and Fume Hoods System in Whitmore Laboratory

Technical Report II

AE 481W

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Table of Content

Executive Summary

This report is proposed to analyze the Casework and Fume Hoods System of Whitmore Laboratory. The analysis covers mainly three topics; schedule, cost, and site logistics.

Labor loaded detailed scheduled is developed using Primavera Professional R8.3. The schedule is broken down to two main subcategories: Preconstruction and Construction, where Construction is broken down to Phase I and Phase II. The actual work on the lab casework and fume hoods start on September 1st, 2015 and ends on June 28th, 2016. Counting the calendar days between the start and finish dates and excluding the idle period between the two phases, a total of 286 calendar days are spent designing and installing the system.

Utilizing Sage 300 Timberline with assistance from RSMeans Commercial Renovation 2014 and RSMeans Construction Cost Data 2015, the cost we estimated. As a result, the total cost of lab casework and fume hoods system is **$2,149,580**. That is 3.4% higher than the actual cost which is **$2,079,000**. The lab casework and fume hoods system is 8.5% of the total project cost.

In order to create a clear illustration of the site logistics, a special logistics plan is developed for this phase. The plan includes: the existing conditions, traffic and pedestrian flow, heavy equipment locations and staging area.

Production Plan

System Construction Means and Methods

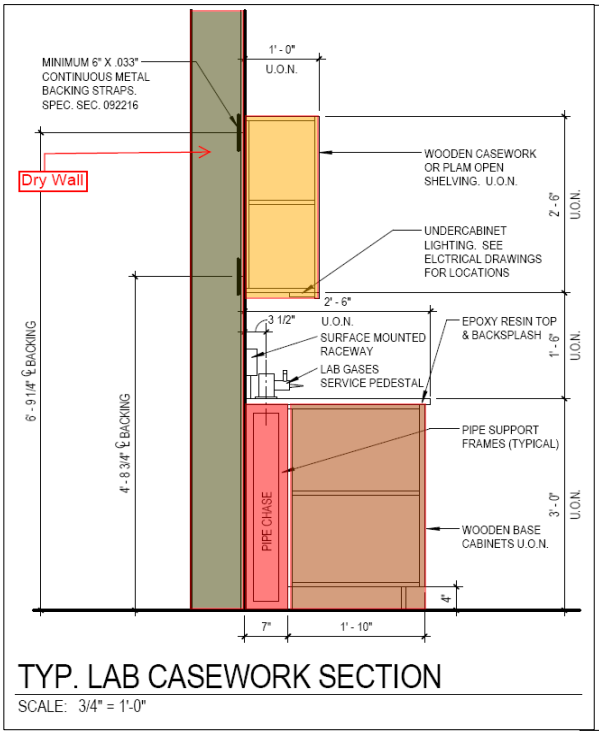


Figure 2- Casework details

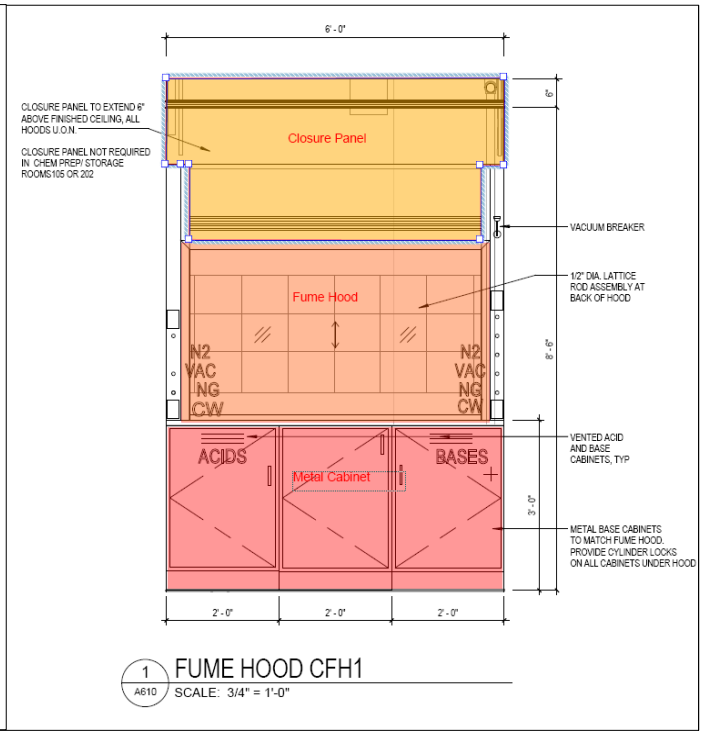


Figure 1- Fume Hood Details

There are 11 laboratories in the first floor, two in the second floor and two on the third floor. The lab on the second floor is the largest and occupies approximately half of the floor area. Total fume hoods to be installed is 116 fume hoods; 92 of them are in the second floor. As illustrated figure 1 and figure 2, casework and fume hood system includes:

- Fume hoods with their service fixtures (water, gas, etc.)
- Fume hood base support
- Fume hood metal enclosure 6" above ceiling
- Work surfaces, sinks, and cup sinks in fume hoods
- Inset Steel Lab Casework
- Table frame, work surface, metal cabinet doors (metal and glazed)
- Accessory equipment and keying requirement
- Wood Lab Casework
- Light fixtures associated with the casework and fume hoods
- Peg board, coat hook strips, casters

Fume hoods base stands must withstand the load of the fume hood, work top and 75-lb/ft. The hoods must comply with the following specifications:

1. Average Face Velocity 100 fpm
2. Face-Velocity Variation: not more than 20% of average
3. Sash position: Fully opened
4. As-Manufactured rating: 0.05 ppm
5. As-Installed rating: 0.10 ppm
6. Static Pressure Loss: not more than 62 Pa

Regarding the casework, there will be steel casework and wood casework as specified in the drawings. The components and accessories are specified as following:

1. Steel Sheet: cold-rolled, commercial steel sheet, galvanized steel 18 and 20 gauge.
2. Glass-Fiber-reinforced Polyester coat on the exposed face, flame-spread index of 25 or less.
3. Epoxy: Factory molded, modified epoxy-resin formulation with smooth non-specular finish.
4. Glazing Materials: Clear, laminated safety tempered, Condition A, Type I, Class I, Quality-Q3; with two lites not less than 3.0 mm thick.
5. Ceiling closure panels: Minimum 18 gauge; finish matching hood exterior.
6. Hood rear exterior finish panel with finish matching hood exterior.
7. Sash Elements: Average tensile strength of 2,400 pounds; maximum working load of 480 pounds.
8. Sash pull: Corrosion resistant steel with chemical resistant powder coating. Maximum 1.5" thick.

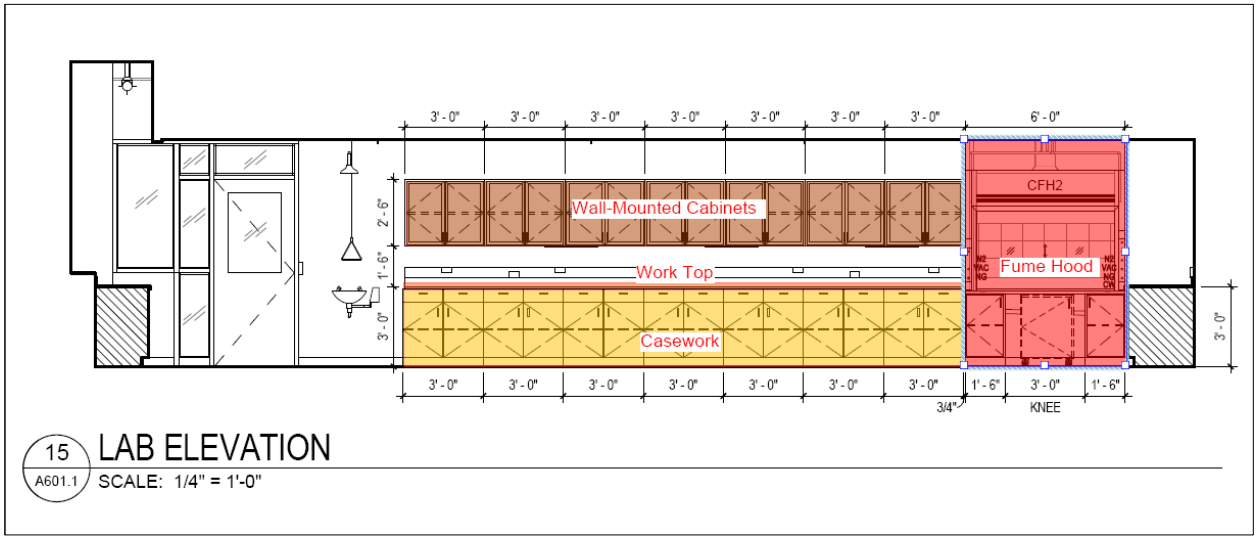


Figure 4- Lab Elevation

Before installing the casework or fume hoods, coordination must be established with the mechanical, electrical and plumbing subcontractors. Casework and fume hood subcontractor is responsible for providing ducts, wires and pipes until the point where these services connect to the building main services. Pipe unistruts are installed before screwing the racks of the casework on the

Figure 3- Pipe Unistrut installed

floor (shown in figure 3). The imaginary red box represents the space where the casework will be.

Fume hoods will be assembled in the factory to the greatest possible extents but not greater than 35" x 79" to fit into a door opening. All accessories associated with the fume hood are pre-mounted in factory. Other services such as: wiring, plumbing and in-fume ducting are completed in the shop prior to delivery. All fume hoods are fed by a #12 AWG 3-wire, 20-amp, 120V and connected to junction box in the plenum just to the right of each fume hood.

The racks of the casework provide the structural support to the casework. First, the aluminum racks are screwed to the floor and then cabinets and drawers are fitted in and secured in place. Next, the counter tops are placed and screwed from below to be attached to the racks. After that, the sinks are installed and supported by a hanging aluminum channel (figure xx). When all the parts of the casework are fixed, the services (power, plumbing and ducting) are connected to the building services. Besides, wall mounted cabinets are above the countertop and to the defined height. Finally, Epoxy is applied to the specified areas and left to dry.

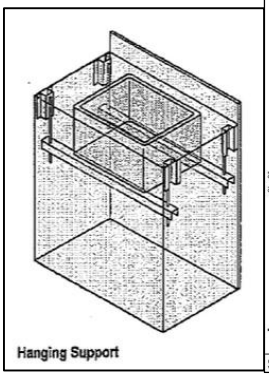


Figure 5- Aluminum Channel supporting the Sink

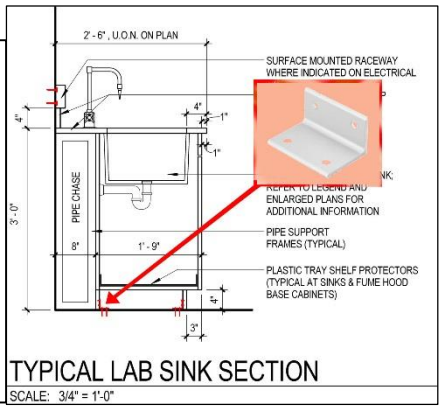


Figure 6- Aluminum Angle Fixing the Rack

In order to complete the process described above, resources and equipment must be input to the process. The following resources are needed:

- Fume Hoods
- Casework Racks
- Counter tops
- Cabinets and drawers
- Wall-mounted drawers
- Emergency equipment (safety equipment, eye wash, hand held)
- Epoxy
- Commercial Dishwasher
- Fasteners

Materials are delivered to site and hoisted to the designated floor by a telescopic forklift. Once the materials are on the floor, they are moved around using a forklift for heavy loads and pallet jack for lighter loads. To install the lab casework, saw-hammer drill, screw and gun-laser for leveling. Diamond blade saw is used to cut and fit for Epoxy. Hydraulic lift is used for the fume hoods. Later on, brushes and paint roller are used to apply the epoxy on the surfaces.

Figure 7- Equipment Used in This Task

Production Schedule

While developing the schedule, the official not-working days of State of Pennsylvania are taking into consideration. That includes the Thanksgiving, Christmas, Independence Day, and the New Year holidays. Materials quantities were taken off from the shop drawings and the architectural drawings. Based on an 8hr/day work, a detailed schedule was produced using Microsoft Excel and then exported to Primavera P6 R8.3. The total calendar days for phase I and phase II for the lab casework and fume hood is 286. The table below summaries the important results of the detailed schedule. The full detailed schedule with a Gant chart is attached in the appendices.

Table 1- summary Schedule

Description	*Quantity (days)*
Total working days	207
Preconstruction	104
Construction Phase I	50
Construction Phase II	53

The two figures below show how the crews are distributed throughout the project life span. The top graph is for phase one and the bottom graph for phase two. It is worth mentioning that each all crew has perform work during the entire project. However each crew has a period of time where it has the dominant work in the area. At the final part of the project, the testing crew is taking over to conduct ASHRE tests.

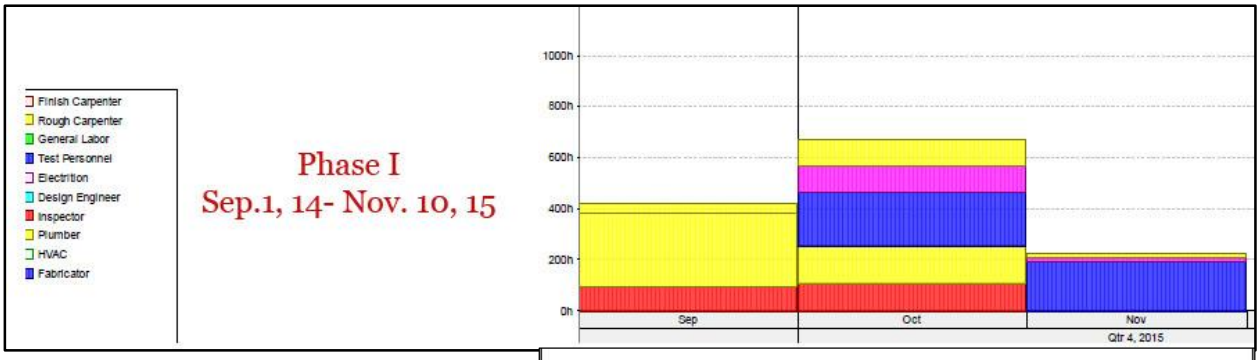


Figure 8- S Curve Phase I

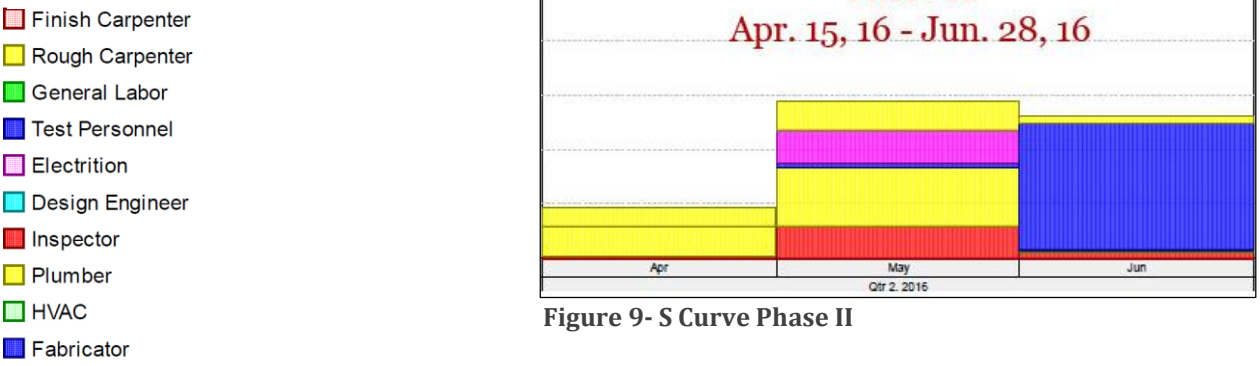


Figure 9- S Curve Phase II

Detailed Cost

The cost of the lab casework and fume hoods system is calculated using Sage 300 Timberline. Due to the fact that Timberline database does not include data for neither casework nor fume hoods, RSMeans Commercial Renovation 2014 and RSMeans Construction Cost Data 2015 were consulted to obtain the necessary unit cost. The total cost of material, labor and equipment were summed up and then added to Timberline database. Materials quantities were taken off from the shop drawings and the architecture drawings. 10% CM fee is added to the final cost. As a result, the total cost of lab casework and fume hoods system is $2,364,513. The two tables below shows the break-down of the cost and the calculation of the total cost.

Group	Phase	Description	Takeoff Quantity	Labor Cost/Unit	Material Price	Material Amount	Other Amount	Total Cost/Unit	Total Amount
15950.00		TEST-ADJUST-BALANCE							
	FumeHood.	Fume Hood							
		Advanced FumeHo	701.60 lf	-	1,120.00 /lf	785,792	-	1,120.00 /lf	785,792
	Dishwashe	Commercial Dish Washer							
		3 HP commercial dishwasher	1.00 C	-	3,150.00 /C	3,150	-	3,150.00 /C	3,150
	Emergency	Metal Counter top							
		Emergency equipment	17.00 C	-	190.00 /C	3,230	-	190.00 /C	3,230
	LabCasew	Lab Metal Casework							
		Metal Caseework With doors, drawers an	824.00 lf	-	450.00 /lf	370,800	-	450.00 /lf	370,800
	WallCabint	Wall Mounted cabinets 6'							
		wall mounted cabintes each 6' long	54.25 lf	-	15,300.00 /lf	830,025	-	15,300.00 /lf	830,025
	MetalCount	Metal Counter top							
		Metal Counter top	824.00 lf	-	190.00 /lf	156,560	-	190.00 /lf	156,560

Description	Amount	Totals	Hours	Rate	Allocatable	Cost Basis	Cost per Unit	Percent of Total	
Equipment									
Other									
Profit & Overh	214,956			10.000 %		Total		9.09%	
	2,364,513	2,364,513						100.00	100.00%
Total		*2,364,513*							

Figure 10- Detailed Cost Break Down

Site Plans and Logistics

The project is done in two phases because part of the building must be operating while the other part is under construction. For this particular system, a telescopic forklift is placed at some point on the perimeter of the building to hoist the materials to the second floor. Another electrical forklift is placed inside. Traffic comes from the south side and after unloading it moves out through east outlet passing the parking lot. There is no closing of the normal-everyday traffic or pedestrian pathways.

The work starts from top down. It starts from the third floor north and moving south and then to the lower floor. The gradient colors in the graph and the numbers indicate where the work starts and ends. Darker area mean the starting point and moving toward the faded area. There is an exception to the workflow where the basement needs to be completed first because it houses the mechanical room and two electrical rooms. The same flow applies for phase I and phase II.

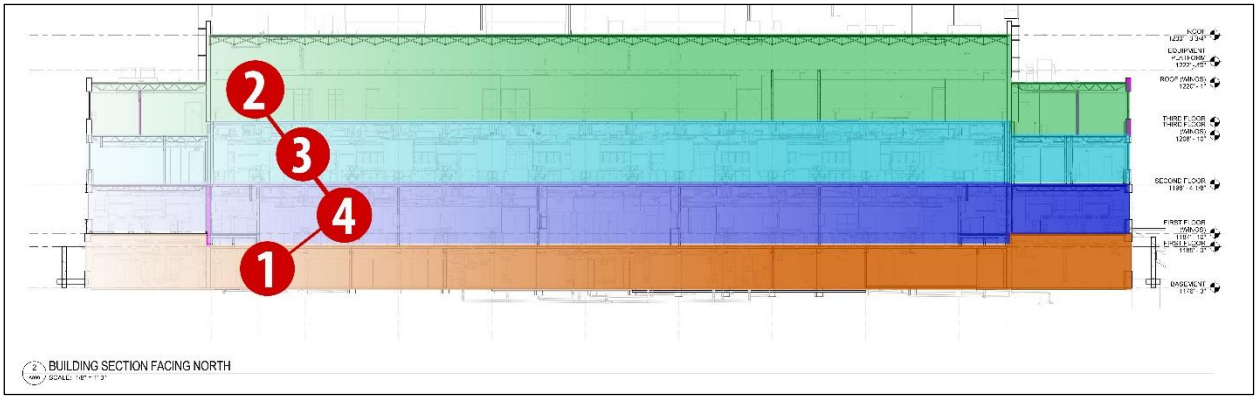


Figure 11- Workflow

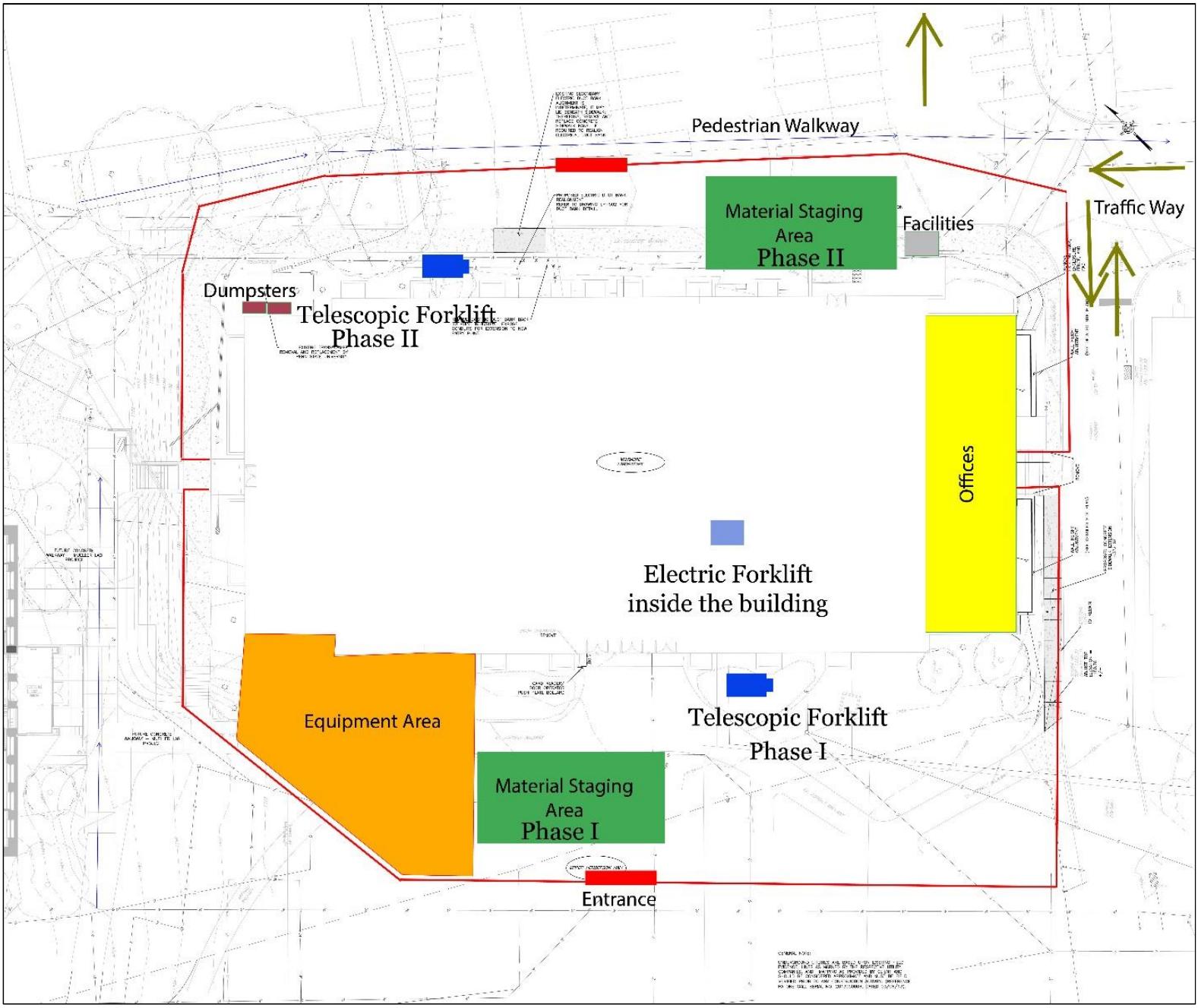


Figure 12- Site Logistics Plan

Production Analysis

Production analysis

To better understand the construction constraints for the lab casework and fume hoods system, the main concerns should be explained. First, laboratories are ducted intensively. That being said, the tasks that involve dust and flying particles should be completed before ducting to avoid dirt from settling in the ducts. Therefore, floors are finished prior to installing ducts or fume hoods and the finishing is a layer of Epoxy. While using heavy equipment in the lab, the floor must be protected with corrugated cardboard all the time and the installation should be done carefully to avoid destroying the floor. Secondly, there is zero tolerance in any type of leakage in liquids or gases. Due to the hazardous liquids and gases in the lab, plumbing and ducting must be done with extra care.

There are five main crews involved in this job: fume hood installation, case work installation, ducting, plumbing, and wiring. However each crew work depends on the previous crew work. For example, fume hood is install first then duct is placed. The proposed schedule allows overlapping where crews can start work as soon as the previous crew leaves the area and the process repeats its self for 116 fume hoods. As an advantage, all the involved crews are from the same company (Northeast Mechanical) which leads to easier communication and coordination. In short, the schedule is efficient and effective. RSMeans specifies 32 labor-hour to install one fume hood while in this project it takes only 14.5 labor hours. Labor hour is calculated as the following:

$$\frac{35\ days\ \times 8\ hrs \times 6\ laborers}{116\ fume\ hoods} = 14.5\ labor - hours$$

Cost analysis

As an issue raised up while conduction the estimate, Timberline database does not include neither assemblies nor items for fume hoods or case work. To solve the problem, RSMeans was advised to find material, labor, and equipment costs. Then, theses item costs were plugged into Timberline and total cost was calculated. The detailed estimate for the lab casework and fume hoods system sums up to $2,149,580 which is 3.5% higher than the actual cost ($2,079,000). The difference is potentially because of the type of the lab casework chosen from the RSMeans that is listed as the maximum quality casework. Not to mention, the actual cost may go up due to the lagging in the schedule and the need of working overtime. However the estimate falls within the accuracy range of the detailed estimate- 5%.

Comparing the estimate with the square foot estimate, they are very close where the square foot estimates suggests a cost of $24.29/SQFT. That unit price adds up to $2,283,595 for the lab casework and fume hoods. The square foot estimate is 6.2% higher than the detailed estimate which is in the reasonable range.

Logistical analysis

The site fence surrounds a large area around the building. It is true that the site was utilized efficiently in the first stages of the project when there are a lot of heavy equipment and demolished materials. As the project proceeds forward, that big area becomes unnecessary since there will be no scaffolding or excavator in site. Therefore, that area can be excluded from the site but that will not be a wise option for many reasons. First, since the University provided that piece of land to the construction team why would they hand it back? Secondly, that piece of land needs landscape improvement and it is

not efficient to have the landscape subcontractor come and work on separate areas and separate periods.

The delivery time is coordinated to be on the day of installation so they do not need to store the materials in site. As soon as the deliverables arrives, they are moved to the designated room to be installed.

Field Superintendent Interview

Schedule Acceleration Scenarios

The installation of the fume hoods falls in the critical path and it is necessary for the ASHRE testing and inspection. However, the biggest concern in this system is that it might cause unbalance in the supply air and exhaust air. Fume hoods exhaust a tremendous amount of air leading to the formation of pressure unbalance and turbulence. To ensure that does not happen in a dramatic way, the system will be completed two months before the completion date leaving enough time for testing and adjusting if necessary.

Constructability and Logistical Challenges

One of the challenges the team faces is working in a room that has the mechanical ducts fitted and the floor is finished. The issue arises when using heavy equipment like fork lift and hydraulic lift in the room which may destroy the floor. The second aspect is that it is not acceptable to do tasks that result in a lot of dust. For the first problem, the team covered the entire floor with corrugated cardboard to protect the floor and they will tear it down before installing the fume hoods or the lab casework. A solution for the second problem is to do the cutting outside and also keep the ducts aperture covered with plastic sheet.

Figure 13- Construction issues

Appendix I- Interview Questions

Q1: What are the key areas that can accelerate the installation process?
A1: 1-we installed as it was delivered

Q2: Regarding the answer for the question above, what resources needed to perform these activities?
A2: N/A

Q3: Doing the casework and the fume hood, what is the biggest risk to the project completion date?
A3: N/A

Q4: How did the team overcome these challenges?
A4: N/A

Q5: If you will have the same job in the future, will you change the methods and how?
A5: N/A

Q6: Where are the materials stored in site? And how long are the delivered before installation?
A6: N/A

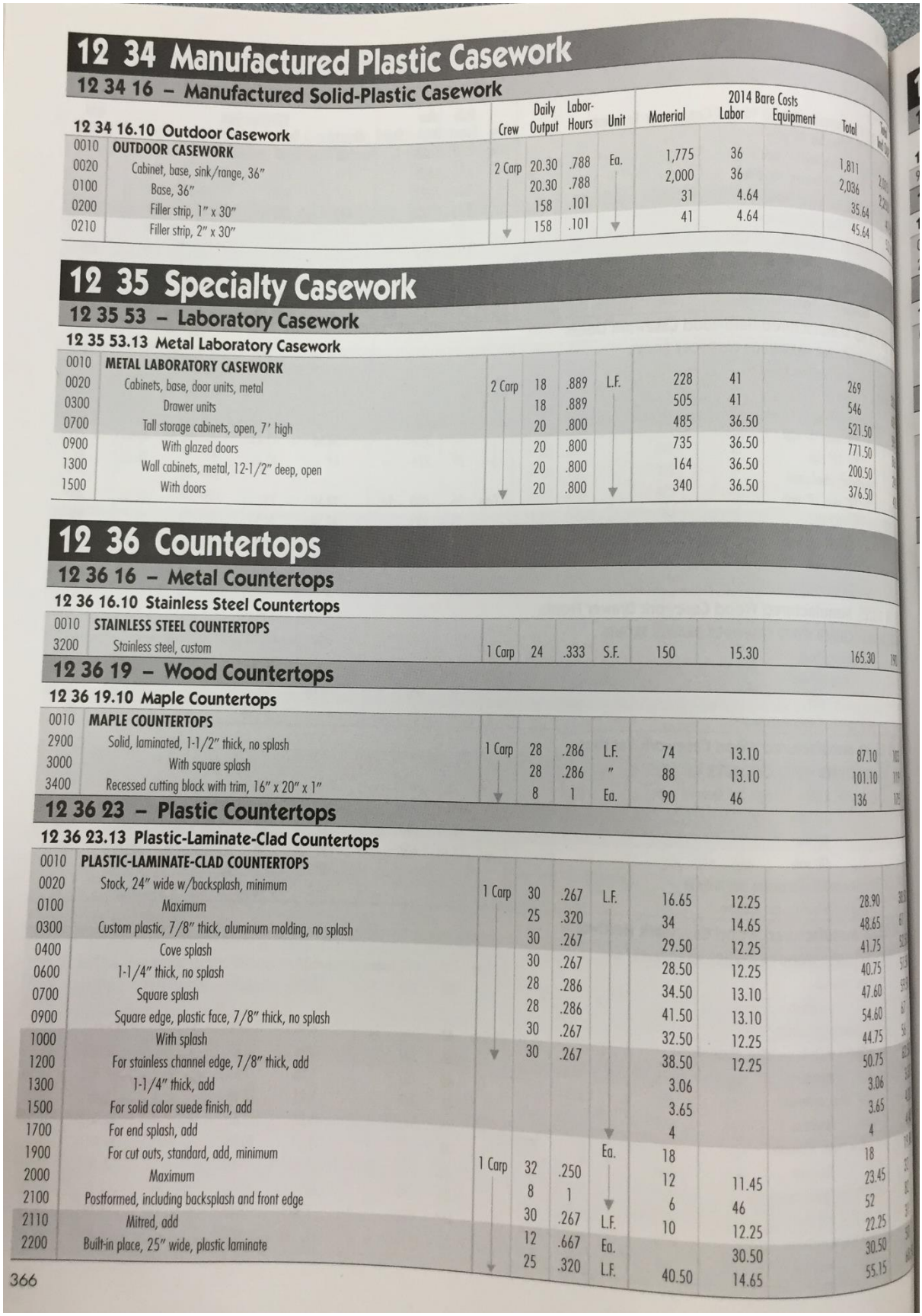
Q7: How big is the lab casework crew?
A7: six

Q8: How big is fume hood crew?
A8: four

Q9: what are the equipment needed to move and install the lab casework and the fume hoods?
A9: we used fork lift and pallet jack for the unload. To install casework table saw-hammer drill -screw gun-laze for leveling diamond blade saw to cut and fit epoxy for fume hood install hydraulic lifts.

Q10: Where did the workflow start and what is its direction?
A10: we started at the north end and worked to the south.

Appendix II- RSMeans Sample Page



12 34 Manufactured Plastic Casework

12 34 16 – Manufactured Solid-Plastic Casework

12 34 16.10 Outdoor Casework	Crew	Daily Output	Labor-Hours	Unit	2014 Bare Costs Material	Labor	Equipment	Total
0010 OUTDOOR CASEWORK								
0020 Cabinet, base, sink/range, 36"	2 Carp	20.30	.788	Ea.	1,775	36		1,811
0100 Base, 36"		20.30	.788		2,000	36		2,036
0200 Filler strip, 1" x 30"		158	.101		31	4.64		35.64
0210 Filler strip, 2" x 30"		158	.101		41	4.64		45.64

12 35 Specialty Casework

12 35 53 – Laboratory Casework

12 35 53.13 Metal Laboratory Casework								
0010 METAL LABORATORY CASEWORK								
0020 Cabinets, base, door units, metal	2 Carp	18	.889	L.F.	228	41		269
0300 Drawer units		18	.889		505	41		546
0700 Tall storage cabinets, open, 7' high		20	.800		485	36.50		521.50
0900 With glazed doors		20	.800		735	36.50		771.50
1300 Wall cabinets, metal, 12-1/2" deep, open		20	.800		164	36.50		200.50
1500 With doors		20	.800		340	36.50		376.50

12 36 Countertops

12 36 16 – Metal Countertops

12 36 16.10 Stainless Steel Countertops								
0010 STAINLESS STEEL COUNTERTOPS								
3200 Stainless steel, custom	1 Carp	24	.333	S.F.	150	15.30		165.30

12 36 19 – Wood Countertops

12 36 19.10 Maple Countertops								
0010 MAPLE COUNTERTOPS								
2900 Solid, laminated, 1-1/2" thick, no splash	1 Carp	28	.286	L.F.	74	13.10		87.10
3000 With square splash		28	.286	"	88	13.10		101.10
3400 Recessed cutting block with trim, 16" x 20" x 1"		8	1	Ea.	90	46		136

12 36 23 – Plastic Countertops

12 36 23.13 Plastic-Laminate-Clad Countertops								
0010 PLASTIC-LAMINATE-CLAD COUNTERTOPS								
0020 Stock, 24" wide w/backsplash, minimum	1 Carp	30	.267	L.F.	16.65	12.25		28.90
0100 Maximum		25	.320		34	14.65		48.65
0300 Custom plastic, 7/8" thick, aluminum molding, no splash		30	.267		29.50	12.25		41.75
0400 Cove splash		30	.267		28.50	12.25		40.75
0600 1-1/4" thick, no splash		28	.286		34.50	13.10		47.60
0700 Square splash		28	.286		41.50	13.10		54.60
0900 Square edge, plastic face, 7/8" thick, no splash		30	.267		32.50	12.25		44.75
1000 With splash		30	.267		38.50	12.25		50.75
1200 For stainless channel edge, 7/8" thick, add					3.06			3.06
1300 1-1/4" thick, add					3.65			3.65
1500 For solid color suede finish, add					4			4
1700 For end splash, add				Ea.	18			18
1900 For cut outs, standard, add, minimum	1 Carp	32	.250		12	11.45		23.45
2000 Maximum		8	1		6	46		52
2100 Postformed, including backsplash and front edge		30	.267	L.F.	10	12.25		22.25
2110 Mitred, add		12	.667	Ea.		30.50		30.50
2200 Built-in place, 25" wide, plastic laminate		25	.320	L.F.	40.50	14.65		55.15

366

Appendix III- Take Offs

Lab Casework :-

1st Floor :-

- 3 x 180"
- 2 x 326"
- 2 x 326"
- 2 x 326" Σ = 307.33'
- 2 x 326"
- 3 x 180"

- 3 x (180" x 2) sinks
- 2 x 326' x 4 sinks Σ = 208'
- 4½ x 326 x 4 sinks

2nd Floor :-

- 4 x 284", 8 sinks
- 3 x 284", 8 sinks Σ = 260⅔'
- 4½ x 284, 8 sinks

- 2 x 290' x 8 sinks Σ = 48.33'

Σ = 824'

Fume Hoods :-

1st floor :-

- 3 ~~RH~~ 1RH
- 4 2LH
- 2 2RH
- 3 1LH

- 3 1RH (24)
- ~~4~~ 4 1LH
- 4 2RH
- 1 2LH

Second Floor

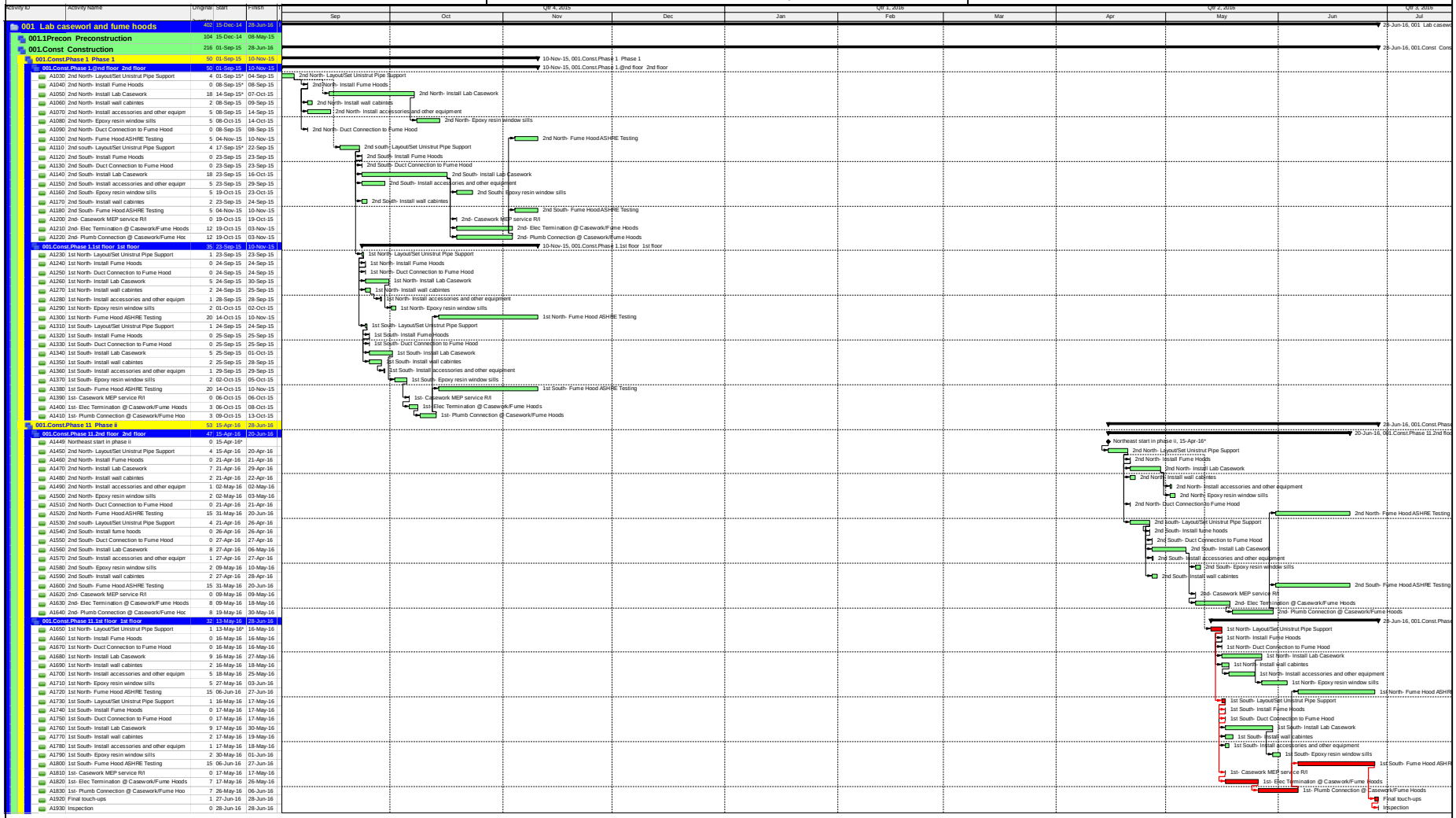
- ~~29~~ 30 3LH
- ~~28~~ 30 3RH
- 4 4RH
- 4 4LH
- 2 5LH
- 2 5RH

Second Floor :-

- 8 5RH
- 8 5LH
- 1 8RH
- 1 8LH
- 1 3RH
- 1 3LH

Appendix IV- Schedule and Gantt Chart

Lab caseworl and fume hoods | Classic Schedule Layout | 13-Oct-15 23:49



Actual Level of Effort | Remaining Work
Actual Work | Critical Remaini...

TASK filter: All Activities