered. If trucks have the opportunity to dump excavated material nearby rather than leaving the campus, less trucks will be needed and dirt can be removed from site faster and more effectively during the excavation phases. An alternate location for contractor trailers was also proposed to provide a comfortable location for those on the job.

Asbestos Research:

Asbestos is often an issue in construction today when there is necessary demolition, especially on older buildings. It is common for large universities such as Pennsylvania State University and the University of Maryland to have separate parties in control of asbestos removal on all campus projects. Only professionals should enter buildings with friable asbestos containing materials during these removal processes. To ensure removal in a timely manner, licenses should be checked early to make sure all members involved have proper certification. All parties involved should begin coordinating together as early as possible to minimize conflicts that may arise once removal has begun.

LESSONS LEARNED

Lessons Learned

Throughout this year of work on my senior thesis, I have learned new things and profited in many ways. I was able to apply the skills that I have acquired during my five years in school to actual construction situations in real life. I utilized these skills and experimented with new ideas in an attempt to add value to the Bioscience Research Building project.

During the Independent Building Analysis, I had to look into some structural aspects of a building. I learned how to use the *SAP 2000* software to size and design a basic column and beam layout. After this was complete, I used skills that I have learned over the past few years to apply this to the schedule and cost of the project. From the results of this analysis, I learned that changing one thing on a building may seem simple at first but it has an effect on nearly every aspect of the construction process.

The Site Logistics Analysis will be helpful to me on future projects that I deal with once I am working in the construction industry. It enabled me to take an alternate approach to the site layout and develop my creative skills at trying to think of ways it could be improved. Some of the ideas I proposed for the site plan are not easily feasible when working on a college campus and usually there are a lot of guidelines which the client sets for you.

Through my research on asbestos, I learned many things that I did not know anything about before. I had always heard a lot about asbestos, but never knew the exact effects it could have on an individual and how it plays a role on construction projects today. I also learned what kinds of building areas and materials that asbestos can commonly be found in. While researching asbestos, I was able to read about some of the organizations founded today to help ensure the safety of individuals and the environment. Overall, I have benefited largely from the work done on my senior thesis and I am confident that I will be able to apply it the construction industry in the future.

APPENDIX

Calculations – Ind. Bldg. Analysis

Load Calculations:

- Floors
    - "6" concrete slab
    - Metal decking – 2" composite 20 gauge w/ ribs 12" o.c.

Live Load: **150 psf**

Dead Load: **97 psf**

Concrete: (6" thick / 12) x 150 psf = 75 psf

Deck: 2 psf

Reinforcement: 5 psf

Superimposed Load: 15 psf

- Roof
    - Assumed 6" concrete slab
    - ½" type B, wide rib, 20 gauge

Live Load: **20 psf** (snowload)

Dead Load: **93.5 psf**

Concrete: (6" thick / 12) x 150 psf = 75 psf

Deck: 3.5 psf

NOTE: Load calculations are converted from psf → klf before using SAP computer program

A

Steel calculations

The following calculations were taken from Figures 1.4-1.6 (framing diagrams)

Side A

- Columns (quantities in parentheses)
    - (21) W 12 X 65 → 15.33’ x 65 lb/ft x 21 units = 20,925 lbs = 10.46 tons
    - (7) W 18 X 76 → 15.33’ x 76 lb/ft x 7 units = 8,156 lbs = 4.08 tons
- Beams
    - (6) W 12 X 40 → 22’ x 40 lb/ft x 6 units = 5,280 lbs = 2.64 tons
    - (18) W 12 X 65 → 22’ x 65 lb/ft x 18 units = 25,740 lbs = 12.87 tons

Side B

- Columns
    - (12) W 18 X 55 → 15.33’ x 55 lb/ft x 12 units = 10,118 lbs = 5.06 tons
- Beams
    - (8) W 12 X 65 → 20’ x 65 lb/ft x 8 units = 10,400 lbs = 5.20 tons

Side C

- Columns
    - (12) W 18 X 19 → 15.33’ x 19 lb/ft x 12 units = 3,495 lbs = 1.75 tons
- Beams
    - (2) W 14 X 90 → 35’ x 90 lb/ft x 2 units = 6,300 lbs = 3.15 tons
    - (6) W 14 x 109 → 35’ x 109 lb/ft x 6 units = 22,890 lbs = 11.45 tons

Additional members

- Beams
  - (1) W 14 X 90 → 30’ x 90 lb/ft x 1 unit = 2,700 lbs = 1.35 tons
  - (3) W 14 X 109 → 30’ x 109 lb/ft x 3 units = 9,810 lbs = 4.91 tons

Adding up all of the members yields

- Columns – 21.35 tons
- Beams – 40.22 tons
- Total steel – 61.57 tons
- Average additional tons per floor (4 floors) – 15.39 tons

Calculations for additional wall items

Additional wall perimeter = 132’ + 40’ + 100’ = 272’

The following calculations performed using *RS Means 2005* guides

Foundation Walls

- Excavation: 16 ft deep, sand gravel or common dirt, hauled offsite
  - 272’ x 2’ x 1.9/SF = $1,034
- Foundation Walls (including formwork, reinforcement and labor): cast-in-place
  - crane & bucket = 225/LF
  - 272’ x 225/LF = $61,200
- Total foundation wall cost = **$62,234**

Exterior Walls: type of brick face – standard, stud gage – 20 gage, stud spacing – 16”
bond pattern – running w/some Flemish

- Running bonds: $17.60 / SF, Flemish bonds: $22.65 / SF, Used $20.10 / SF

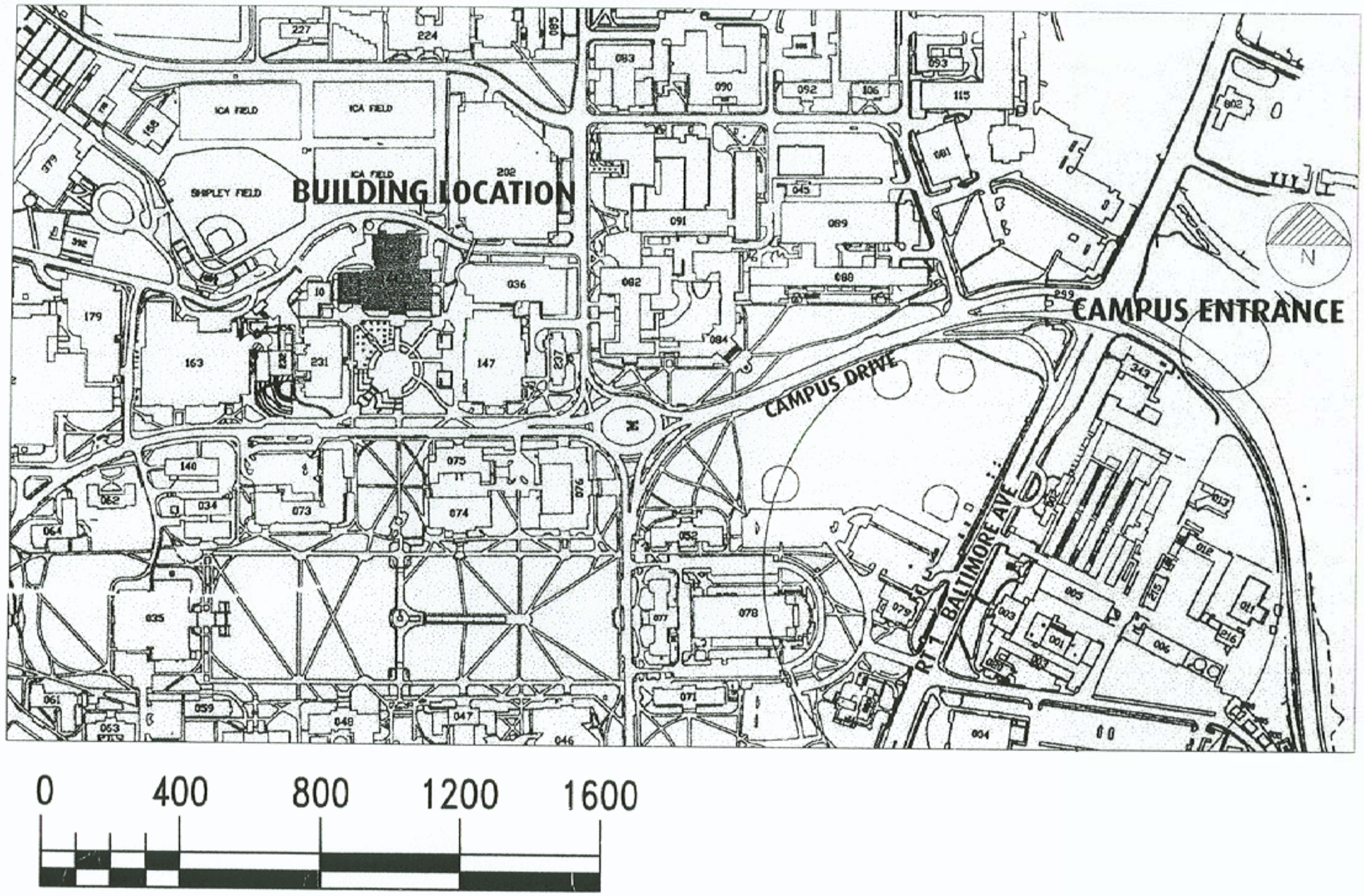
- Curtain wall: glazing panel, 1” thick, clear - $23.20 / SF
- Assumed 70% brick wall, 30% curtain wall
- Calculation:
    - Brick: (20.10 x 0.7 x (885 + 272) x 15.33 x 4)/140,000 = $7.13/SF
    - Curtain wall: (23.2 x 0.3 x 1157 x 15.33 x 4)/140,000 = $3.53/SF
    - Each x 16,679 SF of wall face = $118,921 + $58,876 = **$177,797**

Additional Doors: solid wood, double – 6’ x 8’, 48 SF @ $3,800 each

- 4 doors x $3,800 each = **$15,200**

B

LOCATION / VICINITY MAP



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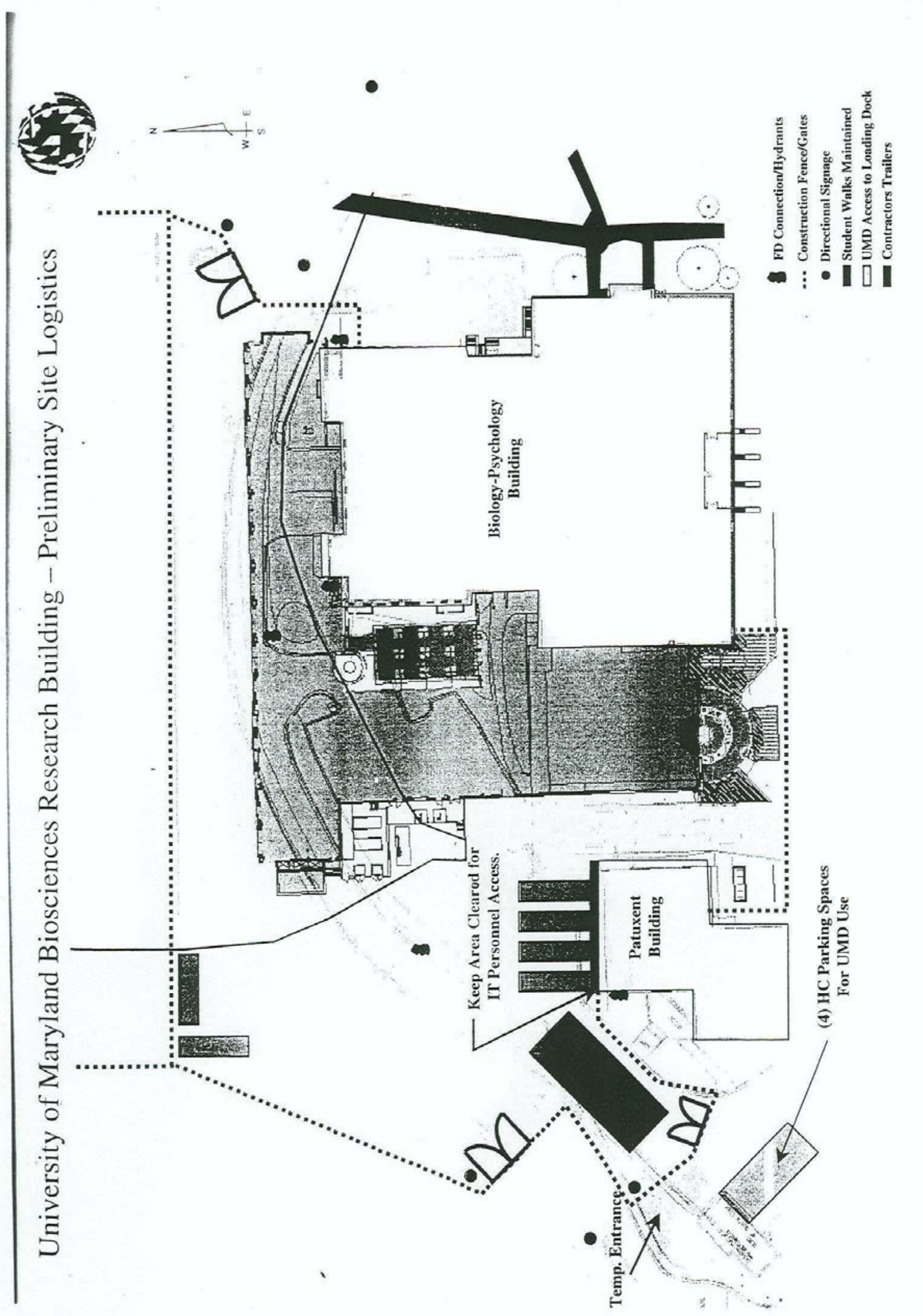
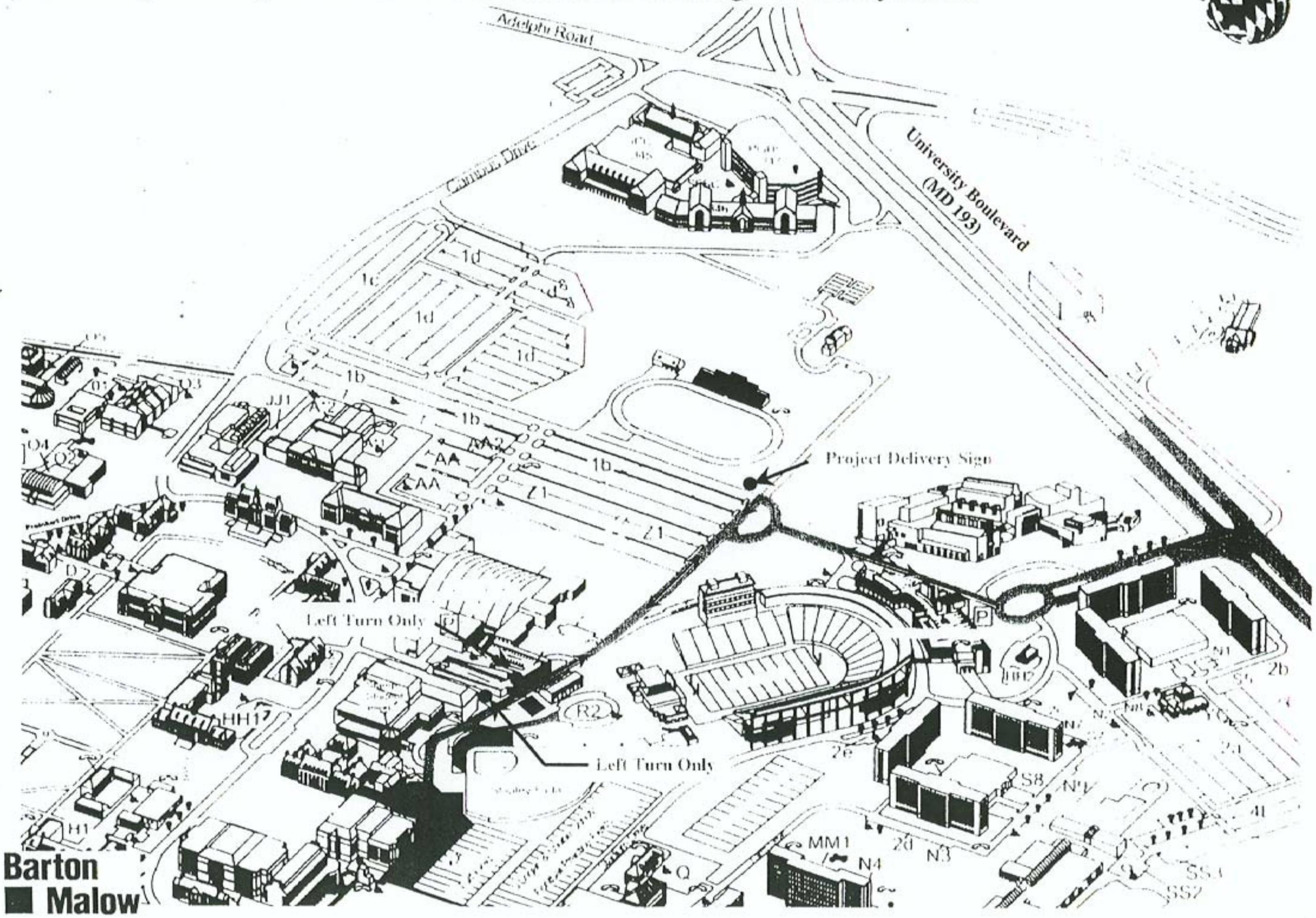


University of Maryland Biosciences Research Building – Preliminary Site Logistics
Biology-Psychology Building
Patuxent Building
Keep Area Cleared for IT Personnel Access.
(4) HC Parking Spaces For UMD Use
Temp. Entrance
FD Connection/Hydrants
Construction Fence/Gates
Directional Signage
Student Walks Maintained
UMD Access to Loading Dock
Contractors Trailers

University of Maryland Biosciences Research Building – Delivery Route



B

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Personal Contacts:

- Tim Lupcho – Barton Malow
- Owner's representative (Anonymous)
- Mike Burke – Environmental Health and Safety

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- www.epa.gov
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- R.S. Means Guides 2005 – Assemblies Costs, Construction Costs
- Vulcraft: Steel Roof and Floor Deck Manual. 2001. (New York, USA)

Computer Software:

- CostWorks Version 8.0 (R.S. Means 2005 data)