Written By: Brenton Decker
Option: Construction management
Faculty Advisor: Chimay Anumba
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Thesis Technical Assignment #1

Construction Project Management

George Mason University PE Building

Renovation & Expansion

Fairfax, Virginia

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Executive Summary

During the experience of working on Technical Assignment #1 – Construction Project Management, many aspects of this building were studied. The George Mason PE Building is a multi-functional recreational facility housing three gymnasiums, a state of the art strength-training and fitness center, racquetball/squash courts, as well as admin. offices and lounge areas for the students. It will be under construction for approximately a year and a half before being completed in the summer of 2009 at the George Mason University Fairfax campus in Virginia.

Being that the PE Building project is a renovation/expansion project, it provides some interesting challenges. One of these challenges was that extensive demolition work was required. Asbestos was also encountered and disposed of, presenting another interesting challenge. This project was not a LEED rated project, but might be worth researching at a later time how to get it LEED certified due to the fact that Gilbane had already put together a small sustainability plan. This project is being delivered in a standard CM at Risk fashion.

In analyzing the project schedule, and compressing it to less than 30 activities, the distinct construction phases became apparent. They include: Demolition, Renovations, New Construction, Sitework, etc. It appears the schedule was phased in this manner not only to create a logical work order, but to minimize site congestion as well since there are virtually no staging areas. One interesting detail that stood out in the schedule was landscaping occurs during the winter months. It will be interesting to see if this ends up delaying the project due to possible bad weather conditions.

Project Schedule Summary

The construction schedule for this project spans a time period of around two years. It started in the fall of 2007 and is expected to be completed in the summer of 2009. Some major phases of this project are as follows:

- Demolition
- Sitework
- Renovation of Linn Gym
- Renovation of Cage Gym
- Renovation of Existing Core
- New Construction

As in any construction project, the foundation, structural, and finishes sequences are important in turning over a building on time. For George Mason, there are several key elements to these sequences that need to be taken into consideration to make sure that happens. Several underground utilities needed to be relocated from the existing building to lay the foundations for the new gym. Being sure they did not run into any unforeseen conditions along with weather conditions, since the foundations were poured in early February, were key elements in making sure this sequence ran smoothly. The key element to the structural sequence was material staging. GMU's site is rather small and congested, so ensuring adequate space for lay down to provide efficient work was of high importance. Key elements for the finishes sequence are coordination of trades and on-time material delivery. This is especially important for the renovation of the Linn and Cage gyms as they are being turned over for usage before the rest of the project is finished. See Appendix A for the overall project schedule summary including important activities and milestones.

Building Systems Summary

Figure 1 (right) shows a summary checklist of all of the building systems included in George Mason's PE Building. The following information is to provide a background of each system:

Building Systems Checklist

Yes	No	Work Scope
X		Demolition Required?
X		Structural Steel Frame
X		Cast in Place Concrete
	X	Precast Concrete
X		Mechanical System
X		Electrical System
X		Masonry
X		Curtain wall
X		Support of Excavation

Figure 1.

Demolition

Various materials were disposed of during the demolition phase. These materials include: sheet metal, tile, paint, wood, etc. Being that the existing building is an older building, asbestos was encountered during this process. Appendix B shows a table including locations asbestos was found. No lead paint was encountered during demolition.

Structural Steel Frame

The steel frame for this building consists of a series of braced bays with moment connections. The typical beam size is a W21 X 62. Columns are encased in 8in. X 8in. X 4in. CMU blocks. Steel members were erected using a 70 ton hydraulic truck crane.

Cast in Place Concrete

No horizontal formwork was required for this project due to all elevated slabs being poured on metal decking. The vertical formwork was mostly constructed of plywood/rough carpentry. However, in the mechanical courtyard area, west of the new Venue Gym, large metal forms with an expansive shoring system were used. Curved sections were used as well to construct the South side of the large retaining wall. As previously mentioned, all concrete was poured into place.

Mechanical System

The mechanical plant is located in the Southwest corner of the site, adjacent to the Venue Gym. It is home to (3) 59 HP boilers and (2) 320 ton centrifugal chillers. The air is distributed by (6) VAV Air Handlers located on the roof. The main fire protection system consists of a 500 gpm pump with a dry-pipe sprinkler system. The backup protection is provided by a 20 gpm jockey pump.

Electrical System

The electrical system consists of a 1200A, 480/277 V Main Service Switchboard. Power is supplied by the campus utilities, and comes into the transformers at 75 KVA where it is reduced to 480/277 V and 208/120 V respectively. The emergency backup system consists of an emergency generator set that is 100KW, 200A, and 480 V.

Masonry

The majority of the brick masonry is used as a veneer. It is connected by using a shelf angle and masonry ties at 16” O.C. to the bond beam behind. Scaffolding was erected and used to place the brick around the Venue Gym.

Curtain Wall

A large glass curtain wall makes up almost the entire East façade. This façade encloses the new strength-training and fitness center. The glass for the curtain walls consist of a combination of insulated and spandrel glass. These glass panels are being constructed using a man and material hoist.

Support of Excavation

Excavation support was only required at the North wall of the mechanical room. Soldier piles and wood lagging were used at this location. They were left in place to ensure the integrity of the Cage Gym. Dewatering systems were not used at all on this project.

Project Cost Evaluation

The costs of the building systems were evaluated by performing several tasks:

- Reporting actual project costs
- Producing a parametric estimate using D4 Cost 2002
- Producing a square foot estimate using RS Means

Figure 2 (right) shows the actual project costs and costs per square foot obtained from the CM on the job.

Actual Project Costs	
Cost Type	**Cost ($)**
Construction	24 million
Construction per SF	205.96
Overall Project	29 million
Project per SF	248.86
Major Systems	12.6 million
Systems per SF	108.72

Figure 2.

D4 Estimate

The D4 estimating software was used to create a quick estimate by comparing similar projects to George Mason's PE Building. Two similar projects were selected and then averaged using George Mason's building statistics to obtain the estimate. The two projects used were Miami University's Recreational Sports Center and Texas A&M University's Student Rec. Center. These projects were strategically selected based upon similar project details. Some of the common attributes these projects share with GMU are listed below:

- Demolition
- Steel Superstructure
- Concrete Foundations
- 2 Floors
- Gymnasiums
- Admin Offices
- Café/Lounge
- Strength-Training Facilities

A couple subtle differences between these projects and GMU are that their building square footage is larger and the height is taller. See Figure 3 (next page) containing the D4 cost comparison to George Mason's PE Building.

D4 Cost Comparison			
Project	**Building Size (SF)**	**# of Floors**	**Total Project Cost**
Miami U. Rec. Center	159,300	2	17.6 million
Texas A&M Rec. Center	286,050	2	27.2 million
Average today vs. GMU	116,166	2	20.6 million

Figure 3.

As one can see, despite the vast similarities and the fact that the two comparable buildings were larger and taller, the total project estimate came in lower than George Mason's actual cost. This differential could be caused by a couple different factors. First, GMU's PE Building is part renovation as well as new construction. The two comparable projects are new buildings. So the renovation aspect of GMU along with the removal of asbestos could account for a substantial amount of the difference. Secondly, GMU's large 2-story glass curtain wall façade as well as several smaller curtain walls enclosing the building dwarf any curtain walls described for the other two projects. Curtain wall systems are very expensive, which in turn could amount for some of the cost difference between the projects. A breakdown by CSI division of the D4 cost estimate can be seen in Appendix C.

RS Means Estimate

RS Means Square Foot Costs 2008 was used to create a rough estimate of the overall project based upon its square footage. In using this method to obtain an estimate for George Mason, a few different building types had to be combined. These include a gymnasium, college classroom, and college student union. These three building types were combined to create the most accurate estimate possible since George Mason's PE Building is a multi-functional facility and RS Means did not have one particular building type that would cover every aspect needed.

The gymnasiums category was used to estimate the three gyms housed within the PE Building. Although the exterior wall types vary around the building's entire perimeter, reinforced concrete block and face brick with concrete block back-up were used for this estimate for simplicity. Additives included with these estimates are as follows:

- Bleachers
- Scoreboard
- Basketball Hoops
- Lockers
- Sound System

The college classroom category was used to estimate the remainder of the PE building. Again, for simplicity the exterior wall type used was face brick with concrete block back-up. Additives used for this are as follows:

- Elevators
- Lockers
- Locker Benches
- Classroom Seating
- Smoke Detectors

The only aspect the college student union category was used for was to account for the glass curtain walls. See figure 4 (below) for RS Means estimate with location factor included.

RS Means Cost Comparison		
Building Section	**Building Size (SF)**	**Cost ($)**
Venue Gym	14,437	2,453,647
Linn Gym	15,995	2,298,073
Cage Gym	14,232	2,074,701
Rest of Building	71,502	25,192,763
Total	116,166	29, 457, 649

Figure 4.

As one can see, the RS Means estimate is slightly higher than the actual construction cost for George Mason's PE Building. The main factor that could have contributed to the estimate being high is that RS Means is accounting for complete new construction of these facilities. In GMU's case, half of the project is a renovation of the existing building instead of the construction of an entire new one, which generally should be less expensive. A second possible factor could be the quantities of additives used during the estimate. While care was taken to provide ballpark quantities, they were by no means exact and could have caused some of the monetary discrepancy. See Charts in Appendix C for information on how the RS Means estimate was obtained.

RS Means vs. D4

While the D4 cost estimate produced a lower number and the RS Means estimate produced a higher estimate, when averaging these estimates together it produces an estimate fairly accurate to the actual construction costs. See figure 5 (next page) for the comparison of these two estimates.

D4 vs. RS Means	
Estimate	**Cost ($)**
D4	20.6 million
RS Means	29.5 million
Average	25 million

Figure 5.

Site Plan of Existing Conditions

The site for George Mason's PE Building is located on GMU's Fairfax campus in Virginia. It lies in the midst of a wooded area on the western part of campus. There are no adjacent buildings surrounding the site. The only surrounding structures are tennis courts and a football field to the North. See Figure 6 (below) for the location of the site on the GMU campus map. The site is the area shaded in blue. Specific site plan can be seen in Appendix D.

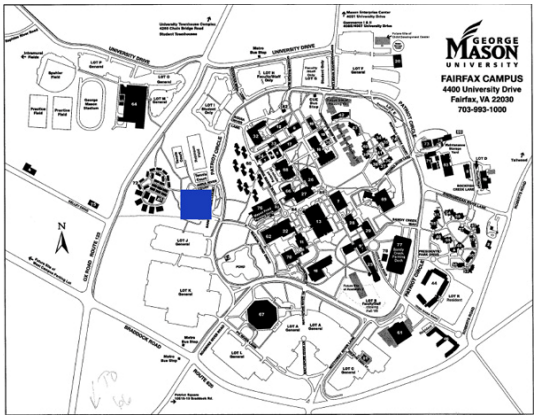


Figure 6.

Local Conditions

In researching construction methods around Fairfax, no preferred methods of construction were found. Concrete and steel structures are used similarly throughout this region. Construction parking for the George Mason PE Building project is at a minimum. With the site being so congested, it allows only minimal parking for the Gilbane employees. Subcontractors were prompted to buy parking passes to park at the nearby Field House, Northwest of the site. See Figure 7 (right) depicting the parking to site relationship.

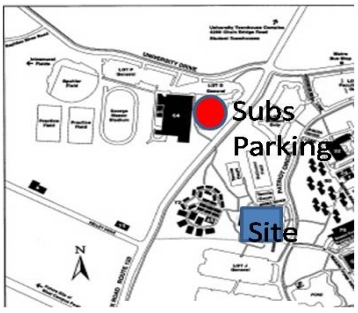


Figure 7.

Recycling locations near the jobsite and around Fairfax are readily available. To put it into perspective, there are at least fifteen recycling centers within a 20 mile radius of the site. The average tipping fee for recycling in the state of Virginia is around $57 per ton.

The PE Building site rests on soils with five defined strata levels below approximately 6 inches of top soil. These strata levels include the following:

Stratum A – silt fill with variable amounts of sand, mica, bricks, crushed stone, etc.

Stratum B – fat clay, elastic silt, silt, quartz rock fragments, etc.

Stratum C – silty sand, well graded gravel, mica, quartz rock, etc.

Stratum D – disitegrated rock, sandy silt, silty sand, quartz rock, etc.

Stratum E – schist rock, bedrock

It was recommended that the first two strata levels be removed up to a depth of 2 feet and backfill 4 inches of crushed stone before pouring floor slabs. Groundwater was observed at depths ranging from 9.2 – 22.3 feet below the surface.

Client Information

George Mason University's two most important ideals are freedom and learning. The PE Building is being renovated and expanded to bring it up to date with modern society and technology. This building is meant to accommodate the future demands for recreational opportunities for students, and will ultimately become the main recreation center on campus.

GMU's cost, quality, schedule, and safety expectations for this project are very high. The PE Building is meant to be somewhat of a signature building to the campus, so ensuring that it is completed at the highest level of quality is crucial. Cost, schedule, and safety expectations are typically high on any construction project. The owner always wants their building turned over on time and within the budget. To put this into perspective, they started organizing closeout procedures and requiring mock-up documents from the subcontractors approximately halfway through the project to help accelerate this process in the end. GMU promotes safety on the job everyday with making daily/weekly safety toolbox talks mandatory, as they do not want any accidents to occur.

Project Delivery System

George Mason's PE Building project is being delivered in a CM at Risk fashion. This particular delivery method was chosen because Gilbane, the CM on the job, is a construction management firm rather than a regular general contractor. However, George Mason typically works with general contractors. To account for this, Gilbane is combining the CM and GC styles by holding all of the subcontractors' contracts, hence creating the CM at Risk approach. This has made their relationship different since neither of them is used to doing business in this manner. An organizational chart depicting this delivery system can be seen in figure 8 (below).

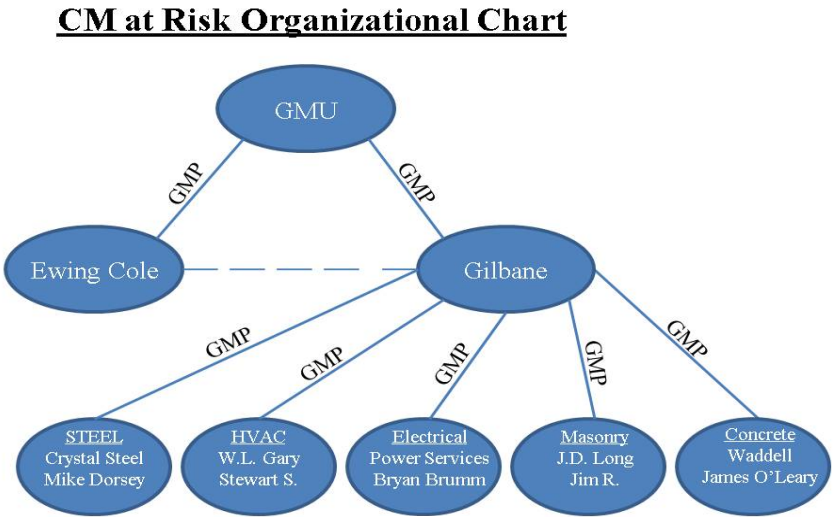


Figure 8.

As seen in figure 7 (above), all contracts involved between the different players are GMP contracts. The benefit of this type of contract is that it gives the party in charge of that contract a set price in advance. This way if the party performing the work under that contract goes over budget, it falls on them instead of the party holding the contract. Vice versa if the party performing the work comes in under budget, they make a profit.

The subcontractors on this job were mainly selected by low bid. However, there are a few exceptions to this as Gilbane selected/did not select a few contractors based on past experiences. Gilbane provides all of the bonding for the subcontractors. This is done because they can provide it to the owner at a cheaper rate, which in turn makes them a profit. It is done just to help them keep up with their subcontractors better as well. The delivery method and contract types chosen for this project are appropriate being that it is a fairly straightforward project with not too many challenges.

Staffing Plan

Figure 9 (below) represents Gilbane's staffing plan for the George Mason PE Building project.

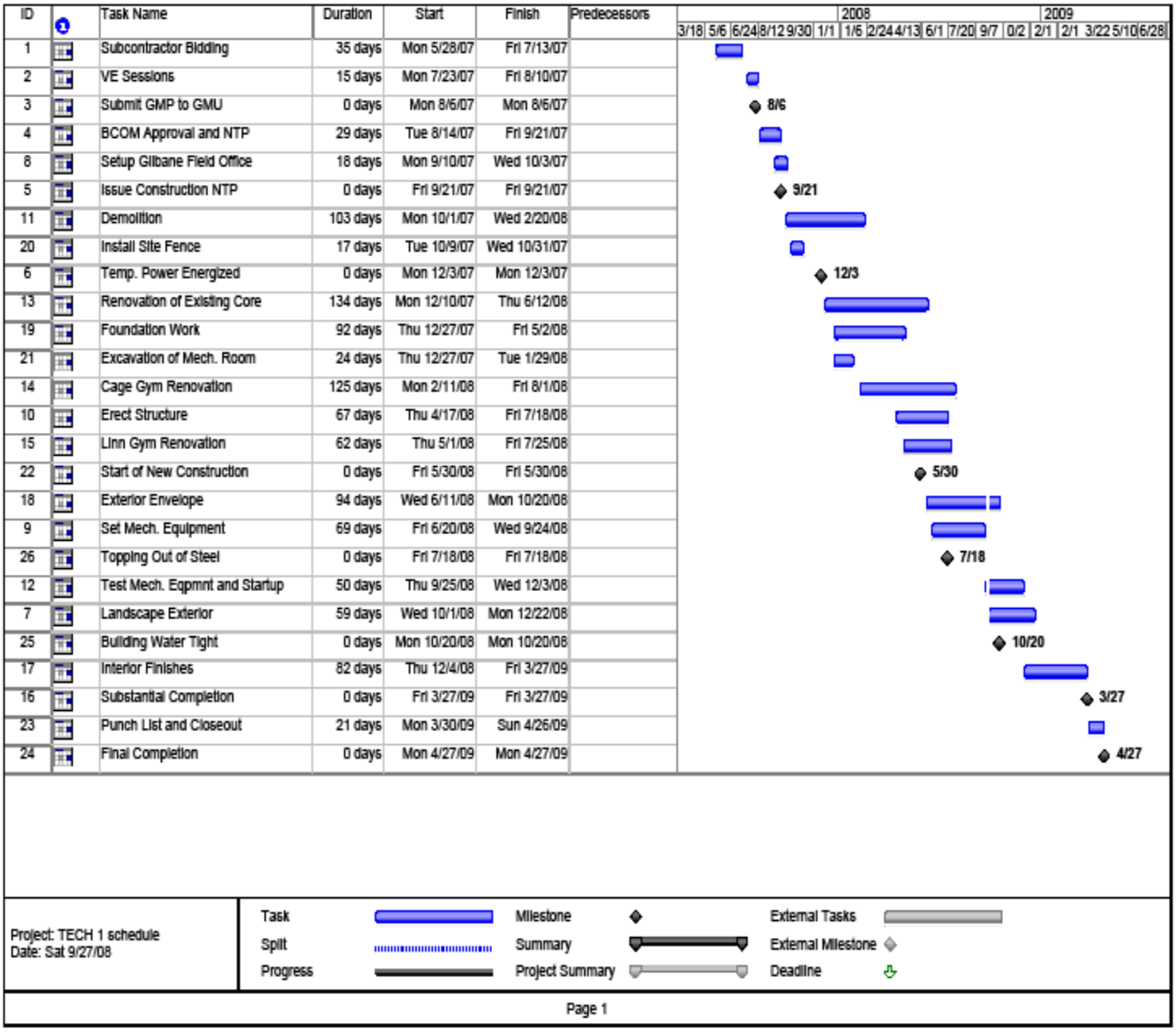
Role	Assigned Personnel	Project Responsibility	Skills Required	Estimated Start Date	Duration Required
Project Team					
Project Manager	Ed von Roemer	Manage team, Subs, etc.	Project Management	May 2007	April 2009
Cost Engineer/Assistant PM	Priya Varadan	Evaluate spending, cash flow, etc.	Financing, Project Management, Accounting	August 2007	July 2008
Cost Engineer/Assistant PM	Unknown	Evaluate spending, cash flow, etc.	Financing, Project Management, Accounting	August 2008	July 2009
Project Engineer	Adam Davis	Process submittals, RFI's, Change Orders, etc.	Read Contract Documents, Review Submittals	May 2007	April 2009
Superintendent	Ray Register	Walk the job, supervise subs, etc.	Read Contract Documents	October 2007	April 2009

Figure 9.

This structure, being that there are only four team members, provides a close working relationship between everyone. It fosters easy communication as well as providing a great overall understanding of the whole project for all team members. As seen in the figure above, Gilbane moved their original cost engineer to a different project and brought someone else in to finish the job.

Appendix A- Project Schedule Summary

Appendix A



ID	Task Name	Duration	Start	Finish	Predecessors
1	Subcontractor Bidding	35 days	Mon 5/28/07	Fri 7/13/07	
2	VE Sessions	15 days	Mon 7/23/07	Fri 8/10/07	
3	Submit GMP to GMU	0 days	Mon 8/6/07	Mon 8/6/07	
4	BCOM Approval and NTP	29 days	Tue 8/14/07	Fri 9/21/07	
8	Setup Gilbane Field Office	18 days	Mon 9/10/07	Wed 10/3/07	
5	Issue Construction NTP	0 days	Fri 9/21/07	Fri 9/21/07	
11	Demolition	103 days	Mon 10/1/07	Wed 2/20/08	
20	Install Site Fence	17 days	Tue 10/9/07	Wed 10/31/07	
6	Temp. Power Energized	0 days	Mon 12/3/07	Mon 12/3/07	
13	Renovation of Existing Core	134 days	Mon 12/10/07	Thu 6/12/08	
19	Foundation Work	92 days	Thu 12/27/07	Fri 5/2/08	
21	Excavation of Mech. Room	24 days	Thu 12/27/07	Tue 1/29/08	
14	Cage Gym Renovation	125 days	Mon 2/11/08	Fri 8/1/08	
10	Erect Structure	67 days	Thu 4/17/08	Fri 7/18/08	
15	Linn Gym Renovation	62 days	Thu 5/1/08	Fri 7/25/08	
22	Start of New Construction	0 days	Fri 5/30/08	Fri 5/30/08	
18	Exterior Envelope	94 days	Wed 6/11/08	Mon 10/20/08	
9	Set Mech. Equipment	69 days	Fri 6/20/08	Wed 9/24/08	
26	Topping Out of Steel	0 days	Fri 7/18/08	Fri 7/18/08	
12	Test Mech. Eqpmnt and Startup	50 days	Thu 9/25/08	Wed 12/3/08	
7	Landscape Exterior	59 days	Wed 10/1/08	Mon 12/22/08	
25	Building Water Tight	0 days	Mon 10/20/08	Mon 10/20/08	
17	Interior Finishes	82 days	Thu 12/4/08	Fri 3/27/09	
16	Substantial Completion	0 days	Fri 3/27/09	Fri 3/27/09	
23	Punch List and Closeout	21 days	Mon 3/30/09	Sun 4/26/09	
24	Final Completion	0 days	Mon 4/27/09	Mon 4/27/09	

Project: TECH 1 schedule
Date: Sat 9/27/08

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

Appendix B – Asbestos Results Tables

Appendix B

Asbestos Sample Results
George Mason University – Physical Education Building

#	Material	Location	Asbestos %	Type	Friable
1	2'x2' ceiling tile	#204	NAD	NA	NA
2	2'x2' ceiling tile	L2 hall	NAD	NA	NA
3	***HVAC mastic, white***	***L2 hall***	*7*	*chrysotile*	*Cat. II, non-friable*
4	***HVAC mastic, white***	***#204***	*5*	*chrysotile*	*Cat. II, non-friable*
5	base cove mastic	L2 hall	NAD	NA	NA
6	base cove mastic	#204	NAD	NA	NA
7	***12" floor tile, tan#204***	*3*	*chrysotile*	*Cat. I non-friable*	
	carpet mastic, yellow		NAD	NA	NA
	floor tile mastic, black		*10*	*chrysotile*	*Cat I. non-friable*
8	***12" floor tile, tan L2 hall***	*3*	*chrysotile*	*Cat. I non-friable*	
	carpet mastic, yellow		NAD	NA	NA
	floor tile mastic, black		*7*	*chrysotile*	*Cat I. non-friable*
9	joint compound	#204	NAD	NA	NA
	drywall		NAD	NA	NA
10	joint compound	#204	NAD	NA	NA
	drywall		NAD	NA	NA
11	asphalt roof roll	entry roof	NAD	NA	NA
	flashing		NAD	NA	NA
	fiber board		NAD	NA	NA
12	asphalt roof roll	entry roof	NAD	NA	NA
	flashing		NAD	NA	NA
	fiber board		NAD	NA	NA
13	asphalt roof roll	entry roof	NAD	NA	NA
	flashing		NAD	NA	NA
	fiber board		NAD	NA	NA
14	flashing tar, remnant	entry roof	NAD	NA	NA
15	flashing tar, remnant	entry roof	NAD	NA	NA
16	built-up tar	entry roof	NAD	NA	NA
17	built-up tar	entry roof	NAD	NA	NA
18	***pipe hanger insulation***	*L1 entry lobby*	*15/30*	*chrysotile/amosite*	*friable TSI*
19	***pipe hanger insulation***	*L1 entry lobby*	*15/35*	*chrysotile/amosite*	*friable TSI*
20	***spray-on insulation***	*L1 entry lobby*	*10*	*chrysotile*	*friable SM*
21	***spray-on insulation***	*L1 entry lobby*	*15*	*chrysotile*	*friable SM*

Locations & Estimated Quantities – RACM / PACM
George Mason University – Physical Education Building

Material	Location	Estimated Quantity
Boiler/tank insulation	Mech. Rm. 111	~800 square feet
Breech/stack insulation	Mech. Rm. 111	~750 square feet
Pipe insulation	4 - 6" OD, Mech. Rm. 111	~600 linear feet
Pipe insulation	4" OD, Mech. Rm. 217A	~75 linear feet
Pipe insulation	4" HWS / HWS-R L1 & L2	~3,200 linear feet
Pipe hanger insulation	1.5" HWS / HWS-R L1 & L2	~140 linear feet on ~800 lin. ft. of pipe
Spray-on beam insulation	structural steel (common)	~6,000 square feet
Ceiling plaster finish coat	front (East) stairwell and L2 hall	~360 square feet
12" floor tile & black mastic	L1 & L2 (common)	~12,400 square feet
HVAC insulation mastic	L1 & L2 (common)	~1,200 square feet on ~2,000 lf.of duct
Caulk compound	exterior door and window units	~10 linear feet
Fire doors	L1 & L2 (common)	~22 units
Metal-clad door panels	L1	~4 units (~120 square feet)

Appendix C – D4 & RS Means Data

Appendix C – D4 Report

Estimate of Probable Cost

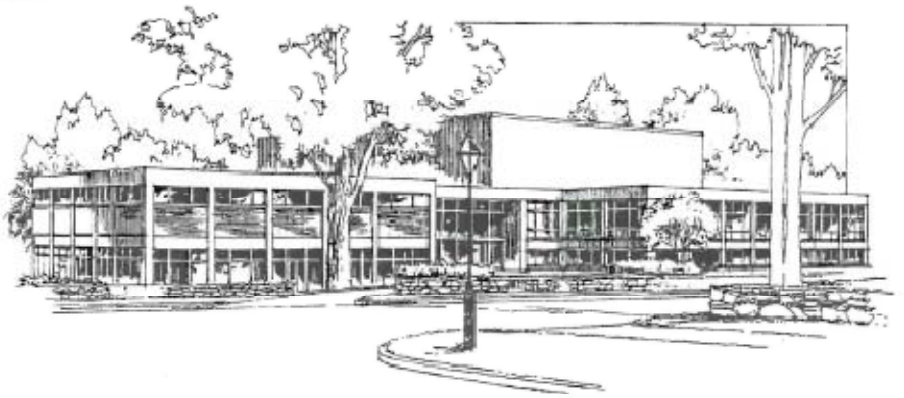
gmu comparison - Oct 2007 - VA - Other

Prepared By:		Prepared For:	
	Fax:		Fax:
Building Sq. Size:	116166	Site Sq. Size:	573588
Bid Date:		Building use:	
No. of floors:	2	Foundation:	
No. of buildings:		Exterior Walls:	
Project Height:		Interior Walls:	
1st Floor Height:		Roof Type:	
1st Floor Size:		Floor Type:	
		Project Type:	

Division		Percent	Sq. Cost	Amount
00	**Bidding Requirements**	**0.85**	**1.51**	**175,209**
	Bidding Requirements	0.85	1.51	175,209
01	**General Requirements**	**4.16**	**7.39**	**859,039**
	General Requirements	4.16	7.39	859,039
02	**Site Work**	**5.20**	**9.24**	**1,073,220**
	Site Work	5.20	9.24	1,073,220
03	**Concrete**	**12.09**	**21.50**	**2,497,446**
	Concrete	12.09	21.50	2,497,446
04	**Masonry**	**11.01**	**19.58**	**2,274,668**
	Masonry	11.01	19.58	2,274,668
05	**Metals**	**12.79**	**22.75**	**2,643,107**
	Metals	12.79	22.75	2,643,107
06	**Wood & Plastics**	**0.78**	**1.39**	**161,162**
	Wood & Plastics	0.78	1.39	161,162
07	**Thermal & Moisture Protection**	**7.34**	**13.05**	**1,515,456**
	Thermal & Moisture Protection	7.34	13.05	1,515,456
08	**Doors & Windows**	**2.93**	**5.20**	**604,621**
	Doors & Windows	2.93	5.20	604,621
09	**Finishes**	**7.36**	**13.09**	**1,520,987**
	Finishes	7.36	13.09	1,520,987
10	**Specialties**	**0.70**	**1.25**	**145,328**
	Specialties	0.70	1.25	145,328
11	**Equipment**	**1.00**	**1.79**	**207,412**
	Equipment	1.00	1.79	207,412
12	**Furnishings**	**0.13**	**0.24**	**27,709**
	Furnishings	0.13	0.24	27,709
13	**Special Construction**	**7.54**	**13.40**	**1,556,643**
	Special Construction	7.54	13.40	1,556,643
14	**Conveying Systems**	**0.39**	**0.70**	**81,437**
	Conveying Systems	0.39	0.70	81,437
15	**Mechanical**	**17.76**	**31.58**	**3,668,000**
	Mechanical	17.76	31.58	3,668,000
16	**Electrical**	**7.97**	**14.18**	**1,646,755**
	Electrical	7.97	14.18	1,646,755
Total Building Costs		**100.00**	**177.83**	**20,658,201**

Appendix C – RS Means Data Sheets

COMMERCIAL/INDUSTRIAL/INSTITUTIONAL | **M.160** | **College, Student Union**



Costs per square foot of floor area

Exterior Wall	S.F. Area	15000	20000	25000	30000	35000	40000	45000	50000	550
	L.F. Perimeter	354	425	457	513	568	583	629	644	68
Brick Face with Concrete Block Back-up	Steel Frame	161.00	156.10	151.20	148.95	147.25	144.75	143.70	142.05	141.
	R/Conc. Frame	152.55	147.65	142.75	140.40	138.80	136.30	135.20	133.55	132.
Precast Concrete Panel	Steel Frame	162.55	157.60	152.45	150.15	148.50	145.80	144.70	142.95	142.
	R/Conc. Frame	154.45	149.35	144.25	141.85	140.15	137.55	136.35	134.60	133.
Limestone Face Concrete Block Back-up	Steel Frame	177.65	171.15	164.15	160.95	158.70	155.05	153.60	151.10	150.
	R/Conc. Frame	169.20	162.70	155.60	152.55	150.25	146.60	145.10	142.60	141.
Perimeter Adj., Add or Deduct	Per 100 L.F.	8.40	6.30	5.05	4.15	3.65	3.15	2.75	2.45	2.
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	2.10	1.90	1.65	1.45	1.50	1.35	1.25	1.10	1.

For Basement, add $32.20 per square foot of basement area

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $113.80 to $232.20 per S.F.

Common additives

Description	Unit	$ Cost
Carrels Hardwood	Each	655 - 1200
Elevators, Hydraulic passenger, 2 stops		
2000# capacity	Each	56,400
2500# capacity	Each	57,800
3500# capacity	Each	62,100
Emergency Lighting, 25 watt, battery operated		
Lead battery	Each	278
Nickel cadmium	Each	800
Escalators, Metal		
32" wide, 10' story height	Each	115,900
20' story height	Each	136,000
48" wide, 10' Story height	Each	121,900
20' story height	Each	141,500
Glass		
32" wide, 10' story height	Each	113,900
20' story height	Each	136,000
48" wide, 10' story height	Each	121,900
20' story height	Each	141,500

Description	Unit	$ Co
Lockers, Steel, Single tier, 60" or 72"	Opening	165 - 2
2 tier, 60" or 72" total	Opening	104 - 1
5 tier, box lockers	Opening	58 - 7
Locker bench, lam. maple top only	L.F.	20.5
Pedestals, steel pipe	Each	62
Sound System		
Amplifier, 250 watts	Each	222
Speaker, ceiling or wall	Each	18
Trumpet	Each	34

Costs per square foot of floor area

Exterior Wall	S.F. Area	12000	16000	20000	25000	30000	35000	40000	45000	50
	L.F. Perimeter	440	520	600	700	708	780	841	910	9
Reinforced Concrete Block	Lam. Wood Arches	145.70	139.40	135.60	132.60	128.25	126.55	125.10	124.00	12
	Rigid Steel Frame	146.45	140.10	136.35	133.25	129.00	127.30	125.80	124.75	12
Face Brick with Concrete Block Backup	Lam. Wood Arches	170.70	161.50	156.00	151.65	144.35	141.75	139.40	137.80	13
	Rigid Steel Frame	171.40	162.25	156.75	152.35	145.05	142.45	140.15	138.55	13
Metal Sandwich Panels	Lam. Wood Arches	141.35	135.55	132.05	129.20	125.45	123.90	122.60	121.60	12
	Rigid Steel Frame	142.05	136.20	132.75	129.95	126.20	124.65	123.30	122.35	12
Perimeter Adj., Add or Deduct	Per 100 L.F.	6.15	4.60	3.70	2.90	2.45	2.10	1.80	1.70	1
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	0.90	0.80	0.70	0.60	0.60	0.55	0.50	0.50	C
Basement—Not Applicable										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $67.20 to $200.75 per S.F.

Common additives

Description	Unit	$ Cost
Bleachers, Telescoping, manual		
To 15 tier	Seat	111 - 154
16-20 tier	Seat	227 - 279
21-30 tier	Seat	242 - 292
For power operation, add	Seat	44 - 69.50
Gym Divider Curtain, Mesh top		
Manual rollup	S.F.	11.55
Gym Mats		
2" naugahyde covered	S.F.	3.95
2" nylon	S.F.	6.85
1-1/2" wall pads	S.F.	9
1" wrestling mats	S.F.	6.05
Scoreboard		
Basketball, one side	Each	3100 - 10,900
Basketball Backstop		
Wall mtd., 6' extended, fixed	Each	2050 - 2625
Swing up, wall mtd.	Each	2275 - 6550

Description	Unit	$ C
Lockers, Steel, single tier, 60" or 72"	Opening	165
2 tier, 60" or 72" total	Opening	104
5 tier, box lockers	Opening	58
Locker bench, lam. maple top only	L.F.	20
Pedestals, steel pipe	Each	6
Sound System		
Amplifier, 250 watts	Each	2
Speaker, ceiling or wall	Each	1
Trumpet	Each	3
Emergency Lighting, 25 watt, battery operated		
Lead battery	Each	2
Nickel cadmium	Each	8

Costs per square foot of floor area

Exterior Wall	S.F. Area	15000	20000	28000	38000	50000	65000	85000	100000	150000
	L.F. Perimeter	350	400	480	550	630	660	750	825	1035
Face Brick with Concrete Block Back-up	Steel Frame	199.20	187.60	177.55	170.00	164.75	159.65	156.30	154.85	151.65
	Bearing Walls	198.70	185.95	175.00	166.55	160.70	154.80	151.05	149.35	145.70
Decorative Concrete Block	Steel Frame	191.70	181.15	172.05	165.35	160.75	156.35	153.55	152.20	149.45
	Bearing Walls	191.20	179.55	169.50	161.85	156.65	151.50	148.20	146.70	143.50
Stucco on Concrete Block	Steel Frame	188.50	178.10	169.05	162.45	157.95	153.70	150.85	149.55	146.85
	Bearing Walls	190.35	178.85	168.90	161.35	156.25	151.20	147.90	146.40	143.30
Perimeter Adj., Add or Deduct	Per 100 L.F.	8.30	6.25	4.45	3.20	2.55	1.90	1.50	1.25	0.85
Story Hgt. Adj., Add or Deduct	Per 1 Ft.	2.05	1.70	1.50	1.20	1.10	0.90	0.85	0.75	0.65
For Basement, add $30.85 per square foot of basement area										

The above costs were calculated using the basic specifications shown on the facing page. These costs should be adjusted where necessary for design alternatives and owner's requirements. Reported completed project costs, for this type of structure, range from $105.05 to $246.90 per S.F.

Common additives

Description	Unit	$ Cost
Carrels Hardwood	Each	655 - 1200
Clock System		
20 Room	Each	15,400
50 Room	Each	37,400
Elevators, Hydraulic passenger, 2 stops		
1500# capacity	Each	55,100
2500# capacity	Each	57,800
3500# capacity	Each	62,100
Additional stop, add	Each	9000
Emergency Lighting, 25 watt, battery operated		
Lead battery	Each	278
Nickel cadmium	Each	900
Flagpoles, Complete		
Aluminum, 20' high	Each	1425
40' High	Each	3200
70' High	Each	9975
Fiberglass, 23' High		1725
39'-5" High	Each	3250
59' High	Each	8200

Description	Unit	$ Cost
Lockers, Steel, single tier, 60" or 72"	Opening	165 - 298
2 tier, 60" or 72" total	Opening	104 - 137
5 tier, box lockers	Opening	58 - 79
Locker bench, lam. maple top only	L.F.	20.50
Pedestals, steel pipe	Each	62
Seating		
Auditorium chair, all veneer	Each	218
Veneer back, padded seat	Each	264
Upholstered, spring seat	Each	264
Classroom, movable chair & desk	Set	65 - 120
Lecture hall, pedestal type	Each	208 - 620
Smoke Detectors		
Ceiling type	Each	174
Duct type	Each	445
Sound System		
Amplifier, 250 watts	Each	2225
Speaker, ceiling or wall	Each	181
Trumpet	Each	345
TV Antenna, Master system, 12 outlet	Outlet	299
30 outlet	Outlet	192
100 outlet	Outlet	170

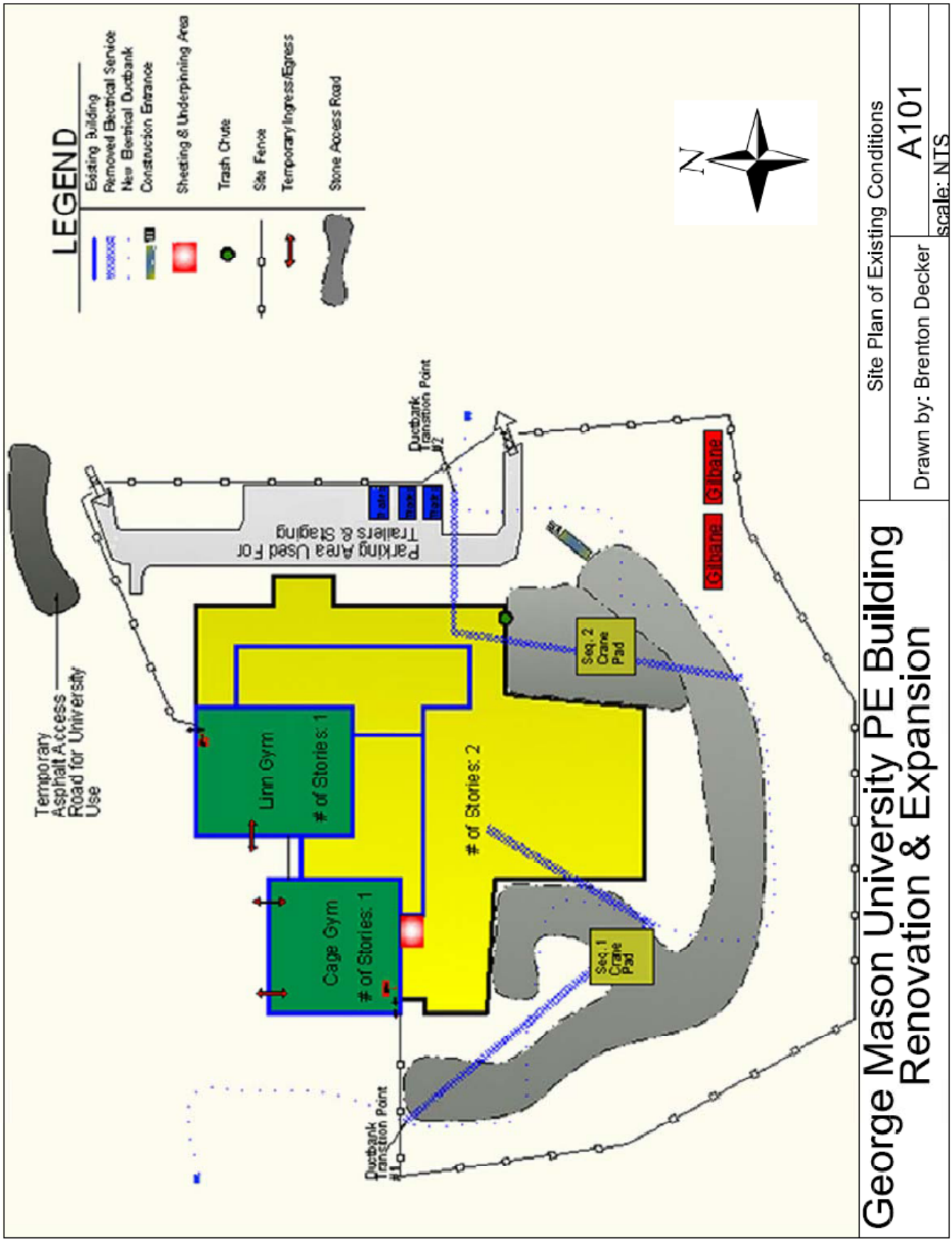
Location Factors

STATE/ZIP	CITY	Residential	Commercial
UTAH (CONT'd)			
845	Price	.71	.78
846-847	Provo	.81	.87
VERMONT			
050	White River Jct.	.76	.80
051	Bellows Falls	.79	.83
052	Bennington	.81	.84
053	Brattleboro	.81	.86
054	Burlington	.82	.85
056	Montpelier	.83	.85
057	Rutland	.82	.86
058	St. Johnsbury	.79	.81
059	Guildhall	.78	.80
VIRGINIA			
220-221	Fairfax	1.02	.92
222	Arlington	1.04	.92
223	Alexandria	1.07	.94
224-225	Fredericksburg	.94	.88
226	Winchester	.92	.86
227	Culpeper	1.00	.88
228	Harrisonburg	.90	.86
229	Charlottesville	.91	.86
230-232	Richmond	.99	.88
233-235	Norfolk	1.00	.87
236	Newport News	1.00	.87
237	Portsmouth	.92	.86
238	Petersburg	.98	.88
239	Farmville	.90	.82
240-241	Roanoke	.98	.86
242	Bristol	.85	.81
243	Pulaski	.84	.80
244	Staunton	.92	.84
245	Lynchburg	.97	.87
246	Grundy	.84	.80
WASHINGTON			
980-981,987	Seattle	1.02	1.04
982	Everett	1.05	1.02
983-984	Tacoma	1.01	1.03
985	Olympia	1.00	1.02
986	Vancouver	.99	1.02
988	Wenatchee	.94	.96
989	Yakima	.97	.98
990-992	Spokane	1.00	.96
993	Richland	.98	.97
994	Clarkston	.98	.96
WEST VIRGINIA			
247-248	Bluefield	.88	.89
249	Lewisburg	.89	.92
250-253	Charleston	.95	.95
254	Martinsburg	.86	.89
255-257	Huntington	.96	.96
258-259	Beckley	.90	.93
260	Wheeling	.93	.96
261	Parkersburg	.91	.95
262	Buckhannon	.92	.95
263-264	Clarksburg	.91	.95
265	Morgantown	.92	.95
266	Gassaway	.92	.96
267	Romney	.88	.92
268	Petersburg	.90	.93
WISCONSIN			
530,532	Milwaukee	1.08	1.03
531	Kenosha	1.05	1.01
534	Racine	1.04	1.01
535	Beloit	1.00	.99
537	Madison	1.00	.99
538	Lancaster	.98	.95
539	Portage	.98	.96
540	New Richmond	1.00	.96
541-543	Green Bay	1.01	.97
544	Wausau	.95	.94
545	Rhinelander	.96	.96
546	La Crosse	.95	.95
547	Eau Claire	.99	.97
548	Superior	.95	.97
549	Oshkosh	.96	.95
WYOMING			
820	Cheyenne	.83	.86
821	Yellowstone Nat. Pk.	.75	.81
822	Wheatland	.75	.82

STATE/ZIP	CITY	Residential	Commercial
WYOMING (CONT'd)			
823	Rawlins	.75	.83
824	Worland	.74	.81
825	Riverton	.74	.81
826	Casper	.77	.83
827	Newcastle	.74	.81
828	Sheridan	.80	.84
829-831	Rock Springs	.79	.83
CANADIAN FACTORS (reflect Canadian currency)			
ALBERTA			
	Calgary	1.13	1.12
	Edmonton	1.13	1.12
	Fort McMurray	1.16	1.14
	Lethbridge	1.13	1.10
	Lloydminster	1.08	1.06
	Medicine Hat	1.08	1.06
	Red Deer	1.08	1.06
BRITISH COLUMBIA			
	Kamloops	1.06	1.07
	Prince George	1.06	1.08
	Vancouver	1.07	1.09
	Victoria	1.01	1.03
MANITOBA			
	Brandon	1.03	1.00
	Portage la Prairie	1.03	1.00
	Winnipeg	1.03	1.02
NEW BRUNSWICK			
	Bathurst	.96	.95
	Dalhousie	.95	.95
	Fredericton	1.03	.98
	Moncton	.96	.96
	Newcastle	.96	.95
	St. John	1.03	.99
NEWFOUNDLAND			
	Corner Brook	.97	.98
	St Johns	.99	.99
NORTHWEST TERRITORIES			
	Yellowknife	1.08	1.07
NOVA SCOTIA			
	Bridgewater	.98	1.00
	Dartmouth	.99	1.00
	Halifax	1.01	1.03
	New Glasgow	.98	.99
	Sydney	.97	.98
	Truro	.98	.99
	Yarmouth	.98	.99
ONTARIO			
	Barrie	1.14	1.09
	Brantford	1.16	1.11
	Cornwall	1.16	1.09
	Hamilton	1.18	1.14
	Kingston	1.16	1.10
	Kitchener	1.11	1.07
	London	1.15	1.11
	North Bay	1.12	1.08
	Oshawa	1.15	1.10
	Ottawa	1.17	1.10
	Owen Sound	1.13	1.09
	Peterborough	1.13	1.09
	Sarnia	1.16	1.11
	Sault Ste Marie	1.09	1.06
	St. Catharines	1.11	1.06
	Sudbury	1.09	1.06
	Thunder Bay	1.14	1.06
	Timmins	1.12	1.08
	Toronto	1.19	1.14
	Windsor	1.13	1.06
PRINCE EDWARD ISLAND			
	Charlottetown	.93	.95
	Summerside	.93	.95
QUEBEC			
	Cap-de-la-Madeleine	1.15	1.05
	Charlesbourg	1.15	1.05
	Chicoutimi	1.18	1.07
	Gatineau	1.14	1.04

Appendix D – Site Plan

Appendix D


LEGEND
Existing Building
Removed Electrical Service
New Electrical Ductbank
Construction Entrance
Sheeting & Underpinning Area
Trash Chute
Site Fence
Temporary Ingress/Egress
Stone Access Road
N
Temporary Asphalt Access Road for University Use
Parking Area Used For Trailers & Staging
Ductbank Transition Point #2
Ductbank Transition Point #1
Linn Gym
# of Stories: 1
Cage Gym
# of Stories: 1
# of Stories: 2
Seq. 2 Crane Pad
Seq. 1 Crane Pad
Gilbane
Gilbane
George Mason University PE Building
Renovation & Expansion
Site Plan of Existing Conditions
A101
Drawn by: Brenton Decker
scale: NTS