GOUVERNEUR HEALTHCARE SERVICES

227 MADISON STREET,
NEW YORK, NY, 10002

SENIOR THESIS FINAL REPORT

ALEX D. DESPOTOVICH

FACULTY ADVISOR: DR. JOHN I. MESSNER

WEDNESDAY, APRIL 4, 2012

GOUVERNEUR HEALTHCARE SERVICES

227 MADISON STREET, NEW YORK, NY, 10002

ALEX DESPOTOVICH | CONSTRUCTION MANAGEMENT

PROJECT TEAM

- OWNER: New York City Health and Hospitals Corporation
- CLIENT: Dormitory Authority of the State of New York
- CONSTRUCTION MANAGER: Hunter Roberts Construction Group
- GENERAL CONTRACTOR: J. Petrocelli Contracting, Inc.
- ARCHITECT: RMJM Hillier Architects
- LANDSCAPE ARCHITECT: EKLA
- STRUCTURAL ENGINEER: Greenman-Pedersen, Inc.
- MEP ENGINEER: AKF Engineers

GENERAL BUILDING INFORMATION

- OCCUPANT TYPE: Healthcare Facility
- GROSS BUILDING AREA: 438,000 SF Renovation and Addition
- TOTAL FLOORS: Existing- 2 below grade, 14 above grade
  New- 1 below grade, 5 floors above grade
  plus 9 story "Tower"
- TOTAL PROJECT COST: $207 Million
- DATES OF CONSTRUCTION: January 2009—December 2013
- PROJECT DELIVERY METHOD: Design-Bid-Build with CM Agency

CONSTRUCTION METHODS

- Due to active facility conditions during construction, the project schedule contains six phases
- First major turnover includes new five story "podium" and eight story tower and entire thirteenth floor
- Remaining turnovers include demolition and renovation of all existing floors as coordinated between owner and construction management team

STRUCTURAL SYSTEM

- Foundation support includes a combination of 100 ton piles, pile caps, piers, strip footers, and grade beams for structural stability
- New building structure contains an integrated castellated beam and W-beam design with typical HSS8x8x5/8 and HSS 16x8x5/8 members for lateral load stability.
- Floor slab consists of 4 ¼" lightweight concrete fill reinforced with 6x6-W2.1x2.1 WWF placed 1" from the top of slab on a 2" 16 gage galvanized composite floor deck.

MECHANICAL SYSTEM

- Three new variable air volume air handling units deliver 114,000 CFM to spaces throughout the new building.
- Four new variable air volume air handling units deliver 197,000 CFM to spaces throughout the existing building
- Fire suppression incorporates a pre-action integrated sprinkler system and dry pipe sprinkler total pac system supported by a new automatic fire pump.

ELECTRICAL SYSTEM

- Electrical service feeds 208/120V power to two 4000 amp, 3 phase service boards
- Service boards distribute power to one 4000 amp, 3 phase and one 3000 amp, 3 phase main distribution boards
- An 3000 amp and 800 amp bus duct distributes power throughout the existing and new building
- A 1000KW, 480/277V emergency generator supplies emergency power to the building

Thesis Website: http://www.engr.psu.edu/ae/thesis/portfolios/2012/ADD5065/index.html

EXECUTIVE SUMMARY

The content of this report contains the results of four technical analyses and two breadth studies on the design and construction of the Gouverneur Healthcare Services project. The project scope includes interior demolition and renovation of the existing 328,665 square foot facility, a new 109,336 square foot addition, and complete modernization of the existing mechanical infrastructure. The studies performed throughout this report are focused on a central theme of efficient design and construction.

TECHNICAL ANALYSIS I: THE USE OF BUILDING INFORMATION MODELING

Based on the success of the use of Building Information Modeling methods on the Fiterman Hall project, it was determined that it would be feasible to use a 3D model for the coordination of design and construction of the new addition to the Gouverneur Healthcare Services to reduce schedule and decrease the quantity of change orders. Through the utilization of the VELA Systems software equipped iPad's for the punchlist process, it was determined that the initial cost of the system of about $25,000 can be quickly overcome by the estimated 2000 man hour savings by increasing the efficiency of the punchlist process.

TECHNICAL ANALYSIS II: SCHEDULE RE-SEQUENCING AND TENANT OCCUPANCY

A re-sequencing of the project schedule created a direct phasing relationship between residential floors six through eleven which allowed for an overall schedule savings of 168 days and cost savings of $206,732. The utilization of the FM:Systems facility management system allowed for a more efficient method of moving occupants from existing to new spaces, which allows the facility to potentially generate $428,854 in revenue for residential floors, reduce the overall schedule by 14 days, and save $140,182 in general conditions costs.

TECHNICAL ANALYSIS III: MATERIAL STAGING AND SYSTEM PREFABRICATION

The concept of prefabricated, integrated MEP racks was analyzed to implement in the design and construction of the new building. Through the implementation of prefabrication, the total duration reduction of construction of the mechanical, electrical, plumbing, and fire protection work in the corridors is 200 days and the total labor cost savings is about $1,673,293, which accounts for a 9% cost savings for the mechanical, electrical, plumbing, and fire protection packages, and a 3% total cost savings for the construction of the new building.

TECHNICAL ANALYSIS IV: SUSTAINABLE GREEN ROOF GARDEN

Due to financial restrictions, it was decided that it was not in the owner's best interests to implement the alternate green roof garden into the design of the sixth floor roof. A new green roof layout was designed which would utilize 7050 square feet and incorporate GroRoof extensive green roof modules. A structural breadth concluded that the current design will provide adequate support for the added load of the green roof system and a mechanical analysis concluded that the owner can save approximately $3,746 per year through the reduction of heating and cooling loads. With a 21 year payback period and 50 year life expectancy, the owner can expect a net profit of up to $113,090 in energy savings.

Acknowledgements

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HHC New York City Health and Hospitals Corporation

Dormitory Authority State of New York

FM:Systems

MGV GroRoof™ Innovations in Green Roof Technology

Vela Systems

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Leasha Jackson, Lead Development Representative at FM:Systems

Zach Miller, Director of Technical Sales at Metro Green Visions

My Family and Friends

TABLE OF CONTENTS

PROJECT OVERVIEW

PROJECT BACKGROUND

The Gouverneur Healthcare Services facility is an existing healthcare facility that is undergoing a major modernization which includes complete renovation of the existing thirteen story building, modernization of the existing mechanical infrastructure, and a new addition to the building. The healthcare facility is located on 227 Madison Street in New York City, NY, 10002. The existing building is about 328,665 square feet which is comprised of a sub-cellar and cellar below grade, thirteen stories above grade, and mechanical penthouse. The new addition to the building is designed to be 109,336 square feet which is comprised of a cellar below grade, five stories above grade, an eight story "bump out" above, and a mechanical penthouse on the sixth and fourteenth floor.

The preconstruction for the Gouverneur Healthcare Services building began in 2007 and the job broke ground in January of 2009. Substantial completion for the entire project is scheduled for December of 2013. The cost for the overall project is currently estimated to be $207 million. The project is being delivered as a Design-Bid-Build with a CM Agency. Listed in Table 1 below is the project team directory containing the main parties involved in the project.

TABLE 1: PROJECT TEAM DIRECTORY

Project Team Member	Project Team Member Name
Owner	New York City Health and Hospitals Corporation
Client	Dormitory Authority of the State of New York
Construction Manager	Hunter Roberts Construction Group
General Contractor	J. Petrocelli Contracting, Inc.
Architect	RMJM Architects
Landscape Architect	EKLA
Structural Engineer	Greenman-Pedersen, Inc.
MEP Engineer	AKF Engineers
Civil Engineering and Land Surveying	Hirani Engineering
Food Service, Laundry, and Waste Management Consultants	Marrack + Associates Inc.
Telecom / Security Consultants	McCorp

The existing building has been designed by RMJM Architects to allow for the hospital to expand their long term bed count from 210 to 295 beds. Many of the floors will function as residential floors where patients will reside in suites that share a bathroom. These floors will feature a welcoming fireplace area, two country style kitchens, a spa room, and other amenities.

The new building will be a five story building that will house ambulatory care departments for the hospital which include Surgery, Podiatry, OB/Gyn, Adult Behavioral Program, WIC, and

Pharmacy departments. The new building also features an eight story "bump out", floors 6-13, that is connected to the existing building and will serve as added square footage achieve the hospitals long term bed count goal. The new main entrance, located on Madison Street, will feature a storefront glazing system and revolving door which enters into a four story atrium featuring a one story marble staircase and two skylights.

The building enclosure for Gouverneur Healthcare Services contains a variety of building materials that compose the building façade. The existing buildings façade is composed of an existing brick veneer, concrete columns, and punch-out windows. The existing 2' x 4' windows will be replaced with new 3' x 6' punch windows. The new eight story tower façade is comprised of fabricated wall panel assemblies, structural sealant glazed curtainwall, brozne tinted low-e insulating glass, and a flat resin panel screen up on the penthouse level. The new five story building façade is comprised of bronze tinted low-e insulated glass, glazed aluminum curtainwall, fabricated wall panel assemblies, and flat resin panel screen on the 6th floor penthouse. The described façade can be seen in Rendering 1 and Rendering 2, both courtesy of RMJM Architects. The new main entrance will feature a bronze tinted glazed revolving door and glazed aluminum storefront doors. The roofing system of the building consists of a hot fluid-applied, rubberized asphalt waterproofing membrane, elastomeric flashing sheet, fiberglass reinforced rubberized asphalt sheet, insulation drainage panels, filter fabric, and stone ballast.

Rendering 1: Perspective Exterior View

Rendering 2: New Featured Main Entrance

The Gouverneur Healthcare Services building will not be constructed as a LEED project. Design consultants implemented the use of lighting motion sensors as replacement to manual switches for a majority of areas throughout the building. Additionally, as required by code, mechanical infrastructure upgrades will feature energy efficient systems. An alternate to the design, which is to be decided at a later time, is to feature a green roof garden for the use of patients of the hospital on the 6th floor roof.

PROJECT SCHEDULE

From architectural design and preconstruction services to final project substantial completion, the Gouverneur Healthcare Services facility will serve as a four year project beginning pre-construction and design on January 2, 2007 and ending on December 30, 2013. During that time, the facility will receive a complete renovation of the existing building, mechanical infrastructure upgrades, and a new five story building and eight story "bump out" of additional space to the existing building. Throughout the entire project, the healthcare facility will remain fully operationally for staff and patients. In order to prevent disruption to the staff and patients, the construction of the facility will occur in six different phases including 1, 2, 2A, 3, 4, and 5. This will allow certain floors to be turned over in order to proceed with demolition and renovation services on other floors.

Please refer to Figure 1 and Figure 2 to establish the difference between the new and existing building. Additionally, please note for the new building, the podium is considered floors 1-5 and the tower is considered floors 6-13. These titles will be referenced in the project summary schedule and throughout this technical report.

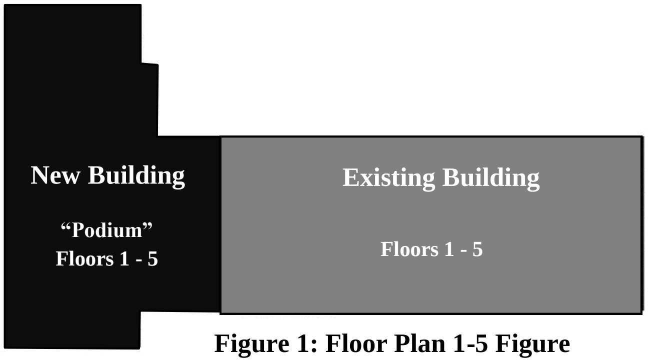


Figure 1: Floor Plan 1-5 Figure

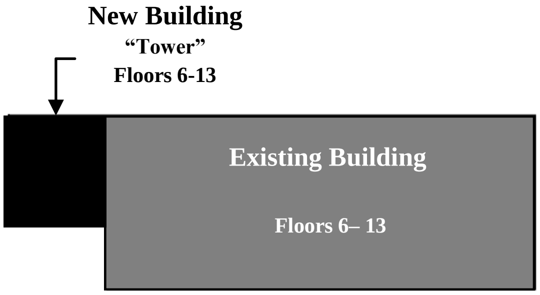


Figure 2: Floor Plan 6-13 Figure

The project summary schedule, which is located in Appendix A, is organized into two main categories, New Building Construction and Existing Building Construction. It deemed most efficient to organize the schedule this way because the Temporary Certificate of Occupancy for the new building was the first major section of the project to be turned over to the owner on September 6, 2011. Also turned over at that time was the 13th floor of both the existing and new building. Upon completion of the new building, departments of the healthcare facility are able to move out of the existing building into their new spaces. As staff and patients move out of the existing building, other phases of demolition and renovation of existing floors are able to proceed in the existing building. The remaining phases of construction included turning over the tower of the new building and the demolition and renovation of existing floors as coordinated between the owner and construction management team.

The construction of the new building consisted of typical New York City methods using steel construction and concrete slab on metal deck construction. The detailed phases of construction for the new building are as follows:

- Soil Remediation
- Excavation
- Foundations
- Structural Steel Erection
- Steel Deck Installation
- Pour Concrete Slab
- Steel Fireproofing
- Curtain Wall Installation
- MEP Rough-In
- Interior Fit Out
- MEP Installation
- Interior Finishes

The construction of the existing building consisted of complete demolition and renovation of the existing conditions. The detailed phases of construction for the existing building are as follows:

- General Floor Demolition
- General Abatement
- MEP Systems Demolition
- Existing Window Demolition
- Install New Punch Windows
- Install New Punch Windows
- MEP Rough-In
- Interior Fit Out
- MEP Installation
- Interior Finishes

The detailed project schedule for the Gouverneur Healthcare Services project is located in Appendix A. The project schedule is organized into two major categories, New Building Construction and Existing Building Construction. The New Building Construction category features a detailed schedule for the foundation, structural steel, concrete, curtain wall, and interior phases of construction. The Existing Building Construction category features a detailed schedule for the demolition and interior renovation phases of construction. The interior phases of construction for both categories are organized by floor and depicts five major phases of construction including Demolition of Existing Interior; MEP Systems Overhead and Rough-In; Interior Wall and Ceiling Framing; Interior Wall, Ceiling, and Floor Finishes; and MEP Installation. The major items included in the interior phases of demolition, renovation, and new construction can be seen below for each category.

Demolition of Existing Interior:

- General Demolition
- General Abatement
- MEP Systems Demolition
- Existing Window Demolition

MEP Systems Overhead and Rough-In:

- Install Overhead Ductwork
- Install Overhead Plumbing
- Install Overhead Sprinkler
- Install Overhead Electrical
- Rough-In Electrical
- Rough-In Plumbing
- Insulate/Inspect Plumbing
- Pull and Terminate Telecom/Security Cables

Interior Wall and Ceiling Framing:

- Layout
- Install Top Track
- Install Framing and Doors
- Install Black Iron
- Install Ceiling Grid

Interior Wall, Ceiling, and Floor Finishes:

- Install Sheet Rock (Walls and Ceilings)
- Tape Coats on Walls
- Polish Sheet Rock Walls
- Apply Coats of Paint
- Install Casework

MEP Installation:

- Install Ceiling HVAC Drops
- Install Electrical Box Drops
- Install Sprinkler Drops
- Install Electrical Switches/Outlets
- Install Plumbing Fixtures
- Install Control Devices
- Install Ceiling Lights
- Install Fire Alarm Components

To efficiently depict the project schedule, the two main categories are broken down by floor to allow for one to understand the various phases of construction. This will further an understanding for how Hunter Roberts Construction Group is working closely with the owner to efficiently deliver construction while maintaining an active healthcare facility. Table 2 on the next page highlights the major start and finish dates of construction categorized by activity and floor.

TABLE 2: PROJECT SCHEDULE SUMMARY CHART

Phase	New Building Construction		Existing Demolition and Renovation	
	Start Date	Finish Date	Start Date	Finish Date
Foundations	1-30-2009	8-21-2009	-	-
Structural Steel	8-8-2009	12-15-2009	-	-
Superstructure Concrete	8-31-2009	12-15-2009	-	-
Curtain Wall	11-16-2009	5-17-2010	-	-
1st Floor Work	11-2-2009	9-1-2011	8-10-2012	5-22-2013
2nd Floor Work	12-7-2009	8-22-2011	10-26-2011	7-26-2012
3rd Floor Work	1-4-2010	8-22-2011	10-26-2011	7-26-2012
4th Floor Work	2-1-2010	9-2-2011	10-26-2011	7-26-2012
5th Floor Work	3-4-2010	8-29-2011	1-5-2011	6-25-2012
6th Floor Work	4-27-2010	11-16-2011	4-6-2011	6-25-2012
7th Floor Work	5-19-2011	11-30-2011	9-21-2011	6-25-2012
8th Floor Work	6-2-2010	12-14-2011	9-21-2011	10-10-2012
9th Floor Work	6-7-2010	12-30-2011	7-11-2012	4-10-2013
10th Floor Work	6-10-2010	1-13-2012	10-25-2011	10-8-2013
11th Floor Work	6-16-2010	1-20-2012	4-25-2013	12-30-2013
12th Floor Work	6-22-2010	9-6-2011	-	-
13th Floor Work	7-1-2010	9-6-2011	9/24/2009	9/6/2011
MEP Modernization	-	-	2-26-2010	13-30-2011

Note that the 12th floor of the existing building does not have dates listed for demolition and renovation. This is due to the fact that this floor was previously demolished and renovated prior to the current project. For a further breakdown of the values that were determined, please see Appendix A. Appendix A features a summary and detailed project schedule to help further an understanding of the durations and phasing of construction for each floor of the new and existing building construction.

BUILDING SYSTEMS SUMMARY

TABLE 3: BUILDING SYSTEM SUMMARY CHECKLIST

Yes	No	Scope of Work
X		Demolition Required
X		Structural Steel Frame
X		Cast-in-Place Concrete
X		Precast Concrete
X		Mechanical System
X		Electrical System
X		Curtain Wall
X		Masonry
X		Support of Excavation
	X	LEED Certification

DEMOLITION

In order to fully renovate the thirteen stories of existing facility, a full demolition of the interior is required, as well as the demolition of existing windows in preparation for new punch out windows. Figure 3 depicts the completed product of a full demolition of a floor in the existing building.

The existing Gouverneur Healthcare Services facility was opened in 1972. At that time, construction methods that were used to build the facility are not currently accepted by code and city agencies. Asbestos was applied through various methods of construction including flooring; window and door caulking; block tar coating; pipe insulation; mechanical equipment and materials; and electrical components. Prior to demolition, existing plans were used to develop new plans to locate the use of all asbestos in preparation for removal. In preparation for removal of asbestos, the contractor must totally isolate the area of removal preventing other workers and hospital staff from entering the area. Figure 4 depicts an area in the existing structure receiving asbestos removal treatment with proper use of negative pressurization and signage. In order to remove asbestos from the exterior of the building, the scaffolding system used to install windows throughout the building was used.

Figure 3: Existing 13th Floor Demolition

Figure 4: Existing 13th Floor Abatement

Existing plans for the building were also used in preparation of hazardous material, universal waste, and polychlorinated biphenyl (PCB) removal. Hazardous material and universal waste that were removed throughout the building include chlorofluorocarbon or CFC containing equipment; PCB containing equipment; HID lighting; fluorescent bulbs and ballasts; chemical; mercury containing materials; and red bagged waste. PCB material that was removed throughout the building includes exterior window caulking, expansion joint caulking, slop sink caulking, and louver frame caulking.

STRUCTURAL STEEL FRAME

The existing structure is comprised of a typical concrete structure incorporating a concrete beam, column, and slab system. The structural engineer deemed the existing structure's design to be acceptable to support the newly renovated spaces, therefore, requiring no added structural support to support the floors.

The new podium and tower being constructed is a structural steel and concrete slab system. The base columns on the inside of the building are supported by 12' x 6' piers which each rely on 5 to 10, 100 ton piles for stability. All columns that support the structure are W-flanged members that typically span two to three floors at a time. Compared to a typical W-beam support system, structural designers incorporated a castellated beam and W-beam design. The integrated design would allow for equal floor elevations between the new buildings steel structure and the existing buildings concrete structure. The design also provided the maximum allowable heights achievable between floors, which serves as a benefit to the high volume of MEP equipment and material that will support the healthcare facility. Supported by the beam is 4 ¼" lightweight concrete fill reinforced with 6x6-W2.1x2.1 WWF placed 1” from the top of slab on a 2” 16 gage galvanized composite floor deck. For lateral load stability, the structure is supported with horizontal bracing members typically consisting of HSS8x8x5/8 and HSS16x8x5/8 members. Additionally, all structural steel columns located on the exterior to support overhangs are encased in a round lightweight concrete column. The following figures, Figures 5 through 7, depict some of the structural descriptions mentioned above.

Figure 5: New Building Structural Steel System

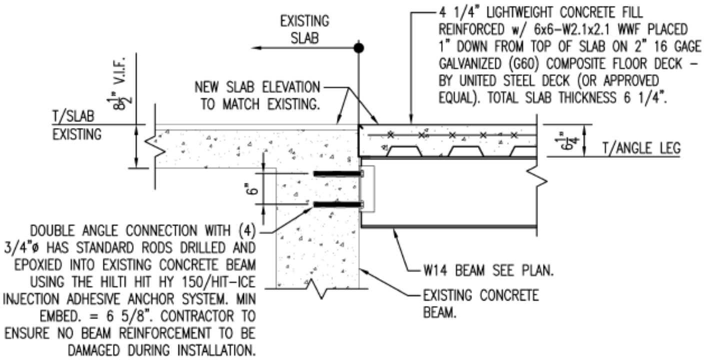


Figure 6: Slab Elevation Details

Figure 7: Exterior Support Columns

A Manitowoc 4100 crawler crane was used to pick steel members throughout the entire erection of the structural steel frame. The crawler crane has a maximum lifting capacity of 230 tons and a reaching capability of up to 250 feet. For the majority of the erection phase, the crane traveled a designated path along the corner of Madison Street and Jefferson Street. For a better understanding of the crawler crane’s location, see the Superstructure Planning Layout in Appendix B.

CAST-IN-PLACE CONCRETE

The foundation that will support the new building structure, including the footers, piers, floor slab, and grade beams, consists of cast-in-place concrete. The concrete used for foundation work and floor slabs was placed using a traditional pump truck that transported the concrete by pump from the truck to the location of placement. Conventional wood formwork was used to form and support the concrete where necessary. Additionally, on the exterior, all of the new sidewalks, planters, ramp, and front entrance staircase base used cast-in-place concrete and was formed using traditional horizontal and vertical wooden formwork, as seen in Figure 8 below. Most of this concrete was delivered by concrete truck and placed using a concrete placement buckets.

Figure 8: New Main Entrance Stair Base

Figure 9: New Atrium Lobby Terrazzo

On the interior of the new building, the floor slabs consisted of cast-in-place 4 ¼” lightweight concrete which was support by a 2” 16 gage galvanized deck. No shoring was required for these pours because the steel deck used in design met the allowable deflection requirements. On the first floor, a cast-in-place terrazzo flooring system was incorporated in the design throughout the atrium and lobbies, as seen in Figure 9 above. Additionally, cast-in-place concrete infill’s were used to patch flooring throughout the existing building.

PRECAST CONCRETE

Precast concrete was not used for this project, except in a couple instances. In the main lobby of the new building, a one story feature staircase will use precast terrazzo treads and risers. Also, the exterior main entrance staircase will feature precast granite block to serve as the tread and riser of the staircase. The precast concrete used on the job was cast in an off-site location and delivered to the site for installation. The precast systems used can be seen in the Figure 10 and Figure 11 below.

Figure 10: New Main Entrance Granite Stairs

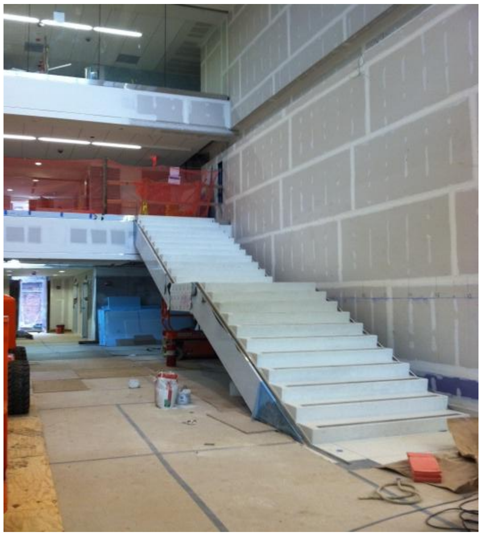


Figure 11: New Terrazzo Atrium Stairs

MECHANICAL SYSTEM

The Gouverneur Healthcare Services facility will undergo a complete modernization of its existing infrastructure and receive new equipment and support systems that will support both the new and existing facility. Overall, the mechanical system will feature a combination of eleven air handling units that are capable of delivering a combined air flow of 350,200 CFM to spaces throughout the building. Additionally, the mechanical system will feature three induced draft cooling towers to supply chilled water to various mechanical components that support the building.

Located on the 6th floor of the new building are three variable air volume air handling units, AHU-5, AHU-6, and AHU-7, which will distribute air to the podium, floors 1-5, of the new building. AHU-5 will primarily serve the four story atrium with 14,000 CFM of air, while AHU-6 and AHU-7 will each provide 50,000 CFM of air throughout the various podium spaces located in the new building. Located on the 14th floor roof/penthouse of the existing building are four variable air volume air handling units, AHU-1, AHU-2, AHU-3, and AHU-4, which will distribute air to spaces throughout the existing building. AHU-1 will serve the north end with 17,000 CFM of air, AHU-2 will serve the south end with 20,000 CFM of air, AHU-3 will serve the west end 100,000 CFM of air, and AHU-4 will serve the east end 60,000 CFM of air. Additionally, there are four existing air handling units that are to remain in the building which will serve the existing building's cellar and first floor including the main lobby, auditorium, and staff locker rooms.

To ensure the safety of all occupants of the building, a variety of methods have been incorporated in the design of the building fire suppression system. Approximately 195 fire smoke dampers have been incorporated into the fire suppression design that are connected to a number of duct smoke detectors that will use the ductwork as a method of smoke control during a fire. The fire protection design incorporates a combination of both a pre-action integrated sprinkler system and dry pipe sprinkler total-pac system. The sprinkler system will be fed by a new, automatic fire pump located in the cellar of the existing building.

ELECTRICAL SYSTEM

The Gouverneur Healthcare Services facility will undergo a complete modernization of its existing infrastructure through replacement of most of the electrical systems. The electric service is fed to the building by Con Edison of New York. The service is fed into the electrical room in the cellar of the existing building at 208/120V power to two 4000 amp, 3 phase service boards, Service Board "A" and Service Board "B". Each service board feeds power to a 4000 amp, 3 phase Main Distribution Board "MBD-A" and a 3000 amp, 3 phase Main Distribution Board "MBD-B" which distributes the power where necessary throughout the building. Service Board "A" serves a 3000 amp bus duct which supplies power to the electrical closets of the existing building and 14th floor penthouse. Main Distribution Board "MDB-B" serves an 800 amp bus duct which supplies power to the electrical closets of the new building and 6th floor roof mechanical equipment. Service Board "B" also distributes power to a fire alarm fused cut-out panel that controls the fire command station, central station, pre-action panel system, and DGP riser. A new 1000KW, 480/277V emergency generator will feed power through a step down transformer to support Service Board "B" in the case of an emergency. Power created by the generator also distributes power to the fire pump and a 480/277V, 200 amp Service Board "E" which feeds hospital equipment that must remain active during an emergency outage. When necessary, power is stepped up or switched from 208/120V to 480/277V by use of a transformer to systems that require such type of power.

CURTAIN WALL

The design of the new addition will step away from the existing brick veneer by incorporating a glazed curtain wall system. The eight story tower façade is comprised of fabricated wall panel assemblies, structural sealant glazed curtain wall, bronze tinted low-e insulating glass, and a flat resin panel screen up on the penthouse level. The five story building façade is comprised of bronze tinted low-e insulated glass, glazed aluminum curtain wall, fabricated wall panel assemblies, and flat resin panel screen on the 6th floor penthouse. The new main entrance to the facility will feature a bronze tinted, glazed revolving door and glazed aluminum storefront doors. Figure 12 and Figure 13 can be seen below to gain a better understanding of the new curtain wall system.

Figure 12: New Featured Main Entrance Curtain Wall

Figure 13: New Curtain Wall System

The curtain wall design for the new building was designed by one of New York City's largest metal and glass company and country's largest supplier of structural glass systems, W&W Glass LLC. In addition to the design, W&W also installs the curtain wall system work with their own union labor work force of glaziers and ironworkers.

For the construction of the system, the curtain wall was delivered in protective crates, transported up the hoist, and staged on its designated floor of installation. In order to install the system, a Beech Counterweight Hydraulic Floor Crane was used. The crane was set one or two stories above the installation location and would allow workers to pick sections of the system from the floor below and set the system into place while other workers fastened connections.

MASONRY

The design of the new addition to the Gouverneur Healthcare Services facility does not incorporate the use of any load bearing or veneer masonry. The existing thirteen story structure, however, uses a brick veneer to serve as the exterior façade. During the renovation of the existing structure, an engineered traditional scaffolding system will rise from the ground to the roof. This scaffold will be used to replace the existing 2’ x 4’ windows with new 3’ x 6’ punch windows, to paint all of the exterior columns, and if necessary, make repairs to the existing brick veneer.

SUPPORT OF EXCAVATION

The excavation done, in preparation for installation of foundation work, served as quite challenge for the project superintendents. Some of the challenges posed included coordinating work with the New York City Department of Transportation and the New York City Department of Design and Construction, monitoring the foundation of the existing building during excavation, and understanding the location of existing, active underground utilities in the area of excavation. Additionally, the excavation crew discovered historical foundations of buildings estimated to have been built back in the 1800’s.

In order to handle tight site conditions between excavation and active sidewalks and roadways, a mixture of excavation support methods were applied. Where excavation occurred on Madison Street, a sheeting and shoring support system was used to support excavation in order to prevent disruption to the active sidewalk and bicycle lanes. As work progressed away from Madison Street towards Henry Street, excavation was able to meet OSHA slope ratio requirements without disrupting adjacent streets or sidewalks.

During the installation of the piles that are to support major foundation components, a dewatering pump system was installed to remove water from the pile holes. A major scope of work during excavation included a soil remediation plan that removed contaminated soil and water caused by existing utilities. During this process, a dewatering plan was put in effect that would remove and filter the water during remediation and would have to been overseen by the New York City Department of Environmental Protection agency.

LEED Certification

The Gouverneur Healthcare Services building renovation and addition will not be constructed as a LEED project, therefore no efforts will be put forth to acquire a LEED rating. Design consultants implemented the use of lighting motion sensors as replacement to manual switches for a majority of areas throughout the building. Additionally, as required by code, mechanical infrastructure upgrades will feature energy efficient mechanical, electrical, and plumbing systems. The sixth floor roof is to feature a roof garden for use of patients of the hospital which will house multiple benches and a variety vines, shrubs, and perennial herbs. See Figure 14 and Figure 15 below for a better understanding of the alternate green roof details.

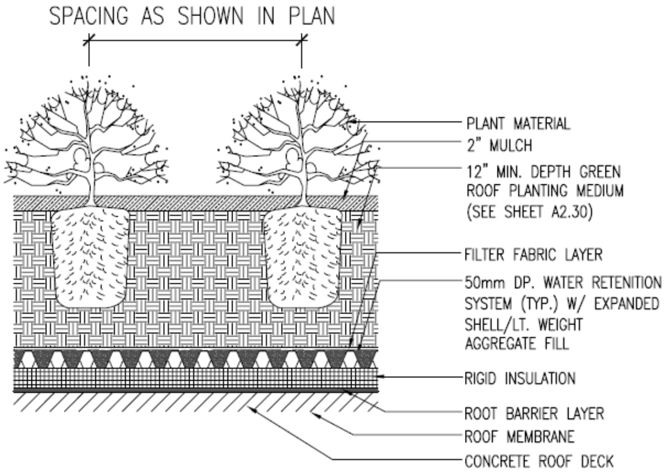


Figure 14: Green Roof Shrub Planting Detail

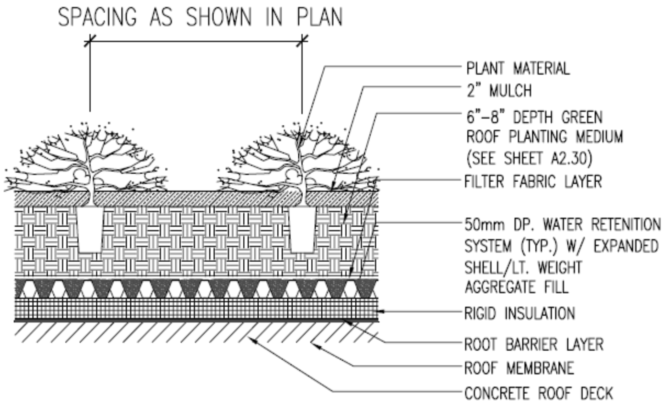


Figure 15: Green Roof Ground-Cover Planting Detail

PROJECT COST EVALUATION

The total cost of the modernization to the Gouverneur Healthcare Service facility is currently budgeted at approximately $207 million. All listed project costs have been provided by Hunter Roberts Construction Group and are forecasted project costs estimated by the construction management team.

PROJECT PARAMETERS

- NEW BUILDING SQUARE FOOTAGE: 116,954 SF
- EXISTING BUILDING SQUARE FOOTAGE: 328,665 SF
- TOTAL BUILDING SQUARE FOOTAGE: 445,610 SF
- TOTAL BUILDING PERIMETER: 1,035 LF

BUILDING CONSTRUCTION COSTS

- CONSTRUCTION COSTS: $157,445,805
- CONSTRUCTION COSTS PER SQUARE FOOT: $353.33/SF

TOTAL PROJECT COSTS

- PROJECT COSTS: $207,350,938
- PROJECT COSTS PER SQUARE FOOT: $465.32/SF

BUILDING SYSTEMS COSTS

TABLE 4: BUILDING SYSTEM COSTS

Building System	Projected Costs	Projected Costs/SF
Structural Steel	$ 7,302,390.00	$ 16.39
Mechanical System	$ 24,503,029.00	$ 54.99
Fire Suppression System	$ 3,350,826.00	$ 7.52
Plumbing System	$ 13,941,380.00	$ 31.29
Electrical System	$ 18,988,728.00	$ 42.61
Telecommunications/Security	$ 3,216,908.00	$ 7.22
Curtain Wall System	$ 8,217,346.00	$ 18.44
Total	$ 79,520,607.00	$ 178.46

SITE PLANS

EXISTING CONDITIONS

The Gouverneur Healthcare Services building is located on the Lower East Side of New York City at 227 Madison Street, New York, NY, 10002. The building occupies a full city block and is surrounded by very active streets including Madison Street to the south, Henry Street to the north, Clinton Street to the east, and Jefferson Street to the west, three of which are one way streets. The area contains a variety of buildings including residential, mixed-use, open space, community facilities and manufacturing, all of which are less than 10 stories above the street level. See Figure 16 for a better understanding of the location and surrounding area.

Figure 16: Front and Rear Existing Conditions View

For a more detailed reference of the existing conditions of the Gouverneur Healthcare Services project, please refer to Appendix B. This particular healthcare project serves as a great challenge to the team constructing it due to the fact that the hospital will remain active during the entire phase of construction. The safety of the workers, staff and patients of the facility, and many pedestrians that travel alongside the site is of the upmost importance. In order to do so, overhead protection was constructed in locations surrounding the site to protect passing pedestrians. The underground utilities that service the existing building will remain during and after construction. Working with limited on site space, the construction fence extends out past the property line into the surrounding streets on Jefferson Street and Madison Street. During construction, approval was obtained by the New York City Department of Transportation to occupy the existing sidewalk and partial street because it would not disrupt the one way street traffic on Jefferson Street. Pedestrian and vehicular traffic would be accommodated accordingly.

The existing entrance of the facility is located on Madison Street. During construction, the main entrance will be moved to Clinton Street to allow the new building to be constructed and provide the construction team with more site space. At the end of the first major phase of construction, the new building will be turned over to the owner and will feature the new main entrance to the facility. Also, an existing service road runs parallel to Henry Street adjacent to the existing facility. After construction, the proposed design will eliminate that service road and a new one will be constructed entering the site from the corner of Henry Street and Jefferson Street.

SITE LAYOUT PLANNING

The site layout drawings are phased into four separate plans including Excavation/Foundation, Superstructure, Interiors Phase 1, and Interiors Phase 2 in order to accommodate the owners needs to maintain an operational facility while achieving an efficient production of construction. All site layout planning drawings can be seen in Appendix B.

During the Excavation/Foundation phase of construction, the location of the new building is the only space that will be closed off to the public. Working with the New York City Department of Transportation, the construction boundary was able to extend out into Jefferson Street. Additionally, the side walk that is consumed by construction on Madison Street has been accommodated for by using barriers to create a safe path for pedestrians. With an extension of the construction boundary, a construction gate entrance and exit was laid out for trucks to enter along Jefferson Street and exit onto Madison Street. An equipment entrance and exit has been placed at the north end of the site to allow construction equipment to access the excavation area, as well as access for dump trucks to transport excavated soil off the site. A concrete pump truck has been placed on the sidewalk where a concrete truck can park next to it, pump concrete, and exit the site in an efficient manner. Due to lack of site space, any necessary office space for construction personnel has been located inside the building on a floor that has been turned over to the construction team for demolition.

As the Excavation/Foundation phase of construction proceeds to Superstructures, the hospital will turn over the existing main entrance to allow for more site access for construction personnel.

A temporary main entrance has been located on Clinton Street for visitors and staff of the facility, and the existing main entrance will now serve as a construction personnel entrance. The path of travel for the concrete and steel trucks will remain the same. For the structural steel erection, a crawler crane has been strategically located at the south end of the site that allows the crane to make picks to any location. Additionally, during the curtain wall installation, a beech hydraulic counterweighted crane will be used to pick sections of glass at any point along the outside of the building. It will be located on the interior of the building and its path of travel can be seen on the Superstructure Plan. A personnel and material hoist has been located along Madison Street and will rise to the 13th floor during the superstructure phase of construction to deliver manpower and material to their designated floors. Due to lack of site space, any necessary office space for construction personnel has been located inside the building on a floor that has been turned over to the construction team for demolition. Site superintendents have a conveniently located site trailer along Madison Street for easy access to both the existing building and new construction.

The interior site layout planning drawing has been divided into two phases. During phase one of the interior plans, the new building is progressing towards turnover while demolition and renovation will only occur on the 13th floor prior to new building turnover. Most of the work being done during this phase consists of interior fit out and finishes, but site work on the exterior of the new building will still be taking place. The access road to the site will remain the same with interior delivery path located towards the corner of Henry Street and Jefferson Street up to the new building's first floor or down into the cellar. Also, concrete trucks will continue to use this access road to deliver concrete for site work that is being done on Madison Street and Jefferson Street. Since almost all work has moved inside, bathrooms have been built out for the use of construction workers. Temporary power exists in the same location but will also be fed into the building for interior work. During phase two of the interior plan, all work being done will consist of demolition and renovation of existing floors throughout the building. At this point in time, the new building will have been turned over to the owner and the new entrance will be open to the public. All deliveries will be made through the facilities loading dock and delivered by elevator from the cellar. The loading dock will also be for garbage removal during demolition and renovation. The site has drastically changed at this point because the new building has been turned over. Construction trailers for the construction management and general contractor will remain in their location and the contractor's trailers will be located in the existing parking lot. Although the main entrance for the new building has opened, a covered temporary entrance will still remain on Clinton Street.

Overall, the construction management team has done an excellent job in preparing site layout plans for the facility. The team has successfully planned around the owner's needs and lack of site space by coordinating work with the City. Working with a tight site can pose many challenges on a job site, but through coordination and planning it can be done successfully. As with all projects, the safety of pedestrians, faculty, patients, and construction workers are of the upmost importance on this project.

LOCAL CONDITIONS

In the New York City area, the preferred method of construction is steel due to the height of structures being built and site restrictions for many projects throughout the city. On the Lower East Side, however, many of the buildings were built in the mid 1980’s and were either constructed using concrete or load bearing masonry structures. In current day, steel construction is a very common practice due to the high productivity rates achieved using this method. The existing Gouverneur facility, built in 1972, is a concrete structure with a brick veneer façade, but the new building will be built using steel construction methods.

Due to very tight site conditions, the availability for construction parking does not exist on site. If workers choose to travel by car, there are various parking options on surrounding streets and parking lots, but none specifically dedicated to workers on the project. However, in New York City, it’s not very common for one to travel by car to work, so many take advantage of the elaborate amount of public transportation including subways, buses, and cabs. Located directly on Madison Street are bus stops that travel to directly to the PATH station, for those who commute from New Jersey. Located a few blocks away on Rutgers Street and East Broadway are subway stops that allow one to travel one of the many subways that run underneath the city.

The availability of recycling and tipping fees does not exist on the Gouverneur Healthcare Services. Although no recycling was used, typical separation of materials is monitored when processing garbage on the jobsite.

After reviewing the geotechnical report produced by GZA GeoEnvironmental of New York, it was determined that the soil below grade contained a variety of silt-based soils, including silty clay and silty sand. Groundwater readings were made over a stabilization time of 25 hours recorded readings of a 5-10 depth.

CLIENT INFORMATION

The owner of the Gouverneur Healthcare Services facility is the New York City Health and Hospitals Corporation, HHC. The New York City HHC is an integrated healthcare delivery system that provides medical, mental health, and substance abuse services through a variety of care hospitals, nursing facilities, community based clinics, and diagnostic and treatment centers. Through a five year, $824 million investment plan, HHC is modernizing existing and new structures to "facilitate the delivery of effective, efficient and patient-centered care, maximizing the comfort and dignity all HHC patients deserve," according to the HHC website.

New York City HHC is looking to completely renovate and expand the Gouverneur Healthcare Services facility to provide faculty and patients with more comfortable and user friendly spaces. The modernization of the mechanical infrastructure will provide the facility with new energy efficient and state of the art equipment to support the building. At the end of day, the renovation and expansion will reach Gouverneur's goal to expand their patient bed count from 210 beds to 295 beds. The new building will provide Gouverneur with space to house ambulatory care departments including Surgery, Podiatry, OB/GYN, Adult Behavioral Program, Women Infants and Children, and Pharmacy.

The construction management team, Hunter Roberts Construction Group, is working very closely with the owner and the Dormitory Authority for the State of New York, DASNY, in order to deliver the project with the highest quality of construction while meeting both schedule and cost expectations. The sequencing of the schedule has been strategically planned to deliver construction in six phases to meet the owner's needs in maintaining a fully operational facility during construction, as well as maintaining occupancy requirements as required by New York City. Because the facility will remain operational, the safety of not only the construction workers, but also the patients and staff throughout, is of the upmost importance.

In order to complete the project to the owner's satisfaction, it is important that Hunter Roberts, HHC, and DASNY work closely in design and coordinating work to prevent disruption throughout the active facility. Also, working closely to meet schedule needs is very important in maintaining satisfaction for not only the owner and staff, but also for the patients.

PROJECT DELIVERY METHOD

The Gouverneur Healthcare Services renovation and expansion project is being delivered as design-bid-build, in prime contractor format, with a construction management agency. New York City Health and Hospitals Corporation, HHC, is state agency for the city of New York who is the owner and operator of the healthcare facility.

When working in the educational and healthcare sector of construction in New York City, typically there is a state agency involved in the project, whether it may be to oversee design and construction or provide funding or both. In this case, the Dormitory Authority for the State of New York, DASNY, is contracted directly through HHC to oversee the modernization project from conceptual design to final completion, as well as providing the facility with a budget to fully fund the project. DASNY is contracted by HHC through a Memorandum of Understanding.

As part of the design and construction process, DASNY is the major player for the project to which they hold the contracts between all parties involved, including the design consultants, prime contractor, and vendors. Contractors for the job publically bid for work and work directly for DASNY if awarded the contract. Contracts held between DASNY and the contractors are all Prime Lump Sum contracts. The design consultants are contracted by DASNY through a Lump Sum contracts as well. Hunter Roberts Construction Group is contracted by Memorandum of Understanding through DASNY to serve as a construction management agency to both DASNY and the Health and Hospitals Corporation. Because this job is built under the public sector, every party involved on the job is responsible for their own bonding and insurance plans.

Please refer to Figure 17 for a visual understanding of the project delivery method used on the Gouverneur Healthcare Services modernization project.

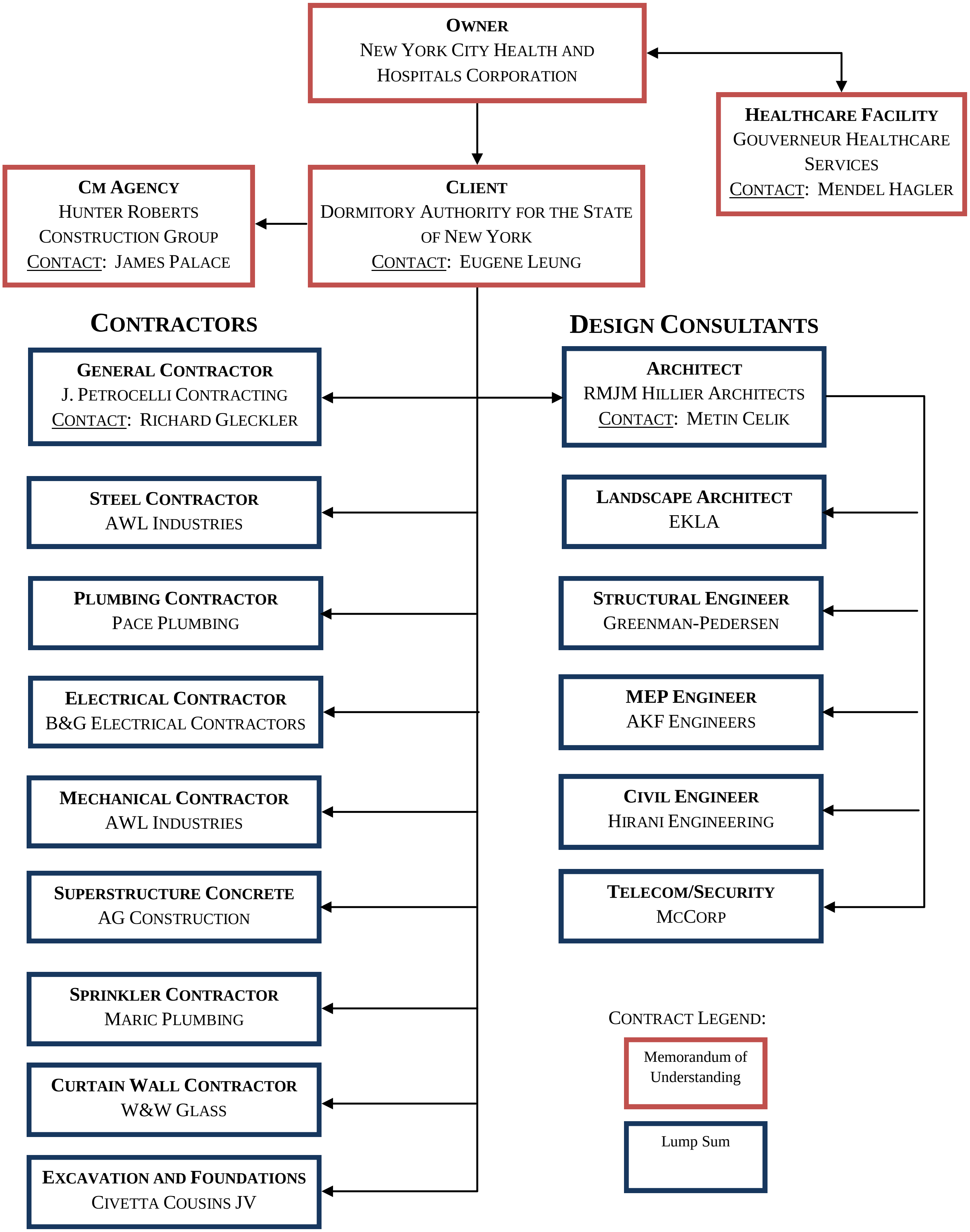


Figure 17: Project Delivery Method

STAFFING PLAN

The staffing plan assigned for the Gouverneur Healthcare Service renovation and expansion can be seen in Figure 18 below. This plan shows the staff assigned for the construction management agency, Hunter Roberts Construction Group. Senior project executive, James Palace, and his team work very closely to efficiently manage the construction process in order to provide the owner with a high quality product while maintaining schedule and cost expectations.

The project management team staffed to the job work very closely with the owner, design consultants, and construction contractors to resolve issues in design, monitor costs, meet schedules requirements, and working with the owner to coordinate work in a very active healthcare facility.

Due to the volume of construction taking place for this project, four superintendents are staffed to monitor all work being put in place in the field and coordinate work between various trades on site. With the complete mechanical infrastructure being upgraded, it was deemed necessary to have staffed two MEP superintendents to monitor the high volume of equipment and new infrastructure being installed throughout the building.

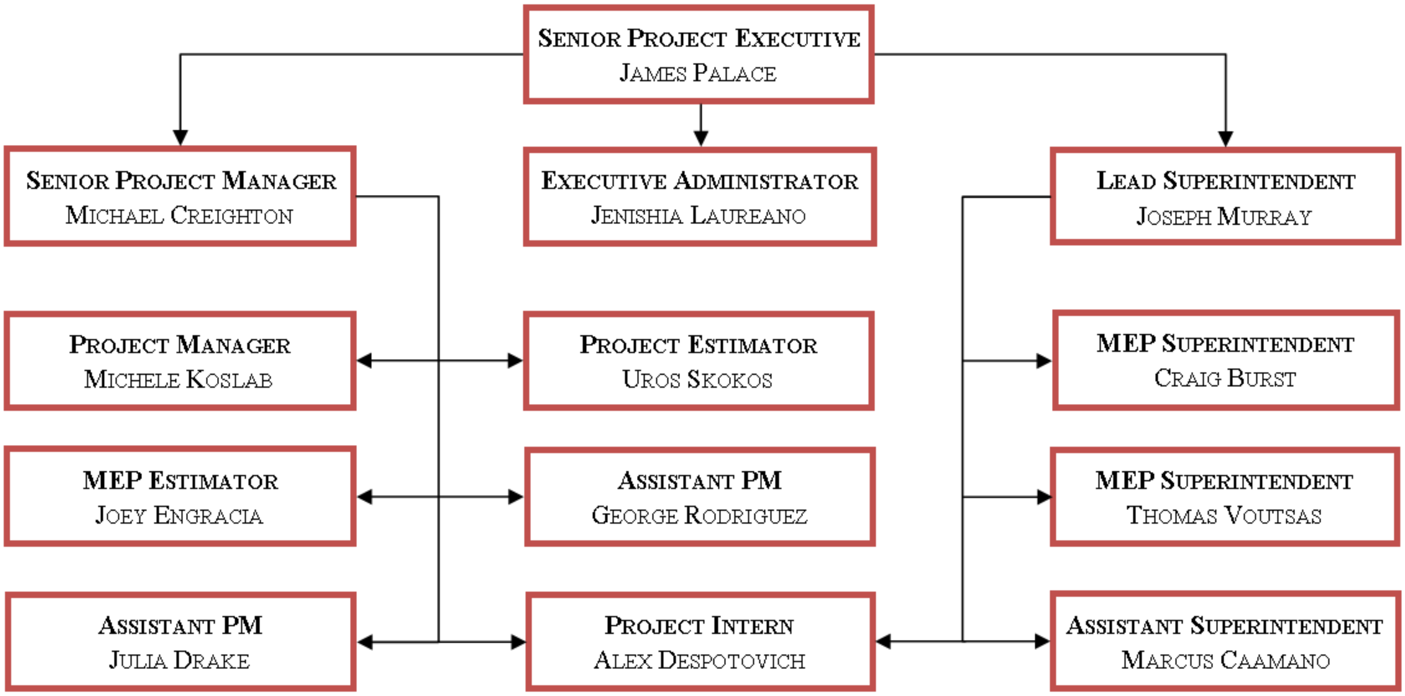


Figure 18: Project Staffing Plan

TECHNICAL ANALYSIS I: THE USE OF BUILDING INFORMATION MODELING

PROBLEM IDENTIFICATION

The Gouverneur Healthcare Services project faced many challenges involving the schedule phasing of the active facility, site logistics, and the coordination of the high volume of mechanical, electrical, and plumbing systems that will support the buildings function. Through studies involved in Technical Assignment 2 and Technical Assignment 3, it was determined that Building Information Modeling methods were not applied to the Gouverneur Healthcare Services facility for the design, construction, or facilities management phases of the project. Due to the occupancy phasing requirements and complexity of the MEP systems in the facility, the use of BIM methods could benefit the project in delivering safer and more efficient construction.

RESEARCH GOALS

The goal of this technical analysis is to determine how a healthcare facility of this magnitude and complexity can benefit through the use of a variety of BIM methods through design, construction, and operations. Particularly, the goal of the analysis is to determine the cost impacts, schedule impacts, and overall benefits related to implementing the following BIM methods:

- 3D Modeling and Coordination
- Field Technologies – VELA

Upon completion of this analysis, the information discovered through research will be integrated throughout the other technical analyses.

METHODOLOGY

- Gain understanding for why BIM methods were not initially applied to the project by interviewing project team and understanding requirements of the owner when the project was bid in 2007
- Gain understanding of BIM experience of the owner and construction management team through research of past projects performed by both
- Research case studies related to a project of this magnitude and understand the impact of BIM methods on those projects in terms of cost and schedule
- Interview Hunter Roberts Construction Group project team and other personnel to gain insight on the specific BIM methods that have been successfully applied to past healthcare projects

- Perform a cost and schedule impact analysis by understanding the costs associated with applying certain BIM methods and performing a cost comparison of initial costs to potential savings that have resulted in data collected from past case studies of similar projects

RESOURCES AND TOOLS

- Industry Professionals - Hunter Roberts BIM Coordinator
- Historical Data of Past BIM Projects from Hunter Roberts
- Department of Architectural Engineering Faculty
  - Dr. John Messner
  - Dr. Robert Leicht
  - Dr. Craig Dubler
  - Dr. Chimay J. Anumba
- Penn State BIM Project Execution Planning Guide V2.0
- Applicable Case Studies and Literature

EXPECTED OUTCOMES

The results of the research performed will provide one with a better understanding to applicable BIM methods that the Gouverneur Healthcare Services project could potentially benefit from. Through the research of past case studies and the process of conducting interviews with industry professionals, it is expected that the information collected will provide accurate data to show positive cost and schedule impacts of implementing BIM methods on a project of this magnitude.

GOUVERNEUR HEALTHCARE SERVICES AND BUILDING INFORMATION MODELING

Through a conversation with James Palace, Senior Project Executive at Hunter Roberts Construction Group, it was determined that the project team did in fact use Building Information Modeling during the design and construction of the Gouverneur Healthcare Services project. As mentioned in previous sections of this report, one of the major phases of construction included a complete modernization of the existing mechanical infrastructure including major system components in the mechanical penthouse.

Due to the facility remaining open operative during construction, this scope of work proved to be a challenge for the project team because in many instances, the new equipment would be located where old equipment was. The use of Building Information Modeling was used in the process to plan out the sequencing of the Mechanical Equipment Room reconstruction on the fourteenth floor. A 3D model of this space was created and used to visualize the demolition of the old equipment with the replacement of new equipment. A Primavera schedule of the work to be performed was integrated with the 3D model to create a 4D model to get a better sense of what had to be done, when it had to be done, and what systems were impacted at different times in the schedule. At the end of the day, the 4D model of the work sequence was used to create a color coded video presentation which was used in coordination meetings between all parties including the owner, construction manager, design consultants, and contractors.

Hunter Roberts Construction Group was responsible for this process which included creating a Primavera schedule for the sequence of work and hiring a Building Information Modeling modeler to model the fourteenth floor existing space, existing equipment, and new equipment. The use of Building Information Modeling was not used moving forward because many of the contractors were not up to date on this fairly new technology. As a reminder, pre-construction for this project started back in 2007 when the use of Building Information Modeling was a fairly new concept to the industry so the project was not designed and coordinated through the use of a 3D model.

PROJECT TEAM AND BUILDING INFORMATION MODELING

In order to understand why further Building Information Modeling efforts were not put forth on the Gouverneur Healthcare Services project, it is essential to understand the project team's experience in this aspect of design and construction including the New York City Health and Hospitals Corporation, the Dormitory for the State of New York, and Hunter Roberts Construction Group.

Currently, the use of Building Information Modeling on projects is becoming more of a standard for design and construction, especially with bigger projects where the quality of the contractor is capable of working with this fairly new technology. Hunter Roberts Construction Group is successfully using 3D coordination on a few of their projects including Fiterman Hall, which will be discussed in a proceeding case study, and in pre-construction of the new Durst pyramid residential tower on 57th Street in downtown Manhattan.

The Dormitory for the State of New York and the New York City Health and Hospitals Corporation have not required the use of Building Information Modeling methods in their specifications for many projects, although it is likely that over the next couple years it will start becoming a requirement. Back in 2007 when pre-construction planning actually started for this project, the use of these methods were definitely not a requirement because of how new they were to the industry.

In the current day, however, because the use of Building Information Modeling is becoming more of a standard for design and construction, the project team including the owner, owner's representative, construction manager, designers, and contractors would be capable of implementing the use of a 3D model for coordination on the Gouverneur Healthcare Services project.

3D MODELING AND COORDINATION

In an attempt for a more efficient method of design and construction for the coordination of building systems including structural, mechanical, electrical, and plumbing systems, the idea of utilizing a 3D model to perform coordination of these systems will be analyzed to determine if it would be feasible based on the project conditions. This section of the analysis will examine a case study of a Hunter Roberts Construction Group project that implemented a 3D model for system coordination the project specific implementation of a 3D model on the Gouverneur Healthcare Services project.

FITERMAN HALL CASE STUDY

In order to best understand the potential project impact of implementing a 3D model for building system coordination on the Gouverneur Healthcare Services project, it is essential to understand the success of past projects, particularly Hunter Roberts Construction Group projects that have utilized such technology to coordinate design and construction. The amount of potential success that this project could reap from the application of a 3D model will be measured through the success of the Fiterman Hall project which implemented a 3D model for design and construction to coordinate various building systems.

Figure 19: Fiterman Hall Perspective View

Fiterman Hall is a 400,000 square foot, 14 story educational facility, located in New York, New York, that contains a variety of classrooms computer labs, libraries, art galleries, and staff offices and is being constructed by Hunter Roberts Construction Group for the City University of New York and the Borough of Manhattan Community College. Hunter Roberts Construction

Group utilized a 3D model for the coordination of design and construction between the various building systems that will support the buildings function. The following results are based on the project teams experience and feedback of using a 3D model to perform the coordination and planning on the project. Their experience and feedback has been categorized into three sections including the following:

- Project Start-Up
- Coordination Process
- Project Impact

The following information about the implementation of a 3D model on the Fiterman Hall project is based on an interview with Gavin Schiraldo, Project Manager with Hunter Roberts Construction Group, who was actively involved in the projects 3D coordination process.

PROJECT START-UP

Hunter Roberts Construction Group initially became involved with the Fiterman Hall project with pre-construction services in 2006. As previously mentioned, the use of a 3D model for the coordination of design and construction was a fairly new concept in the industry at this time. Fiterman Hall was traditionally designed by the architects and engineers in two dimensions. It was at the decision of Hunter Roberts Construction Group to initiate the use of a 3D model. One of the first steps in this process was determining a method for modeling. The project team hired a lead, outside source Building Information Modeling modeler to model the architectural, mechanical, electrical, and plumbing components of the building to use for 3D coordination. The overall 3D model can be seen in Figure 20 to the right. The steel subcontractor was the first to be brought on-board with the modeling process. The steel subcontractor would merge their 3D model with the one produced by the lead modeler which would allow for the coordination process to begin.

Figure 20: Fiterman Hall 3D Model

COORDINATION PROCESS

The 3D model created by the lead modeler hired by Hunter Roberts Construction Group was merged with the steel subcontractor's 3D model which would ultimately contain all components necessary for extensive coordination including architectural, structural, mechanical, electrical, plumbing, and fire protection components. Because the steel subcontractor was the first to be brought on-board with the coordination process, the structural steel system was coordinated with the architectural layout of the building to detect any major clashes between the systems. An example of a clash between the structural system and architectural layout detected during the coordination process can be seen in Figure 21, where a toilet stall was designed with a structural column located inside of it. From this point on, the coordination process proceeded as it generally would with traditional, two dimensional coordination. The mechanical subcontractor was the second to be brought on-board in order to perform extensive clash detection between structural steel and mechanical components, followed by the further coordination between system components of the plumbing, fire protection, and electrical subcontractors. Hunter Roberts Construction Group brought all subcontractors in on a weekly basis for coordination to resolve clashes between systems. If there were major clashes between only certain systems, those specific subcontractors were required to meet as necessary to determine a solution.

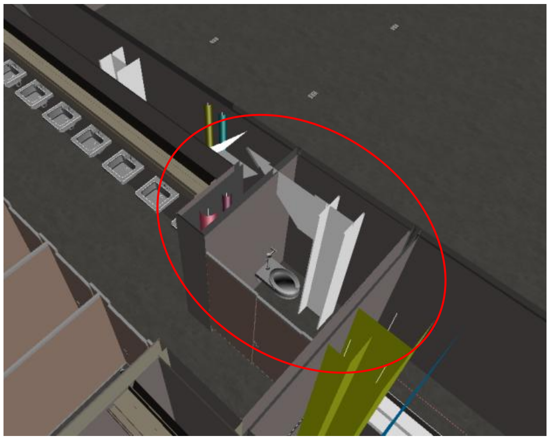


Figure 21: Structural vs. Architectural Clash

PROJECT IMPACT

The overall most beneficial aspect of implementing a 3D model for the coordination of design and construction is that parties involved in coordination are able to look at the building and the systems that support it as a 3D snapshot. It allows for everyone involved to get a more in depth understanding of size and location of system components and how the interact with the other systems.

From the construction management and coordination point of view, through the use of a 3D model and clash detection, the project team at Fiterman Hall was able to dramatically reduce the number of clashes in the field between the building systems by allowing the design team to understand the quantity of clashes prior to construction. From day one of coordination, there was an average of between 75 and 100 clashes detected per floor between all of the building systems. Although difficult determine, the capability of determining clashes before construction most definitely benefitted the project in terms of reducing costs and schedule due to a reduction of change orders and resolution of in the field clashes. The total estimated cost that project was subject to for implementing a 3D model can be seen in Table 5 below.

TABLE 5: PROJECT COST IMPACT OF 3D MODEL AND COORDINATION

Item	Cost	
Building Information Modeling Operator	$	75,000
Added Bulletins as a Result of Coordination	$	10,000
Total	$	85,000

For the construction management team, the use of a 3D model also benefited the project because the team used the model as a resource to plan out crane locations and support and multiple phasing scenarios of major equipment. New York City poses many challenges on terms of site logistics, particularly on the Fiterman Hall project where the project team had no choice but to locate the crane within the building footprint. Figure 22 below shows the structural support system that was put in place to support the tower crane. The 3D model became a very useful tool in visualizing clashes between the added structural support system and the mechanical, electrical, and plumbing system components that support the basement floor. Figure 23 displays the resulting layout of these systems so accommodate the crane support.

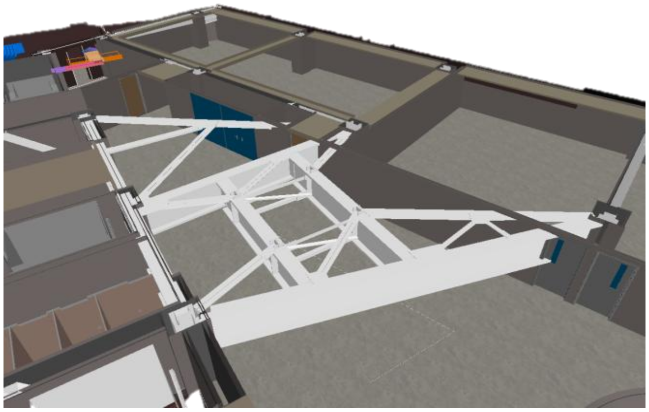


Figure 22: Structural Support System for Crane

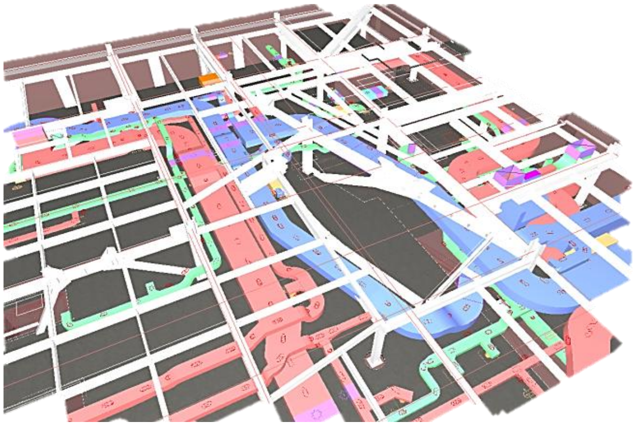


Figure 23: Coordinated MEP Systems in Basement

The project team was said to have benefitted most through the use of a 3D model for the coordination of equipment and components located in the 14th floor penthouse. Located in the 14th floor penthouse is a large amount of mechanical, electrical, and plumbing equipment that supports the buildings function. Due to the size of the air handling units, the project team utilized the 3D model to help visualize various rigging scenarios for the sequencing of installation and help understand sizes of the equipment. The associated components of these air handling units includes major supply and return ductwork that, in most cases, travels the height of the building to provide cooling and heating to the floors. Due to the size of the ductwork, many clashes were detected with other building systems, and even within the mechanical system design itself. Figure 24 and Figure 25 display clashes both within the mechanical system design and with other building system components.

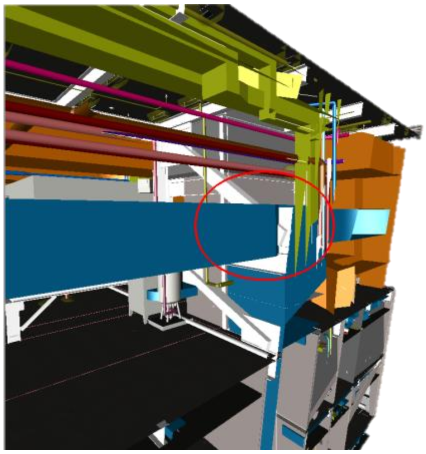


Figure 24: Ductwork vs. Steel Column Clash

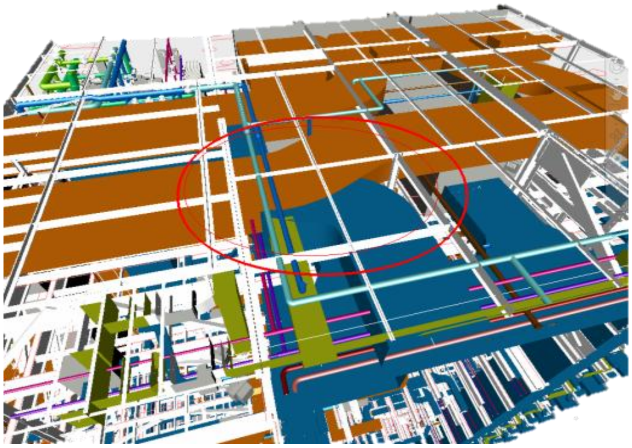


Figure 25: Supply vs. Return Ductwork Clashes

The use of Autodesk Navisworks Manage for coordination allows the user to focus in on a group of clashes between various systems located on a specific floor. By viewing the 3D model as a floor plan, it allows the subcontractors understand what issues need to be resolved in the two dimensional drawings. An example of this can be seen in Figure 26 where a variety of clashes were detected, labeled, and given to the subcontractor to make revisions.

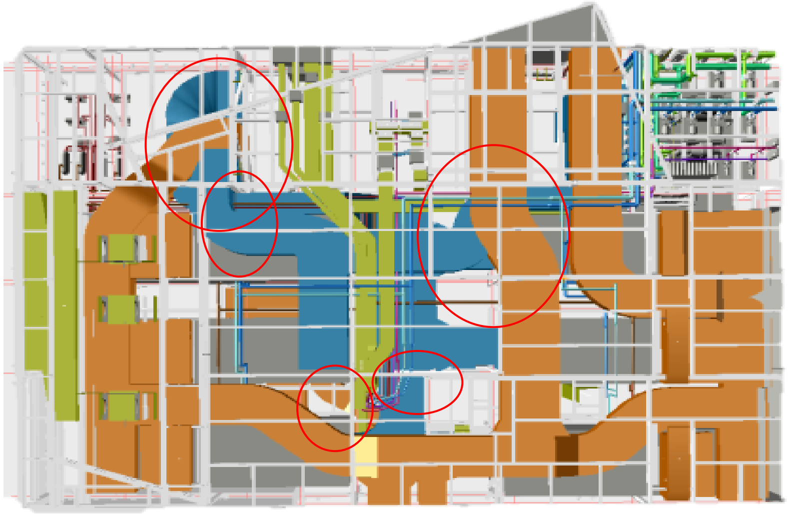


Figure 26: Overview of Penthouse Clashes for Subcontractor

As previously mentioned, day one of clash detection there were between 75 to 100 clashes per floor between building systems. In terms of coordination, there was a lot of time spent by the project team working through every single of those clashes which was stated as one of the downsides to using a 3D model for coordination. There was so much time spent in working the clashes that sometimes everyday tolerances between systems were overlooked, particularly the human error tolerances. Also, because this building is for educational use, there was a high volume of fire dampers built into the mechanical systems design which became difficult to track in the 3D model.

Overall, the project team had much success through the use of a 3D model for coordination of design and construction for the Fiterman Hall project. The 3D model was used extensively for clash detection between the building support systems, as well as to assist with major planning for crane locations and support and multiple phasing scenarios of major equipment. Ultimately, the project team was able to save both cost and schedule through detecting clashes between building system components prior to construction. At the end of the day, the 3D model generated from this project will be turned over to the owner and used to produce as-built drawings. Although not required in the specifications, the owner could use this model, at a later time, for facility management by attaching equipment operations and maintenance manuals, product cut sheets, etc. to components throughout the model.

PROJECT SPECIFIC IMPLEMENTATION

Upon completion of understanding how Hunter Roberts Construction Group implemented a 3D model for the coordination of design and construction of Fiterman Hall, it will be determined based on the specific circumstances of the Gouverneur Healthcare Services project if it would be feasible to do the same. It was previously stated that pre-construction for this project started back in 2007 when the use of Building Information Modeling was a fairly new concept to the industry. However, based on the Fiterman Hall case study, it is believed that even though there may have been a wide learning curve for subcontractors, it would have been beneficial to the project, in terms of cost and schedule, to implement a 3D model.

NEW BUILDING CONSTRUCTION

Based on Hunter Roberts Construction Group’s success with implementing a 3D model for the coordination of design and construction of Fiterman Hall, it definitely seems feasible to have followed the same process that the project team at Fiterman Hall had for the new building construction. The new 109,336 square foot addition contains about $18,235,198 worth of mechanical, electrical, plumbing, and fire protection equipment and components to support the facility's new Surgery, Podiatry, OB/Gyn, Adult Behavioral Program, WIC, and Pharmacy departments.

The high volume of equipment that is to be installed in the new building was designed and coordinated in two dimensions, but based on a change order analysis, it would have been beneficial to perform clash detection through the use of a 3D model. Studies have shown the number of change orders a project endures can be dramatically reduced through the use of a 3D model. Table 6 below shows a breakdown of change order costs due to field conditions, or clashes between systems in the field, based on construction until April 2, 2012. This table, however, does not mean that through the use of a 3D model for coordination the entire quantity of change orders could have been eliminated.

Table 6: Change Order Cost Analysis

Scope of Work	Total Cost of Change Orders
Mechanical System	$ 91,680.00
Electrical System	$ 218,683.00
Plumbing System	$ 226,536.00
Fire Protection System	$ 174,384.00
Total Cost of Change Orders	$ 711,283.00

As previously stated, the Dormitory Authority for the State of New York and the New York City Health and Hospital Corporation did not require the use Building Information Modeling methods in 2007 during pre-construction. Therefore, Hunter Roberts Construction Group would have had to initiate the process and coordination of a 3D model as it was done with the Fiterman Hall project. The costs are assumed to have been approximately the same for hiring a Building Information Modeling modeler at $75,000 and the quantity of added bulletins is expected to be about $5,000 bringing the total cost to about $80,000 to implement a 3D model for the coordination of design and construction.

Some complications may arise when modeling the 3D model due to the fact that the new building is an addition to the existing facility. Although the existing facility would not have to be modeled in detail, much effort would need to be put forth in modeling how the two structures will tie together. In order for this to accurately be done, the construction management team would need to hire surveyors and work with existing as-built drawings of the old facility, which may not be very accurate. Knowing these details also raises concern about whether or not it would be feasible to use a 3D model for the coordination of design and construction in the existing building.

Overall, it is believed that the design and construction of the new building could have benefitted through the implementation of a 3D model as the Fiterman Hall project did. Although difficult to predict, it is believed that through the use of a 3D model, the project could have reduced schedule and change order costs that far exceeds the initial costs for implementing a 3D model.

EXISTING BUILDING DEMOLITION AND RENOVATION

The existing building poses many challenges for implementing a 3D model for coordination of design and construction because the facility is remaining active during demolition and renovation. In order to create a 3D model of an existing facility, the 3D modeler has two options which include either relying on existing as-built drawings or using laser scanning to model the space. The Gouverneur Healthcare Services facility does not seem suitable for either option based on the project conditions.

The existing facility was designed and constructed in late 1960's and early 1970's. If the modeler were to rely on as-built drawings that were over 40 years old, they would take a great risk in modeling inaccurate spaces throughout the building. In many instances, older as-built drawings are known for inaccurate dimensions and locations on the floor layouts, especially with mechanical, electrical, and plumbing equipment. Because the facility is remaining active during construction, some of the main mechanical, electrical, and plumbing lines must remain during construction to continue support the existing spaces that have not been demolished and renovated. Therefore, the modeler would not be able to model the spaces as if the inside of the existing building was completely demolished and consisted of just a core and shell.

A modern alternative to relying on as-built drawings is the use of laser scanning to accurately model the existing space and its supporting components. The use of laser scanning, however, would be not be ideal for this particular project because of how the project is phased to accommodate the owner's needs. As mentioned throughout this report, floors are turned over to construction by the owner on a single basis. When the floors are turned over to construction, the mechanical, electrical, and plumbing systems will have already been coordinated based on two dimensional drawings. Upon turnover, the interior of the floors are demolished and construction immediately begins. In order to accurately model the conditions at the start of renovation on a floor by the use of a 3D model, demolition would have to occur, followed by laser scanning, incorporating the laser scans into the 3D model, coordination between the systems, and then proceed with construction. This process for every floor would be extremely costly in terms of actually using laser scanning, as well as the delays in construction, therefore defeating the entire purpose of using a 3D model.

Overall, it is believed that the design and construction of the existing building would not have benefited through the implementation of a 3D model as the Fiterman Hall project did. This is believed because relying on the existing as-built drawings to model and coordinate old systems with new systems would not be a very accurate approach and the use of laser scanning would be extremely costly and cause delays in construction because of the process involved.

VELA SYSTEMS FOR PUNCHLIST

In an attempt for a more efficient method of performing punchlist in the 445,610 square foot Gouverneur Healthcare Services facility, the idea of utilizing the VELA Systems software to perform the punchlist will be analyzed to determine if it would be feasible based on the project conditions. This section of the analysis will examine a case study of a Hunter Roberts Construction Group project that implemented VELA for punchlist and the project specific implementation of VELA on the Gouverneur Healthcare Services project.

HUDSON GREENE CASE STUDY

In order to best understand the potential project impact of implementing the VELA system for punchlist on the Gouverneur Healthcare Services project, it is essential to understand the success of past projects that have used this technology to manage construction in the field. The amount of potential success that this project could reap from this application will be measured through the success of the Hudson Greene project which implemented VELA enabled tablets for the punchlist process.

The project scope for the construction of Hudson Green, located in Jersey City, New Jersey, consisted of two fifty-story residential towers totaling 1.5 million square feet and a ten floor parking garage. The two residential towers, approximately 1.5 million total square feet, contains about 980 high-end condominium and rental apartment units fitted with floor to ceiling curtain wall glazing, hard wood flooring,

Figure 27: Hudson Greene Towers

marble bathrooms, European-style kitchens, and high end appliances.

The project team at Hunter Roberts Construction Group used VELA Systems throughout the punch listing process to ensure a quality product to the owner at the end of the day. The following results are based on the project teams experience and feedback of using VELA system to perform project closeout punch listing on the two, fifty-story residential space towers. Their experience and feedback has been categorized into four sections including the following:

- VELA System Project Start-Up
- Project Implementation
- Project Closeout and Turnover
- Future Project Recommendations

The project team at Hudson Greene utilized the VELA system software and tablets to perform all work throughout the punch listing phase of the project.

The following information about the implementation of VELA on the Hudson Greene project is based on a Hunter Roberts Construction Group case study supplied by Eve Shapiro, Assistant Project Manager, who was involved in the projects punch listing process.

VELA SYSTEM PROJECT START-UP

Starting with project customization, the staff at VELA was very flexible in accommodating all of the project needs for both the owners of the job, one for each tower, and the Hunter Roberts Construction Group project team. These accommodations included everything from custom tailoring the report layouts to fit what the owners, project team, and other consultants based on what aspects of the projects they wanted to track to customizing how specific areas throughout the building were listed in the software to allow for quicker viewing access by the field personnel. The VELA staff was able to upload quality assurance and quality control checklist specific to the construction manager and owners requirements, which were uploaded into the system and set as the standard checklist for all users of the software to use during their punchlist walkthroughs.

The hardware that was used to implement the VELA punchlist software included desktops, laptops, and portable tablets, which can be seen in Figure 28 to the right. The utilization of the portable tablets allowed for the mobility of VELA in the construction field. Each user becomes equipped with punchlist

Figure 28: VELA Equipped Tablet

technology that allows them to bring the tablet into the field, log issues that are discovered in the field, and even take photos of the issue which would be attached to individual issues in the report printout. The project team on Hudson Greene utilized four total tablets for eight project users. Only four tablets were utilized because the VELA software was also available on desktops and laptops located in the field office.

The total cost for the implementation of the VELA software and tablets on the Hudson Greene project can be seen in Table 7 below.

TABLE 7: VELA SYSTEMS COST BREAKDOWN

Item	Cost
Project Setup on VELA Systems' Servers	$5000 – One Time Cost
VELA Training Session – 1 Day	$3000 – One Time Cost
License Cost per User – 8 Total Users	$200 per Month per User - $1600 per month
Field Tablets – 4 Total Tablets	$3000 per Tablet - $12,000 Total

Based on the overall experience, although this is an expensive upfront cost to implement the VELA system, the costs were quickly overcome by the man hours saved through the gain in efficiency for punchlist, which can be seen in the *Project Use* section of this study.

The cost of training was based on a one day on-site visit from VELA staff who intensively trained the core personnel that would utilize the system for five to seven hours. Those personnel who were trained during this session were then responsible for training the remainder of field personnel on the project and any other parties that would be utilizing the system. The system was rated as highly user-friendly, with a simple point-and-click interface where a non-core user can be trained within an hour to perform in the field punchlist with the VELA equipped tablet. Upon the completion of training, the technical support provided by VELA Systems involved around the clock customer support from project start-up to project implementation to project close-out. This support included a wide variety of assistance including mass data transfer, software updates, maintaining project data, and further customized punchlist reports.

PROJECT IMPLEMENTATION

One of the biggest benefits to implementing the VELA system for punchlist is the efficiency that was gained through its implementation. The use of a VELA equipped tablet allowed for basically all punchlist tasks to be performed out in the field, which ultimately eliminated the need handwrite in the field punch lists and return to the office to fill out various punchlist and quality assurance and control forms for owner or subcontractor submission. Table 8 below shows a breakdown of man hours using traditional punchlist procedures versus the VELA punchlist procedure on the Hudson Greene project. The man hours shown in the table are based on a best case scenario on a single floor containing twelve units after personnel full adapted to using VELA as the primary punch listing tool.

TABLE 8: TRADITIONAL PUNCHLIST VERSUS VELA PUNCHLIST PROCEDURE [6]

Traditional Punchlist Procedure	Man Hours	VELA Punchlist Procedure	Man Hours
HRCG punchlist hand written during walkthrough	16	HRCG punchlist entered into Vela during walkthrough	5
HRCG punchlist entered into Excel and delivers copy to Owner	8	Punchlist uploaded to system via Sync and Owner instantly receives punchlist	0
Owner reviews hard copy and adds handwritten list to punchlist	48	Owner reviews and adds to punchlist via Vela	16
Owner enters hand written items into excel and emails them to HRCG	8	Owner uploads revised punchlist via Sync – HRCG instantly receives list	0
HRCG combines lists in excel, sorts by subcontractor and prints legible reports for Sub to complete	6	HRCG prints list by sub out of Vela and provides to Subcontractor	1
Subcontractor completes list	-	Subcontractor completes list	-
HRCG reviews list to see if complete and hand writes updates	16	HRCG reviews list to see if complete	5
HRCG updates Excel spreadsheet to reflect updates	8	HRCG updates Vela to reflect updates via Sync	0
Owner reviews updated Excel spreadsheet to confirm items as completed	16	Owner reviews Vela to confirm items updated are completed	6
List of completed items is updated in Excel and returned to HRCG	8	List of completed items is updated in Excel and returned to HRCG via Sync	0
Total Hours Prior to Vela	134	Total Hours Using Vela	33

Based on the table above, the Hudson Greene project team was able to save 101 hours per floor per tower in man hours through the use of the VELA equipped tablets. Comparing the traditional punchlist procedure man hours to the VELA punchlist procedure man hours, it is estimated that the project team was able to save a total of 10,100 man hours for punch listing 12 units per floor per tower.

The user-friendliness of the VELA interface allowed Hunter Roberts Construction Group to assign assistant project managers and administrative assistants to create punch lists which saved costs and time associated with project manager and/or superintendents performing the same task. As previously mentioned, the construction manager and owner were able to create customized lists of what is expected during the punchlist process which was used to train personnel on re-occurring items that were addressed. The VELA staff was also able to train personnel in knowing the quality of interior finish qualities without a time consuming learning curve.

Document management is a very important aspect of successfully completing the punchlist process on a project. The utilization of the VELA system allowed the project team to upload a variety of documents including drawings, specifications, Requests for Information, etc. to the data base for access on the laptop software or on the tablets. During the punchlist process, any issues that were determined in the field allowed personnel to attach the document with the location of the issue identified along with any pictures of issue that were taken with the tablet. When an issue was documented within the VELA data base, a history of issues was created which allowed the project team to recall issues for cost or time analysis.

Another important benefit of implementing the VELA system for punchlist is the increase of communication between the owners, architect, design consultants, construction management team, and the subcontractors. With the use of VELA, the automatic sync of information stored on the tablet to the laptops allowed for instant communication of punch lists between all parties. For owners, the increase in communication allowed them to play a more active role in approving what work was complete versus incomplete and allowed them to update this status instantly in the VELA system. The instantaneous communication from the owners allowed Hunter Roberts Construction Group to quickly respond to their concerns and relay messages to subcontractors. The subcontractors used the VELA reports as a valuable tool for efficiently completing their work and getting paid on time. Since much of the punchlist work was repetitive, the trades recognized this and were able to eliminate much of the punchlist process on the upper floors of the building by addressing repeated items before the punchlist process. The use of VELA also increased communication between the construction manager, the architect, and other design consultants to facilitate sign-off meetings.

PROJECT CLOSEOUT

The VELA system was used as a primary tool for project closeout by the owner to ensure that all punchlist items were complete before the owner approved final payments for the building. At the completion of the project, the field tablets were turned over to the owner for future use to manage building operations and maintenance.

FUTURE PROJECT RECOMMENDATIONS

Based on the Hudson Greene project teams' experience, the following feedback was given for future project implementation of the use of VELA Systems for punch listing. New technologies for portable tablets are available such as the Apple iPad, which VELA has created an application, which will reduce the cost from $3000 a tablet to about $700. Because Hunter Roberts Construction Group personnel have already been intensively trained to operate the VELA software, future training costs from VELA Systems can be eliminated through internal training sessions. During bidding, the VELA System could have been used as a tool to state contract expectations for various interior finish items by specifying the finish levels on pre-loaded lists in the program for subcontractors to follow during bidding and construction.

Although the project team at Hudson Greene only utilized the punchlist function of the VELA software, the use of all other VELA modules could have been beneficial to the project. With a more in-depth document upload, the tablets could have been turned over as an entire closeout package that could be used by the owners for facility management. The Request for Information VELA module could have been used to increase the communication to all parties on the project and help maintain an organized log of all incoming RFI's and responses. In addition to punchlist field technology, VELA has a module that allows superintendents to fill out and update daily reports in the field rather than in notebooks and recording reports in the office. For use of all trades on a project, the VELA QA/QC module could have been utilized to set standards and expectations for what is expected by the owner, construction manager, and design team prior to issues showing up on the punch lists.

Overall, the project team at the Hudson Greene project was able to successfully implement the VELA Systems software to increase efficiency of the punchlist process in both 50 story towers. The costs of utilizing the field tablets for this process was quickly overcome by the savings in man hours

PROJECT SPECIFIC IMPLEMENTATION

Upon completion of understanding how Hunter Roberts Construction Group successfully implemented the VELA Systems software for the punchlist process on the Hudson Greene project, it has been determined that the Gouverneur Healthcare Services project has the potential to reap the same amount of success, if not more, by increasing efficiency during the punchlist process.

Based on the lessons learned from the Hudson Greene project, there are some cost savings available due to new technologies and Hunter Roberts Construction Group's personnel experience with the VELA punchlist system. The total cost for the implementation of the VELA software and tablets on the Hudson Greene project can be seen in Table 9 below. As shown in the table, the one day VELA training session has a zero cost associated with it because Hunter Roberts Construction Group can take advantage of their personnel's experience and hold training sessions within the company at no extra cost. Additionally, advanced technologies would allow the project team to utilize the VELA software in the field through the use of iPad's rather than the traditional tablets. Due to the size of the project, only two iPad's would be needed for about four core users including two assistant superintendent's and two assistant project manager's.

TABLE 9: VELA SYSTEMS COST BREAKDOWN

Item	Cost
Project Setup on VELA Systems' Servers	$5000 – One Time Cost
VELA Training Session – 1 Day	$0
License Cost per User – 4 Total Users	$200 per Month per User - $800 per month
Field Tablets – 2 Total Tablets	$700 per Tablet - $1,400 Total

Although this is a reduced cost compared to the Hudson Greene project, it may still seem as an expensive upfront cost to implement the VELA system. The costs, however, can be quickly overcome by the man hours saved through the gain in efficiency for punchlist. The man hours shown in Table 10 are based on expected punchlist results for a single residential floor containing 40 units, which are identical from floors six through eleven.

TABLE 10: TRADITIONAL PUNCHLIST VERSUS VELA PUNCHLIST PROCEDURE

Traditional Punchlist Procedure	Man Hours	VELA Punchlist Procedure	Man Hours
HRCG punchlist hand written during walkthrough	25	HRCG punchlist entered into Vela during walkthrough	8
HRCG punchlist entered into Excel and delivers copy to Owner	13	Punchlist uploaded to system via Sync and Owner instantly receives punchlist	0
Owner reviews hard copy and adds handwritten list to punchlist	48	Owner reviews and adds to punchlist via Vela	16
Owner enters hand written items into excel and emails them to HRCG	13	Owner uploads revised punchlist via Sync – HRCG instantly receives list	0
HRCG combines lists in excel, sorts by subcontractor and prints legible reports for Sub to complete	9	HRCG prints list by sub out of Vela and provides to Subcontractor	2
Subcontractor completes list	-	Subcontractor completes list	-
HRCG reviews list to see if complete and hand writes updates	16	HRCG reviews list to see if complete	5
HRCG updates Excel spreadsheet to reflect updates	13	HRCG updates Vela to reflect updates via Sync	0
Owner reviews updated Excel spreadsheet to confirm items as completed	16	Owner reviews Vela to confirm items updated are completed	6
List of completed items is updated in Excel and returned to HRCG	8	List of completed items is updated in Excel and returned to HRCG via Sync	0
Total Hours Prior to Vela	160	Total Hours Using Vela	36

Based on the table above, it is estimated that the project team could save about 124 hours per residential floor in man hours through the use of the VELA equipped tablets. Comparing the traditional punchlist procedure man hours to the VELA punchlist procedure man hours, it is estimated that the project team could save a total of 865 man hours for punch listing 40 units per floor for seven residential floors.

The man hours shown in Table 11 are based on expected punchlist results for exam and procedure room floors containing an average of 60 units, which reflects floors two through five.

TABLE 11: TRADITIONAL PUNCHLIST VERSUS VELA PUNCHLIST PROCEDURE

Traditional Punchlist Procedure	Man Hours	VELA Punchlist Procedure	Man Hours
HRCG punchlist hand written during walkthrough	40	HRCG punchlist entered into Vela during walkthrough	13
HRCG punchlist entered into Excel and delivers copy to Owner	20	Punchlist uploaded to system via Sync and Owner instantly receives punchlist	0
Owner reviews hard copy and adds handwritten list to punchlist	48	Owner reviews and adds to punchlist via Vela	16
Owner enters hand written items into excel and emails them to HRCG	20	Owner uploads revised punchlist via Sync – HRCG instantly receives list	0
HRCG combines lists in excel, sorts by subcontractor and prints legible reports for Sub to complete	15	HRCG prints list by sub out of Vela and provides to Subcontractor	3
Subcontractor completes list	-	Subcontractor completes list	-
HRCG reviews list to see if complete and hand writes updates	16	HRCG reviews list to see if complete	5
HRCG updates Excel spreadsheet to reflect updates	20	HRCG updates Vela to reflect updates via Sync	0
Owner reviews updated Excel spreadsheet to confirm items as completed	16	Owner reviews Vela to confirm items updated are completed	6
List of completed items is updated in Excel and returned to HRCG	8	List of completed items is updated in Excel and returned to HRCG via Sync	0
Total Hours Prior to Vela	203	Total Hours Using Vela	42

Based on the table above, it is estimated that the project team could save about 161 hours per exam and procedure room floor through the use of the VELA equipped tablets. Comparing the traditional punchlist procedure man hours to the VELA punchlist procedure man hours, it is estimated that the project team could save a total of 1127 man hours for punch listing 60 units per floor for seven residential floors.

Based on the two previous tables, it is estimated that the project could save almost 2000 man hours through the use of the VELA equipped tablets for the punchlist process. A man hour savings of almost 2000 can quickly overcome the initial cost of the system of about $25,000. Based on the efficiencies gained on the Hudson Greene project and the estimated savings in man hours, it would be feasible to utilize the VELA Systems software for the punchlist process on the Gouverneur Healthcare Services project.

SUMMARY AND CONCLUSIONS

- It was determined that the project team did in fact use Building Information Modeling during the design and construction of the Gouverneur Healthcare Services project for the coordination and sequencing of the Mechanical Equipment Room reconstruction on the fourteenth floor.
- Based on the success of the use of Building Information Modeling methods on the Fiterman Hall project, it was determined that it would be feasible to use a 3D model for the coordination of design and construction on the Gouverneur Healthcare Services project and doing so could have reduced schedule and change order costs that far exceeds the initial costs for implementing a 3D model.
- It was determined that it would not be feasible to use a 3D model, however, for the coordination of design and construction for the existing facility because of complications with the phasing of the project. Relying on the existing as-built drawings to model and coordinate old systems with new systems would not be a very accurate approach and the use of laser scanning would be extremely costly and cause delays in construction because of the process involved.
- Based on the success of utilizing the VELA Systems software equipped tablets on the Hudson Greene project, it was determined that it would be feasible to utilize the VELA Systems software for the punchlist process on the Gouverneur Healthcare Services project, using with more advanced technology currently available on the market.
- It was determined that through the utilization of VELA equipped iPad’s, the initial cost of the system is about $25,000, but can be quickly overcome by the estimated 2000 man hour savings by increasing the efficiency of the punchlist process.
- In conclusion, through the implementation of a 3D model for design and construction coordination for the new building construction and the utilization of VELA equipped iPad’s to increase the efficiency of the punchlist process, the project has the potential to reduce schedule, decrease the quantity of change orders, and reduce the number of man hours spent on the punchlist process.

TECHNICAL ANALYSIS II: SCHEDULE RE-SEQUENCING AND TENANT OCCUPANCY

PROBLEM IDENTIFICATION

The Gouverneur Healthcare Services facility will remain fully operational for staff and patients throughout six major phases from the beginning of construction to project substantial completion. Because of these circumstances, demolition and renovation of the existing thirteen story building is highly phased, where the owner turns over floors to construction in a scattered ordered. The order in which floors are turned over to construction reduces flow efficiency because subcontractors mobilize and demobilize individual, random floors throughout the duration of construction of the existing building. The design for residential floors six through eleven contain identical floor layouts and share a phasing relationship where the completion of each floor affect the dates in which the other floors are turned over by the owner to construction. This phasing relationship is also affected by the duration in which it takes the owner to transfer occupants from existing to completed spaces.

RESEARCH GOALS

The goal of this analysis is to perform an in-depth schedule re-sequencing in order to make it possible for the owner to turn over floors to construction in a more efficient and grouped manner. The ultimate goal is to accelerate the schedule by grouping identical floor turnovers to construction, increasing the efficiency in which the owner transfers occupants from existing to completed spaces, and increasing the efficiency of construction flow between floors.

METHODOLOGY

- Interview James Palace, Senior Project Executive, at Hunter Roberts Construction Group and owner representatives to better understand the approach for the schedule phasing of the project
- Re-sequence the schedule based on identical floor relationships and develop an understanding for why durations are different between these floors
- Evaluate how the project team currently strategizes the mobilization and demobilization of trades throughout the duration of construction for the existing building and compare to proposed schedule re-sequencing
- Assess the schedule impact as a result of re-sequencing and the cost savings associated with re-sequencing the schedule

- Research and apply methods related to facilities management such as FM:Systems software for a more efficient process of moving occupants into new spaces

RESOURCES AND TOOLS

- Project Staff of Hunter Roberts Construction Group
- Owner Representatives for the Gouverneur Healthcare Services facility and the New York City Health and Hospitals Corporation
- Representatives of FM:Systems
- Microsoft Project 2012 for Schedule Re-Sequencing
- Department of Architectural Engineering Faculty
    - Dr. John Messner
    - Dr. Robert Leicht
    - Dr. Craig Dubler
    - Dr. Chimay J. Anumba
- Penn State BIM Project Execution Planning Guide V2.0
- Applicable Literature

EXPECTED OUTCOMES

Upon completion of this analysis, it is expected that a more efficient phasing sequence can be implemented for the demolition and renovation phases of existing thirteen story building. Through an in-depth analysis of the schedule, it is expected that the owner can turnover identical floors to construction by grouping them together during turnover based on their relationship to one another. Research on facilities management tools, such as FM:Systems, related to occupancy move-in is expected to display more efficient and organized methods for transferring occupants from existing to completed spaces. The organized floor turnover sequence and occupancy move-in is expected to reduce the overall duration of the schedule, thus reducing overall costs for the project.

RE-SEQUENCING THE PROJECT SCHEDULE

In a complexly phased project, it is essential to understand the project schedule and who is affected when making changes to the schedule. Specifically to the Gouverneur Healthcare Services building, understanding floor plans in the existing building both before and after construction are critical pieces of information to understand when phasing a project of this magnitude. Because the existing facility is undergoing a phased demolition and renovation in order to remain active during construction, the project team must understand what facility departments are located on each floor prior to construction, as well as their designated floor after construction is complete.

The schedule for the Gouverneur Healthcare Services becomes very challenging for the project team because the old and new floors plans for the existing building are not designated for the same departments and uses. Therefore, a re-sequencing of the schedule will require an understanding to where departments will be located before and after construction. For the purpose of this analysis, the floors that are being considered for a sequencing of the schedule are the sixth through eleventh floors of the existing building. The design for residential floors six through eleven contain identical floor layouts and share a phasing relationship where the completion of each floor affect the dates in which the other floors are turned over by the owner to construction. It has also been determined that the old and new floor plans for these floors contain the same space designation, where these floors will serve as residential spaces before and after construction. This overall phasing of the existing building schedule can be seen in Figure 29. The original project schedule that will be referenced and re-sequenced for this analysis is located in Appendix C.

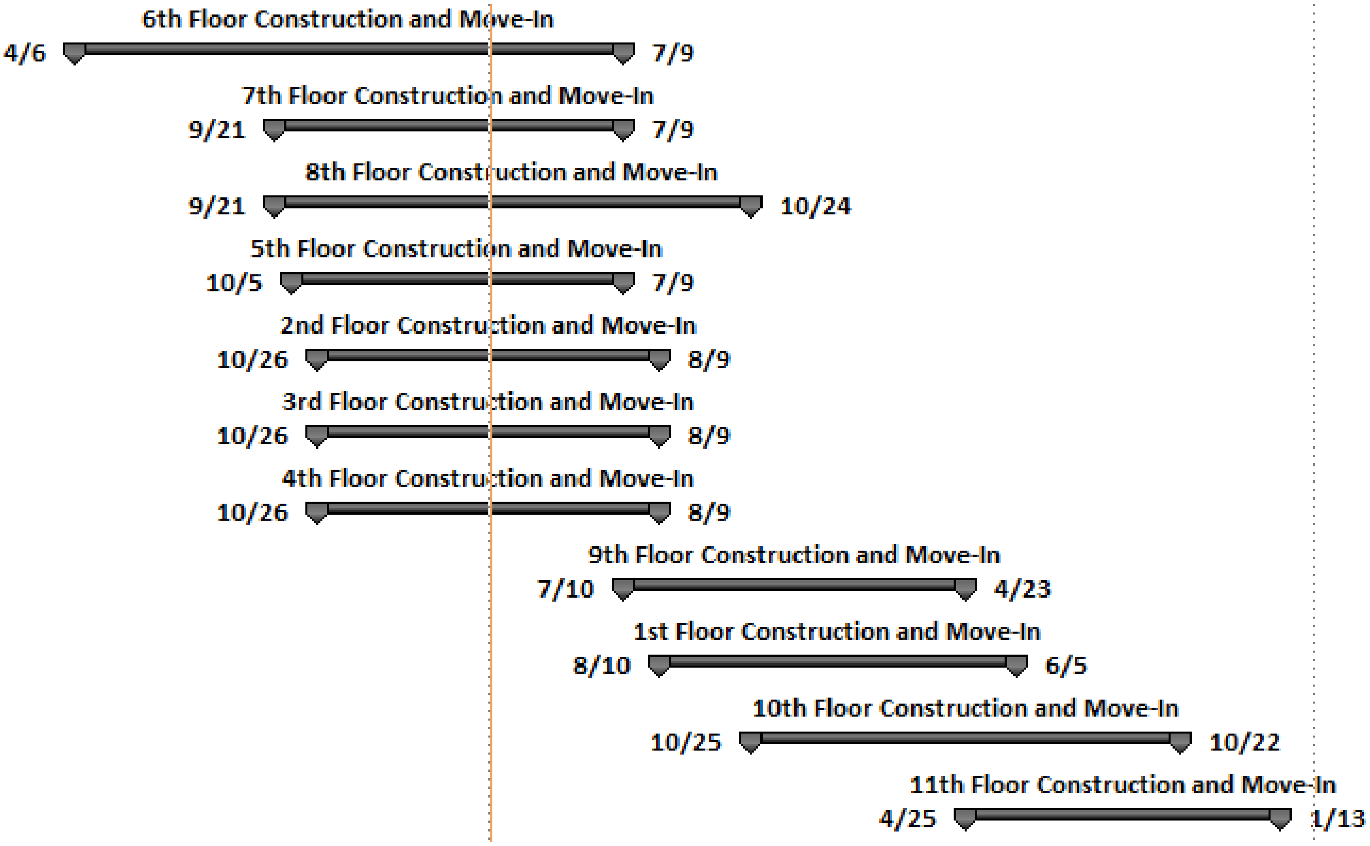


Figure 29: Overall Existing Building Schedule Phasing

The purpose of this analysis will be to see the affects in terms of schedule savings, cost savings, and project logistics by performing a schedule re-sequence that applies a finish-to-start relationship between floors six, seven, and eight and floors nine, ten, and eleven. The logic behind why a re-sequencing of the schedule seems feasible is because of the existing space designations of the floors prior to construction. Also, by September 21, 2011 during the first phase of residential floor construction and move-in, the facility has three floors, six through eight, turned over to construction at one time. Therefore, it is feasible in the second phase of residential floor construction and move-in for the facility to create a direct relationship between the remaining residential floors, where by October 25, 2012, floors nine through eleven can be turned over to construction at one time. The direct relationship in the schedule between residential floors six through eleven upon completion of re-sequencing the schedule can be seen in Figure 30.

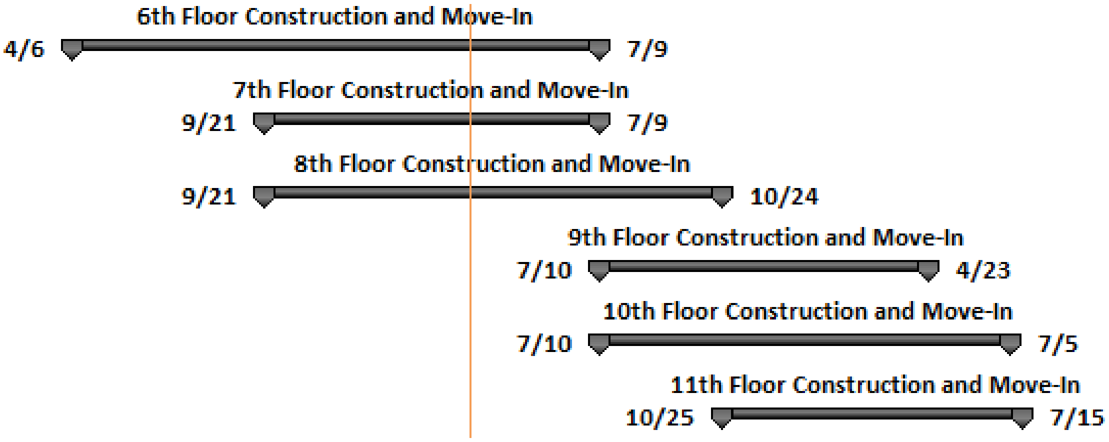


Figure 30: Re-sequencing of Schedule Phasing for Floors Six through Eleven

The following are descriptions of the phasing relationships between residential floors six through eleven and can be seen in Figure 31, Figure, 32, and Figure 33:

- 9th Floor Construction and Move-In cannot proceed until the completion of the 6th Floor Construction and Move-In and the two activities share a Finish-to-Start relationship

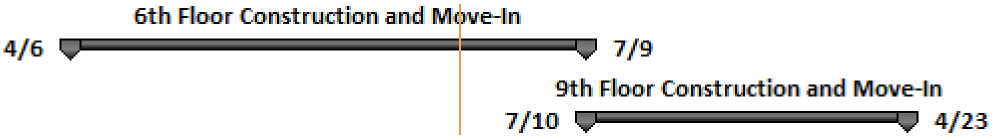


Figure 31: Phasing Relationship between Floors Six and Nine

- 10th Floor Demolition and Renovation has a Finish to Start relationship with the 7th Floor Construction and Move-In

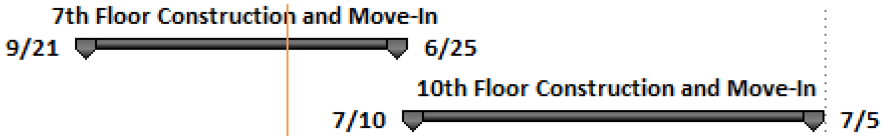


Figure 32: Phasing Relationship between Floors Seven and Ten

- 11th Floor Demolition and Renovation has a Finish to Start relationship with the 8th Floor Construction and Move-In

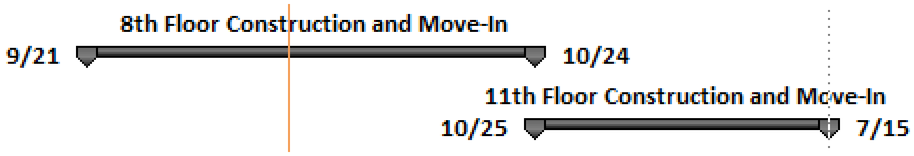


Figure 33: Phasing Relationship between Floors Eight and Eleven

Table 12 shows a comparison of start and finish dates of the original schedule versus the re-sequenced schedule and the total schedule duration saved.

TABLE 12: ORIGINAL AND RE-SEQUENCED SCHEDULE REDUCTION

Task Name	Original Schedule		Re-Sequenced Schedule		Duration Saved
	Start	Finish	Start	Finish	
6th Floor Construction and Move-In	4/6/2011	7/9/2012	4/6/2011	7/9/2012	0
7th Floor Construction and Move-In	9/21/2011	7/9/2012	9/21/2011	7/9/2012	0
8th Floor Construction and Move-In	9/21/2011	10/24/2012	9/21/2011	10/24/2012	0
9th Floor Construction and Move-In	7/10/2012	4/23/2013	7/10/2012	4/23/2013	0
10th Floor Construction and Move-In	10/25/2012	10/22/2013	7/10/2012	7/5/2013	107
11th Floor Construction and Move-In	4/25/2013	1/13/2014	10/25/2012	7/15/2013	182
Project Substantial Completion	12/30/2013	12/30/2013	7/15/2013	7/15/2013	168

This schedule duration saved shown in Table 12 implies through the re-sequencing of the project schedule, the 10th floor construction and move-in can begin construction 107 days earlier, the 11th floor construction and move-in can begin construction 182 earlier, and the overall project substantial completion duration will be reduced by 168 days. In Technical Assignment II, it was determined that the general conditions for this project cost the owner approximately $300,380 per month, which is equivalent to about $10,013 per day. Table 13 displays the total cost savings in general conditions upon re-sequencing the project schedule.

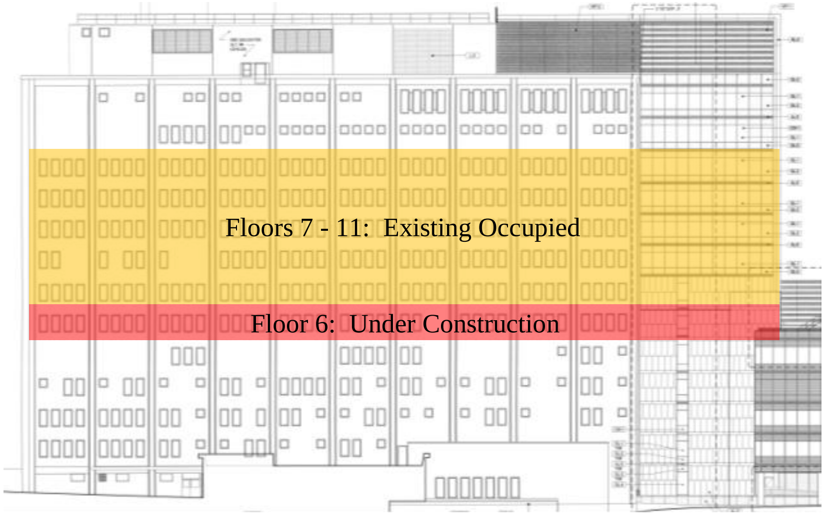
TABLE 13: SCHEDULE RE-SEQUENCING GENERAL CONDITIONS COST SAVINGS

Task Name	Duration Saved	General Conditions per Day	Total Cost Savings
Project Substantial Completion	168	$ 10,013	$ 1,682,184
Total			$ 1,682,184

As shown in Table 13, the total general condition costs that could be saved through re-sequencing the schedule is $1,682,184.

CONSTRUCTION IMPACT

Through re-sequencing the project schedule, there is an expected increase in flow efficiency for trades because the newly re-sequenced schedule for the residential floors develops a positive relationship between floors six through eleven. Although the floors will still be turned over to construction by the owner on an individual basis, this relationship will allow subcontractors to mobilize and demobilize in a more organized manner by moving up the building from floor six, seven, and eight to nine, ten, and eleven rather than the previously scattered ordered. The following figures, Figure 34 through Figure 37, depict how contractors will be able to establish an efficient flow of work by working their way up the building in order from floors six to eleven.



LEGEND

🟨 Occupied Floors

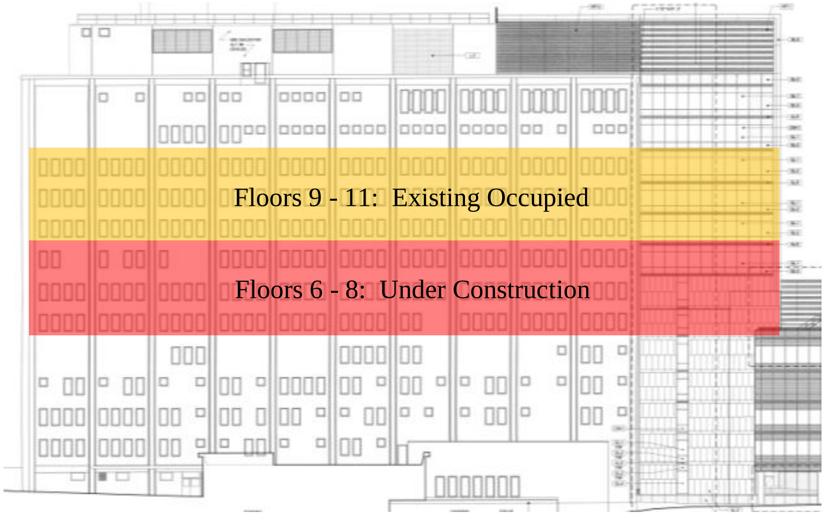
🟥 Under Construction

PHASE I

Mobilize 6th floor for demolition and renovation

Floors 7 through 11 remain occupied by the owner

Figure 34: Building Elevation of Work Flow – Phase I



PHASE II

6th floor remains mobilized for demolition and renovation

Mobilize 7th and 8th floor for demolition and renovation

Floors 9 through 11 remain occupied by the owner

Figure 35: Building Elevation of Work Flow – Phase II

LEGEND

🟨 Occupied Floors

🟥 Under Construction

PHASE III

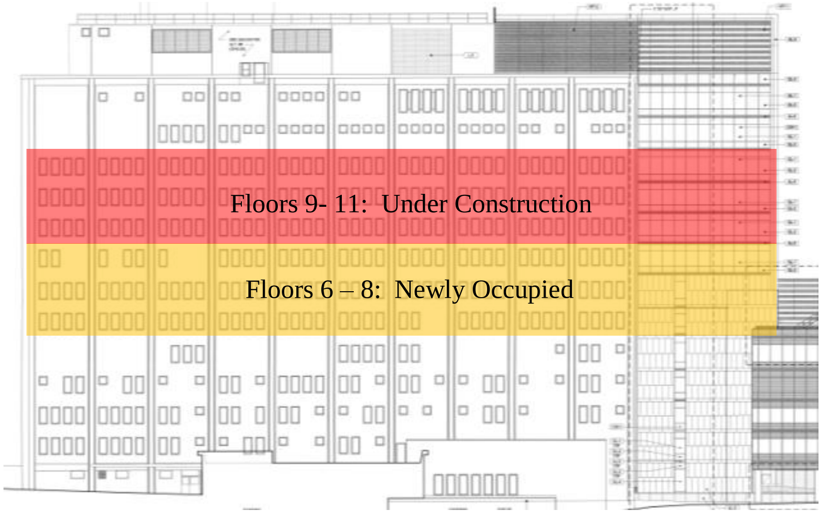
6th and 7th floor are demobilized, turned over to the owner, and newly occupied

8th floor remains mobilized

Mobilize 9th and 10th floor for demolition and renovation

11th floor remains occupied by the owner

Figure 36: Building Elevation of Work Flow – Phase III



PHASE IV

8th floor is demobilized, turned over to the owner, and newly occupied

Floors 9 and 10 remain mobilized for demolition and renovation

Mobilize 11th floor for demolition and renovation

Floors 9 through 11 will be demobilized, turned over to the owner, and newly occupied at the end of Phase 4

Figure 37: Building Elevation of Work Flow – Phase IV

Based on the previous Figures, it is clear that an efficient flow of work can be created from floor to floor for residential floors six through eleven through re-sequencing the schedule. This will not only positively affect the mobilization and demobilization of the subcontractors, but also positively affect worker productivity because there will be less travel distance to obtain tools and materials. The relationship created through re-sequencing the project schedule is similar to traditional construction where the flow of work proceeds from the bottom floors to the top floors in order to create an efficient work flow.

OWNER CONCERNS

Through re-sequencing the phasing of the schedule for floors six through eleven of the Gouverneur Healthcare Services facility, there are expected concerns from the owner including a business plan to make up for the loss of revenue by turning these floors over to construction earlier and a plan of action for relocating occupants on those floors.

FACILITY BUSINESS PLAN

In order for the Gouverneur Healthcare Services facility to make revenue, it must be able to accommodate incoming patients because they are the primary source for income. However, through re-sequencing the project schedule, the owner will have to turn over floors ten and eleven earlier than the original schedule, which will reduce from possible revenue from patients on that floor.

With the knowledge of duration saved by beginning the construction and move-in on the tenth and eleventh floors earlier than the original schedule, one can make the comparison of possible revenue that can be accrued if the re-sequencing had not been performed versus the amount of money that can be saved through construction general conditions of Hunter Roberts Construction Group. A study from the Department of Health for the State of New York stated that in 2008 the average cost for patients in long-term residential care spaces is $226.80 per day [9]. Based on the studies increase in costs by from previous years by about 3% per year, the 2012 equivalent cost is approximately $255.27 per day. This number was confirmed as an acceptable rate by Dennis G. Shea, Department Head of Health Policy and Administration at The Pennsylvania State University and Kevin Hannifan of the New York University Medical Center. Based on this revenue, Table 14 was created to display the loss in revenue by re-sequencing the schedule. The 10th and 11th floor prior to construction can both accommodate about 40 patients per floor and the costs shown in Table 14 assume that the facility can meet an average of 50% occupancy every day for the total duration saved through re-sequencing the schedule.

TABLE 14: SCHEDULE RE-SEQUENCING REVENUE LOSS

Task Name	Duration Saved	Patient Revenue	Patients per Floor	Total Revenue
10th Floor Construction and Move-In	107	$ 255.27	20	$ 546,278
11th Floor Construction and Move-In	182	$ 255.27	20	$ 929,1823
Total				$ 1,475,461

The total revenue that the facility could have accrued through the duration saved in the re-sequenced schedule is approximately $1,475,461.

Although the 10th floor and 11th floor construction and move-in line items were able to save a combination of 289 days, the overall project substantial completion date was only reduced by a total of 168. Therefore, with 168 total days of schedule reduction, the general conditions cost that were saved as a result of the schedule re-sequencing was approximately $1,682,184. A comparison of the general condition costs savings versus revenue through re-sequencing the schedule can be seen in Table 15.

TABLE 15: SCHEDULE RE-SEQUENCING REVENUE LOSS VERSUS GENERAL CONDITIONS SAVINGS

Item	Cost
General Conditions of Construction Manager	$ 1,682,184
10th and 11th Floor Revenue Loss	$ (1,475,461)
Total Cost Savings	$ 206,723

As seen in Table 15, if the facility were to maintain an average of 50% occupancy on the 10th and 11th residential floors, overall the owner can save about $206,732 in general condition costs after subtracting out the potential revenue loss, through the re-sequencing of residential floors six through eleven of the Gouverneur Healthcare Services facility.

OCCUPANT RELOCATION PLAN

Another concern that the owner may have through the re-sequencing of the schedule is that the occupants on the 10th floor will need to be relocated 107 days earlier and the 11th floor will need to be relocated 168 days earlier. As with the previous residential floors, six through eight, the facility will have to relocate the occupants either to other floors in the building or to other healthcare facilities in the nearby area. Figure 38 is a map of New York City which displays the all of the New York City Health and Hospitals Corporation managed facilities in the Manhattan, Bronx, Brooklyn, Queens, and Staten Island areas.

HEALTHCARE FACILITY LIST

MANHATTAN
Bellevue
Coler-Goldwater
Gouverneur
Harlem
Metropolitan
Renaissance

BROOKLYN
Coney Island
Cumberland
East New York
Kings County
McKinney
Woodhull

QUEENS
Elmhurst
Queens

BRONX
Jacobi
Lincoln
Morrisania
North Central Bronx
Belvis

STATEN ISLAND
Sea View
Mariner's Harbor
Stapleton

Figure 38: Healthcare Facility Map and List Courtesy of New York City Health and Hospitals Corporation

The facilities that would be used in the relocation plan for the Gouverneur Healthcare Services facility based on distance and related services are as follows:

- Bellevue Hospital Center, 462 First Avenue, New York, New York, 10016
- Coler-Goldwater Specialty Hospital and Nursing Facility, Franklin D. Roosevelt Island, New York, New York, 10044
- Cumberland Diagnostic and Treatment Center, 100 North Portland Avenue, Brooklyn, New York, 11205
- Woodhull Medical and Mental Health Center, 760 Broadway, Brooklyn, New York, 11206

With the knowledge of knowing where nearby facilities are located, the Gouverneur Healthcare Services facility can work with the New York City Health and Hospitals Corporation in determining appropriate relocation facilities for the patients on the 10th and 11th floors.

FACILITY MANAGEMENT TOOLS

An aspect of the Gouverneur Healthcare Services project that can further benefit both the owner and construction is a more efficient and effective method of facility management. There are many facility management tools and software made available to developers, owners, and construction management companies to support all aspects of the buildings business processes for operations and maintenance. The purpose of this analysis is to identify a computer-aided facility management tool that can assist in reducing the schedule duration for occupancy-move for the newly constructed and renovated spaces of the building.

FM:SYSTEMS

FM:Systems is a company that provides computer-aided facility management software in order to drive process efficiency, improved reporting and facilitating better planning. The product of FM:Systems that will be further analyzed for implementation on the Gouverneur Healthcare Services facility is the web-based FM:Interact Workplace Management Suite and FM:Interact Modules which utilize the following modules:

FM:INTERACT WORKPLACE MANAGEMENT SUITE

- Space Management
- Strategic Planning
- Asset Management

FM:INTERACT MODULES

- Maintenance Management
- Project Management
- Move Management
- Real Estate Portfolio Management
- Sustainability

By providing such a wide variety of facility management software, FM:Systems allows multiple participants of an organizations business and maintenance processes to become involved in using their software. The FM:Interact Workplace Management Suite is the core product that is used for facility management and the additional FM:Interact Modules can be utilized in addition to the suite for project specific facility management needs which will be further discussed in this analysis. The information discussed in this portion of the analysis was obtained through documents provided by Leasha Jackson, Lead Development Representative for FM:Systems, Inc.

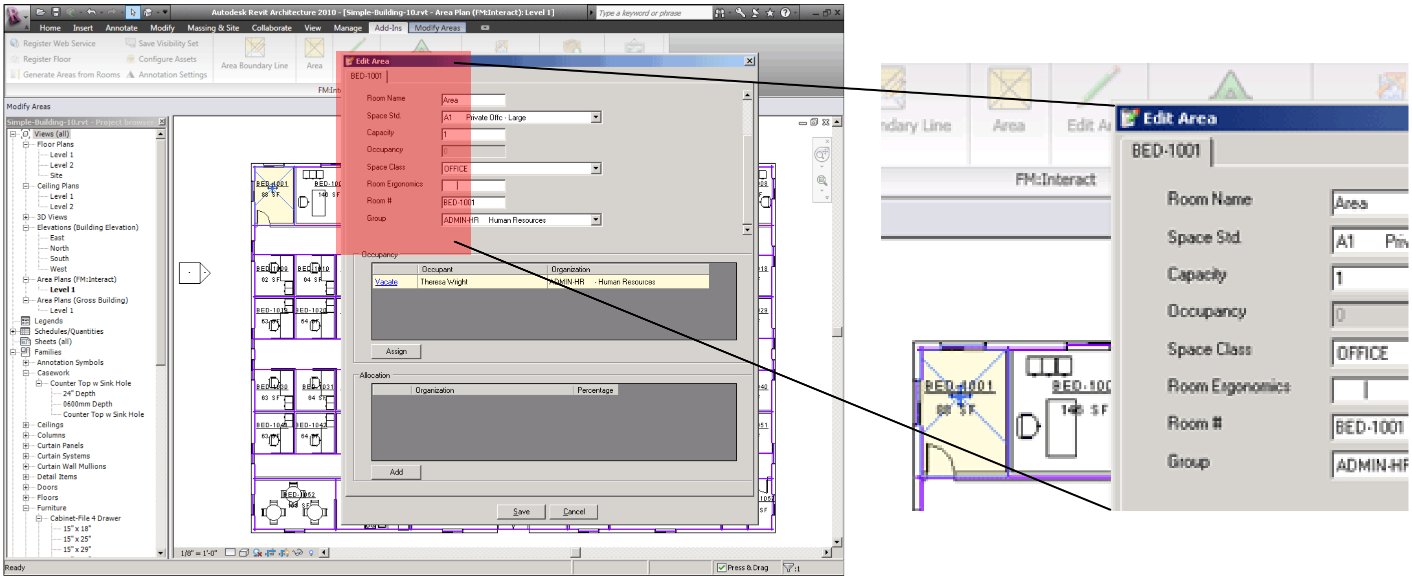
FM:SYSTEMS AND BIM

One of the unique aspects of the FM:Interact product is the new BIM integration component which allows for a direct integration between the FM:Systems software and Autodesk Revit Architecture software. The use of the BIM integration component allows for an integration of the project architectural, engineering, and construction model to be utilized in the FM:Systems software for facility management purposes which ranges of space management to financial management to system maintenance. This integration allows the architect, engineers, construction management team, and facility managers to share building information as the project progresses from initial design and construction to building operations.

Figure 39: FM:Systems BIM Integration [12]

The BIM Integration component of the FM:Systems software allows the owner to manage space and occupancy by detailing an accurate inventory of space based on the BIM model which helps facility managers and owners make more efficient use of their building space. The component assists in managing and maintaining building equipment which will help facility managers create maintenance management systems and keep an accurate inventory of equipment to prevent wasted time and money for equipment maintenance. It also allows the user to view floor plans from the 3D model which can be color coded by the facility manager to help clients understand the spaces throughout the building, which will be particularly important for implementing the FM:Interact Move Management module.

Figure 40 below displays screenshots taken by users of the FM:Systems BIM Integration component to show how information is inserted into the program. Both of the Figures display the use of Autodesk Revit Architecture floor plans from the 3D model to input information for individual rooms to allow for an accurate description of how and who is using the space or the potential the room has to move another occupant into the space.



Room Name: Area
Space Std.: A1 Private Offc - Large
Capacity: 1
Occupancy: 0
Space Class: OFFICE
Room Ergonomics: |
Room #: BED-1001
Group: ADMIN-HR Human Resources

Occupancy

	Occupant	Organization
Vacate	Theresa Wright	ADMIN-HR - Human Resources

Allocation

	Organization	Percentage

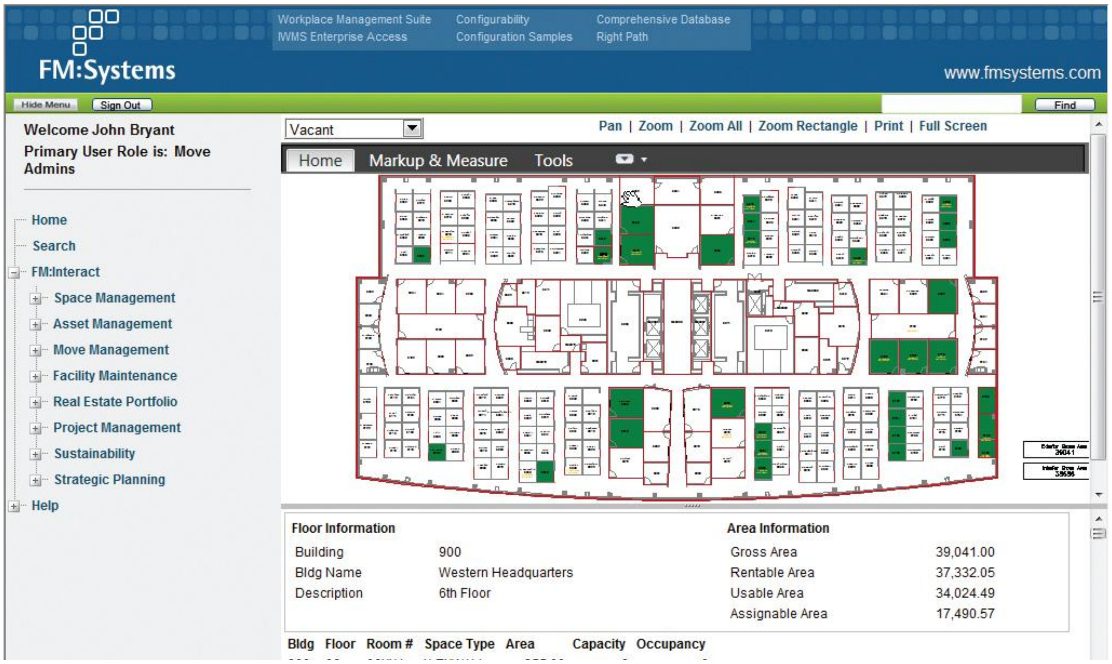
Figure 40: FM:Systems BIM Integration Component User Screenshots [12]

After performing studies for Technical Analysis I: The Use of Building Information Modeling, it was determined that the implementation of a 3D model for coordination would have benefitted the Gouverneur Healthcare Services performing. Had a 3D model been used, the project could have greatly benefitted through the use of the FM:Systems BIM Integration component both during and after construction to help manage space throughout the facility.

FM:INTERACT MOVE MANAGEMENT

The FM:Interact Move Management module is a specifically designed to integrate with the FM:Interact Workplace Management Suite software to help further manage building occupancy moves and cut costs down associated related to occupancy moves within an organization. The primary purpose behind further analyzing the implementation of the FM:Interact Move Management module is to reduce the time and cost it takes to move occupants out of existing spaces and into the newly constructed or renovated spaces of the facility during construction.

For the purpose of moving occupants during construction, the Move Management module will assist in minimizing delays and errors and improving communication between the owner, facility managers, and the occupants that are being moved. Through the use of this program, it will enhance move planning through the knowledge of real-time spaces, occupancy, and move data. This will be done through the use of either AutoCAD type files of floors plans or the use of Revit Architecture 3D model floors plans if the BIM Integration component is being utilized. The program will allow users to view the floors plans to differentiate spaces types as shown in screenshot in Figure 41 below. All of the spaces in green are of the same use-type which allows the users to understand the floor layout and where occupants will be moving to.



Welcome John Bryant
Primary User Role is: Move Admins

Floor Information

Building	900
Bldg Name	Western Headquarters
Description	6th Floor

Area Information

Gross Area	39,041.00
Rentable Area	37,332.05
Usable Area	34,024.49
Assignable Area	17,490.57

Bldg	Floor	Room #	Space Type	Area	Capacity	Occupancy

Figure 41: FM:Systems Move Management User Screenshots [13]

The floor plan viewer of the Move Management module allows the user to view vacant spaces and color-code departments as shown in the above Figure. This function allows the user to select entire departments and depict where either the department or individuals will be located after the move. All updates that are made in the Move Management module are automatically updated in the FM:Interact Space management module, the core module of the program, which ensures that the latest changes of occupancy are shown throughout all modules for the most real-time data possible. The Move Management module could also be used to manage facility assets to ensure that an occupant's assets such as their computer, reach the move location prior to the occupant.

Overall, through the use of the FM:Interact Move Management module, the Gouverneur Healthcare Services project can benefit by creating more organized moves during the various phases in the project, which, as shown in FM:System case studies, is capable of moving twice the people in half the time. This system can help reduce occupancy move time which allows for the owner to turn floors over to construction at a faster rate, as well as generate revenue on those floors earlier than the traditional methods of move management would have allowed for.

Project Implementation

In order to effectively meet the customer's requirements, the FM:Systems team developed a "RightPath" implementation schedule. There are four main phases in the process of implementing the FM:Systems software which establishes a project schedule that defines team member roles and responsibilities to allow for successful implementation.

The RightPath Implementation Methodology for successful implementation of the FM:Systems software can be seen in Figure 42.

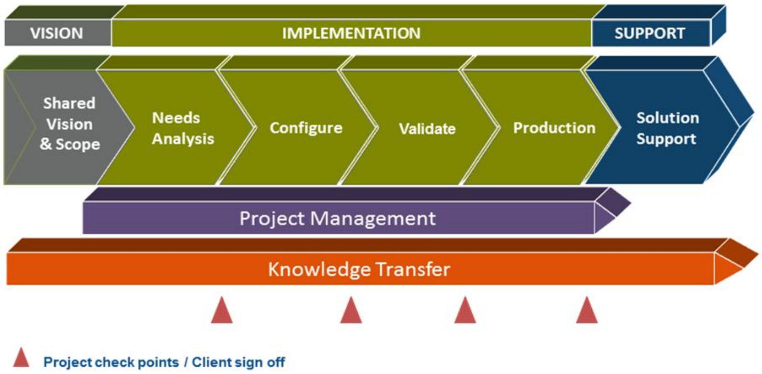
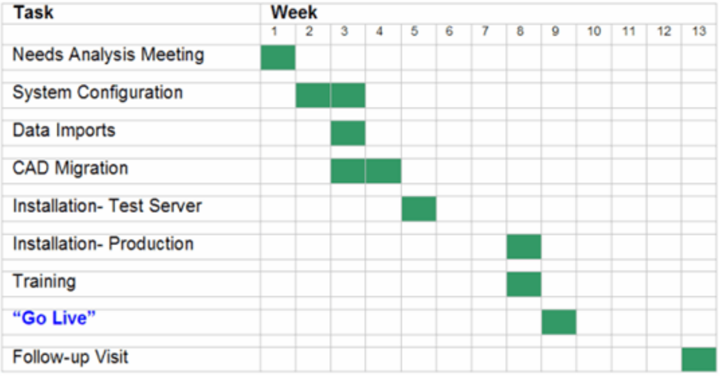


Figure 42: RightPath Implementation Methodology Courtesy of FM:Systems [11]

- Phase I: The first phase of the process consists of a thorough needs analysis meeting that will take place between the customer and FM:Systems representative. In this meeting, the goals of the project are defined in order to effectively implement specific FM:Systems modules to meet the customer's needs which include expectations, requirements, associated costs, and implementation schedule.
- Phase II: All information that was developed and acquired during the needs analysis is established by FM:Systems and is used to configure a solution for the customer's goals.
- Phase III: The customer will validate if the configuration created in Phase II by FM:Systems will meet the originally stated needs and goals for the project.
- Phase IV: After validation that needs and goals for the project have been met, phase four deploys the solution into a production environment and the FM:System consultants begin the training sessions for the end users of the product.

- Phase V: All knowledge for application of the product will be transferred to the customer to guarantee all team responsibilities and project activities are ready for close out and sign off. FM:Systems customer support will now provide day-to-day support to the customer for assistance during the application process.

The RightPath implementation schedule shown in Figure 43 displays the overall process and schedule duration for specific steps that will be taken for successful project completion.



Task	Week												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Needs Analysis Meeting	🟩												
System Configuration		🟩	🟩										
Data Imports			🟩										
CAD Migration			🟩	🟩									
Installation- Test Server					🟩								
Installation- Production								🟩					
Training								🟩					
"Go Live"									🟩				
Follow-up Visit													🟩

Figure 43: RightPath Implementation Plan Courtesy of FM:Systems [11]

FM:Systems Cost Impact

Through a consultation with Leasha Jackson, a further understanding was developed in terms of how the implementation of the FM:Systems modules will affect the owner in terms of project costs. The overall cost of the product ranges from $50,000 to $150,000 depending on the magnitude and extent to which the product will be implemented on the project. The stated price includes the needs analysis, system configuration, CAD and data imports, training, roll-out, and on-going maintenance. Additional charges can arise by adding modules to the base product and by increasing the number of power users, users who can add, edit, and delete information for the program. On the other hand, there is an unlimited amount of general users who can access data and run reports in the program at no additional charge. Depending on how long the software will be used, there is an annual maintenance fee of 15% of the total system cost which includes technical support, product upgrades, and system updates. Based on the given information, Table 16 shows the impact of implementing the FM:Systems software to the Gouverneur Healthcare Services facility. The dates shown in Table 16 considers an eight week lead time, taken from the RightPath implementation schedule, prior to the implementing the FM:Systems product to floors one through five of the new building construction. The initial cost that is stated in the table is based on a basic core product cost and the additional purchase of the move management software.

Table 16: FM:Systems Move Management Total Cost

Item	Initial Cost	Start	Finish	Duration in Years	Maintenance Fee	Total Cost
FM:Systems Move Management	$ 100,000	7/13/2011	7/1/2013	2	15%	$ 129,548

The overall cost to implement the FM:Systems Move Management system based on a two year period of use is $129,548.

Cost and Schedule Analysis

The purpose of implementing the use of FM:Interact Workplace Move Management software is to save the owner time and money by allowing occupancy of newly constructed floors to begin at an earlier date. FM:System case studies have shown that through the successful use of the Move Management software, facility managers were able to move twice the occupants in half the time. Table 17 shows a comparison of start and finish dates of the original move-in schedule versus the schedule in which the FM:Systems Move Management software is implemented and the total schedule duration saved through this implementation. The original duration for the occupancy move-in for floors one through five in the new building is 28 days and floors one through thirteen in the existing building is 14 days. These durations are based on 7 day work weeks because the facility operates 24 hours a day, 7 days a week and will be moving occupants based on this schedule. The original and reduced tenant phasing schedules can be seen in Appendix C.

Table 17: Original and Reduced Tenant Phasing Schedule Reduction

Task Name	Original Schedule		Re-Sequenced Schedule		Duration Saved
	Start	Finish	Start	Finish	
New Building Occupancy Move-In	**9/7/2011**	**10/4/2011**	**9/7/2011**	**9/20/2011**	14
Podium -Floors 1-5 Occupancy Move-In	9/7/2011	10/4/2011	9/7/2011	9/20/2011	14
Existing Building Occupancy Move-In	**8/23/2011**	**7/15/2013**	**8/23/2011**	**7/8/2013**	7
13th Floor Occupancy Move-In	8/23/2011	9/5/2011	8/23/2011	8/29/2011	7
6th Floor Occupancy Move-In	6/26/2012	7/9/2012	6/26/2012	7/2/2012	7
7th Floor Occupancy Move-In	6/26/2012	7/9/2012	6/26/2012	7/2/2012	7
8th Floor Occupancy Move-In	10/11/2012	10/24/2012	10/11/2012	10/17/2012	7
5th Floor Occupancy Move-In	6/26/2012	7/9/2012	6/26/2012	7/2/2012	7
2nd Floor Occupancy Move-In	7/27/2012	8/9/2012	7/27/2012	8/2/2012	7
3rd Floor Occupancy Move-In	7/27/2012	8/9/2012	7/27/2012	8/2/2012	7
4th Floor Occupancy Move-In	7/27/2012	8/9/2012	7/27/2012	8/2/2012	7
9th Floor Occupancy Move-In	4/10/2013	4/23/2013	4/4/2013	4/9/2013	14
1st Floor Occupancy Move-In	5/23/2013	6/5/2013	5/23/2013	5/29/2013	7
10th Floor Occupancy Move-In	6/24/2013	7/5/2013	6/17/2013	6/21/2013	14
11th Floor Occupancy Move-In	7/2/2013	7/15/2013	5/28/2013	7/1/2013	14
Project Substantial Completion	**7/15/2013**	**7/15/2013**	**7/1/2013**	**7/1/2013**	14

The dates listed in the previous table are based on the results of the schedule re-sequencing performed in the previous section of this analysis. Because a direct relationship was created between the sixth and ninth floor, seventh and tenth floor, and eighth and eleventh floor, the reduction in occupancy move-in time for these floors reduces the schedule further by allowing construction to begin at an earlier date. As shown in the table, this relationship led to a 14 day schedule reduction for the ninth, tenth, and eleventh floors and an overall schedule reduction of 14 days. Table 18 displays the general condition cost savings associated with the potential schedule savings.

Table 18: Schedule Re-Sequencing General Condition Cost Savings

Task Name	Duration Saved	General Conditions per Day	Total Construction Cost Savings
Schedule Reduction	14	$ 10,013	$ 140,182
Total Cost Savings			$ 140,182

The primary purpose behind the implementation of FM:Systems Move Management software is to benefit the owner in being able to occupy floors by reducing the move-in duration by one-half. Table 19 displays the duration saved and the potential revenue that can be generated by utilizing the Move Management software. Shown in the schedule is revenue that could be generated from the residential floors in the facility but there is definitely more potential for revenue generation on the other floors of the facility.

Table 19: Reduced Tenant Phasing Schedule Revenue Cost Savings

Task Name	Duration Saved	Patient Revenue per Day	Patients per Floor	Total Revenue
New Building Occupancy Move-In				
Floors 1-5 Occupancy Move-In	14	$ 255.27	20	$ 71,476
Existing Building Occupancy Move-In				
13th Floor Occupancy Move-In	7	$ 255.27	20	$ 35,738
6th Floor Occupancy Move-In	7	$ 255.27	20	$ 35,738
7th Floor Occupancy Move-In	7	$ 255.27	20	$ 35,738
8th Floor Occupancy Move-In	7	$ 255.27	20	$ 35,738
5th Floor Occupancy Move-In	7	$ -	-	$ -
2nd Floor Occupancy Move-In	7	$ -	-	$ -
3rd Floor Occupancy Move-In	7	$ -	-	$ -
4th Floor Occupancy Move-In	7	$ -	-	$ -
9th Floor Occupancy Move-In	14	$ 255.27	20	$ 71,476
1st Floor Occupancy Move-In	7	$ -	-	$ -
10th Floor Occupancy Move-In	14	$ 255.27	20	$ 71,476
11th Floor Occupancy Move-In	14	$ 255.27	20	$ 71,476
Total Cost Savings				$ 428,854

To determine if the implementation of the FM:Systems Move Management software will benefit the owner in terms of cost, Table 20 was assembled to compare system costs to general condition and potential facility revenue cost savings.

TABLE 20: OVERALL COST COMPARISON FOR FM:SYSTEMS IMPLEMENTATION

Item	Total Cost	
FM:Systems Move Management	$	(129,548)
General Conditions	$	140,182
Potential Facility Revenue	$	428,854
Total Cost Savings	$	439,488

The total cost savings, which addresses the initial cost of implementing the FM:Systems software and annual maintenance fees, is $439,488.

SUMMARY AND CONCLUSIONS

- Through re-sequencing the project schedule for floors six through eleven, a direct relationship was created between floors six and nine, seven and ten, and eight and eleven, which allowed for an overall schedule reduction of 168 days and a more efficient flow of construction as compared to the previous schedule.
- A cost comparison of revenue lost versus general condition cost savings as a result of re-sequencing the schedule showed that there would still be a cost savings of $206,732, assuming that the facility maintains an average of 50% occupancy on the 10th and 11th floors.
- After further analysis on the FM:Systems Interact web-based facility management system, it is feasible to implement the core product, FM:Interact Workplace Management Suite and additional module, FM:Interact Move Management, to assist in a more efficient method of moving occupants from existing spaces to newly constructed and renovated spaces. The overall cost to implement the FM:Systems Move Management system based on a two year period of use is $129,548.
- A cost and schedule analysis for implementing the FM:Systems software showed that there is the potential to move occupants in half the originally projected time which allows the facility to potentially generate $428,854 in revenue for residential floors only. There was a 14 day schedule reduction in the overall schedule for a general condition cost savings of $140,182. An overall cost comparison including the cost of the system, general conditions, and potential generated revenue showed that owner can save $439,488.
- Overall, it is feasible based on cost and schedule savings to re-sequence the project schedule and implement the FM:Interact Move Management software to the Gouverneur Healthcare Services project.

TECHNICAL ANALYSIS III: MATERIAL STAGING AND SYSTEM PREFABRICATION

PROBLEM IDENTIFICATION

The site logistics of this project served as a challenge for the project team due to the complex phasing of the schedule and the fact that the facility will remain active during the entire duration of construction. The overall footprint of the new and existing building upon the completion of construction will consume four city blocks of space, spanning close to the streets in both the north-south and east-west direction. During all phases of the project, site access for material laydown is a challenge the project team faces on a daily basis. Particularly, during demolition and renovation, the project team faces issues related to site congestion because of how the schedule is phased by the owner to turnover one floor at a time to construction. Additionally, there is a high volume of MEP equipment to support the function of the newly constructed healthcare facility. The idea of implementing prefabricated MEP systems throughout the new and existing building has the potential to save both time and money to the project.

RESEARCH GOALS

The goal of this analysis is to perform in-depth research by exploring options for a “lean” construction approach to material delivery and material storage for the project. Another goal for this analysis is to explore the idea of implementing prefabricated MEP systems for the job and understand its impact on constructability of the systems.

METHODOLOGY

- Explore the idea of implementing a mass off-site material staging plan where multiple subcontractors can store material in a warehouse and deliver material to the site in an integrated way by researching facilities around the Tri-State area that would support such methods of staging and delivery
- Perform an analysis involving labor laws for New York City unions and possible limitations on the previous methodology statement
- Research lean practices such as Just-In-Time delivery and production to eliminate waste on site and determine how these practices can be applied to this specific project
- Contact industry professionals that have experience implementing prefabricated systems and perform literature reviews to better understand the advantages and disadvantages of prefabrication based on constructability issues, associated costs, and schedule impacts

- Determine the location for the utilizing prefabricated MEP systems and determine its impact on the job in terms of delivery, installation, cost, schedule, safety, quality, and manpower

RESOURCES AND TOOLS

- Project Staff of Hunter Roberts Construction Group
- Industry Professionals
- NYC Union Representatives
- Prefabrication Manufacturers
- Department of Architectural Engineering Faculty
    - Dr. John Messner
    - Dr. Robert Leicht
    - Dr. Craig Dubler
    - Dr. Chimay J. Anumba
- Applicable Literature

EXPECTED OUTCOMES

Upon completion of this analysis, it is expected that a more efficient method of delivering site materials and utilizing space on the jobsite will be determined. It is expected that there may be concerns with the mass-off site staging in relationship to the New York City unions but other potential options may be determined for a more efficient method of delivery. Upon completion of the analysis it is expected that prefabricated MEP systems can potentially eliminate site congestion related to these trades and reduce the number of system clashes in the field. This analysis will be integrated with studies performed related to Technical Analysis I. It is expected that there will be a substantial savings in schedule, quality, and worker efficiency, but may add additional costs which can be covered by cost savings through schedule reduction.

MEP SYSTEM PREFABRICATION

In an attempt for a more "lean" approach to the construction of the Gouverneur Healthcare Services facility, the idea of prefabricated, integrated MEP racks will be analyzed to implement in the construction of the new building. This approach will utilize a "just-in-time" production and delivery methodology in an attempt to prevent site congestion and added costs to the job for storage of prefabricated material. Using a prefabricated method of installing the mechanical, electrical, and plumbing equipment allows for the components to be constructed in a controlled environment and provides the following benefits to the project [14]:

- Increased Safety
- Enhanced Product Quality
- Reduced Schedule and Cost Savings
- Lower Labor Costs
- Elimination of Construction Waste
- Overall Facility Improvement

The process of prefabricated highly repetitive building components, as typical a healthcare facility, has the potential to allow the project to be delivered in a more schedule efficient, cost effective, and safer manner.

Miami Valley Hospital Case Study

In order to best understand the potential project impacts of implementing prefabricated, integrated MEP racks, it is essential to understand the success of past projects that have applied this method of construction. The amount of potential success the Gouverneur Healthcare Services facility could reap from this application will be measured through the success of the Miami Valley Hospital project which implemented similar modularized building components.

The Miami Valley Hospital project serves as a very successful example of the application of building component prefabrication in a complex healthcare facility. The healthcare facility, located in Dayton, Ohio, underwent the construction of a $137 million, 12-story, 484,000 SF state-of-the-art cardiac diagnostic and treatment addition. The Miami Valley Hospital, at completion, would be the first hospital project in the United States to fabricate and install an extensive amount of prefabricated building components which implemented the following components: prefabricated patient room components such as water closets, casework, and headwalls; integrated MEP racks above the corridors; modular workstations for the staff; unitized curtain wall sections; and a temporary pedestrian footbridge. Through this application, the project was able to achieve a higher quality of construction, overall project schedule reduction, overall project cost savings, and a safer work environment for all parties involved in construction.

Figure 44: Miami Valley Hospital Perspective View

For the purpose of this analysis, the successful implementation of the prefabricated MEP racks will be used to relate the Miami Valley Hospital project to the Gouverneur Healthcare Services project. Both projects are about the same magnitude of construction related to square footage, however, the new construction at Gouverneur Healthcare Services accounts for about 110,000 square feet of construction while Miami Valley Hospital accounts for about 484,000 square feet of construction. The corridors in terms of mechanical, electrical, and plumbing equipment for both facilities are similar in that they serve a very repetitive floor layout of exam rooms, patient rooms, and consultation rooms, which has high potential for a successful application of prefabricated MEP racks. One primary concern related to the rules of engagement previously mentioned revolves around the fact that there was no extensive use of Building Information Modeling methods applied to the Gouverneur Healthcare Services project. However, the first analysis, "The Use of Building Information Modeling", indicated that 3D modeling could have greatly benefitted the Gouverneur Healthcare Services project in coordinated the mechanical, electrical, and plumbing work on the project. It is assumed that 3D modeling would have definitely been implemented for the coordination of designing, manufacturing, and installing prefabricated MEP racks.

At the completion of the Miami Valley Hospital addition, construction manager, Skanska USA Building, and architectural firm, NBBJ, determined six rules of engagement for applying prefabrication to a construction project. These rules of engagement are as follows [15]:

- It is key for prefabrication to serve the design, not vice versa
- Subcontractors and supplies must become engaged early in the design process
- BIM must be used or it's near impossible for correct prefabrication
- Build several mockups for occupants and end-users to test them
- Employment of just-in-time delivery of modules will keep the job site less congested
- Design modules to be delivered on a conventional flatbed trucks

At the time of design, design team NBBJ was unsuccessful in finding off-the-shelf modules that met the high standard of quality set by them and the owner. The prefabricated components needed to be manufactured by Skanska USA Building and their subcontractors. The construction of these modules took place in a warehouse rented out by Skanska just three miles from the project site. The overhead MEP racks were built as 8x22 foot modules to fit side-by-side in the building's 16 foot corridors throughout five patient-room floors in the new facility. Due to tight site conditions, the team at Skanska USA Building enforced a just-in-time delivery schedule for the delivery of the racks from the location of manufacturing to the site. The process of design, manufacturing, delivery, and installation can be seen through the photographic process map shown below in Figure 45.

BIM 3D Coordination Model | Crews Build MEP Racks at Bench Height | MEP Racks Complete for Delivery

MEP Racks Delivered to Site | Crane Lifts MEP Racks to Designated Floor | MEP Racks Installed in Corridor

Figure 45: Photographic Process Map of Prefabrication

As a result of prefabricating the mechanical, electrical, and plumbing equipment located through patient room corridors on five floors of the Miami Valley Hospital, the construction team was able to improve the quality of construction with greater precision and achieve outstanding success with worker productivity. Studies show that an acceptable output for a plumber installing pipe above the ceiling is about 200 feet per day. Through the use of prefabrication, where workers can work at bench height in a temperature controlled environment with minimal clutter, the output was tripled. For example, a plumber was able to average 600 feet of pipe in a day’s work; an output so efficient that work on the construction site could not keep pace at certain times in the job. Additionally, the workers that were prefabricating the MEP racks in the off-site warehouse were paid about $40 an hour, a 20% reduction in pay compared to the on-site workers receiving $50 compensation per hour.

In conclusion, Bob Eling, Director of Strategic Construction for Premier Health Partners, summed up the advantages of prefabrication on the Miami Valley Hospital construction project in three words: schedule, safety, and quality [15]. He commented that prefabrication components only affected about 11% of the total construction costs, which didn't result in huge cost savings, but savings in worker productivity proved successful application of prefabrication in terms of schedule reduction. The success of implementing prefabricated MEP racks through design and construction on the Miami Valley Hospital shows that there is potential for cost savings, schedule reduction, increase in construction quality, and increase in safety on the Gouverneur Healthcare Services project.

AREA OF IMPLEMENTATION

After further analysis of the previous case study on the Miami Valley Hospital project which has shown success in reducing both cost and schedule for similar healthcare construction projects through the implementation of integrated MEP racks, it will be feasible to apply these methods of construction to the Gouverneur Healthcare Services project.

In determining the locations for the application of the integrated MEP racks, there were a few considerations specifically related to this project. This project is undergoing both new and existing construction. In order to implement integrated MEP racks in the existing building, the racks would need to be transported by the interior elevator hoist because during the demolition and renovation phase of construction, there is no exterior man and material hoist or crane to transport the racks from delivery to the floors. Because of the complexity and high volume of MEP systems that were designed and are to be installed to support the buildings function, the application poses a challenge when determining the location that the racks will be implemented. For this reason, the hallways of commonly designed spaces will be utilized for the application of the integrated MEP racks.

The prefabricated MEP racks will be designed to be implemented in main corridors on the following floors:

- Second Floor: Exam Room and Atrium Corridors
- Third Floor: Exam Room and Atrium Corridors
- Fourth Floor: Mixed-Use and Atrium Corridors
- Fifth Floor: Consultation and Group Room Corridors

Table 21 depicts the percentages of area of prefabrication compared to total ceiling area for a better understanding of how much ceiling space will be utilized for the prefabricated MEP racks.

TABLE 21: PREFABRICATION IMPLEMENTATION CEILING PERCENTAGE

Space Designation	Total Ceiling Area (ft^2)	Total Area of Prefabrication (ft^2)	Percentage Usage
Second Floor	16445	4557	28%
Third Floor	16981	4011	24%
Fourth Floor	15306	3946	26%
Fifth Floor	15919	1990	13%
Total	64651	14504	22%

For a better understanding of the ceiling space usage of the prefabricated MEP racks, see Figure 46 through Figure 49 below depicting floor plans of the implemented corridor spaces highlighted in red indicating the use of prefabrication.

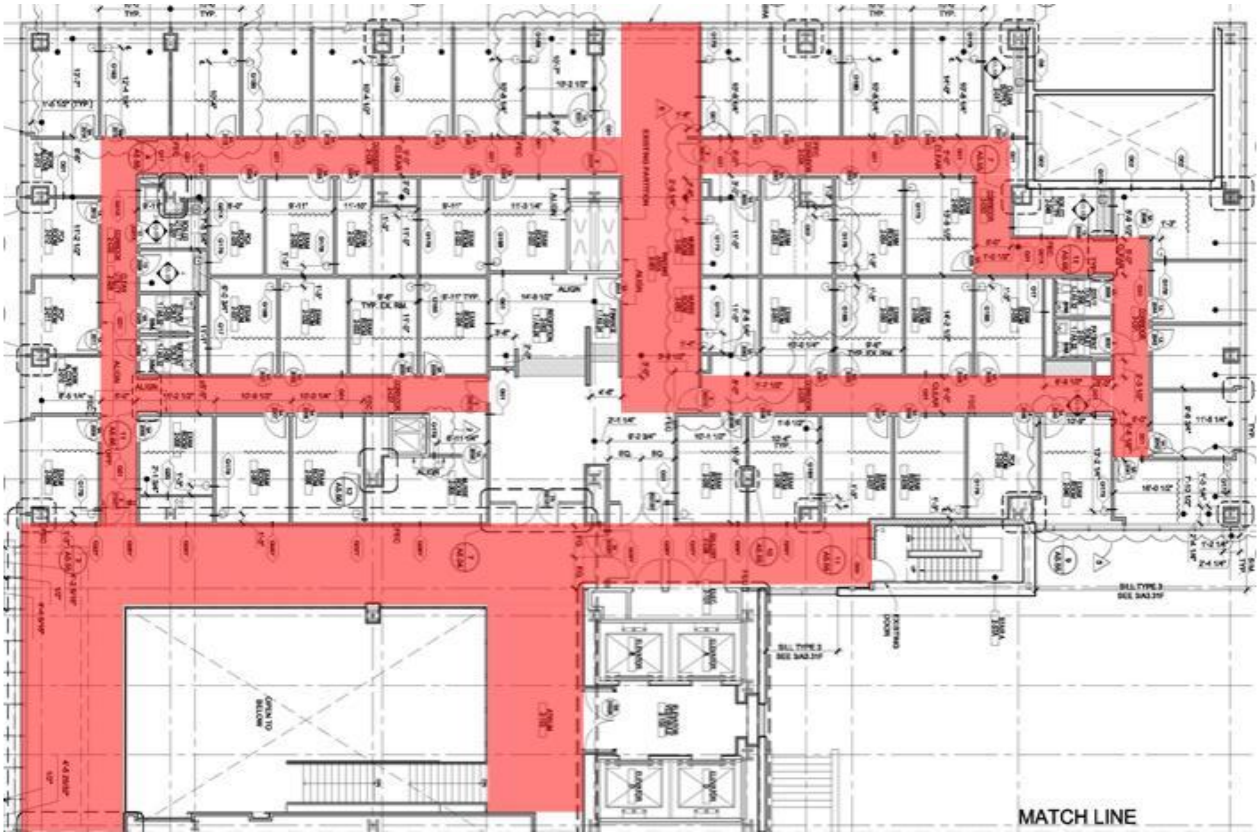


Figure 46: Second Floor Implementation Plan

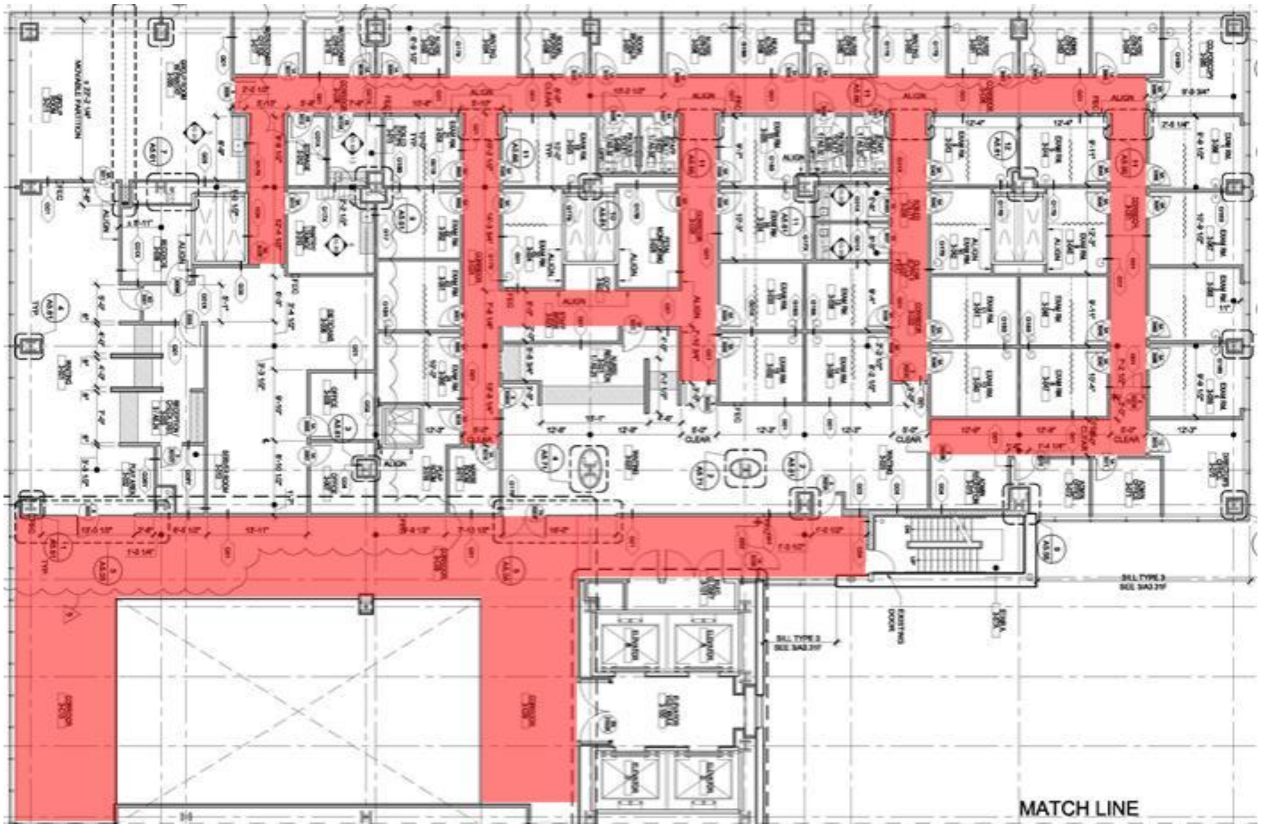


Figure 47: Third Floor Implementation Plan

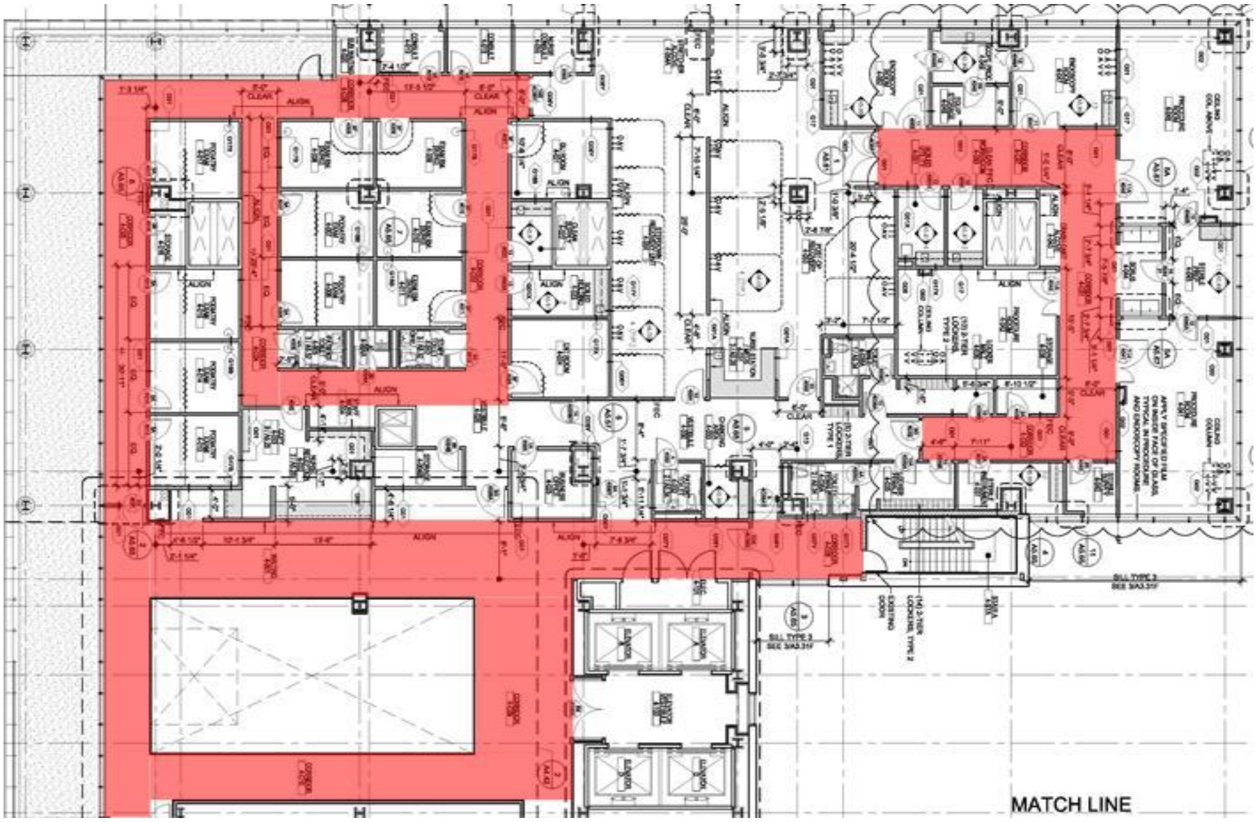


Figure 48: Fourth Floor Implementation Plan

Figure 49: Fifth Floor Implementation Plan

PROJECT SPECIFIC MODULES

In order to best understand the impact of implementing prefabricated MEP racks on the Gouverneur Healthcare Services project, it is important to understand the design of the building and how these racks can be designed and installed throughout the building. As previously mentioned, for the purpose of this analysis, the MEP racks will be studied based on implementation in main corridors throughout the new buildings construction. There are four types of corridors, based on width, including 5 foot, 8 foot, 12 foot, and 16 foot corridors. By determining the total lengths of prefabricated MEP racks based on corridor widths, the quantity of modules can be determined, which will assist in determining the a "lean" approach to delivering the modules to the site and proceeding to installation. The modules will be designed based on the corridor they are to be implemented in as follows:

- 5 foot Corridor: 1 - 5 foot module
- 8 foot Corridor: 1 - 8 foot module
- 12 foot Corridor: 2 - 6 foot modules
- 16 foot Corridor: 2 - 8 foot modules

Table 22 depicts the length of rack and total area of prefabrication for the second, third, fourth, and fifth floors of the building.

TABLE 22: SECOND THROUGH FIFTH FLOOR PREFABRICATION IMPLEMENTATION

Space Designation		Length of Rack (ft)	Total Area of Prefabrication (ft^2)
Second Floor	5 ft Corridor	325	1625
	8 ft Corridor	37	296
	12 ft Corridor	137	1644
	16 ft Corridor	62	992
	Total	561	4495
Third Floor	5 ft Corridor	355	1775
	8 ft Corridor	37	296
	12 ft Corridor	79	948
	16 ft Corridor	62	992
	Total	533	4011
Fourth Floor	5 ft Corridor	290	1450
	8 ft Corridor	150	1200
	12 ft Corridor	64	768
	16 ft Corridor	33	528
	Total	537	3946
Fifth Floor	5 ft Corridor	398	1990
	Total	398	1990

The Gouverneur Healthcare Services facility will utilize 20 foot long MEP racks within the corridors of the second, third, fourth, and fifth floors of the new addition. Figure 50 and Figure 51 depict the typical layout for the MEP racks in the various corridors.

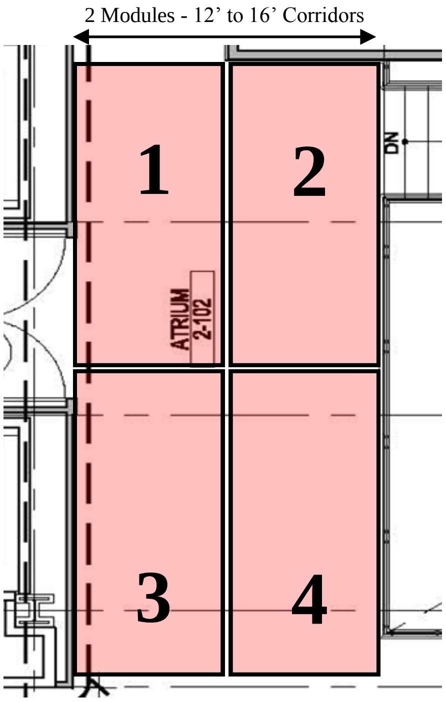


Figure 50: Typical Two Module Layout

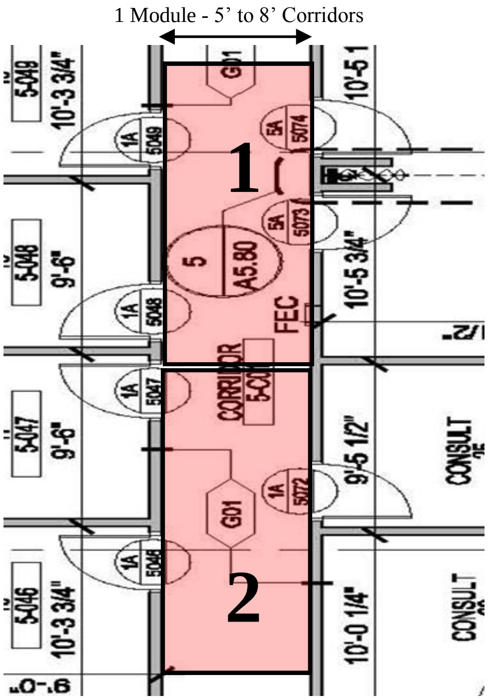


Figure 51: Typical One Module Layout

MATERIAL STAGING

One of the main lessons learned by Skanska Building USA in the implementation of prefabricated MEP racks is the need for a more lean construction approach through a just-in-time manufacturing and delivery methodology. Because productivity proved so efficient during prefabrication, Skanska Building USA had to rent additional space to store the MEP racks until they were ready to be installed on site. The lesson learned through the Miami Valley Hospital will serve as a good area of study for the application of prefabricated MEP units to the Gouverneur Healthcare Services project.

A lean approach to construction can be described as a "way to design production systems to minimize waste of materials, time, and effort in order to generate the maximum possible amount of value [16]." In particular, a "Just-In-Time" lean construction approach to production and delivery refers a maximum efficiency method to producing and delivering materials to a construction site. Implementing a "Just-In-Time" approach implies that materials will be manufactured, delivered to the site upon completion, brought to the location of installation, immediately installed by construction crews. This method of construction eliminates the need for off-site material storage, as seen in the Miami Valley Hospital project, or space consumption on the floors through material laydown and staging areas. A "Just-In-Time" approach is particularly beneficial to projects where site logistics is a challenge for the project team, as with the Gouverneur Healthcare Services project. For the purpose of this analysis, the MEP racks are to be implemented in four floors of the new building during the first major phase of the project. During this phase of construction, the new building footprint spans close to three city blocks to the north, south, and west, while the existing building lies to the east. The site logistics during which the MEP racks are to be installed can be seen in Superstructure Plan in Appendix B. To prevent challenges of site access related to material laydown and storage related to the MEP racks, a "Just-In-Time" delivery method will be utilized.

In order to effectively implement a "Just-In-Time" manufacturing and delivery methodology to the Gouverneur Healthcare Services project, it is essential to understand the manufacturing rates of the MEP racks in the off-site warehouse and the installation rates of the MEP racks once they arrive on site. Table 23 displays the total quantity of 20 foot modules that will be implemented throughout the floors of the new building.

TABLE 23: PREFABRICATION IMPLEMENTATION BY MODULE WIDTH

Corridor Width	Module Specifications			Total Quantity of 20 ft Modules
	Quantity	Width	Total Length	
5 ft	1	5 ft	1368	68
8 ft	1	8 ft	224	11
12 ft	2	6 ft	280	28
16 ft	2	8 ft	157	16
Total				123

A standard flatbed trailer ranges from 45 to 53 feet long, 8 to 8-½ feet wide, and can accommodate an 8-½ maximum load height. Figure 52 below shows the typical specifications of a standard flatbed and how the MEP racks will be organized on the flatbed for delivery.

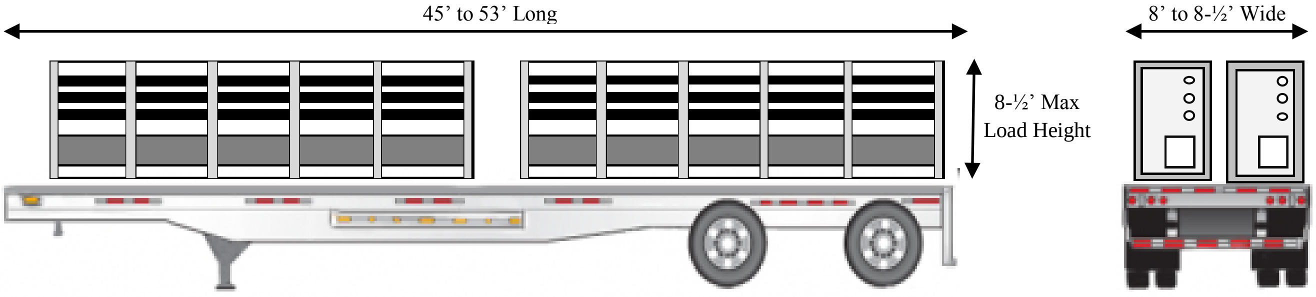


Figure 52: Standard Flatbed Specifications and MEP Rack Delivery Layout

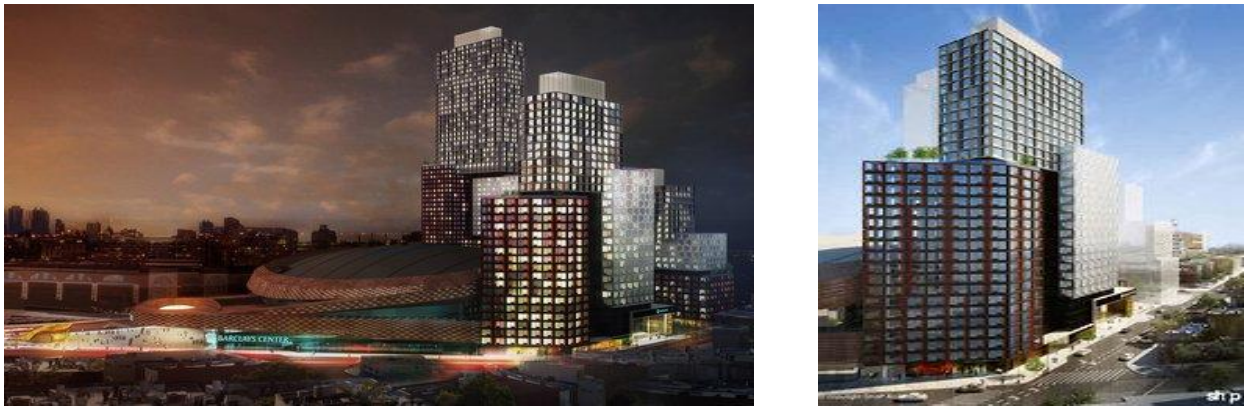
With this method of organizing the MEP racks for shipping, each flatbed delivery is capable of shipping four racks, which results in a 32 total deliveries. Although a specific warehouse will not be determined for where the prefabricated MEP racks will be manufactured, there is a large quantity of warehouses within 10-15 miles of the site. The current national Fair Tran truckload rate in dollars per mile for a short haul flatbed truck is approximately \$2.66 [21]. Based on a 1.33 location factor for New York, New York, the truckload rate in dollars per mile is approximately \$3.54. With warehouse locations within 10-15 miles of the project site, the approximate cost for shipping 123 racks to the site at four racks per truck is between \$2265 and \$3400.

Since it was determined that there will be 32 deliveries of MEP racks for a total of 123 racks, this delivery rate can be used in accordance with the off-site manufacturing rate and on-site installation rate in order to develop an effective "Just-In-Time" manufacturing and delivery methodology to the Gouverneur Healthcare Services project. Precise planning of deliveries and worker output rates can be used to help prevent additional construction costs for warehouse storage.

UNION ANALYSIS

One of the more controversial concerns related to labor and the implementation of integrated MEP racks to the Gouverneur Healthcare Services project is its impact on the New York City Union's labor force. It is expected that there will be concerns with this implementation in relationship to the New York City unions but the purpose of this aspect of the analysis will be to determine if any union laws will prevent or impact to production and installation of these MEP racks. In order to better understand the impact of prefabrication and the New York City unions, a study on a current project in New York City that intends to use prefabricated systems will be analyzed in terms of its effect on the unions and complications the project is facing for wanting to implement off-site prefabricated systems.

The Atlantic Yards project is a $4.9 billion project in Brooklyn, New York designed to contain the new Barclay Center basketball arena and sixteen new high-rise buildings. As part of an obligation to provide affordable housing to the city of New York at within the Atlantic Yards development site, developer, Bruce C. Ratner, and his company, Forest City Ratner, plan to erect a 34-story apartment building to meet this obligation. What sets this apartment building apart from all others in New York City is Mr. Ratner's pursuit to erect the world's tallest prefabricated steel structure in an attempt to cut construction costs in half by saving time and requiring a lesser and cheaper labor force. By the end of design, the 350-unit apartment complex would be comprised of almost 950 modules of prefabricated steel frame boxes built out with finished walls, ceilings, and floors; plumbing, electrical, and mechanical components; and even full bathrooms and kitchens. Rendering 3 displays an image of the Atlantic Yards site at completion and Rendering 4 displays an image of the proposed 34-story prefabricated apartment building that will be discussed in the section of the analysis.



Renderings 3 and 4: Atlantic Yards and Proposed 34-Story Prefabricated Apartment Building

If Forest City Ratner does not begin excavation by May 2013, they are required to pay up to $5 million in penalties per year it falls behind schedule as per their agreement with the State of New York. Mr. Ratner is expecting that prefabricating these apartment units could cut construction costs and schedule by up to 25 percent. There is a big concern with how the application of prefabrication will affect the New York City unions. Gary LaBarbera, president of the Building and Construction Trades Council of Greater New York stated, “This is something that could be great consequence to the building trades. We have never been supportive of prefab buildings, for obvious reasons [17].” The primary reason behind the state and city providing $300 million in subsidies for Atlantic Yards was Mr. Ratner’s promise to provide up to 17,000 union construction jobs.

The New York City unions were a concern with the application of prefabricated MEP racks to the Gouverneur Healthcare Services building and also with how it would be impacted by governing union laws. However, it was stated by Tony Sclafani, spokesman for the New York City Department of Buildings, that there are no city rules that would prohibit Mr. Ratner and his development company from using modular construction to construct the new 34-story apartment building, as long as Department of Building regulations were followed. What concerns union labor officials of New York City the most are the labor savings involved in using prefabrication. Although Mr. Ratner would use union workers to build the prefabricated modules in an off-site warehouse, the union workers would earn a lesser compensation in a factory compared to working on-site. For example, a union carpenter working on-site earns about $85 per hour as compared to $35 per hour in a factory. Gary LaBarbera is working closely with Mr. Ratner in an attempt to reach an agreement that would provide a better solution for the building trades and Forest City Ratner involving union employment.

Particular to prefabricated, integrated MEP racks, an interview with Senior Project Executive of Hunter Roberts Construction Group, James Palace, resulted in the understanding that if the MEP racks had been modularized outside of New York City union boundaries, the MEP racks can be manufactured by a non-union work force but assembled on-site by a union labor force. He explained that the application of prefabricated MEP racks was done successful on a project at North Shore Hospital in Manhasset, New York whose reasoning was to reduce the construction schedule and gain LEED points as part of their LEED accreditation.[19] The prefabricated racks were purchased and assembled in Ohio by non-union laborers but was assembled with a union labor force when it was on site in New York.

Although this type of prefabrication being applied in design and construction at Atlantic Yards isn't to the extent that relates to the topic of this analysis, it displays some of the concerns union officials have with the application. In summary, there are no city rules that prohibit the application of prefabrication construction methods. However, there is concern with union officials regarding the reduction in compensation for union laborers when they transfer from working on-site to working in the factory. It was also determined that if it is decided that prefabrication will take place outside of New York City boundaries, the prefabrication can be performed by non-union laborers but must be assembled on-site by a union labor force.

COST AND SCHEDULE ANALYSIS

The primary driving factors behind using prefabrication methods of construction is to achieve a higher quality of construction, overall project schedule reduction, overall project cost savings, and a safer work environment for all parties involved in construction. Many of the cost savings will be due to reductions in the schedule and reduction in compensation for union laborers working in the off-site warehouse. The reduction in schedule will be determined through a detailed analysis of the installation of the main MEP systems that run in the corridors of the second, third, fourth, and fifth floors of the building.

Through the use of prefabrication at the Miami Valley Hospital, laborers working at bench height in a temperature controlled environment were able to triple the average installation rates. One thing to consider when comparing the Miami Valley Hospital versus the Gouverneur Healthcare Services project is the types of corridor where prefabricated modules were installed. The design of the Miami Valley Hospital called for repetitive 16 foot corridors throughout all the floors of prefabrication implementation, while the Gouverneur Healthcare Services facility contains four different widths of hallways between the second, third, fourth, and fifth floors. Because of this variety of corridor widths, it will be assumed that prefabrication installation rates can reduce the labor for this area of work by one-third. Table 24 below shows a summary of the duration reduction calculations by floor and trade; the full schedule reduction take-off can be seen in Appendix D.

TABLE 24: PREFABRICATION SUMMARY OF DURATION REDUCTION

Location	Installation Activity	Original Installation Duration	Prefabrication Installation Duration	Duration Reduction
Second Floor	Mechanical Installation	45	30	15
	Electrical Installation	26	17	9
	Plumbing Installation	45	30	15
	Fire Protection Installation	13	9	4
Third Floor	Mechanical Installation	45	30	15
	Electrical Installation	26	17	9
	Plumbing Installation	45	30	15
	Fire Protection Installation	13	9	4
Fourth Floor	Mechanical Installation	41	27	14
	Electrical Installation	41	27	14
	Plumbing Installation	102	67	35
	Fire Protection Installation	20	13	7
Fifth Floor	Mechanical Installation	64	42	22
	Electrical Installation	26	17	9
	Plumbing Installation	26	17	9
	Fire Protection Installation	13	8	4
Total		589	388	200

Through the implementation of prefabrication on the Gouverneur Healthcare Services facility, the total duration reduction of construction is 200 days. Note that this duration means it will take 200 days less to install the mechanical, electrical, plumbing, and fire protection equipment in the corridors of the buildings. It does not account for the time it will take to install the racks and make the connection between components from rack to rack. In order to determine the total cost savings through the savings in labor, an analysis of the compensation for the mechanical, electrical, plumbing, and fire protection contractors will be analyzed based on union wages on-site versus off-site. Table 25 depicts the hourly wages for the previously mentioned compensation rates, as well as the number of workers used to install the mechanical, electrical, and plumbing equipment. The reduction of wages from on-site to off-site are assumed to be a 40% compensation reduction, a less extreme case of the previous union analysis' 60% compensation reduction, and the daily costs for all laborers are based on 8-hour work days. The labor rates used in Table 25 are currently approved union rates by the Dormitory Authority for the State of New York.

TABLE 25: HOURLY AND DAILY LABOR RATES FOR PREFABRICATION

Contractor	Hourly Wages		Quantity of Laborers	Daily Costs per Contractor	
	Union On-Site	Union Off-Site		Union On-Site	Union Off-Site
Mechanical	$ 109.57	$ 65.74	6	$ 5,259.36	$ 3,155.62
Electrical	$ 101.67	$ 61.00	5	$ 4,066.80	$ 2,440.08
Plumbing	$ 103.31	$ 61.99	6	$ 4,958.88	$ 2,975.33
Fire Protection	$ 134.80	$ 80.88	3	$ 3,235.20	$ 1,941.12

Upon completion of analyzing the union wages of both on- and off-site construction workers, a total cost savings can be calculated in terms of labor cost savings for implementing prefabricated MEP racks on the Gouverneur Healthcare Services facility. Table 26 displays the original labor costs with the original durations and on-site union wages versus the prefabrication labor costs with the reduced durations and off-site union wages for a total cost savings.

TABLE 26: TOTAL LABOR COST SAVINGS THROUGH PREFABRICATION

Contractor	Original Labor Costs			Prefabrication Labor Costs			Total Cost Savings
	Daily Cost On-Site	Total Duration	Total Cost	Daily Union Off-Site	Total Duration	Total Cost	
Mechanical	$ 5,259	195	$ 1,023,734	$ 3,155.62	128	$ 405,399	$ 618,336
Electrical	$ 4,067	118	$ 478,662	$ 2,440.08	78	$ 189,550	$ 289,112
Plumbing	$ 4,959	217	$ 1,077,565	$ 2,975.33	143	$ 426,716	$ 650,849
Fire Protection	$ 3,235	59	$ 190,392	$ 1,941.12	39	$ 75,395	$ 114,996
Total	-	-	$ 2,770,353	-	-	$ 1,097,060	$ 1,673,293

Through the implementation of prefabricated, integrated MEP racks on the Gouverneur Healthcare Services facility the total cost savings in terms of labor cost savings is $1,673,293. The total cost of the original mechanical, electrical, plumbing, and fire protection packages were about $60,783,963 for both new and existing construction. The new building accounts for about 30% of the total project cost or $18,235,198 for the four specified packages of work and $62,205,281 for the overall new building project costs. Therefore, it was determined that through the implementation of prefabricated MEP racks, the owner will be provided with a 9% cost savings for the four specified packages of work and a 3% cost savings for the overall new building project costs.

SUMMARY AND CONCLUSION

- In order to effectively implement this method of construction, the project team would have to utilize a 3D coordination model, which is not currently being utilized on the project. For this analysis, it would definitely be feasible to utilize a 3D coordination model for the project.
- The area of implementation for the prefabricated MEP racks will be in the second, third, fourth, and fifth floor corridors and will include main mechanical, electrical, plumbing, and fire protection system components that will support the buildings function.

- With the implementation of a “lean” construction approach, just-in-time production and delivery, the project team can deliver 123 racks in 32 deliveries from a warehouse within 10-15 miles of the site for a delivery price between $2265 and $3400.
- At the completion of a union analysis case study on the Atlantic Yards project in Brooklyn, NY, it was determined that there are no laws that will affect the unions from performing the prefabricated work in an off-site warehouse.
- Through the implementation of prefabrication, the total duration reduction of construction of the mechanical, electrical, plumbing, and fire protection work in the corridors is 200 days.
- Through the implementation of prefabrication, the total labor cost savings is about $1,673,293, which accounts for a 9% cost savings for the mechanical, electrical, plumbing, and fire protection packages, and a 3% total cost savings for the construction of the new building.
- In conclusion, it is feasible to implement prefabricated, integrated MEP racks to the second, third, fourth, and fifth floors in the new building of the Gouverneur Healthcare Services facility because of the potential savings in both construction schedule and cost.

TECHNICAL ANALYSIS IV: SUSTAINABLE GREEN ROOF GARDEN

PROBLEM IDENTIFICATION

The Gouverneur Healthcare Services building renovation and addition will not be constructed as a LEED project, therefore no efforts will be put forth to acquire a LEED rating. However, one alternate to the design included a sustainable green roof garden on the 6th floor of the new building. The intentions of the green roof were to provide access for use of patients of the hospital and would feature multiple benches and a variety vines, shrubs, and perennial herbs. Due to financial restrictions, it was decided that it was not in the owner's best interests to implement the green roof garden into the design. However, the green roof design had potential to provide an area for use of occupants, increase energy efficiency, and potentially save the owner long term money.

RESEARCH GOALS

The goal of this analysis is to perform an in-depth study related to implementing the sustainable green roof garden to the 6th floor roof. The ultimate goal is to determine the benefits to the owner and occupants of the facility, as well as the effects on construction related to costs, schedule impacts, and constructability issues. Additionally, out of option breadths will be arise during this analysis to determine how implementing a green roof to the 6th floor will effect structural and mechanical systems that support the buildings function.

METHODOLOGY

- Research various types of green roof system technologies and compare advantages and disadvantages of the systems
- Contact green roof manufacturers for design consultation and pricing of system
- Analyze current design and propose alternate design to gain maximum energy efficiency from the system
- Analyze how the green roof will affect mechanical loads related to decreasing thermal roof loads
- Determine constructability issues, schedule impacts, and perform an in-depth life cycle cost analysis
- Analyze how the existing structure will be affected with the added load of the system

RESOURCES AND TOOLS

- Industry Professionals
- Project Drawings and Specifications
- Material from AE 308, AE 404, and AE 310
- Department of Architectural Engineering Faculty
    - Dr. John Messner
    - Dr. Robert Leicht
    - Dr. Craig Dubler
    - Dr. Chimay J. Anumba
    - Dr. Linda M. Hanagan
    - Dr. Stephen Treado
- Applicable Literature

EXPECTED OUTCOMES

Upon completion of this analysis, it is expected that implementing a sustainable green roof garden to the 6th floor roof will provide a welcoming, outdoor space to the occupants and result in future cost savings to the owner related to reducing the thermal roof and mechanical load for the sixth floor. It is expected upon completion of detailed research, a green roof system will be implemented that would least impact the project schedule and projects costs. The mechanical breadth should show that by implementation of a green roof, the thermal roof load will decrease, therefore decreasing the mechanical load for the floor below.

GREEN ROOF GARDEN INTRODUCTION

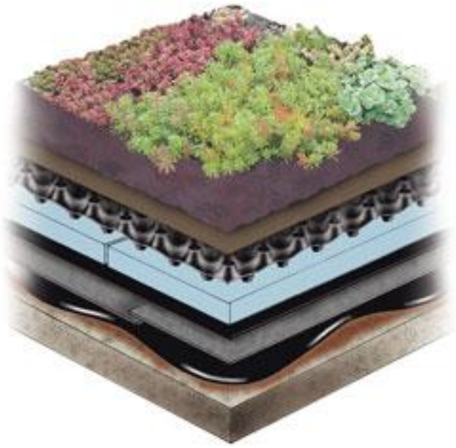
Buildings are responsible for 40% of the United States total energy consumption and 16% of the United States total water consumption.[22] Through the design and application of green building systems and technologies, a building can reduce its energy consumption, thus short and long term cost savings, while benefitting the environment and atmosphere. Regarding developers and builders, there are many potential benefits of green building application including but not limited to the following[22]:

- Reduced Capital Costs
- Reduced Operating Costs
- Marketing Benefits
- Streamlined Building and Zoning Approvals
- Reduced Liability Risk
- Health and Productivity Gains
- New Business Opportunities
- Self-Satisfaction

In particular, one method of green building that can benefit building owners, occupants, and the environment is through the incorporation of a green roof garden. A green roof can be defined as an alternative roof system on a building that incorporates vegetation and a growing medium to provide sustainable benefits to the building and environment. There are two major types of green roofs including intensive and extensive roofs. An intensive green roof is more widely known for incorporating a variety of plants and featuring paths and walkways for the public to travel through the scenery. Intensive green roofs typically use a deeper planting medium, starting at six inches deep, as compared to extensive green roofs, which can add up to 150 pounds per square foot to the structural load. These types of roofs require much maintenance and are often irrigated as part of caring for the plants. An extensive green roof on the other hand is more widely known for its simplistic planting medium, most likely drought tolerant sedums and grasses. Extensive green roofs typically use a shallower planting medium, ranging from one and a half to six inches deep, which can add from 10-35 pounds per square foot to the structural load. Because of the simplistic planting sedum, an extensive roof requires very little maintenance and is typically naturally irrigated by the weather. In the following figures, Figure 53 and Figure 54, one can see the difference in planting medium between an extensive and intensive green roof system.

Courtesy of Hydrotech USA

Figure 53: Intensive Green Roof System



Courtesy of Hydrotech USA

Figure 54: Extensive Green Roof System

With the addition of either an intensive or extensive green roof, an owner and the public can benefit in a variety of ways by incorporating a green roof into the building design in the following ways:

- Energy Savings
- Reduction in Urban Heat Island Effect
- Reduction in Noise Levels
- Public Accessibility
- Improved Storm Water Retention
- Reduction of Dust and Smog Levels
- Creation of Natural Habitat
- Increased Roof Life Expectancy

Throughout this analysis, one can see the comparison of the different green roof designs in relation to the Gouverneur Healthcare Services project and better understand why decisions may have been made to not move forward with its application to the sixth floor roof of the building.

ORIGINAL DESIGN OF GREEN ROOF

The design team for Gouverneur Healthcare Services project proposed an alternate to the sixth floor roof design which is to feature a green roof garden for use of patients of the hospital and will house multiple benches and a variety vines, shrubs, and perennial herbs. See below figures, Figure 55 and Figure 56, for a better understanding of the intensive planting green roof details.

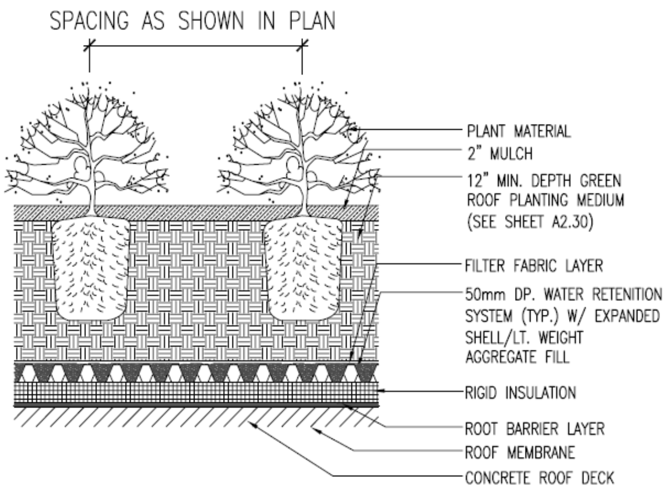


Figure 55: Shrub Planting Detail

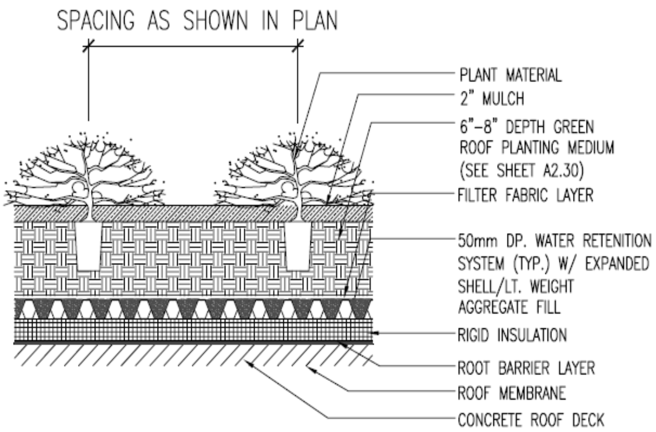


Figure 56: Ground-Cover Planting Detail

The proposed green roof design has the potential to provide an area of use for occupants, increase energy efficiency, and potentially save the owner long term money. However, after further analysis of the proposed green roof design, it was determined that the designers did not utilize the sixth floor roof space to provide much of a return on investment in terms of energy saving potential. Referring to the Figure 57 below, one can see the comparison in potential green roof space versus actual utilized green roof space.

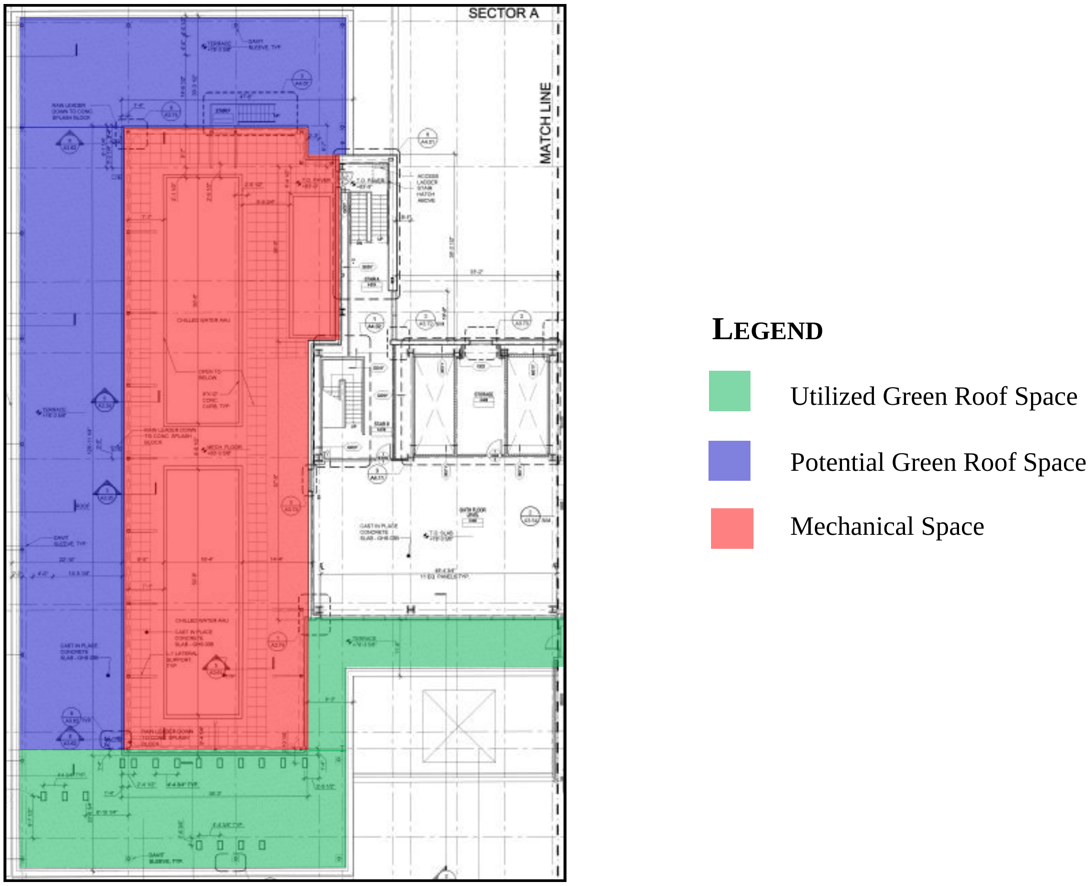


Figure 57: Original Green Roof Space Utilization

The original green roof utilizes about 2250 square foot of space as shown in green on Figure 57, but as shown in blue on the figure, there is about 4800 square foot of potential green roof space. A detailed plan of the original green roof design can be seen in Appendix E showing the details of how the landscape designer utilized the space of the roof to accommodate a green roof for the owner and occupants of the building. The intensive green roof that was originally designed seems it would have served more as a patio space to the occupants rather than a full green roof. The material breakdown of the utilized roof space can be seen in Table 27 below.

TABLE 27: ORIGINAL DESIGN MATERIAL SQUARE FOOTAGE BREAKDOWN

Material	Total Square Footage
8” Depth Lightweight Planting Sedum	585 SF
2” Thick Concrete Pavers	1130 SF
Roofing Ballast	535 SF
Total	2250 SF

After further analysis of the material quantities the original design comprised of, it was determined that there was potential for a more energy efficient green roof, while still considering this space to be accessible to the occupants of the building. For the purpose of this study, a new green roof will designed to utilize the sixth floor roof to its fullest potential in order to be best benefit the owner and occupants of the building.

Proposed Design of Green Roof

The proposed design of the green roof utilizes the facilities sixth floor roof to its fullest potential by incorporating a large square footage of extensive green roof with designated patio space that will be accessible to the occupants of the building. The design of the proposed green roof can be seen in Appendix E. The proposed green roof will utilize 7050 square feet of space as compared to the original 2250 square feet of space. Referring to the Figure 58 below, one can see how the proposed design utilizes the sixth floor roof to its full potential.

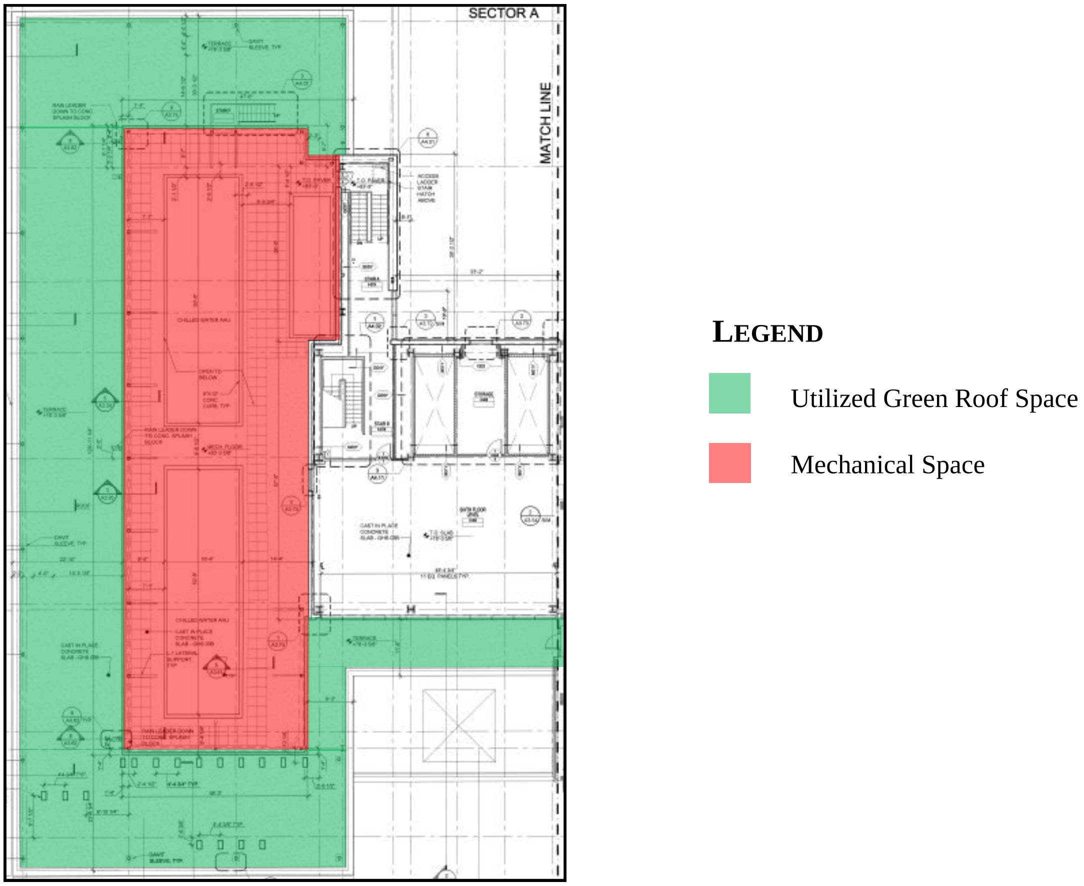


Figure 58: Proposed Roof Space Utilization

The green roof system that was chosen to be utilized for this analysis is the GroRoof Hybrid Modular Green Roof System by Metro Green Visions. Particularly, the designed system is comprised of 18”x18”x4.5” GroRoof Extensive I modules, GroRoof Paver Platforms designed to work with 17-5/8”x 17-5/8” pavers, 2” Lightweight Concrete Pavers, and Roofing Ballast. The material breakdown of the utilized roof space can be seen in Table 28 below.

TABLE 28: PROPOSED DESIGN MATERIAL SQUARE FOOTAGE BREAKDOWN

Material	Total Square Footage
18”x18”x4.5” GroRoof Extensive I modules	4075 SF
GroRoof Paver Platforms and 2” Lightweight Concrete Pavers	1030 SF
Roofing Ballast	1945 SF
Total	7050 SF

Through the design of the newly proposed green roof, there is vast difference between green roof square footage utilized as compared to the original design. With the application 4075 SF of the GroRoof Extensive I modules to cover the sixth floor roof, the owner can expect positive impacts related to a reduction in heating and cooling loads for the fifth floor, as well as storm water management.

GROROOF SYSTEM DETAILS

The GroRoof Green Roof system that was implemented in the design of the proposed sixth floor roof for the Gouverneur Healthcare Services facility is a 18”x18”x4.5” Extensive I Hybrid Modular Green Roof system. This system is comprised of interlocking tray modules with removable side panels for seamless vegetation containing an integrated root stabling and aeration mat; MGV GroMat water retention, filtration, and aeration layer; Metro D-Lite engineering soil; and pre-grown, established extensive vegetation. Figure 59 depicts the green roof system and its components.

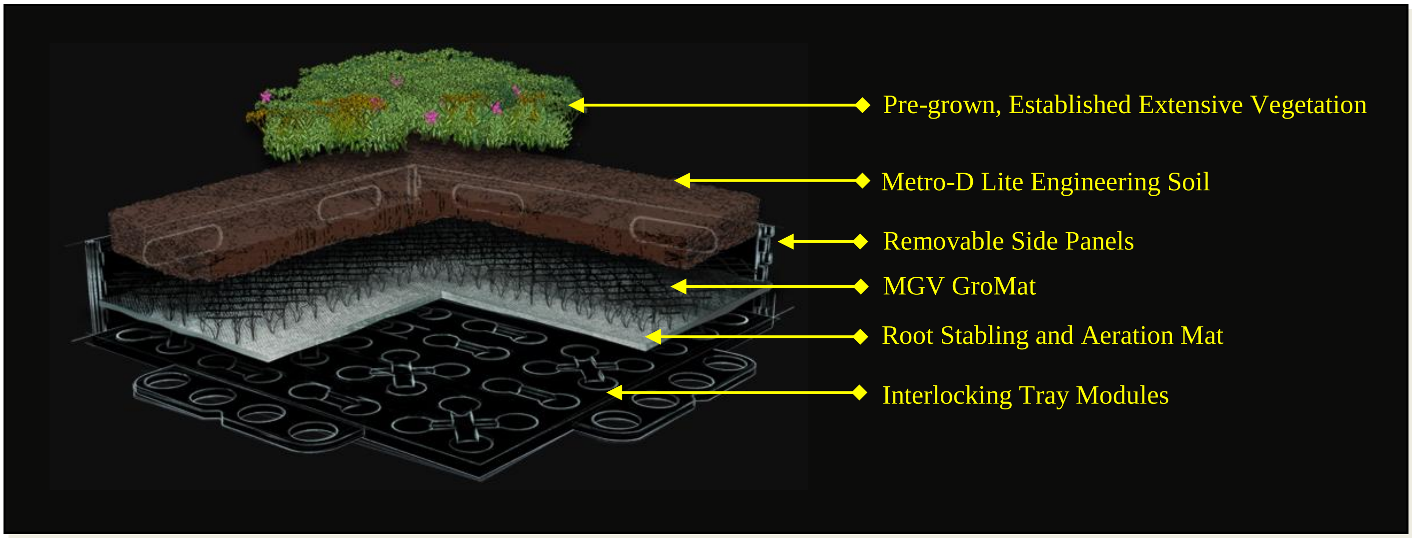


Figure 59: GroRoof Extensive I System Components

This hybrid modular green roof system was chosen because it is able to be transported and installed as an interlocking modular system, but removal of the 100% removable side panels allows for full soil integration with adjacent modules maximizing the thermal value of the system. Designed to be integrated with the green roof modules are the GroRoof Paver Platforms and 2" lightweight concrete pavers. By using the paver platforms, it allows the pavers and extensive green roof modules to be fully integrated as one interlocking system. By using these platforms, it allows for easy access to the roof and waterproofing membrane and can be used as space to run conduit for exterior landscape lighting or irrigation lines. Figure 60 depicts the GroRoof Paver Platforms mounted on the interlocking tray modules. The patio area to be used by occupants of the building will feature 2" thick concrete pavers, provided by Metro Green Visions, which will be installed on the paver platforms to match the height of the green roof vegetation modules.

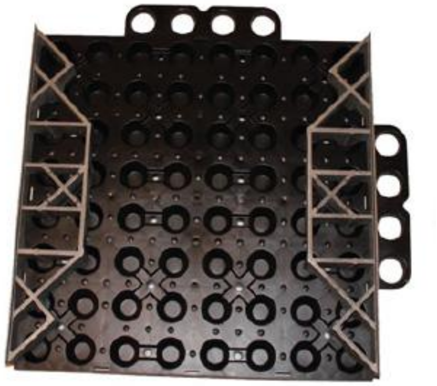


Figure 60: GroRoof Paver Platforms

CONSTRUCTABILITY REVIEW

As a construction manager, the most important considerations when selecting a green roof system are the constructability of the system and how it will impact the project costs and schedule. An analysis of concerns regarding the constructability of green roofs was performed by LEED Accredited Professional and superintendent for Turner Construction Company, Ryan Kline. As part of the constructability review process, Mr. Kline identified six issues that should be addressed during the design phase of a buildings green roof including the following [23]:

1) Access for Construction and Maintenance
2) Installation Specifications
3) Selection of Green Roof Type
4) Irrigation and Drainage Systems
5) Zoning Requirements and Regulations
6) LEED and Government Incentives

In the process of selecting and designing a green roof for the Gouverneur Healthcare Services building, all of the following issues were addressed or would be addressed during the construction of the green roof had the owner decided on implementing it.

ACCESS FOR CONSTRUCTION MAINTENANCE

During construction, there are two access points in which green roof installers can bring material through to the sixth floor roof, as well as an interior elevator that is capable of hoisting the module capacities. After substantial completion, the access paths will still be available to maintenance crews to perform maintenance on the green roof, as well as one access door for occupants of the building to access the patio.

INSTALLATION SPECIFICATIONS

The specifications issue addressed by Mr. Kline concerns leak and flood testing of the waterproofing and the completed green roof system. This issue was not addressed during the design process and will be handled by the construction manager.

SELECTION OF GREEN ROOF TYPE

When designing the green roof system, there are many considerations to account for when selecting either an intensive or extensive green roof. The type of green roof system chosen for application can impact a construction project in a variety of ways including cost, schedule, and impact on other building systems. As previously stated, the newly proposed green roof design for this analysis will feature an 18”x18”x4.5” Extensive I Hybrid Modular Green Roof system by GroRoof and the original design of the green roof incorporates a stick-built intensive green roof. Table 29 below depicts some of the constructability concerns that were addressed when decided to implement a hybrid modular green roof system compared to an intensive green roof system.

TABLE 29: ADDRESSED CONSTRUCTABILITY CONCERNS

Constructability Concern	Extensive Modular Green Roof System	Intensive Green Roof System
Efficient Delivery to Job Site	x	
Labor Installation Efficiency	x	
Pre-Grown Vegetation	x	
Maintenance Intensive		x
Irrigation Required		x
Leak and Flood Testing	x	x
Project Cost Impact (Irrigation not included)	$14-15 per sf	$25-40 per sf [24]
Structural Impact	18-26 lbs per sf	35-50 lbs per sf [24]

As shown in Table 29, the extensive modular green roof design can better benefit the project in terms of both constructability and building impact. Capable of closely benefitting the buildings mechanical and storm water retention system as an intensive green roof is capable, the extensive roof can be delivered and installed more efficiently; require less start-up and long-term maintenance; does not typically require irrigation; has a lower projected cost; and will impact building systems such as the structure less.

IRRIGATION AND DRAINAGE SYSTEMS

Sometimes overlooked in terms of cost for the overall design, application, and maintenance of an intensive green roof is the cost for irrigation and drainage, as well as projected water usage costs for maintaining the vegetation. Compared to an intensive green roof, an extensive green roof, especially in the New York City region, would not require an irrigation system to support the plant life of the green roof system. An irrigation system can make a drastic difference in the overall cost of a green roof system, which is why an extensive green roof was implemented to help reduce system, as well as building utility costs.

ZONING REQUIREMENTS AND REGULATIONS

The zoning requirements and regulations issue addressed by Mr. Kline concerns complying with local zoning codes and regulation for the New York City during both design and construction of the green roof. This issue was not addressed during the design process and will be handled by the construction manager.

LEED AND GOVERNMENT INCENTIVES

Aside from benefitting the owner through increase storm water retention and decreased building energy use, an owner can benefit through the application of a green roof by attaining points through the LEED checklist. The application of the GroRoof Extensive Hybrid Modular Green Roof system has the potential help an owner and construction management team earn up to 20 LEED certification points in the following categories:

SUSTAINABLE SITES

- SS 5.1 Site Development- Protect or Restore Habitat
- SS 5.2 Site Development – Maximize Open Space
- SS 6.1 Quantity Control Storm Water Design
- SS 6.2 Quality Control Storm Water Design
- SS 7.2 Heat Island Effect, Roof
- ID 1.1 Vegetated Roof for Exemplary Performance

WATER EFFICIENCY

- WE 1.1 Water Efficient Landscaping Reduce by 50%
- WE 1.2 Water Efficient Landscaping

ENERGY AND ATMOSPHERE

- EA 1.1 to 1.19 Optimize Energy Performance

MATERIALS AND RESOURCES

- MR 41.-4.2 Recycled Content
- MR 5.1-5.2 Regional Materials

In addition to potential LEED certification points, an owner can benefit through the application of a green roof by obtaining federal and local tax incentives and/or funding.

STRUCTURAL BREADTH ANALYSIS

The current designed roof for the new 6th floor roof consists of a hot fluid-applied, rubberized asphalt waterproofing membrane, elastomeric flashing sheet, fiberglass reinforced rubberized asphalt sheet, insulation drainage panels, filter fabric, and stone ballast. With the addition of a green roof to the 6th floor roof, the current design of the structural system to support this roof may not be sufficient to support the added load of the green roof.

This analysis will satisfy a structural breadth requirement by illustrating skills to perform a structural analysis and redesign of the 6th floor roof. The structural analysis will consist of determining if the existing system is sufficient and redesigning the system if necessary. If changes to the design must occur, the impact on project schedule and costs will also be determined.

The first step in the process of analyzing whether the currently designed structure can support the addition of the GroRoof Extensive Hybrid Modules is to determine what loads the supporting members are designed to withstand. Table 30 displays dead and live loads used for the design of the sixth floor roof structural system which are located on drawing S1.00.

TABLE 30: LIVE AND DEAD LOADS ON SIXTH FLOOR ROOF

Item	Load
4 - ¼ " Lightweight Concrete on 2” LOK-Floor	55 lb/ft^2
Ceiling	2 lb/ft^2
Mechanical and Electrical	10 lb/ft^2
Fire Protection and Miscellaneous	5 lb/ft^2
Roofing and Insulation	9 lb/ft^2
Total Dead Load	81 lb/ft^2
AISC Roof Garden Live Garden (Table 4-1)	100 lbs/ft^2
Total Live Load	100 lbs/ft^2

The typical bay that was selected to further analyze to determine if the existing designed structure can support the load of an added green can be seen in Figure 61 below.

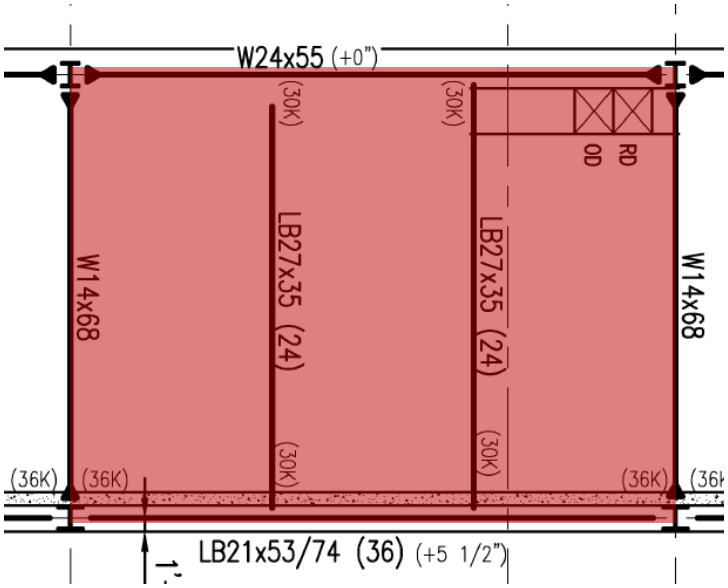


Figure 61: Structural Bay for Analysis

The structure to be analyzed consists of the following members:

- Girders: (1) - 30 ft. W24x55 and (1) - 30 ft. LB21x53/74 (36)
- Beams: (2) - 22 ft. LB 27x35 (24) and (2) - 22 ft.W14x68; spaced at 10 ft. O.C.

With the addition of the GroRoof Extensive Hybrid Modules, there will be an added weight between 18 to 26 lbs/ft^2, where 26 lbs/ft^2 is the fully saturated weight and will be used as a worst case scenario situation for the purpose of this analysis. Because the green roof is replacing the current roofing system, only insulation will applied to the top of the concrete in preparation for the green roof and this load will be reduced to 1 lbs/ft^2. The new total loads to be used for analysis can be seen in Table 31.

TABLE 31: LIVE AND DEAD LOADS ON SIXTH FLOOR ROOF

Item	Load
4 - ¼ " Lightweight Concrete on 2” LOK-Floor	55 lb/ft^2
Ceiling	2 lb/ft^2
Mechanical and Electrical	10 lb/ft^2
Fire Protection and Miscellaneous	5 lb/ft^2
Insulation	1 lb/ft^2
GroRoof Extensive Hybrid Modules	26 lb/ft^2
Beam/Girder Self-Weight (Assumption)	5 lb/ft^2
Total Dead Load	104 lb/ft^2
ASCE Roof Garden Live Garden (Table 4-1)	100 lbs/ft^2
Total Live Load	100 lbs/ft^2

BEAM ANALYSIS CALCULATIONS

W14X68 BEAM CALCULATION

- Live Load Reduction: $L_r = L_o \left[.25 + \frac{15}{\sqrt{K_{LL}A_t}}\right]$
    - where L_o=100 lbs/ft^2, K_{LL}=2 for beams and girders, A_t=220 ft^2
    - L_r = 100 lbs/ft^2 x [.25 x 15 / ($\sqrt{(2)(220ft^2)}$] = 96.51 lb/ft^2
- Factored Distributed Load: $W = (1.2)(D_L) + (1.6)(L_R)$ and $w_u = (W)(Tributary\ Area)$
    - W = (1.2)(104 lbs/ft^2) + (1.6)(96.51 lbs/ft^2) = 279.22 lbs/ft^2
    - w_u = (279.22 lbs/ft^2) x (10 ft) = 2.792 k/ft
- Factored Bending Moment: $M_u = \frac{(w_u)(l^2)}{8}$
    - M_u = [(2.792 lbs/ft^2) x (22 ft)^2] / 8 = 168.92 k-ft
- Factored Shear
    - V_u = [(2.792 k/ft) x (22 ft)] / 2 = 30.71 k
- Beam Comparison:
    - W14x68 Maximum Bending Moment = 431 k-ft from AISC Flexural Design Tables ➔ 431 k-ft > 168.92 k-ft, Acceptable Design
    - W14x68 Maximum Shear = 175 k from AISC Flexural Design Tables ➔ 175 k > 30.71 k, Acceptable Design

L27X35 BEAM CALCULATION

- Live Load Reduction: $L_r = L_o \left[.25 + \frac{15}{\sqrt{K_{LL}A_t}}\right]$
    - where L_o=100 lbs/ft^2, K_{LL}=2 for beams and girders, A_t=220 ft^2
    - L_r = 100 lbs/ft^2 x [.25 x 15 / ($\sqrt{(2)(220ft^2)}$] = 96.51 lb/ft^2
- Factored Distributed Load: $W = (1.2)(D_L) + (1.6)(L_R)$ and $w_u = (W)(Tributary\ Area)$
    - W = (1.2)(104 lbs/ft^2) + (1.6)(96.51 lbs/ft^2) = 279.22 lbs/ft^2
    - w_u = (279.22 lbs/ft^2) x (10 ft) = 2.792 k/ft
- Bending Moment: $M_u = \frac{(w_u)(l^2)}{8}$
    - M_u = [(2.792 lbs/ft^2) x (22 ft)^2] / 8 = 168.92 k-ft
- Factored Shear
    - V_u = [(2.792 k/ft) x (22 ft)] / 2 = 30.71 k

- Beam Comparison: Calculations for this castellated beam are based off of the manufacturers, CMC Steel Products, design software and guidelines.
    - LB27x35 Maximum Bending Moment = 258 k-ft from CMC design software results ➔ 258 k-ft > 168.92 k-ft, Acceptable Design
    - LB27x35 Maximum Shear = 135 k from CMC design software results ➔ 135 k > 30.71 k, Acceptable Design

GIRDER ANALYSIS CALCULATION

W24X55 GIRDER ANALYSIS CALCULATION

- Live Load Reduction: $L_r = \mathrm{L_o}\left[.25 + \frac{15}{\sqrt{K_{LL}A_t}}\right]$
    - where L_o=100 lbs/ft^2, K_{LL}=2 for beams and girders, A_t=330 ft^2
    - L_r = 100 lbs/ft^2 x [.25 x 15 / ($\sqrt{(2)(330ft^2)}$] = 83.39 lb/ft^2
- Factored Distributed Load: $W = (1.2)(D_L) + (1.6)(L_R)$
    - W = (1.2)(104 lbs/ft^2) + (1.6)(83.39 lbs/ft^2) = 258.22 lbs/ft^2
- Figure 62 displays how the factored shear and bending moments were determined.

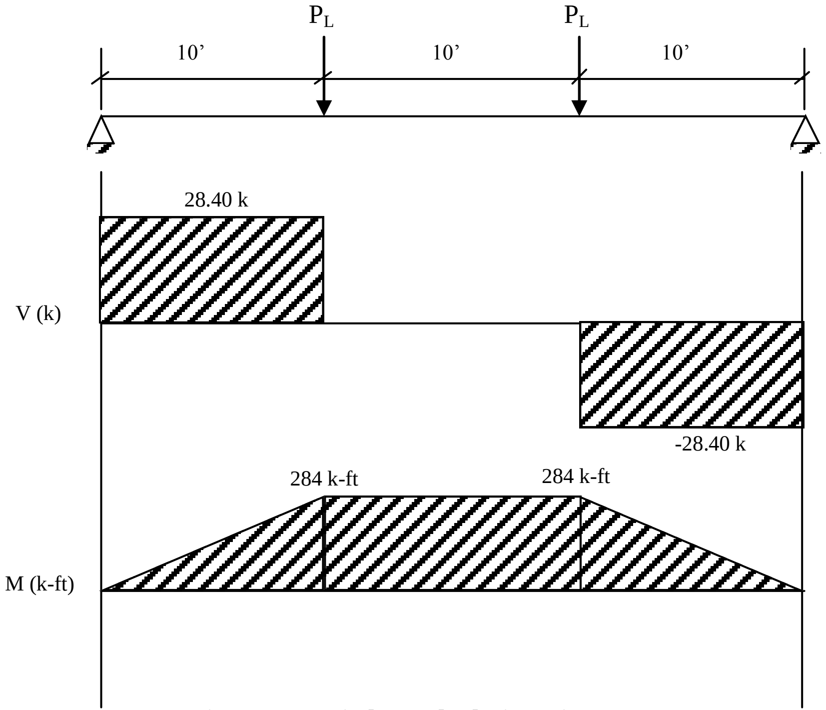


Figure 62: Girder Calculation Figure

- Beam Point Loads: $P_L = \frac{W\ x\ Tributary\ Width\ x\ Tributary\ Length}{1000}$

  - P_L = [(258.22 lbs/ft^2) x (10 ft) x (11 ft)] / 1000 = 28.40 k
- Factored Shear
  - V_u = [(28.40 k) x (2 members)] / 2 = 28.4 k
- Bending Moment:
  - M_u = (28.4 k) x (10 ft) = 284 k-ft
- Girder Comparison:
  - W24x55 Maximum Bending Moment = 503 k-ft from AISC Flexural Design Tables ➔ 503 k-ft > 168.92 k-ft, Acceptable Design
  - W14x68 Maximum Shear = 251 k from AISC Flexural Design Tables ➔ 175 k > 28.4 k, Acceptable Design

LB21X53/74 GIRDER ANALYSIS CALCULATION

- Live Load Reduction: $L_r = L_o \left[.25 + \frac{15}{\sqrt{K_{LL}A_t}}\right]$
  - where L_o=100 lbs/ft^2, K_{LL}=2 for beams and girders, A_t=330 ft^2
  - L_r = 100 lbs/ft^2 x [.25 x 15 / ($\sqrt{(2)(330ft^2)}$] = 83.39 lb/ft^2
- Factored Distributed Load: $W = (1.2)(D_L) + (1.6)(L_R)$
  - W = (1.2)(104 lbs/ft^2) + (1.6)(83.39 lbs/ft^2) = 258.22 lbs/ft^2
- Figure 63 displays how the factored shear and bending moments were determined.

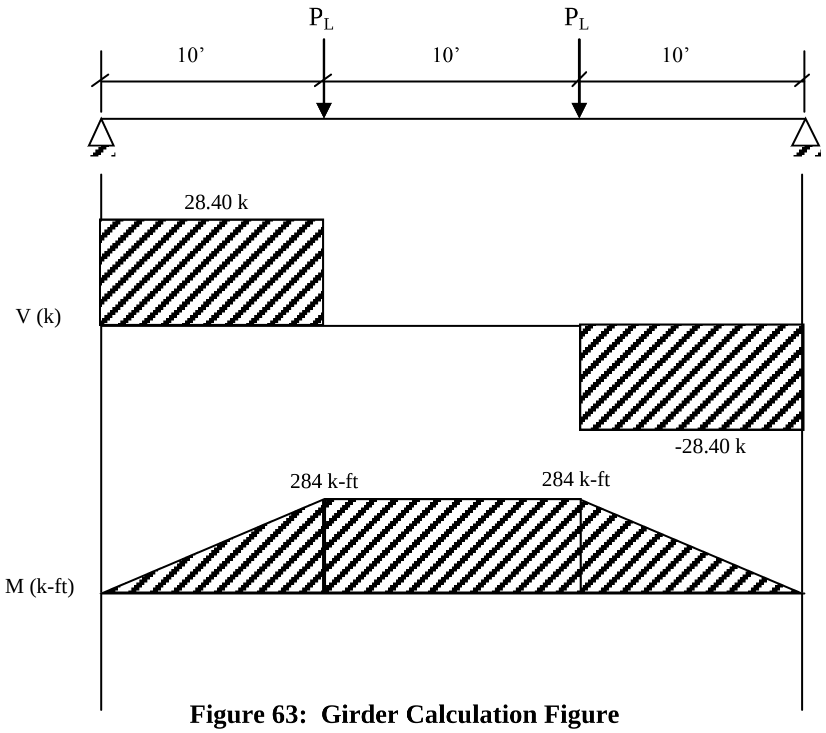


Figure 63: Girder Calculation Figure

- Beam Point Loads: $P_L = \frac{W\ x\ Tributary\ Width\ x\ Tributary\ Length}{1000}$
  - P_L = [(258.22 lbs/ft^2) x (10 ft) x (11 ft)] / 1000 = 28.40 k
- Factored Shear
  - V_u = [(28.40 k) x (2 members)] / 2 = 28.4 k
- Bending Moment:
  - M_u = (28.4 k) x (10 ft) = 284 k-ft
- Girder Comparison: Calculations for this castellated beam are based off of the manufacturers, CMC Steel Products, design software and guidelines.
  - LB21x53/74 Maximum Bending Moment = 264 k-ft from CMC design software results ➔ 264 k-ft > 168.92 k-ft, Acceptable Design
  - LB21x53/74 Maximum Shear = 232 k from CMC design software results ➔ 258 k > 28.4 k, Acceptable Design

Upon completion of the previous structural calculations, it has been determined that the designed structural system can meet the additional loading requirements of the GroRoof Extensive Hybrid Modules green roof system. All structural members have met the maximum shear and moment requirements as stated in the American Institute of Steel Construction Manual. Note that all calculations and sizing methods used in this breadth study were learned in Architectural Engineering 404: Building Structural Systems in Steel and Concrete taught by Dr. Linda M. Hanagan. The summary of calculations for the CMC Steel Products software for the castellated beams has been included in Appendix E.

MECHANICAL BREADTH ANALYSIS

The current designed roof for the new 6th floor roof consists of a hot fluid-applied, rubberized asphalt waterproofing membrane, elastomeric flashing sheet, fiberglass reinforced rubberized asphalt sheet, insulation drainage panels, filter fabric, and stone ballast. With the addition of a green roof to the 6th floor roof, the current design of the mechanical system may be affected due to the thermal properties of the green roof system.

This analysis will satisfy a mechanical breadth requirement by illustrating skills to perform a mechanical analysis of the current roof system compared to the green roof system. The impact of the system will be analyzed in terms of thermal resistance between the two roof systems and their impact on the mechanical load for the floor below. After determining any changes to the heating or cooling loads, mechanical system resizing and load reduction calculations will occur. A cost analysis for the savings involved in the reduction of the mechanical load will be calculated and used as evidence to support the addition of the green roof system.

The first step in the process of determining the heating and cooling load reduction through the application of the GroRoof Extensive Hybrid Module green roof system is to compare the overall R-Value and U-Value for the original roof and green roof system. Table 32 displays the building materials and their associated values for the original roof and green roof system. R-Values for the building materials are listed in the 2001 ASHRAE Handbook of Fundamentals.

TABLE 32: ROOF SYSTEM R- VALUE AND U-VALUE CALCULATION

Material	R-Value (ft^2-^{o}F-hr/BTU)		U-Value (BTU/ft^2-^{o}F-hr)	
	Original Roof	Green Roof	Original Roof	Green Roof
4-1/2" GroRoof System	-	6	-	0.17
Stone Roof Ballast	0.2	-	5.00	-
2" Thick Drainage Insulation Panels	5.88	5.88	0.17	0.17
Hot Fluid Applied, Rubberized Asphalt Waterproofing Membrane	0.15	0.15	6.67	6.67
4" Concrete Slab	0.4	0.4	2.50	2.50
Total	6.63	12.43	0.15	0.08

With the known R-Value and U-Value, the monthly heating and cooling loads can be used to determine the annual heating and cooling loads. The degree heating and cooling degree days are based off recent temperature data provided by degreedays.net using the weather station in New York City Central Park, NY, USA (73.97W, 40.78N) for a base temperature of 65^{o}F. Calculations will be performed through the use of the following equations:

- $Q_{monthly} = (UA)_h \ x \ DD$ x 24 hrs/day
    - where $Q_{monthly}$ is monthly heating or cooling load, U is the heat transfer coefficient, A is the total area, and DD is the heating or cooling degree days
- $E_T = \frac{L_{monthly}}{\eta \ or \ COP}$
    - where E_T is the total heating or cooling energy, and η is the efficiency of the unit or COP is the coefficient of performance

Table 33 displays the yearly heating and cooling loads, categorized by month, for the original roof system.

TABLE 33 : YEARLY HEATING AND COOLING LOAD ORIGINAL ROOF SYSTEM

Month	Degree Days	U-Value (BTU/ft^2-^{o}F-hr)	Area (ft^2)	Q $_{monthly}$ (BTU)	Q $_{yearly}$ (BTU)
Heating Load					
March	722	0.15	7050	18,425,701	116,194,208
April	369	0.15	7050	9,417,013	
May	139	0.15	7050	3,547,330	
October	272	0.15	7050	6,941,538	
November	661	0.15	7050	16,868,959	
December	840	0.15	7050	21,437,104	
January	840	0.15	7050	21,437,104	
February	710	0.15	7050	18,119,457	
Cooling Load					
June	226	0.15	7050	5,767,601	29,042,172
July	453	0.15	7050	11,560,723	
August	295	0.15	7050	7,528,506	
September	164	0.15	7050	4,185,339	

Table 34 displays the yearly heating and cooling loads, categorized by month, for the green roof system.

TABLE 3 4: YEARLY HEATING AND COOLING LOAD GREEN ROOF SYSTEM

Month	Degree Days	U-Value (BTU/ft^2-^{o}F-hr)	Area (ft^2)	Q $_{monthly}$ (BTU)	Q $_{yearly}$ (BTU)
Heating Load					
March	722	0.08	7050	9,828,028	6,1976,476
April	369	0.08	7050	5,022,912	
May	139	0.08	7050	1,892,099	
October	272	0.08	7050	3,702,526	
November	661	0.08	7050	8,997,683	
December	840	0.08	7050	11,434,271	
January	840	0.08	7050	11,434,271	
February	710	0.08	7050	9,664,682	
Cooling Load					
June	226	0.08	7050	3,076,363	1,549,0716
July	453	0.08	7050	6,166,339	
August	295	0.08	7050	4,015,607	
September	164	0.08	7050	2,232,405	

After calculating the yearly heating and cooling loads for both roof systems, the energy heating and cooling energy of both systems will be calculated, which can be seen in Table 35, using the efficiency and coefficient of performance for the 50,000 cfm Rancan Carrier A4D130/148DO Air Handling Unit that serves spaces throughout the new facility.

Table 35: Heating and Cooling Energy Comparison

Heating Energy			Cooling Energy		
Q_{Total} (kWh)	η	E_{Total} (kW)	Q_{Total} (kWh)	COP	E_{Total} (kW)
Original Roofing System					
34052	0.7133	47738	8511	3.5	2432
Green Roofing System					
18163	0.7133	25463	4540	3.5	1297
Energy Difference		22275	Energy Difference		1135

The average cost of electricity in New York City for the year 2012 is approximately $0.16/kWh. Using this cost, the cost savings for the reduction in heating and cooling loads can be calculated and are shown in Table 36.

Table 36: Annual Cost Savings for Heating and Cooling

Heating Energy Savings			Cooling Energy Savings			Total Savings
Energy Difference (kWh)	Cost/kWh	Savings	Energy Difference (kWh)	Cost/kWh	Savings	
22275.22	$ 0.16	$ 3,564.03	1135	$ 0.16	$ 181.55	$3,746

As shown in Table 36, through the implementation of the GroRoof Extensive Hybrid Module green roof system, the annual cost savings for heating and cooling is approximately $3,746 per year.

Cost and Schedule Impacts

Green Roof System Cost

Due to financial restrictions, it was decided that it was not in the owner's best interests to implement the green roof garden into the design. However, the implementation of a green roof has the potential to provide an area for use of occupants, increase energy efficiency, and potentially save the owner long term money. Table 37 shows the projected costs associated with the newly proposed green roof design which incorporates GroRoof 18"x18"x4.5" Extensive I Hybrid modules with concrete pavers supported by GroRoof interlocking Paver Platforms. All stated costs per square foot were provided by Zach Williams, Director of Technical Sales for Metro Green Visions, Inc.

Table 37: Projected Green Roof Costs

Material	Total SF	Total Cost per SF	Total System Cost
GroRoof 18"x18"x4.5" Extensive I Hybrid modules	4075 SF	$14.00	$ 57,050
GroRoof Paver Platforms	1030 SF	$9.50	$ 9,785
2" Concrete Pavers	1030 SF	$7.00	$ 7,210
Roof Ballast	1945 SF	$2.00	$ 3,890
Total	-	-	$ 77,935

As shown in the table, the total projected cost for the application of the extensive hybrid modular green roof system is $77,935. The original roof consists of a hot fluid-applied, rubberized asphalt waterproofing membrane; elastomeric flashing sheet; fiberglass reinforced rubberized asphalt sheet; insulation drainage panels; filter fabric; and stone ballast cost about $88,515. Since the modular green roof will basically be installed on top of the original roof, the total cost of the original roof, with the exception of full stone ballast coverage, and the green roof is approximately $152,350. After the mechanical breadth analysis was performed, it was determined that this system has the potential to reduce cooling and heating by up to $3,746 per year. A life-cycle cost analysis can be seen in Figure 64 showing that the payback period to make up for the costs of the green roof is about 21 years. This life-cycle cost analysis is based on the added cost of the newly designed green roof compared to the original roof system.

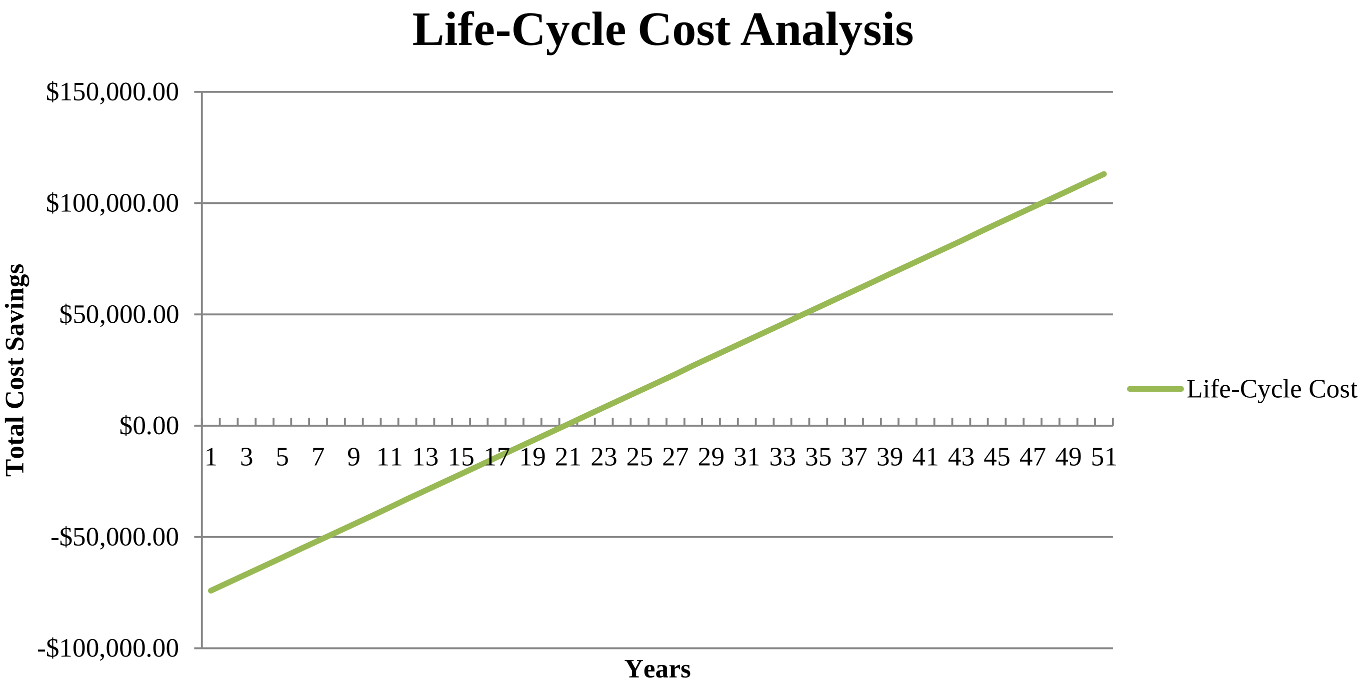


Figure 64: Green Roof Life-Cycle Analysis

Based on the green roofs 50 year life expectancy, the payback period is about 21 years and at the end of year 50, the implementation of the green roof has the potential to save the owner approximately $113,090. This savings does not include any maintenance that may need to be performed on the roof. The table in which Figure 64 is based on can be seen in Appendix E.

Green Roof Schedule Impacts

One of the benefits of utilizing a modular green roof system is the drastic reduction in construction schedule impact as compared to the traditional stick-built green roof systems. In order to efficiently schedule the installation of the green roof, the roof will be divided into two sections: 1) Green Roof and Patio 2) Green Roof, to allow the GroRoof modules to continue installation in section one while the paver platforms, pavers, and roof ballast begin to be installed in section two. The division of the roof can be seen in Figure 65.

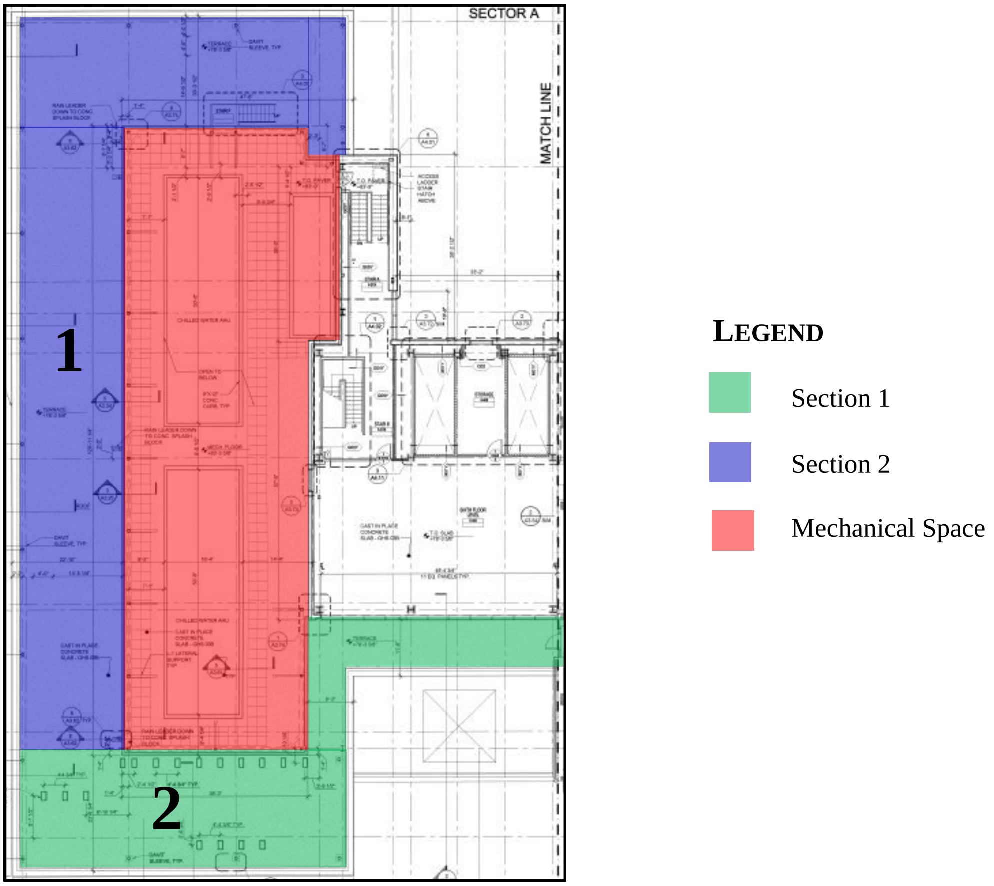


Figure 65: Green Roof Schedule Division

Upon completion and successful inspection of the rubberized waterproofing membrane and insulation drainage panels, the installation of the actual modules takes a minimal amount of a time to install. According to Metro Green Visions representatives, installation of the tray modules takes an estimated 3000 to 5000 SF per day depending on the size and complexity of the project. Because of the incorporation of the paver platform modules, concrete pavers, and roof ballast, a 4000 and 5000 SF per day labor production rate will be used to determine the duration. The schedule durations for the installation of the green roof can be seen in Table 38 below.

TABLE 38: PROJECTED GREEN ROOF DURATIONS

Material	Total SF	Total Duration per SF	Total Duration (Days)
GroRoof 18”x18”x4.5” Extensive I Hybrid modules	4075	4000	1.0
GroRoof Paver Platforms	1030	4000	0.3
2” Concrete Pavers	1030	5000	0.2
Roof Ballast	1945	4000	0.5
Total	-	-	2.0

As shown in the table, the total projected duration for the application of the extensive hybrid modular green roof system is about 2 days. However, because the roof installation is broken into two separate sections, the installation of materials in each section can occur simultaneously, reducing the schedule to about 1.5 days. The detailed schedule for the installation of the green roof can be seen in Appendix E.

SUMMARY AND CONCLUSION

- The design of the original green utilized about 2250 square feet of roof space on the sixth floor roof of the facility. Through this analysis, a new green roof layout was designed which would utilize 7050 square feet in order to maximize the possible energy and cost savings for the owner.
- The new design of the sixth floor green roof will incorporate GroRoof 18”x18”x4.5” Extensive I Hybrid green roof modules, GroRoof Paver Platforms which will support 2” lightweight concrete pavers, and roofing stone ballast.
- A constructability review identified important areas of concern when designing a green roof for a building including access for construction and maintenance, installation specifications, selection of green roof type, irrigation and drainage systems, zoning requirements and regulations, and LEED and Government incentives. This review also identified up to 20 potential LEED certification points through the application of the GroRoof product.
- A structural analysis concluded that the W24x55 and LB21x53/74 girders and LB 27x35 and W14x68 beams will provide adequate support for the added load of the green roof system.

- A mechanical analysis concluded that through the implementation of a green roof, the owner can save approximately $3,746 per year through the reduction of heating and cooling loads.
- A life-cycle analysis of the green roof showed that the payback period is approximately 21 years and with a 50 year life expectancy, the owner can expect up to $113,090 in energy savings.
- The green roof is expected to take approximately 1.5 days to install and is not a critical path item on the schedule so any delays in the construction of the green roof will not impact the overall project schedule.
- In conclusion, with the newly proposed design, it seems feasible based on heating and cooling cost savings, as well as other potential benefits, to implement the GroRoof green roof system to the sixth floor of the Gouverneur Healthcare Services facility.

RECOMMENDATIONS AND CONCLUSIONS

Upon the completion of four technical analyses and two breadth studies on the design and construction of the Gouverneur Healthcare Services facility, the following conclusions have been made to determine the feasibility of implementing each of these studies to the project.

Based on the success of the use of Building Information Modeling methods on the Fiterman Hall project, it was determined that it would be feasible to use a 3D model for the coordination of design and construction of the new addition to the Gouverneur Healthcare Services to reduce schedule and decrease the quantity of change orders, but not feasible for the existing facility because of complications with the phasing of the project. It is also feasible for the project to utilize the VELA Systems software equipped iPad's for the punchlist process because there is an estimated 2000 man hour savings by increasing the efficiency of the punchlist process.

An overall schedule savings of 168 days and cost savings of $206,732 determines it feasible to move forward with re-sequencing the project schedule that would create a direct phasing relationship between residential floors six through eleven. The utilization of the FM:Systems software allowed for a more efficient method of moving occupants from existing to new spaces, which allows the facility to potentially generate $428,854 in revenue for residential floors, reduce the overall schedule by 14 days, and save $140,182 in general conditions costs, which is feasible to implement both from the construction manager and owner's point of view.

Through the implementation of prefabrication, the total duration reduction of construction of the mechanical, electrical, plumbing, and fire protection work in the corridors is 200 days and the total labor cost savings is about $1,673,293, which accounts for a 9% cost savings for the mechanical, electrical, plumbing, and fire protection packages, and a 3% total cost savings for the construction of the new building. Based on the cost and schedule savings, it would be feasible to implement this method of construction.

A full schedule and cost analysis for a new green roof layout that utilizes 7050 square feet and incorporates GroRoof extensive green roof modules determined it would be feasible to implement on the sixth floor roof of the new addition. A mechanical analysis concluded that the owner can save approximately $3,746 per year through the reduction of heating and cooling loads. With a 21 year payback period and 50 year life expectancy, the owner can expect a profit of up to $113,090 in energy savings.

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TECHNICAL ANALYSIS I: THE USE OF BUILDING INFORMATION MODELING

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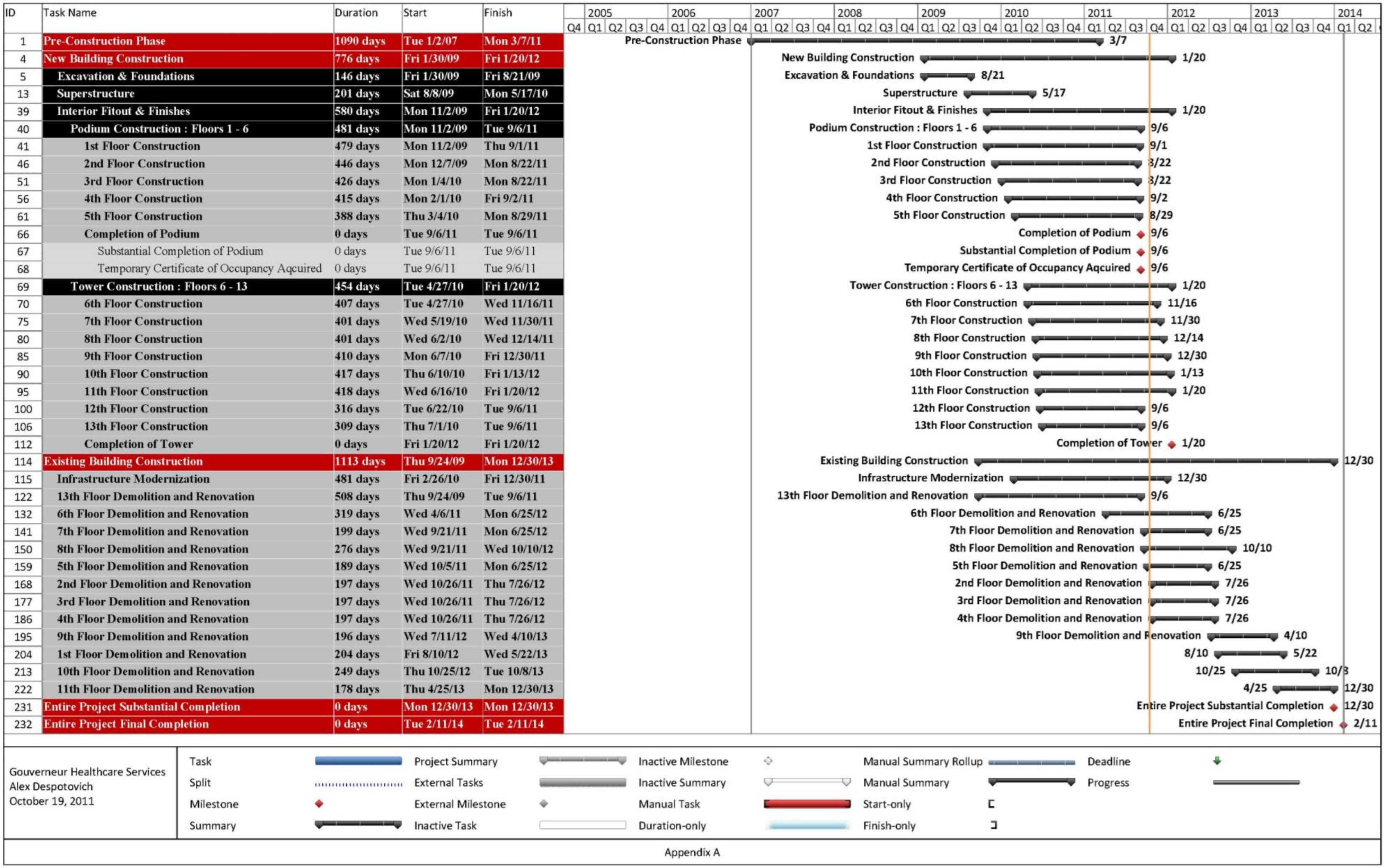
APPENDIX A

PROJECT SCHEDULE

GOUVERNEUR HEALTHCARE SERVICES SUMMARY SCHEDULE



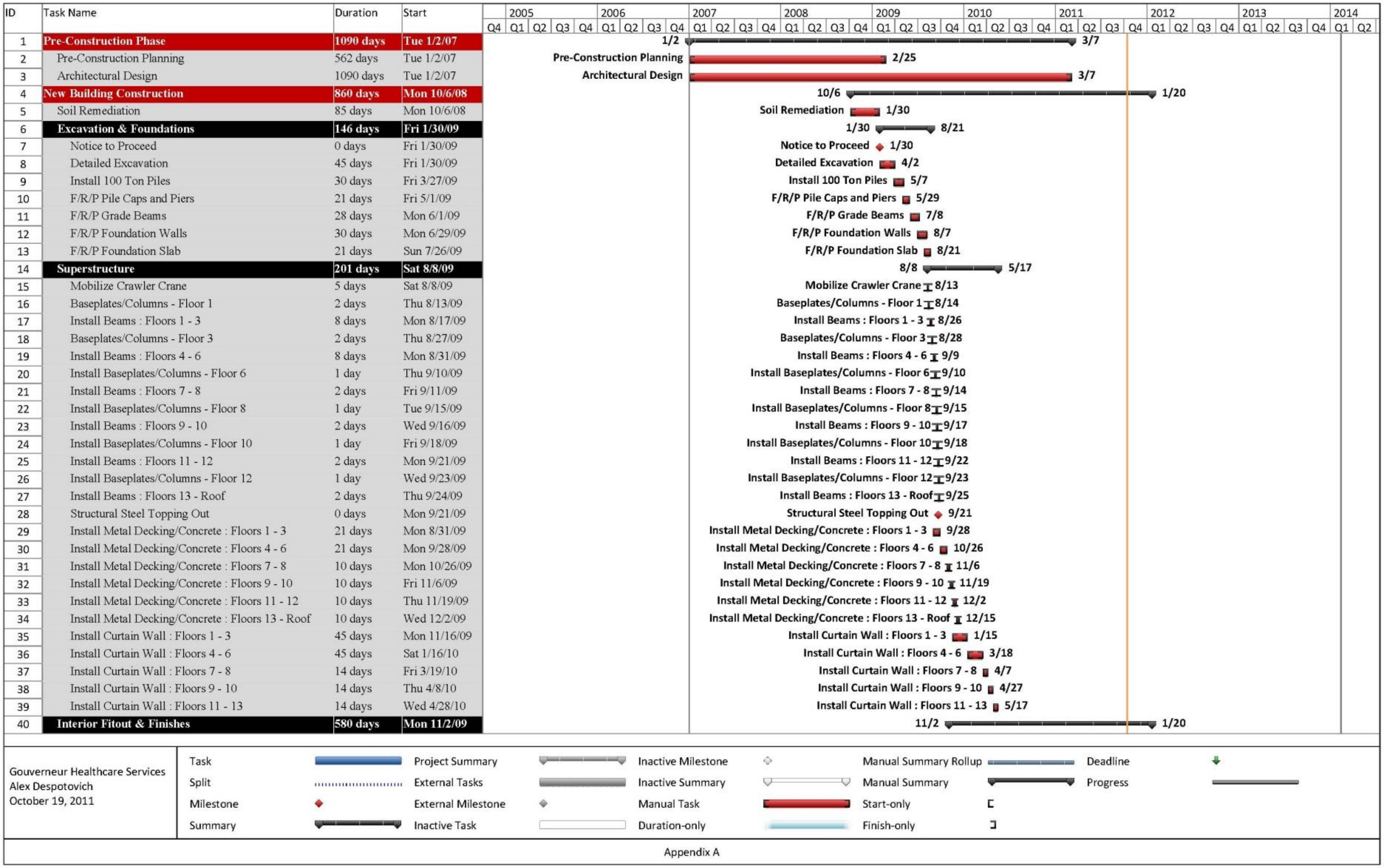
ID	Task Name	Duration	Start	Finish
1	Pre-Construction Phase	1090 days	Tue 1/2/07	Mon 3/7/11
4	New Building Construction	776 days	Fri 1/30/09	Fri 1/20/12
5	Excavation & Foundations	146 days	Fri 1/30/09	Fri 8/21/09
13	Superstructure	201 days	Sat 8/8/09	Mon 5/17/10
39	Interior Fitout & Finishes	580 days	Mon 11/2/09	Fri 1/20/12
40	Podium Construction : Floors 1 - 6	481 days	Mon 11/2/09	Tue 9/6/11
41	1st Floor Construction	479 days	Mon 11/2/09	Thu 9/1/11
46	2nd Floor Construction	446 days	Mon 12/7/09	Mon 8/22/11
51	3rd Floor Construction	426 days	Mon 1/4/10	Mon 8/22/11
56	4th Floor Construction	415 days	Mon 2/1/10	Fri 9/2/11
61	5th Floor Construction	388 days	Thu 3/4/10	Mon 8/29/11
66	Completion of Podium	0 days	Tue 9/6/11	Tue 9/6/11
67	Substantial Completion of Podium	0 days	Tue 9/6/11	Tue 9/6/11
68	Temporary Certificate of Occupancy Aqcuired	0 days	Tue 9/6/11	Tue 9/6/11
69	Tower Construction : Floors 6 - 13	454 days	Tue 4/27/10	Fri 1/20/12
70	6th Floor Construction	407 days	Tue 4/27/10	Wed 11/16/11
75	7th Floor Construction	401 days	Wed 5/19/10	Wed 11/30/11
80	8th Floor Construction	401 days	Wed 6/2/10	Wed 12/14/11
85	9th Floor Construction	410 days	Mon 6/7/10	Fri 12/30/11
90	10th Floor Construction	417 days	Thu 6/10/10	Fri 1/13/12
95	11th Floor Construction	418 days	Wed 6/16/10	Fri 1/20/12
100	12th Floor Construction	316 days	Tue 6/22/10	Tue 9/6/11
106	13th Floor Construction	309 days	Thu 7/1/10	Tue 9/6/11
112	Completion of Tower	0 days	Fri 1/20/12	Fri 1/20/12
114	Existing Building Construction	1113 days	Thu 9/24/09	Mon 12/30/13
115	Infrastructure Modernization	481 days	Fri 2/26/10	Fri 12/30/11
122	13th Floor Demolition and Renovation	508 days	Thu 9/24/09	Tue 9/6/11
132	6th Floor Demolition and Renovation	319 days	Wed 4/6/11	Mon 6/25/12
141	7th Floor Demolition and Renovation	199 days	Wed 9/21/11	Mon 6/25/12
150	8th Floor Demolition and Renovation	276 days	Wed 9/21/11	Wed 10/10/12
159	5th Floor Demolition and Renovation	189 days	Wed 10/5/11	Mon 6/25/12
168	2nd Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
177	3rd Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
186	4th Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
195	9th Floor Demolition and Renovation	196 days	Wed 7/11/12	Wed 4/10/13
204	1st Floor Demolition and Renovation	204 days	Fri 8/10/12	Wed 5/22/13
213	10th Floor Demolition and Renovation	249 days	Thu 10/25/12	Tue 10/8/13
222	11th Floor Demolition and Renovation	178 days	Thu 4/25/13	Mon 12/30/13
231	Entire Project Substantial Completion	0 days	Mon 12/30/13	Mon 12/30/13
232	Entire Project Final Completion	0 days	Tue 2/11/14	Tue 2/11/14

Gouverneur Healthcare Services
Alex Despotovich
October 19, 2011

Task	▬	Project Summary	▬	Inactive Milestone	◇	Manual Summary Rollup	▬	Deadline	⇩
Split	┈	External Tasks	▬	Inactive Summary	▬	Manual Summary	▬	Progress	▬
Milestone	◆	External Milestone	◆	Manual Task	▬	Start-only	[		
Summary	▬	Inactive Task	▭	Duration-only	▬	Finish-only	]		

Appendix A

GOUVERNEUR HEALTHCARE SERVICES DETAILED SCHEDULE



ID	Task Name	Duration	Start
1	**Pre-Construction Phase**	**1090 days**	**Tue 1/2/07**
2	Pre-Construction Planning	562 days	Tue 1/2/07
3	Architectural Design	1090 days	Tue 1/2/07
4	**New Building Construction**	**860 days**	**Mon 10/6/08**
5	Soil Remediation	85 days	Mon 10/6/08
6	**Excavation & Foundations**	**146 days**	**Fri 1/30/09**
7	Notice to Proceed	0 days	Fri 1/30/09
8	Detailed Excavation	45 days	Fri 1/30/09
9	Install 100 Ton Piles	30 days	Fri 3/27/09
10	F/R/P Pile Caps and Piers	21 days	Fri 5/1/09
11	F/R/P Grade Beams	28 days	Mon 6/1/09
12	F/R/P Foundation Walls	30 days	Mon 6/29/09
13	F/R/P Foundation Slab	21 days	Sun 7/26/09
14	**Superstructure**	**201 days**	**Sat 8/8/09**
15	Mobilize Crawler Crane	5 days	Sat 8/8/09
16	Baseplates/Columns - Floor 1	2 days	Thu 8/13/09
17	Install Beams : Floors 1 - 3	8 days	Mon 8/17/09
18	Baseplates/Columns - Floor 3	2 days	Thu 8/27/09
19	Install Beams : Floors 4 - 6	8 days	Mon 8/31/09
20	Install Baseplates/Columns - Floor 6	1 day	Thu 9/10/09
21	Install Beams : Floors 7 - 8	2 days	Fri 9/11/09
22	Install Baseplates/Columns - Floor 8	1 day	Tue 9/15/09
23	Install Beams : Floors 9 - 10	2 days	Wed 9/16/09
24	Install Baseplates/Columns - Floor 10	1 day	Fri 9/18/09
25	Install Beams : Floors 11 - 12	2 days	Mon 9/21/09
26	Install Baseplates/Columns - Floor 12	1 day	Wed 9/23/09
27	Install Beams : Floors 13 - Roof	2 days	Thu 9/24/09
28	Structural Steel Topping Out	0 days	Mon 9/21/09
29	Install Metal Decking/Concrete : Floors 1 - 3	21 days	Mon 8/31/09
30	Install Metal Decking/Concrete : Floors 4 - 6	21 days	Mon 9/28/09
31	Install Metal Decking/Concrete : Floors 7 - 8	10 days	Mon 10/26/09
32	Install Metal Decking/Concrete : Floors 9 - 10	10 days	Fri 11/6/09
33	Install Metal Decking/Concrete : Floors 11 - 12	10 days	Thu 11/19/09
34	Install Metal Decking/Concrete : Floors 13 - Roof	10 days	Wed 12/2/09
35	Install Curtain Wall : Floors 1 - 3	45 days	Mon 11/16/09
36	Install Curtain Wall : Floors 4 - 6	45 days	Sat 1/16/10
37	Install Curtain Wall : Floors 7 - 8	14 days	Fri 3/19/10
38	Install Curtain Wall : Floors 9 - 10	14 days	Thu 4/8/10
39	Install Curtain Wall : Floors 11 - 13	14 days	Wed 4/28/10
40	**Interior Fitout & Finishes**	**580 days**	**Mon 11/2/09**

Gouverneur Healthcare Services
Alex Despotovich
October 19, 2011

Task
Split
Milestone ◆
Summary

Project Summary
External Tasks
External Milestone ◆
Inactive Task

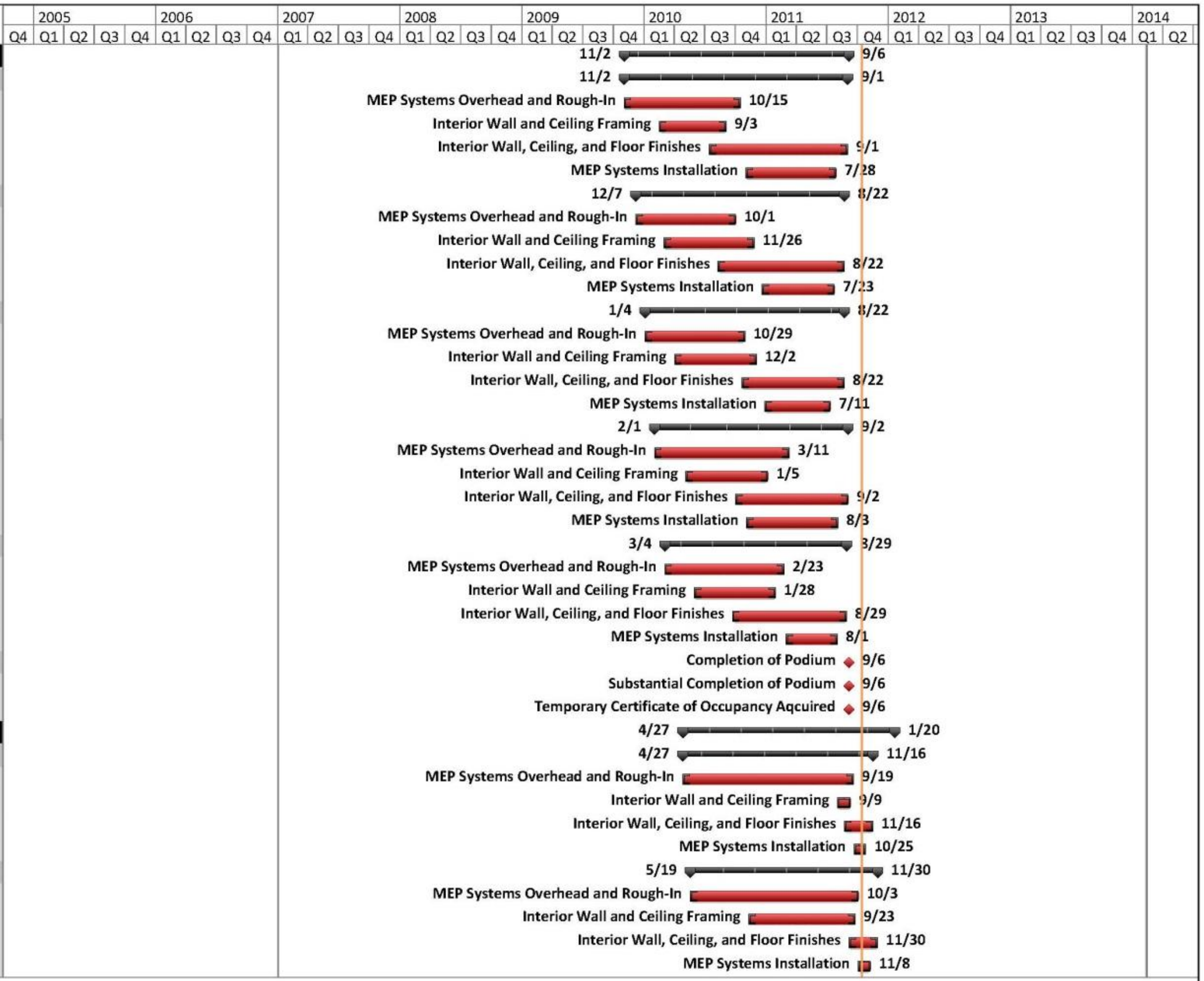
Inactive Milestone ◇
Inactive Summary
Manual Task
Duration-only

Manual Summary Rollup
Manual Summary
Start-only [
Finish-only]

Deadline ⇩
Progress

Appendix A

ID	Task Name	Duration	Start
41	**Podium Construction : Floors 1 - 6**	**481 days**	**Mon 11/2/09**
42	**1st Floor Construction**	**479 days**	**Mon 11/2/09**
43	MEP Systems Overhead and Rough-In	250 days	Mon 11/2/09
44	Interior Wall and Ceiling Framing	145 days	Mon 2/15/10
45	Interior Wall, Ceiling, and Floor Finishes	296 days	Thu 7/15/10
46	MEP Systems Installation	193 days	Tue 11/2/10
47	**2nd Floor Construction**	**446 days**	**Mon 12/7/09**
48	MEP Systems Overhead and Rough-In	215 days	Mon 12/7/09
49	Interior Wall and Ceiling Framing	195 days	Mon 3/1/10
50	Interior Wall, Ceiling, and Floor Finishes	270 days	Tue 8/10/10
51	MEP Systems Installation	156 days	Mon 12/20/10
52	**3rd Floor Construction**	**426 days**	**Mon 1/4/10**
53	MEP Systems Overhead and Rough-In	215 days	Mon 1/4/10
54	Interior Wall and Ceiling Framing	175 days	Fri 4/2/10
55	Interior Wall, Ceiling, and Floor Finishes	219 days	Wed 10/20/10
56	MEP Systems Installation	140 days	Tue 12/28/10
57	**4th Floor Construction**	**415 days**	**Mon 2/1/10**
58	MEP Systems Overhead and Rough-In	290 days	Mon 2/1/10
59	Interior Wall and Ceiling Framing	175 days	Thu 5/6/10
60	Interior Wall, Ceiling, and Floor Finishes	241 days	Sat 10/2/10
61	MEP Systems Installation	196 days	Wed 11/3/10
62	**5th Floor Construction**	**388 days**	**Thu 3/4/10**
63	MEP Systems Overhead and Rough-In	255 days	Thu 3/4/10
64	Interior Wall and Ceiling Framing	175 days	Mon 5/31/10
65	Interior Wall, Ceiling, and Floor Finishes	244 days	Wed 9/22/10
66	MEP Systems Installation	109 days	Wed 3/2/11
67	**Completion of Podium**	**0 days**	**Tue 9/6/11**
68	Substantial Completion of Podium	0 days	Tue 9/6/11
69	Temporary Certificate of Occupancy Aqcuired	0 days	Tue 9/6/11
70	**Tower Construction : Floors 6 - 13**	**454 days**	**Tue 4/27/10**
71	**6th Floor Construction**	**407 days**	**Tue 4/27/10**
72	MEP Systems Overhead and Rough-In	365 days	Tue 4/27/10
73	Interior Wall and Ceiling Framing	29 days	Tue 8/2/11
74	Interior Wall, Ceiling, and Floor Finishes	62 days	Tue 8/23/11
75	MEP Systems Installation	25 days	Wed 9/21/11
76	**7th Floor Construction**	**401 days**	**Wed 5/19/10**
77	MEP Systems Overhead and Rough-In	359 days	Wed 5/19/10
78	Interior Wall and Ceiling Framing	228 days	Wed 11/10/10
79	Interior Wall, Ceiling, and Floor Finishes	62 days	Tue 9/6/11
80	MEP Systems Installation	27 days	Mon 10/3/11

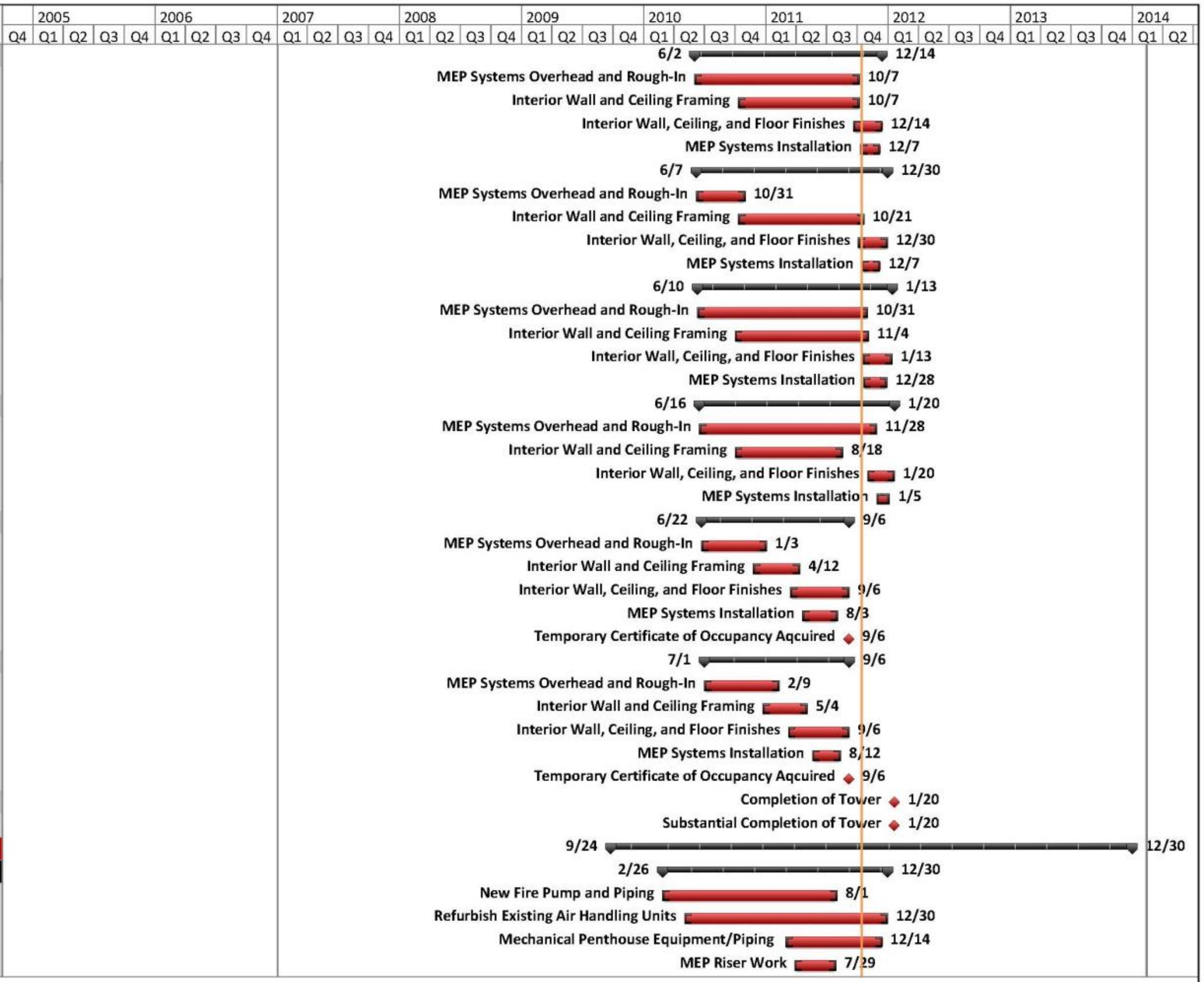


Gouverneur Healthcare Services
Alex Despotovich
October 19, 2011

Task
Split
Milestone ◆
Summary
Project Summary
External Tasks
External Milestone ◆
Inactive Task
Inactive Milestone ◇
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only [
Finish-only]
Deadline ⇩
Progress

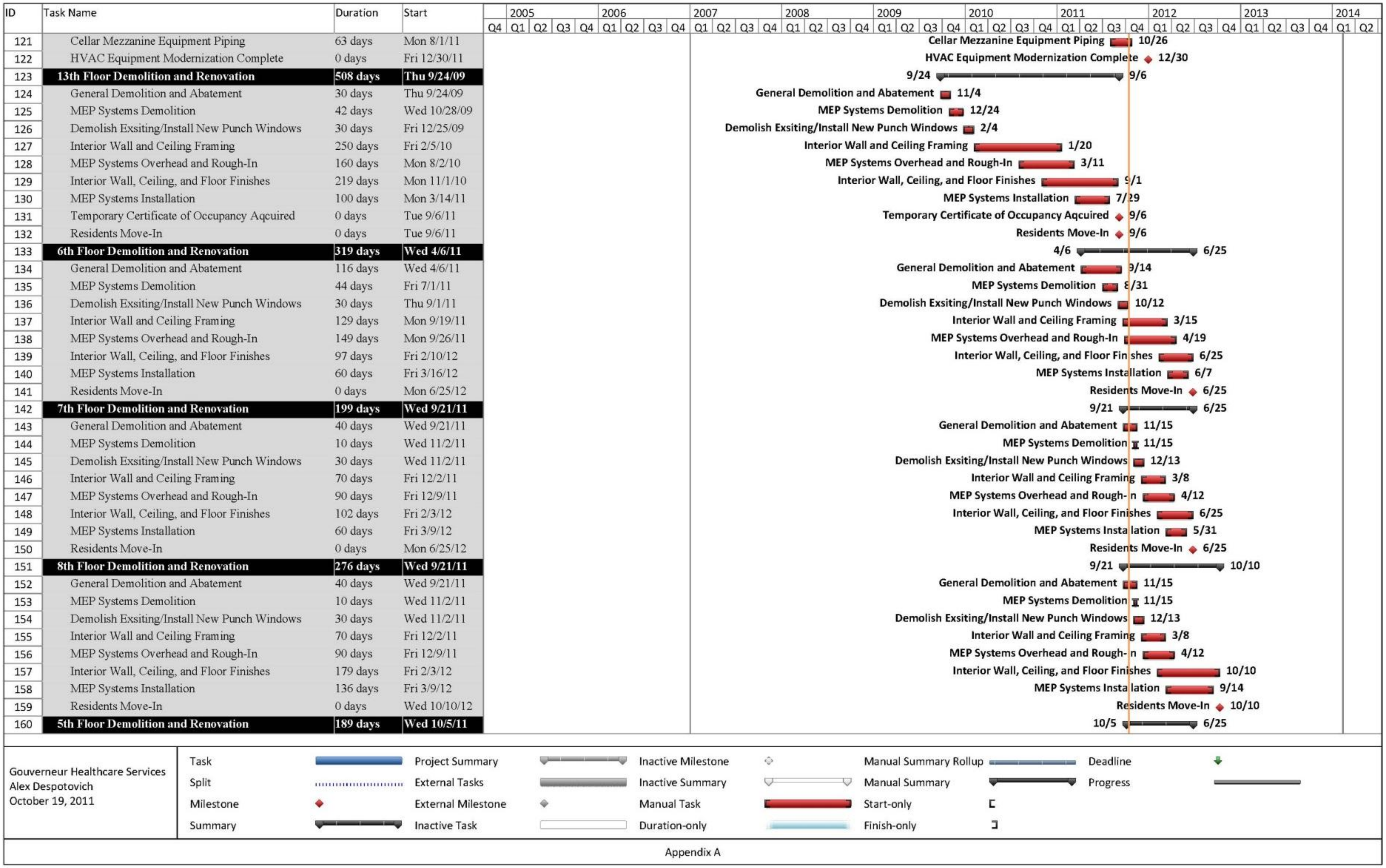
Appendix A

ID	Task Name	Duration	Start
81	**8th Floor Construction**	**401 days**	**Wed 6/2/10**
82	MEP Systems Overhead and Rough-In	353 days	Wed 6/2/10
83	Interior Wall and Ceiling Framing	261 days	Sun 10/10/10
84	Interior Wall, Ceiling, and Floor Finishes	62 days	Tue 9/20/11
85	MEP Systems Installation	43 days	Mon 10/10/11
86	**9th Floor Construction**	**410 days**	**Mon 6/7/10**
87	MEP Systems Overhead and Rough-In	106 days	Mon 6/7/10
88	Interior Wall and Ceiling Framing	271 days	Sun 10/10/10
89	Interior Wall, Ceiling, and Floor Finishes	64 days	Tue 10/4/11
90	MEP Systems Installation	39 days	Fri 10/14/11
91	**10th Floor Construction**	**417 days**	**Thu 6/10/10**
92	MEP Systems Overhead and Rough-In	363 days	Thu 6/10/10
93	Interior Wall and Ceiling Framing	286 days	Fri 10/1/10
94	Interior Wall, Ceiling, and Floor Finishes	64 days	Tue 10/18/11
95	MEP Systems Installation	50 days	Thu 10/20/11
96	**11th Floor Construction**	**418 days**	**Wed 6/16/10**
97	MEP Systems Overhead and Rough-In	379 days	Wed 6/16/10
98	Interior Wall and Ceiling Framing	230 days	Fri 10/1/10
99	Interior Wall, Ceiling, and Floor Finishes	59 days	Tue 11/1/11
100	MEP Systems Installation	29 days	Mon 11/28/11
101	**12th Floor Construction**	**316 days**	**Tue 6/22/10**
102	MEP Systems Overhead and Rough-In	140 days	Tue 6/22/10
103	Interior Wall and Ceiling Framing	100 days	Wed 11/24/10
104	Interior Wall, Ceiling, and Floor Finishes	126 days	Tue 3/15/11
105	MEP Systems Installation	76 days	Wed 4/20/11
106	Temporary Certificate of Occupancy Aqcuired	0 days	Tue 9/6/11
107	**13th Floor Construction**	**309 days**	**Thu 7/1/10**
108	MEP Systems Overhead and Rough-In	160 days	Thu 7/1/10
109	Interior Wall and Ceiling Framing	95 days	Thu 12/23/10
110	Interior Wall, Ceiling, and Floor Finishes	130 days	Wed 3/9/11
111	MEP Systems Installation	61 days	Fri 5/20/11
112	Temporary Certificate of Occupancy Aqcuired	0 days	Tue 9/6/11
113	**Completion of Tower**	**0 days**	**Fri 1/20/12**
114	Substantial Completion of Tower	0 days	Fri 1/20/12
115	**Existing Building Construction**	**1113 days**	**Thu 9/24/09**
116	**Infrastructure Modernization**	**481 days**	**Fri 2/26/10**
117	New Fire Pump and Piping	372 days	Fri 2/26/10
118	Refurbish Existing Air Handling Units	435 days	Mon 5/3/10
119	Mechanical Penthouse Equipment/Piping	207 days	Tue 3/1/11
120	MEP Riser Work	90 days	Mon 3/28/11



Gouverneur Healthcare Services Alex Despotovich October 19, 2011	Task	▬	Project Summary	▬	Inactive Milestone	◇	Manual Summary Rollup	▬	Deadline	⬇
	Split	┅	External Tasks	▬	Inactive Summary	▭	Manual Summary	▬	Progress	▬
	Milestone	◆	External Milestone	◆	Manual Task	▬	Start-only	[		
	Summary	▬	Inactive Task	▭	Duration-only	▬	Finish-only	]		

Appendix A

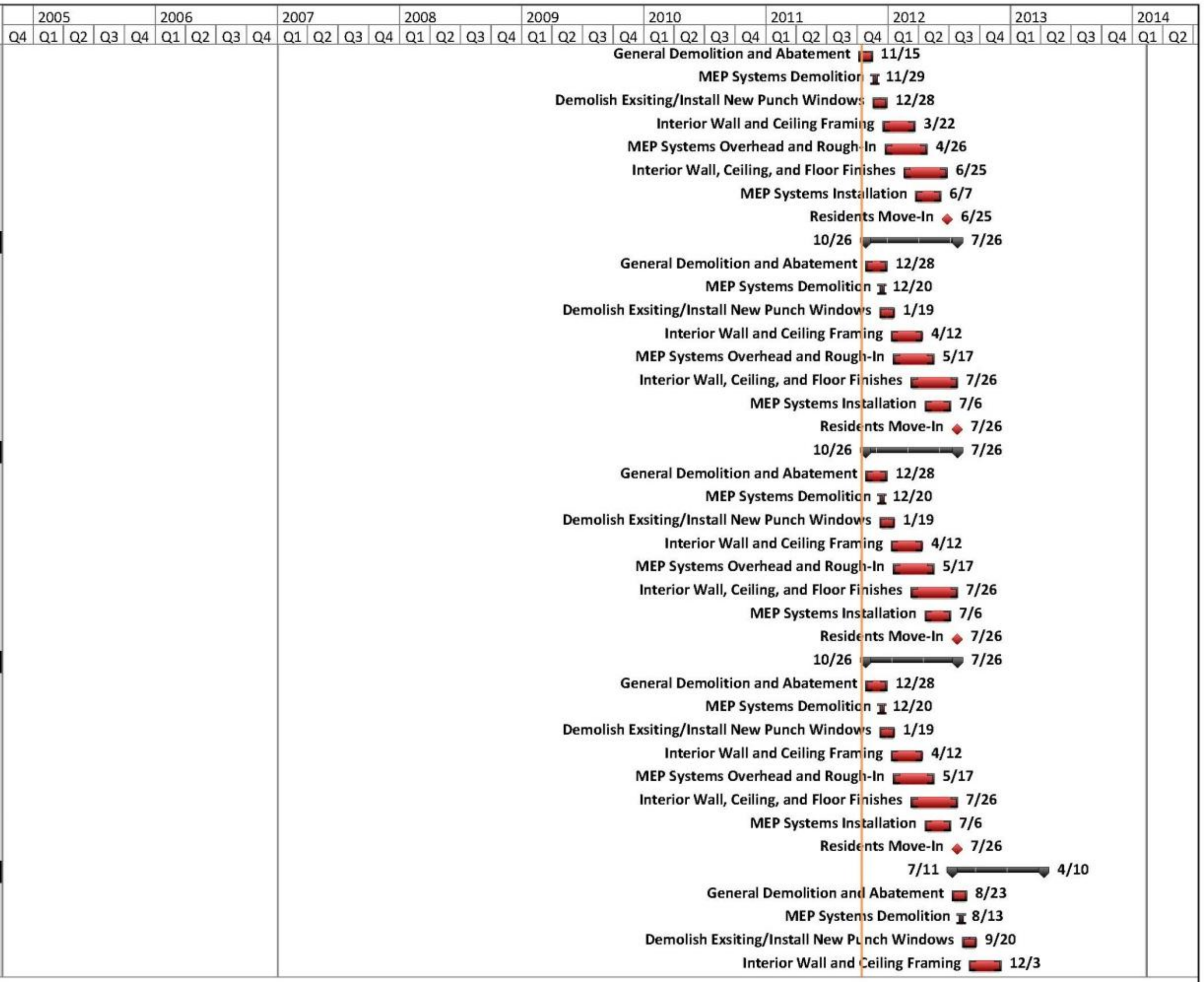


ID	Task Name	Duration	Start
121	Cellar Mezzanine Equipment Piping	63 days	Mon 8/1/11
122	HVAC Equipment Modernization Complete	0 days	Fri 12/30/11
123	**13th Floor Demolition and Renovation**	**508 days**	**Thu 9/24/09**
124	General Demolition and Abatement	30 days	Thu 9/24/09
125	MEP Systems Demolition	42 days	Wed 10/28/09
126	Demolish Exsiting/Install New Punch Windows	30 days	Fri 12/25/09
127	Interior Wall and Ceiling Framing	250 days	Fri 2/5/10
128	MEP Systems Overhead and Rough-In	160 days	Mon 8/2/10
129	Interior Wall, Ceiling, and Floor Finishes	219 days	Mon 11/1/10
130	MEP Systems Installation	100 days	Mon 3/14/11
131	Temporary Certificate of Occupancy Aqcuired	0 days	Tue 9/6/11
132	Residents Move-In	0 days	Tue 9/6/11
133	**6th Floor Demolition and Renovation**	**319 days**	**Wed 4/6/11**
134	General Demolition and Abatement	116 days	Wed 4/6/11
135	MEP Systems Demolition	44 days	Fri 7/1/11
136	Demolish Exsiting/Install New Punch Windows	30 days	Thu 9/1/11
137	Interior Wall and Ceiling Framing	129 days	Mon 9/19/11
138	MEP Systems Overhead and Rough-In	149 days	Mon 9/26/11
139	Interior Wall, Ceiling, and Floor Finishes	97 days	Fri 2/10/12
140	MEP Systems Installation	60 days	Fri 3/16/12
141	Residents Move-In	0 days	Mon 6/25/12
142	**7th Floor Demolition and Renovation**	**199 days**	**Wed 9/21/11**
143	General Demolition and Abatement	40 days	Wed 9/21/11
144	MEP Systems Demolition	10 days	Wed 11/2/11
145	Demolish Exsiting/Install New Punch Windows	30 days	Wed 11/2/11
146	Interior Wall and Ceiling Framing	70 days	Fri 12/2/11
147	MEP Systems Overhead and Rough-In	90 days	Fri 12/9/11
148	Interior Wall, Ceiling, and Floor Finishes	102 days	Fri 2/3/12
149	MEP Systems Installation	60 days	Fri 3/9/12
150	Residents Move-In	0 days	Mon 6/25/12
151	**8th Floor Demolition and Renovation**	**276 days**	**Wed 9/21/11**
152	General Demolition and Abatement	40 days	Wed 9/21/11
153	MEP Systems Demolition	10 days	Wed 11/2/11
154	Demolish Exsiting/Install New Punch Windows	30 days	Wed 11/2/11
155	Interior Wall and Ceiling Framing	70 days	Fri 12/2/11
156	MEP Systems Overhead and Rough-In	90 days	Fri 12/9/11
157	Interior Wall, Ceiling, and Floor Finishes	179 days	Fri 2/3/12
158	MEP Systems Installation	136 days	Fri 3/9/12
159	Residents Move-In	0 days	Wed 10/10/12
160	**5th Floor Demolition and Renovation**	**189 days**	**Wed 10/5/11**

Gouverneur Healthcare Services
Alex Despotovich
October 19, 2011

Appendix A

ID	Task Name	Duration	Start
161	General Demolition and Abatement	30 days	Wed 10/5/11
162	MEP Systems Demolition	10 days	Wed 11/16/11
163	Demolish Exsiting/Install New Punch Windows	31 days	Wed 11/16/11
164	Interior Wall and Ceiling Framing	70 days	Fri 12/16/11
165	MEP Systems Overhead and Rough-In	90 days	Fri 12/23/11
166	Interior Wall, Ceiling, and Floor Finishes	92 days	Fri 2/17/12
167	MEP Systems Installation	55 days	Fri 3/23/12
168	Residents Move-In	0 days	Mon 6/25/12
169	**2nd Floor Demolition and Renovation**	**197 days**	**Wed 10/26/11**
170	General Demolition and Abatement	46 days	Wed 10/26/11
171	MEP Systems Demolition	10 days	Wed 12/7/11
172	Demolish Exsiting/Install New Punch Windows	32 days	Wed 12/7/11
173	Interior Wall and Ceiling Framing	68 days	Tue 1/10/12
174	MEP Systems Overhead and Rough-In	89 days	Mon 1/16/12
175	Interior Wall, Ceiling, and Floor Finishes	100 days	Fri 3/9/12
176	MEP Systems Installation	56 days	Fri 4/20/12
177	Residents Move-In	0 days	Thu 7/26/12
178	**3rd Floor Demolition and Renovation**	**197 days**	**Wed 10/26/11**
179	General Demolition and Abatement	46 days	Wed 10/26/11
180	MEP Systems Demolition	10 days	Wed 12/7/11
181	Demolish Exsiting/Install New Punch Windows	32 days	Wed 12/7/11
182	Interior Wall and Ceiling Framing	68 days	Tue 1/10/12
183	MEP Systems Overhead and Rough-In	89 days	Mon 1/16/12
184	Interior Wall, Ceiling, and Floor Finishes	100 days	Fri 3/9/12
185	MEP Systems Installation	56 days	Fri 4/20/12
186	Residents Move-In	0 days	Thu 7/26/12
187	**4th Floor Demolition and Renovation**	**197 days**	**Wed 10/26/11**
188	General Demolition and Abatement	46 days	Wed 10/26/11
189	MEP Systems Demolition	10 days	Wed 12/7/11
190	Demolish Exsiting/Install New Punch Windows	32 days	Wed 12/7/11
191	Interior Wall and Ceiling Framing	68 days	Tue 1/10/12
192	MEP Systems Overhead and Rough-In	89 days	Mon 1/16/12
193	Interior Wall, Ceiling, and Floor Finishes	100 days	Fri 3/9/12
194	MEP Systems Installation	56 days	Fri 4/20/12
195	Residents Move-In	0 days	Thu 7/26/12
196	**9th Floor Demolition and Renovation**	**196 days**	**Wed 7/11/12**
197	General Demolition and Abatement	32 days	Wed 7/11/12
198	MEP Systems Demolition	10 days	Tue 7/31/12
199	Demolish Exsiting/Install New Punch Windows	30 days	Fri 8/10/12
200	Interior Wall and Ceiling Framing	68 days	Thu 8/30/12

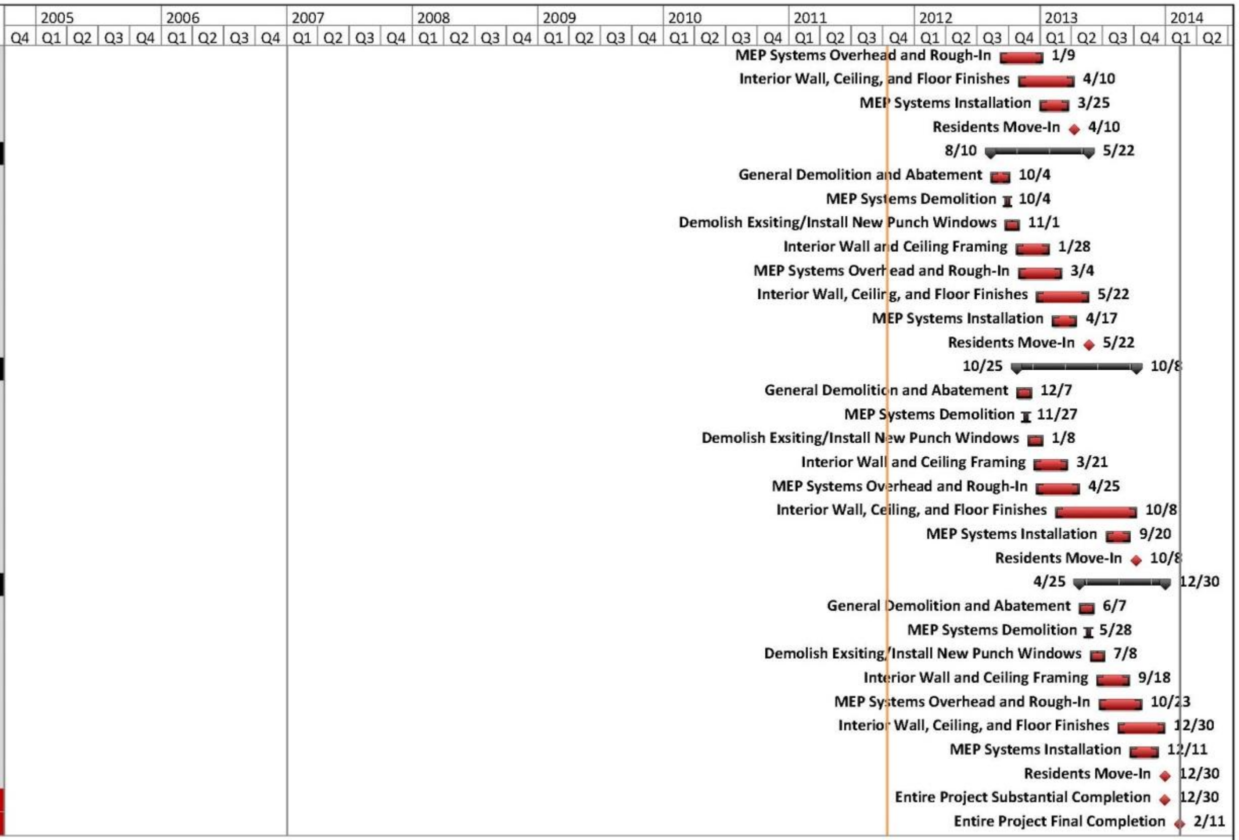


Gouverneur Healthcare Services
Alex Despotovich
October 19, 2011

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	
Summary	Inactive Task	Duration-only	Finish-only	

Appendix A

ID	Task Name	Duration	Start
201	MEP Systems Overhead and Rough-In	90 days	Thu 9/6/12
202	Interior Wall, Ceiling, and Floor Finishes	117 days	Tue 10/30/12
203	MEP Systems Installation	61 days	Mon 12/31/12
204	Residents Move-In	0 days	Wed 4/10/13
205	**1st Floor Demolition and Renovation**	**204 days**	**Fri 8/10/12**
206	General Demolition and Abatement	40 days	Fri 8/10/12
207	MEP Systems Demolition	10 days	Fri 9/21/12
208	Demolish Exsiting/Install New Punch Windows	30 days	Fri 9/21/12
209	Interior Wall and Ceiling Framing	70 days	Tue 10/23/12
210	MEP Systems Overhead and Rough-In	90 days	Tue 10/30/12
211	Interior Wall, Ceiling, and Floor Finishes	109 days	Fri 12/21/12
212	MEP Systems Installation	52 days	Tue 2/5/13
213	Residents Move-In	0 days	Wed 5/22/13
214	**10th Floor Demolition and Renovation**	**249 days**	**Thu 10/25/12**
215	General Demolition and Abatement	32 days	Thu 10/25/12
216	MEP Systems Demolition	10 days	Wed 11/14/12
217	Demolish Exsiting/Install New Punch Windows	32 days	Mon 11/26/12
218	Interior Wall and Ceiling Framing	70 days	Fri 12/14/12
219	MEP Systems Overhead and Rough-In	90 days	Fri 12/21/12
220	Interior Wall, Ceiling, and Floor Finishes	168 days	Fri 2/15/13
221	MEP Systems Installation	51 days	Fri 7/12/13
222	Residents Move-In	0 days	Tue 10/8/13
223	**11th Floor Demolition and Renovation**	**178 days**	**Thu 4/25/13**
224	General Demolition and Abatement	32 days	Thu 4/25/13
225	MEP Systems Demolition	10 days	Wed 5/15/13
226	Demolish Exsiting/Install New Punch Windows	31 days	Mon 5/27/13
227	Interior Wall and Ceiling Framing	69 days	Fri 6/14/13
228	MEP Systems Overhead and Rough-In	89 days	Fri 6/21/13
229	Interior Wall, Ceiling, and Floor Finishes	98 days	Thu 8/15/13
230	MEP Systems Installation	60 days	Thu 9/19/13
231	Residents Move-In	0 days	Mon 12/30/13
232	**Entire Project Substantial Completion**	**0 days**	**Mon 12/30/13**
233	**Entire Project Final Completion**	**0 days**	**Tue 2/11/14**



Gouverneur Healthcare Services
Alex Despotovich
October 19, 2011

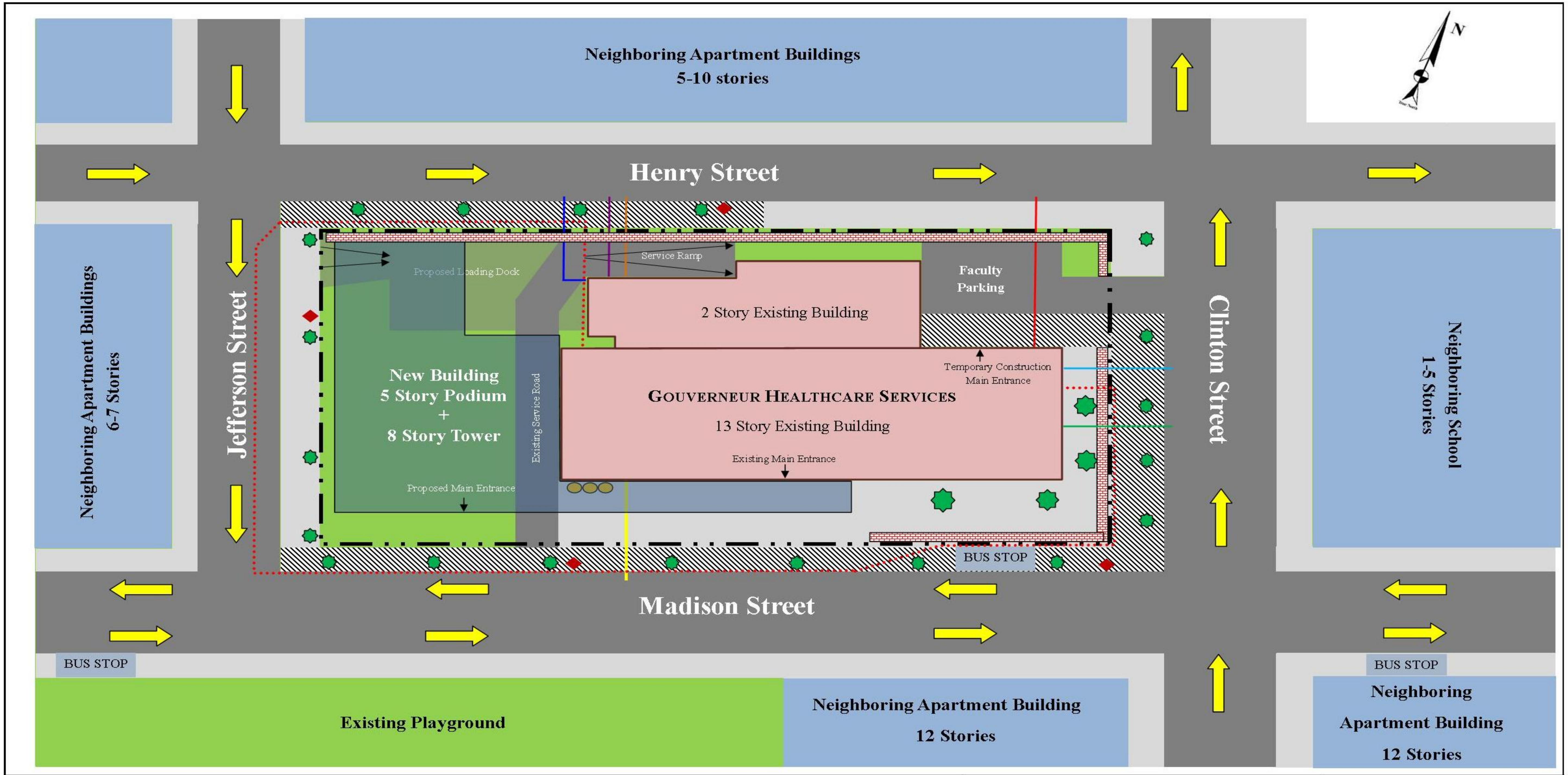
Task	▬	Project Summary	▬	Inactive Milestone	◇	Manual Summary Rollup	▬	Deadline	⇩
Split	┈	External Tasks	▬	Inactive Summary	▭	Manual Summary	▬	Progress	▬
Milestone	◆	External Milestone	◆	Manual Task	▬	Start-only	[		
Summary	▬	Inactive Task	▭	Duration-only	▬	Finish-only	]		

Appendix A

APPENDIX B

PROJECT SITE PLANS

EXISTING CONDITIONS PLAN



LEGEND

➡ Flow of Traffic
▭ Pedestrian Walkway
■ Vehicular Roadway
▨ Protected Walkway

● Site Trees
— · · — Property Line
— Existing Building Perimeter
— New Building Perimeter
······ Construction Fence

◆ Fire Hydrants
● Standpipe
▦ Brick Wall
— Underground Electric
— Underground Telephone

— Underground CTV
— Underground Steam
— Underground Gas
— Underground Oxygen
— Underground Water

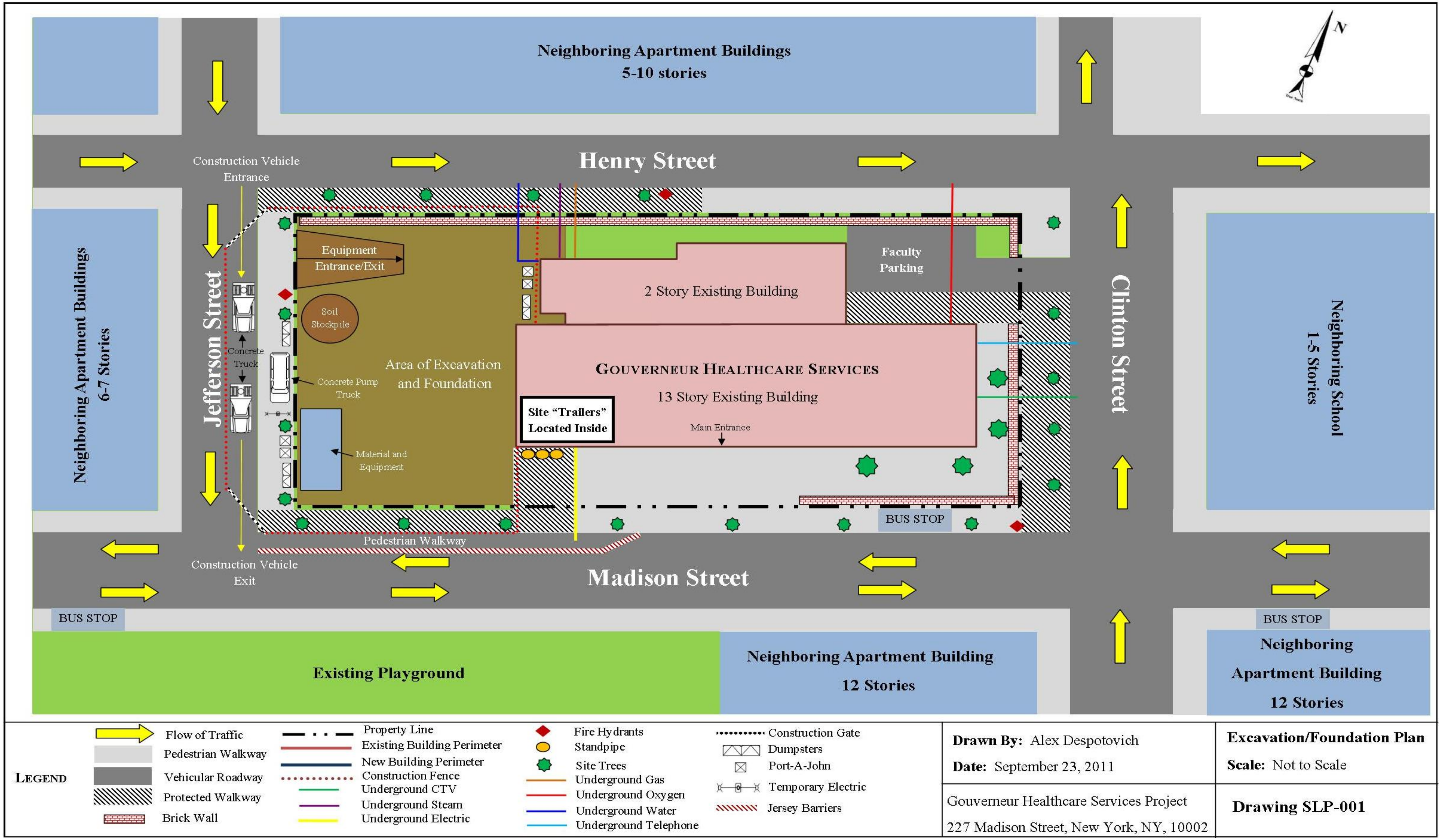
Drawn By: Alex Despotovich
Date: September 23, 2011

Gouverneur Healthcare Services Project
227 Madison Street, New York, NY, 10002

Existing Conditions Plan
Scale: Not to Scale

Drawing E-001

SITE LAYOUT PLANS



Drawn By: Alex Despotovich

Date: September 23, 2011

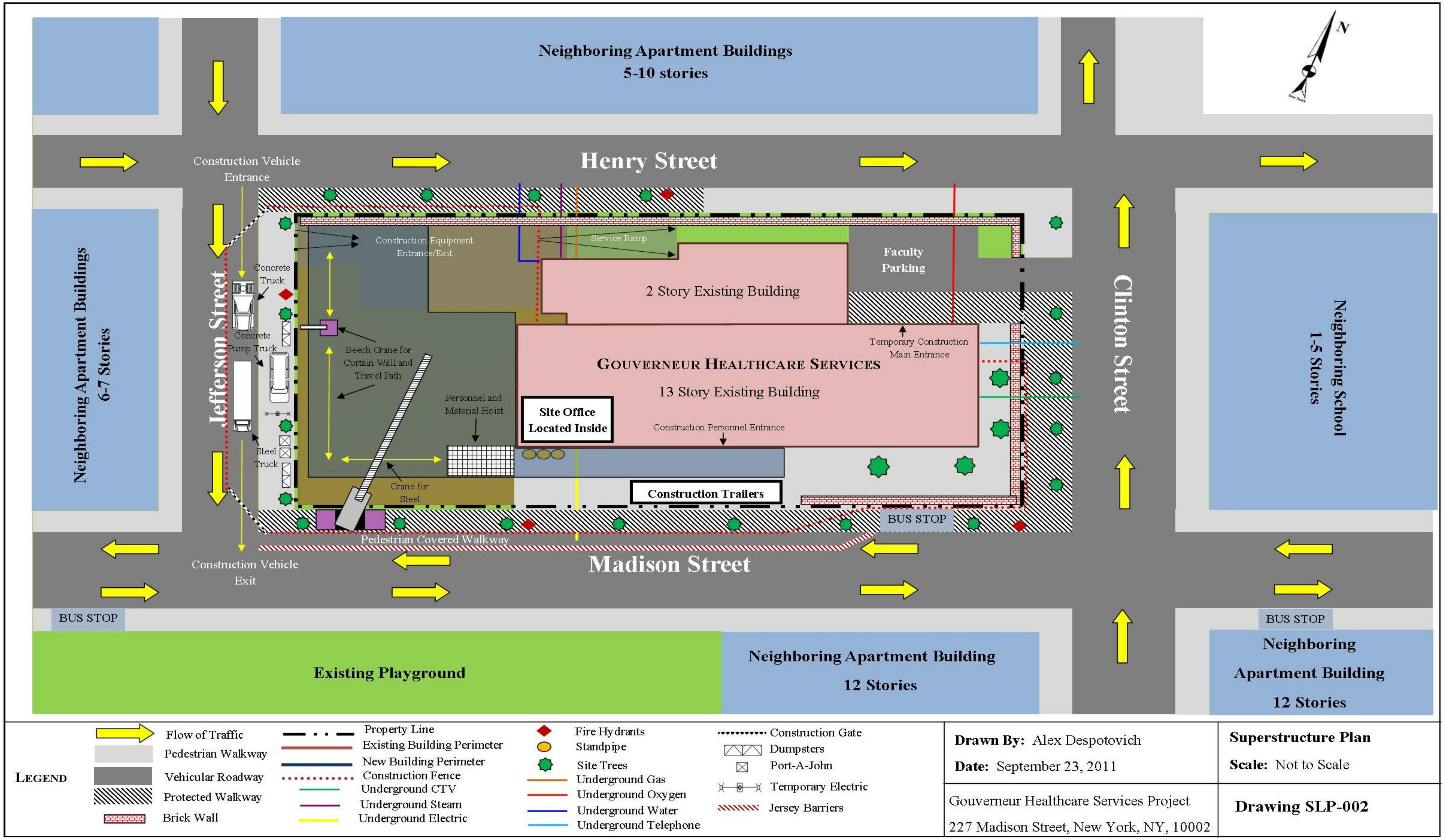
Gouverneur Healthcare Services Project

227 Madison Street, New York, NY, 10002

Excavation/Foundation Plan

Scale: Not to Scale

Drawing SLP-001



Drawn By: Alex Despotovich

Date: September 23, 2011

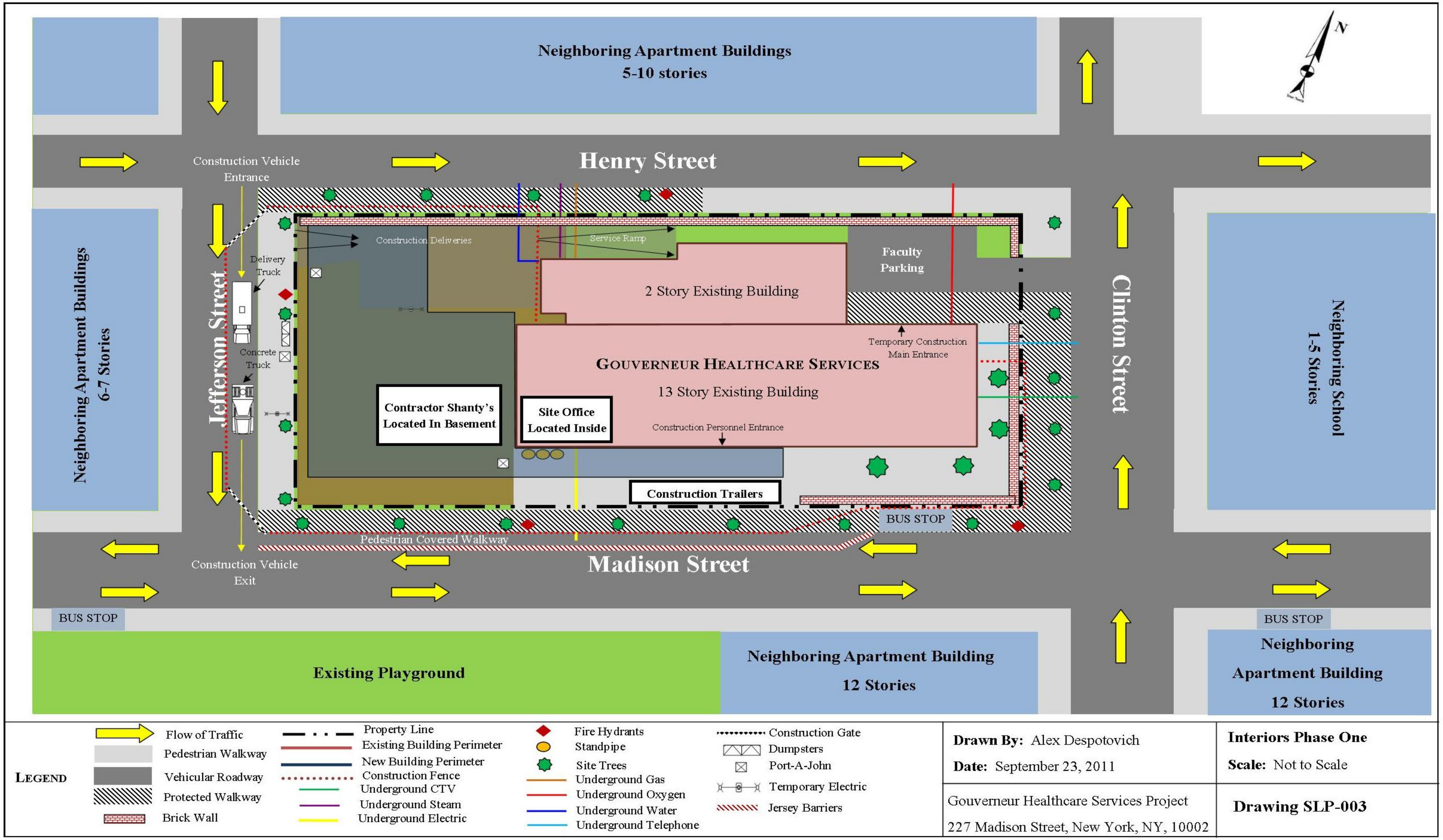
Superstructure Plan

Scale: Not to Scale

Gouverneur Healthcare Services Project

227 Madison Street, New York, NY, 10002

Drawing SLP-002



Drawn By: Alex Despotovich

Date: September 23, 2011

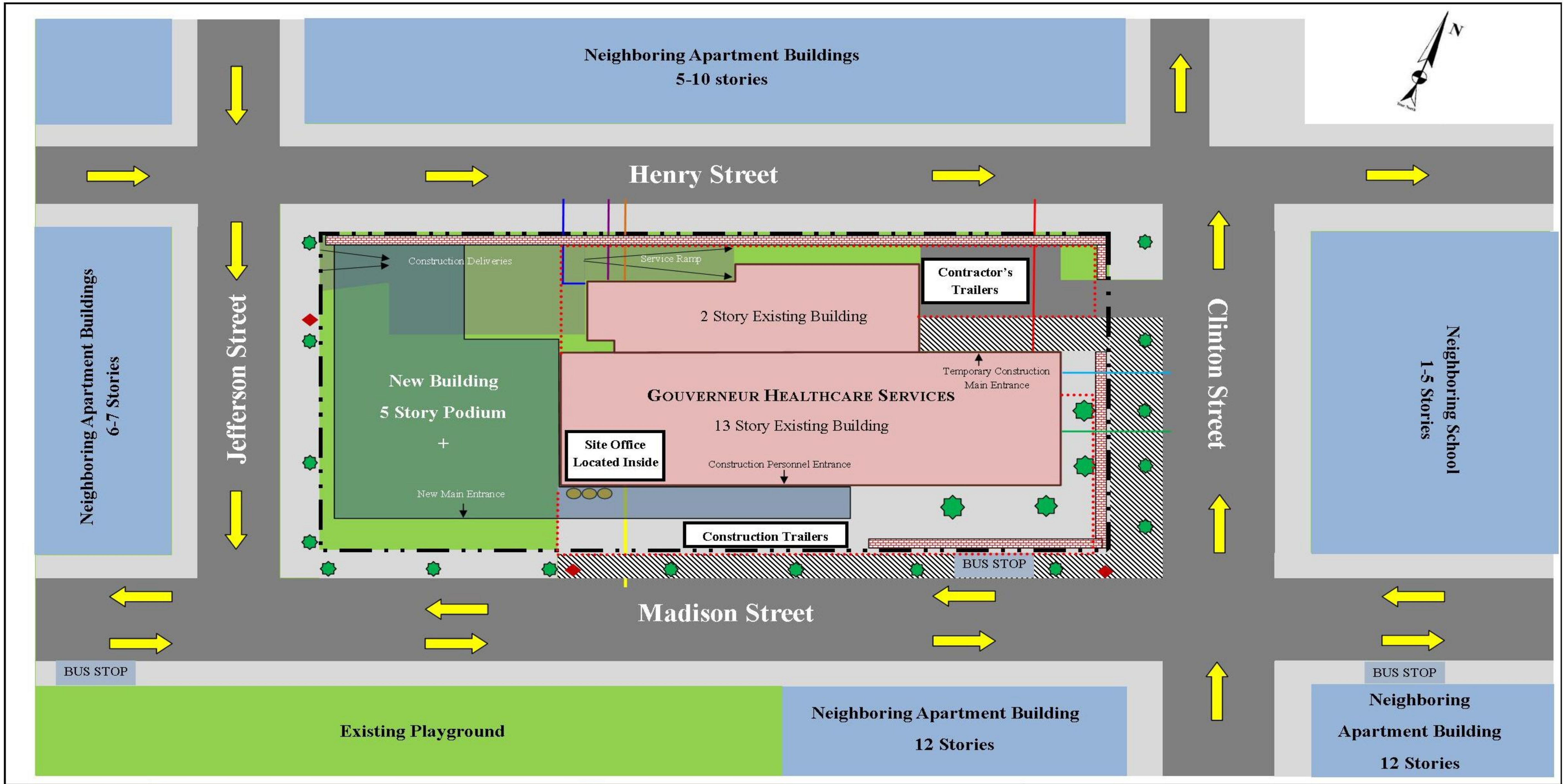
Gouverneur Healthcare Services Project

227 Madison Street, New York, NY, 10002

Interiors Phase One

Scale: Not to Scale

Drawing SLP-003



LEGEND

➡	Flow of Traffic	— · —	Property Line	◆	Fire Hydrants	······	Construction Gate
░	Pedestrian Walkway	—	Existing Building Perimeter	●	Standpipe	⊠	Dumpsters
▓	Vehicular Roadway	—	New Building Perimeter	●	Site Trees	⊠	Port-A-John
▨	Protected Walkway	······	Construction Fence	—	Underground Gas	⊗	Temporary Electric
▦	Brick Wall	—	Underground CTV	—	Underground Oxygen	▨	Jersey Barriers
		—	Underground Steam	—	Underground Water		
		—	Underground Electric	—	Underground Telephone		

Drawn By: Alex Despotovich

Date: September 23, 2011

Interiors Phase Two

Scale: Not to Scale

Gouverneur Healthcare Services Project
227 Madison Street, New York, NY, 10002

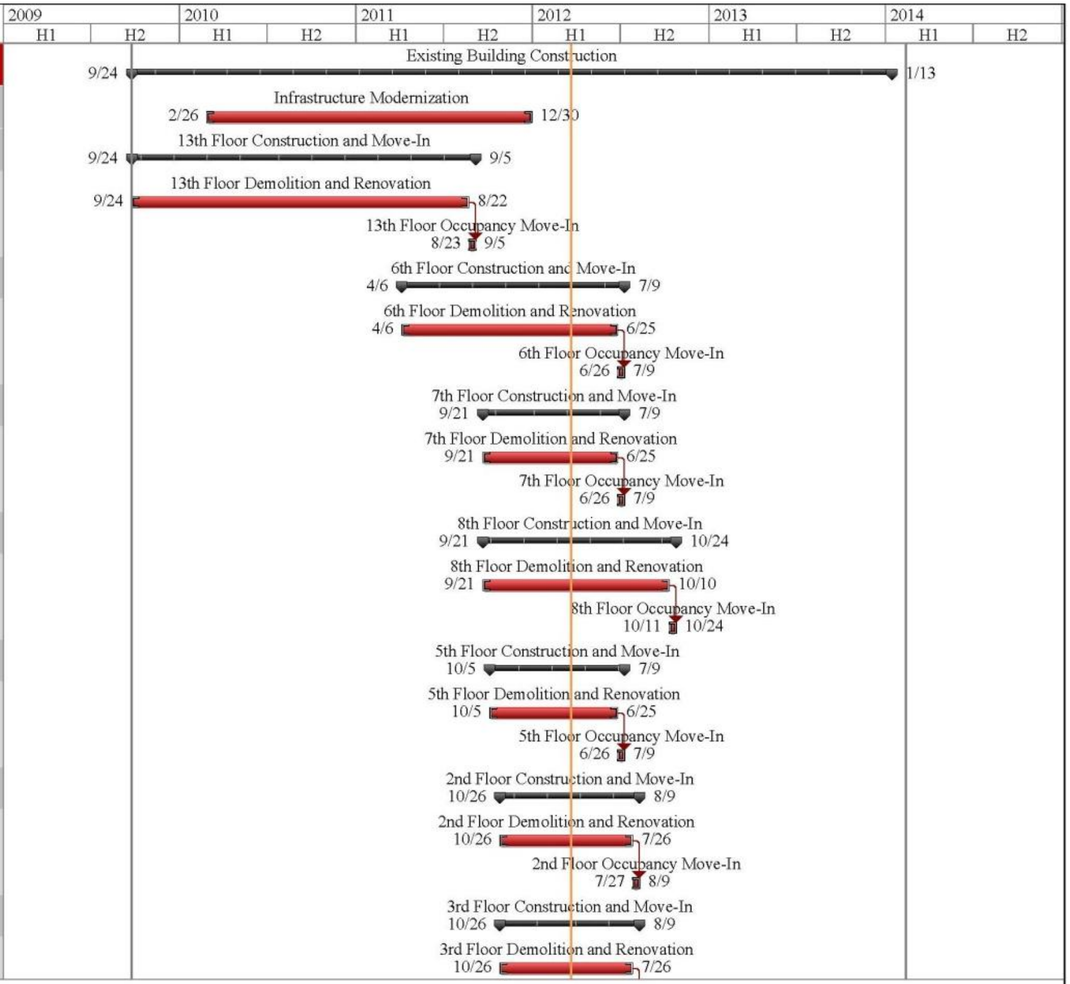
Drawing SLP-004

APPENDIX C

SCHEDULE RE-SEQUENCING AND TENANT OCCUPANCY

GOUVERNEUR HEALTHCARE SERVICES ORIGINAL SCHEDULE

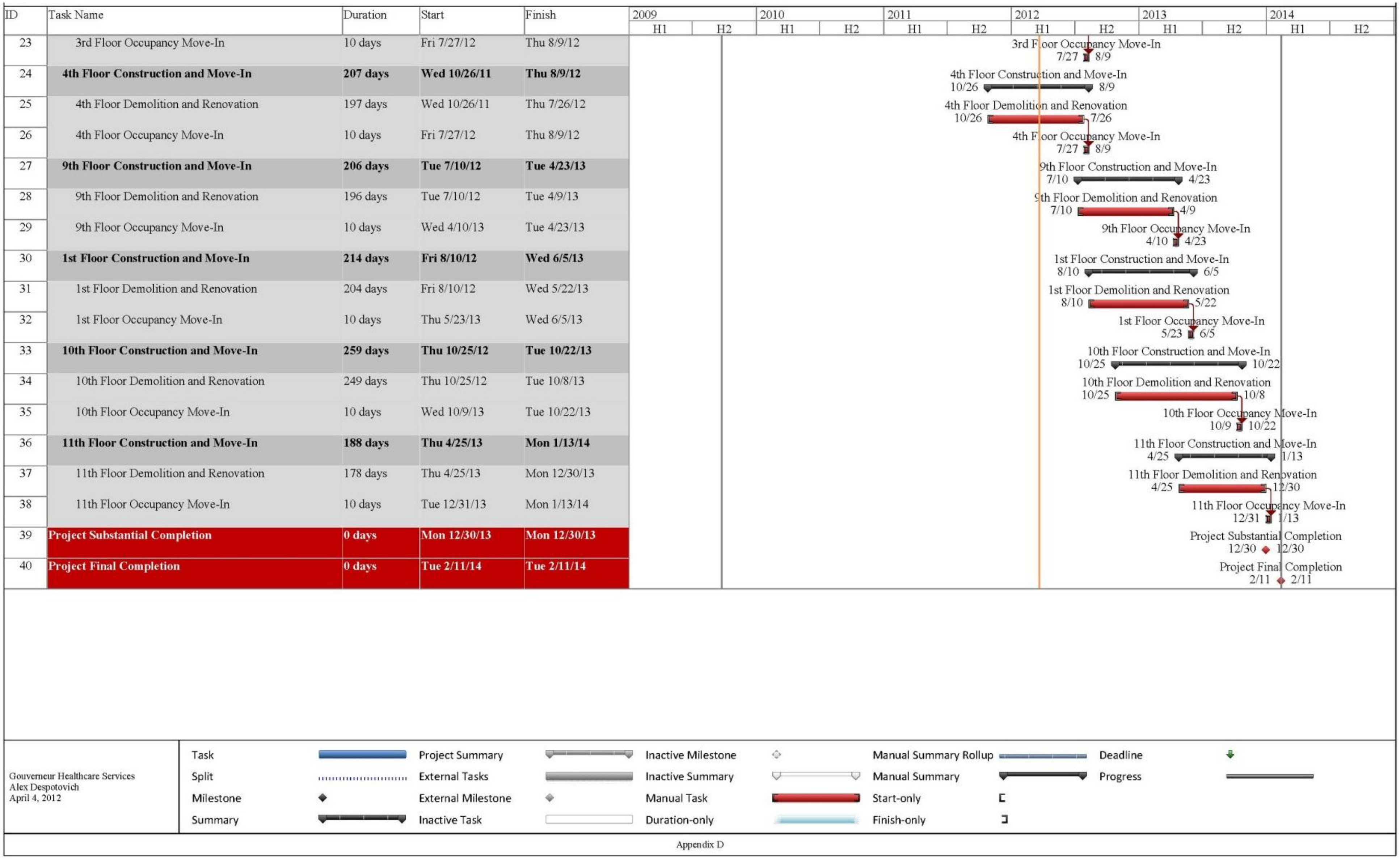
ID	Task Name	Duration	Start	Finish
1	**Existing Building Construction**	**1123 days**	**Thu 9/24/09**	**Mon 1/13/14**
2	**Infrastructure Modernization**	**481 days**	**Fri 2/26/10**	**Fri 12/30/11**
3	**13th Floor Construction and Move-In**	**508 days**	**Thu 9/24/09**	**Mon 9/5/11**
4	13th Floor Demolition and Renovation	498 days	Thu 9/24/09	Mon 8/22/11
5	13th Floor Occupancy Move-In	10 days	Tue 8/23/11	Mon 9/5/11
6	**6th Floor Construction and Move-In**	**329 days**	**Wed 4/6/11**	**Mon 7/9/12**
7	6th Floor Demolition and Renovation	319 days	Wed 4/6/11	Mon 6/25/12
8	6th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
9	**7th Floor Construction and Move-In**	**209 days**	**Wed 9/21/11**	**Mon 7/9/12**
10	7th Floor Demolition and Renovation	199 days	Wed 9/21/11	Mon 6/25/12
11	7th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
12	**8th Floor Construction and Move-In**	**286 days**	**Wed 9/21/11**	**Wed 10/24/12**
13	8th Floor Demolition and Renovation	276 days	Wed 9/21/11	Wed 10/10/12
14	8th Floor Occupancy Move-In	10 days	Thu 10/11/12	Wed 10/24/12
15	**5th Floor Construction and Move-In**	**199 days**	**Wed 10/5/11**	**Mon 7/9/12**
16	5th Floor Demolition and Renovation	189 days	Wed 10/5/11	Mon 6/25/12
17	5th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
18	**2nd Floor Construction and Move-In**	**207 days**	**Wed 10/26/11**	**Thu 8/9/12**
19	2nd Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
20	2nd Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
21	**3rd Floor Construction and Move-In**	**207 days**	**Wed 10/26/11**	**Thu 8/9/12**
22	3rd Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12



Gouverneur Healthcare Services
Alex Despotovich
April 4, 2012

Task	▬	Project Summary	▬	Inactive Milestone	◇	Manual Summary Rollup	▬	Deadline	⬇
Split	┈	External Tasks	▬	Inactive Summary	▭	Manual Summary	▬	Progress	▬
Milestone	◆	External Milestone	◆	Manual Task	▬	Start-only	[		
Summary	▬	Inactive Task	▭	Duration-only	▬	Finish-only	]		

Appendix D



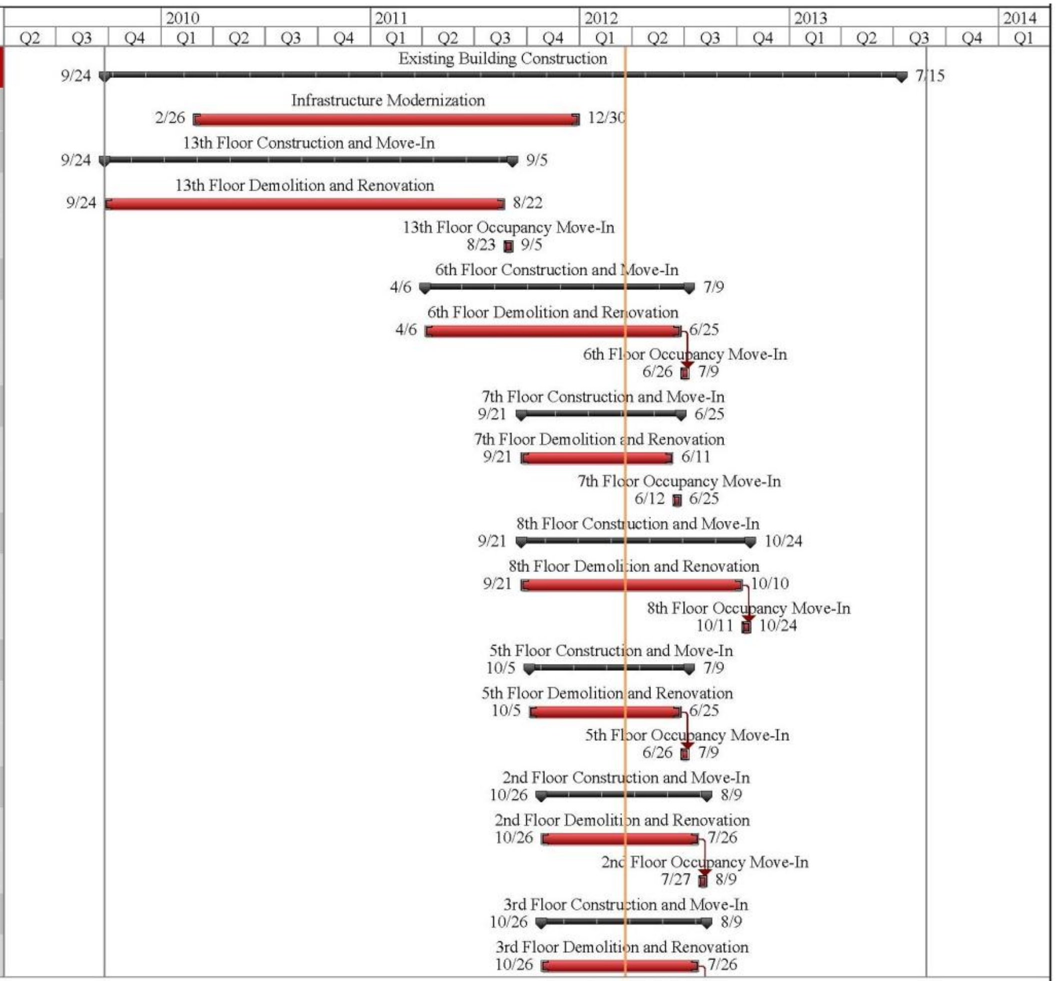
ID	Task Name	Duration	Start	Finish
23	3rd Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
24	**4th Floor Construction and Move-In**	**207 days**	**Wed 10/26/11**	**Thu 8/9/12**
25	4th Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
26	4th Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
27	**9th Floor Construction and Move-In**	**206 days**	**Tue 7/10/12**	**Tue 4/23/13**
28	9th Floor Demolition and Renovation	196 days	Tue 7/10/12	Tue 4/9/13
29	9th Floor Occupancy Move-In	10 days	Wed 4/10/13	Tue 4/23/13
30	**1st Floor Construction and Move-In**	**214 days**	**Fri 8/10/12**	**Wed 6/5/13**
31	1st Floor Demolition and Renovation	204 days	Fri 8/10/12	Wed 5/22/13
32	1st Floor Occupancy Move-In	10 days	Thu 5/23/13	Wed 6/5/13
33	**10th Floor Construction and Move-In**	**259 days**	**Thu 10/25/12**	**Tue 10/22/13**
34	10th Floor Demolition and Renovation	249 days	Thu 10/25/12	Tue 10/8/13
35	10th Floor Occupancy Move-In	10 days	Wed 10/9/13	Tue 10/22/13
36	**11th Floor Construction and Move-In**	**188 days**	**Thu 4/25/13**	**Mon 1/13/14**
37	11th Floor Demolition and Renovation	178 days	Thu 4/25/13	Mon 12/30/13
38	11th Floor Occupancy Move-In	10 days	Tue 12/31/13	Mon 1/13/14
39	**Project Substantial Completion**	**0 days**	**Mon 12/30/13**	**Mon 12/30/13**
40	**Project Final Completion**	**0 days**	**Tue 2/11/14**	**Tue 2/11/14**

Gouverneur Healthcare Services
Alex Despotovich
April 4, 2012

Appendix D

GOUVERNEUR HEALTHCARE SERVICES RE-SEQUENCED SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**Existing Building Construction**	**993 days**	**Thu 9/24/09**	**Mon 7/15/13**
2	**Infrastructure Modernization**	**481 days**	**Fri 2/26/10**	**Fri 12/30/11**
3	**13th Floor Construction and Move-In**	**508 days**	**Thu 9/24/09**	**Mon 9/5/11**
4	13th Floor Demolition and Renovation	498 days	Thu 9/24/09	Mon 8/22/11
5	13th Floor Occupancy Move-In	10 days	Tue 8/23/11	Mon 9/5/11
6	**6th Floor Construction and Move-In**	**329 days**	**Wed 4/6/11**	**Mon 7/9/12**
7	6th Floor Demolition and Renovation	319 days	Wed 4/6/11	Mon 6/25/12
8	6th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
9	**7th Floor Construction and Move-In**	**199 days**	**Wed 9/21/11**	**Mon 6/25/12**
10	7th Floor Demolition and Renovation	189 days	Wed 9/21/11	Mon 6/11/12
11	7th Floor Occupancy Move-In	10 days	Tue 6/12/12	Mon 6/25/12
12	**8th Floor Construction and Move-In**	**286 days**	**Wed 9/21/11**	**Wed 10/24/12**
13	8th Floor Demolition and Renovation	276 days	Wed 9/21/11	Wed 10/10/12
14	8th Floor Occupancy Move-In	10 days	Thu 10/11/12	Wed 10/24/12
15	**5th Floor Construction and Move-In**	**199 days**	**Wed 10/5/11**	**Mon 7/9/12**
16	5th Floor Demolition and Renovation	189 days	Wed 10/5/11	Mon 6/25/12
17	5th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
18	**2nd Floor Construction and Move-In**	**207 days**	**Wed 10/26/11**	**Thu 8/9/12**
19	2nd Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
20	2nd Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
21	**3rd Floor Construction and Move-In**	**207 days**	**Wed 10/26/11**	**Thu 8/9/12**
22	3rd Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12

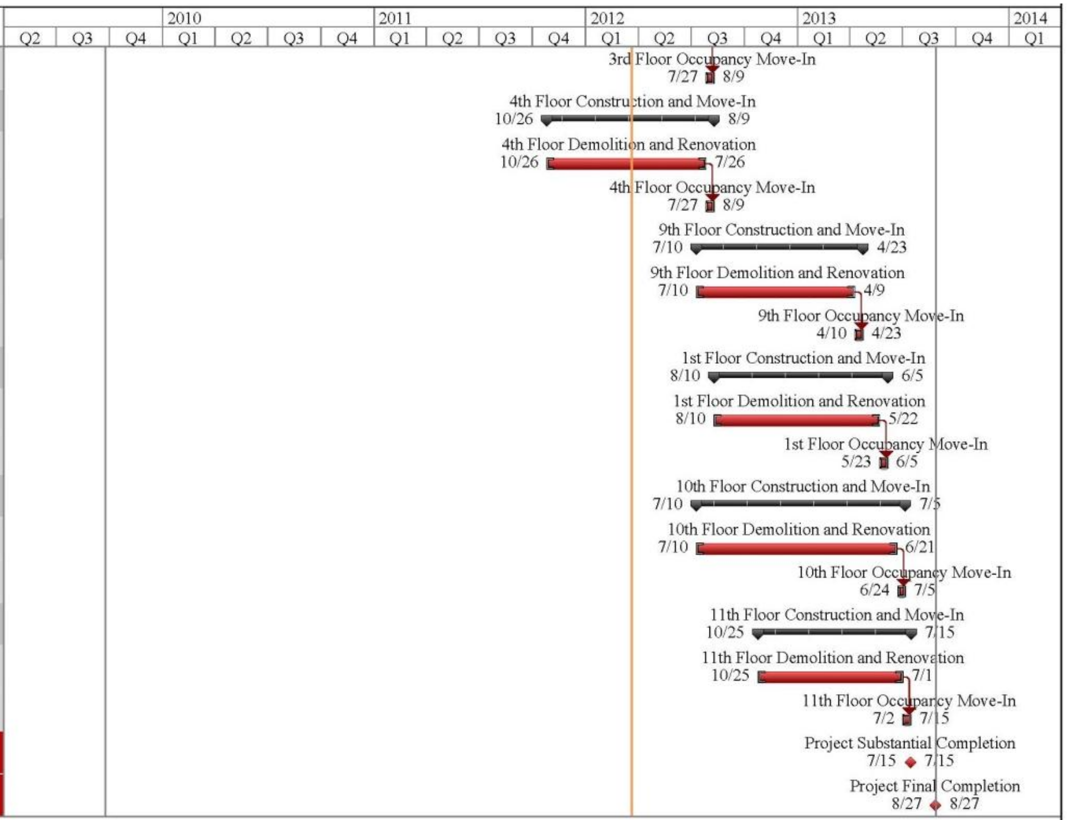


Gouverneur Healthcare Services
Alex Despotovich
April 4, 2012

Task	▬	Project Summary	▬	Inactive Milestone	◇	Manual Summary Rollup	▬	Deadline	⇩
Split	······	External Tasks	▬	Inactive Summary	▭	Manual Summary	▬	Progress	▬
Milestone	◆	External Milestone	◆	Manual Task	▬	Start-only	[		
Summary	▬	Inactive Task	▭	Duration-only	▬	Finish-only	]		

Appendix D

ID	Task Name	Duration	Start	Finish
23	3rd Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
24	**4th Floor Construction and Move-In**	**207 days**	**Wed 10/26/11**	**Thu 8/9/12**
25	4th Floor Demolition and Renovation	197 days	Wed 10/26/11	Thu 7/26/12
26	4th Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
27	**9th Floor Construction and Move-In**	**206 days**	**Tue 7/10/12**	**Tue 4/23/13**
28	9th Floor Demolition and Renovation	196 days	Tue 7/10/12	Tue 4/9/13
29	9th Floor Occupancy Move-In	10 days	Wed 4/10/13	Tue 4/23/13
30	**1st Floor Construction and Move-In**	**214 days**	**Fri 8/10/12**	**Wed 6/5/13**
31	1st Floor Demolition and Renovation	204 days	Fri 8/10/12	Wed 5/22/13
32	1st Floor Occupancy Move-In	10 days	Thu 5/23/13	Wed 6/5/13
33	**10th Floor Construction and Move-In**	**259 days**	**Tue 7/10/12**	**Fri 7/5/13**
34	10th Floor Demolition and Renovation	249 days	Tue 7/10/12	Fri 6/21/13
35	10th Floor Occupancy Move-In	10 days	Mon 6/24/13	Fri 7/5/13
36	**11th Floor Construction and Move-In**	**188 days**	**Thu 10/25/12**	**Mon 7/15/13**
37	11th Floor Demolition and Renovation	178 days	Thu 10/25/12	Mon 7/1/13
38	11th Floor Occupancy Move-In	10 days	Tue 7/2/13	Mon 7/15/13
39	**Project Substantial Completion**	**0 days**	**Mon 7/15/13**	**Mon 7/15/13**
40	**Project Final Completion**	**0 days**	**Tue 8/27/13**	**Tue 8/27/13**

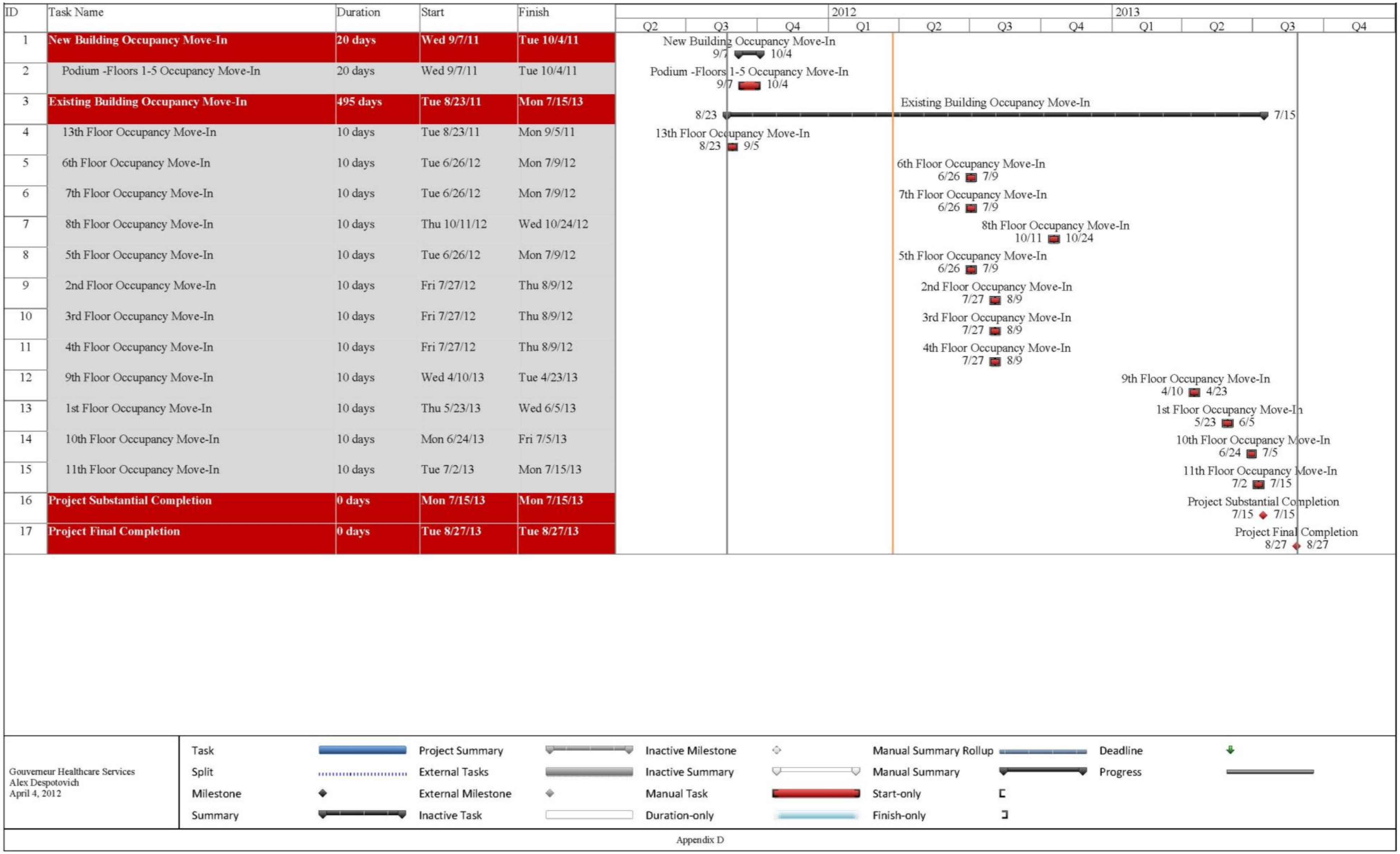


Gouverneur Healthcare Services
Alex Despotovich
April 4, 2012

Task		Project Summary		Inactive Milestone	◇	Manual Summary Rollup		Deadline	⬇
Split		External Tasks		Inactive Summary		Manual Summary		Progress	
Milestone	◆	External Milestone	◆	Manual Task		Start-only	[		
Summary		Inactive Task		Duration-only		Finish-only	]		

Appendix D

GOUVERNEUR HEALTHCARE SERVICES ORIGINAL TENANT PHASING SCHEDULE

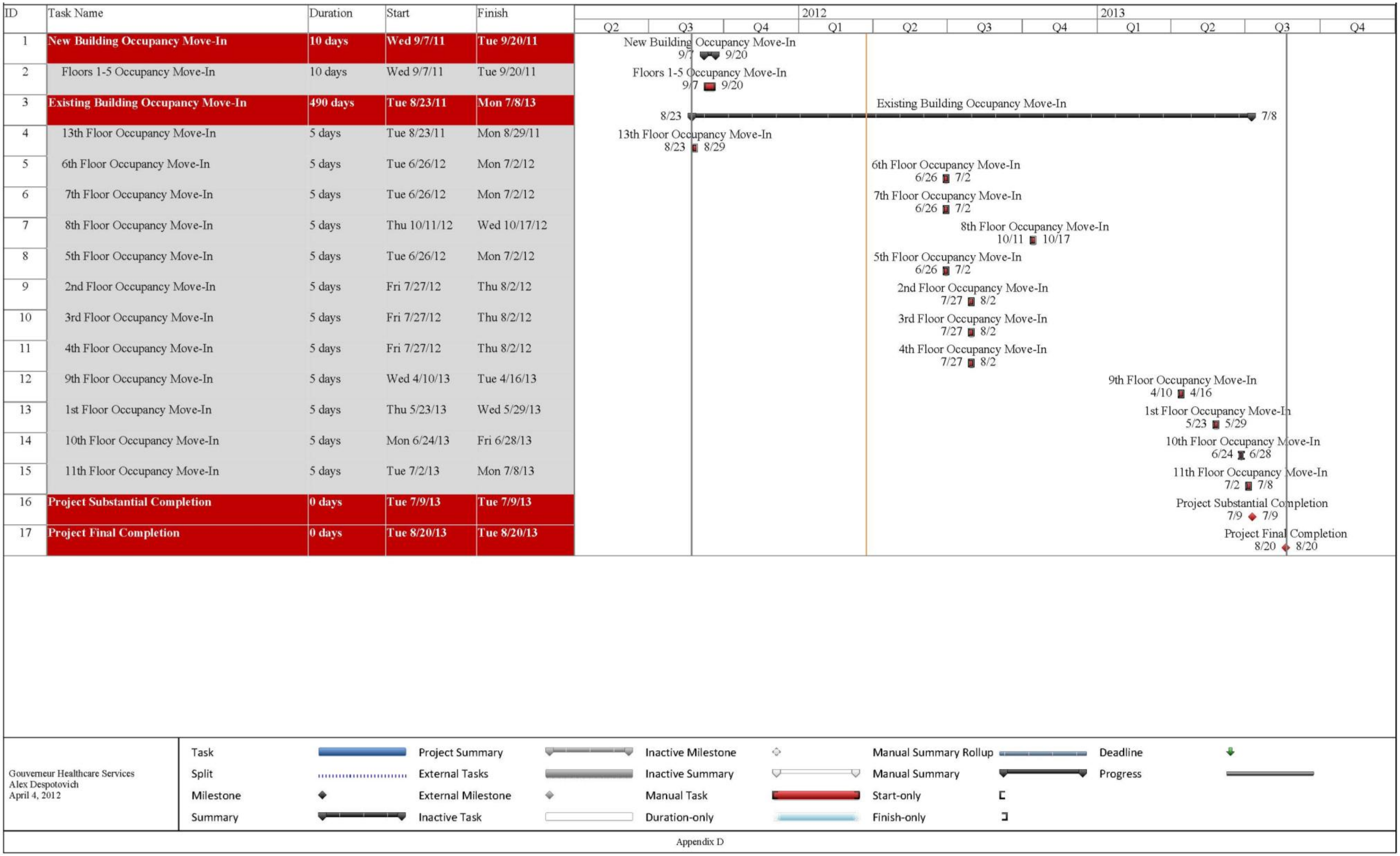


ID	Task Name	Duration	Start	Finish
1	**New Building Occupancy Move-In**	**20 days**	**Wed 9/7/11**	**Tue 10/4/11**
2	Podium -Floors 1-5 Occupancy Move-In	20 days	Wed 9/7/11	Tue 10/4/11
3	**Existing Building Occupancy Move-In**	**495 days**	**Tue 8/23/11**	**Mon 7/15/13**
4	13th Floor Occupancy Move-In	10 days	Tue 8/23/11	Mon 9/5/11
5	6th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
6	7th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
7	8th Floor Occupancy Move-In	10 days	Thu 10/11/12	Wed 10/24/12
8	5th Floor Occupancy Move-In	10 days	Tue 6/26/12	Mon 7/9/12
9	2nd Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
10	3rd Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
11	4th Floor Occupancy Move-In	10 days	Fri 7/27/12	Thu 8/9/12
12	9th Floor Occupancy Move-In	10 days	Wed 4/10/13	Tue 4/23/13
13	1st Floor Occupancy Move-In	10 days	Thu 5/23/13	Wed 6/5/13
14	10th Floor Occupancy Move-In	10 days	Mon 6/24/13	Fri 7/5/13
15	11th Floor Occupancy Move-In	10 days	Tue 7/2/13	Mon 7/15/13
16	**Project Substantial Completion**	**0 days**	**Mon 7/15/13**	**Mon 7/15/13**
17	**Project Final Completion**	**0 days**	**Tue 8/27/13**	**Tue 8/27/13**

Gouverneur Healthcare Services
Alex Despotovich
April 4, 2012

Appendix D

GOUVERNEUR HEALTHCARE SERVICES FM:SYSTEMS TENANT PHASING SCHEDULE



ID	Task Name	Duration	Start	Finish
1	**New Building Occupancy Move-In**	**10 days**	**Wed 9/7/11**	**Tue 9/20/11**
2	Floors 1-5 Occupancy Move-In	10 days	Wed 9/7/11	Tue 9/20/11
3	**Existing Building Occupancy Move-In**	**490 days**	**Tue 8/23/11**	**Mon 7/8/13**
4	13th Floor Occupancy Move-In	5 days	Tue 8/23/11	Mon 8/29/11
5	6th Floor Occupancy Move-In	5 days	Tue 6/26/12	Mon 7/2/12
6	7th Floor Occupancy Move-In	5 days	Tue 6/26/12	Mon 7/2/12
7	8th Floor Occupancy Move-In	5 days	Thu 10/11/12	Wed 10/17/12
8	5th Floor Occupancy Move-In	5 days	Tue 6/26/12	Mon 7/2/12
9	2nd Floor Occupancy Move-In	5 days	Fri 7/27/12	Thu 8/2/12
10	3rd Floor Occupancy Move-In	5 days	Fri 7/27/12	Thu 8/2/12
11	4th Floor Occupancy Move-In	5 days	Fri 7/27/12	Thu 8/2/12
12	9th Floor Occupancy Move-In	5 days	Wed 4/10/13	Tue 4/16/13
13	1st Floor Occupancy Move-In	5 days	Thu 5/23/13	Wed 5/29/13
14	10th Floor Occupancy Move-In	5 days	Mon 6/24/13	Fri 6/28/13
15	11th Floor Occupancy Move-In	5 days	Tue 7/2/13	Mon 7/8/13
16	**Project Substantial Completion**	**0 days**	**Tue 7/9/13**	**Tue 7/9/13**
17	**Project Final Completion**	**0 days**	**Tue 8/20/13**	**Tue 8/20/13**

APPENDIX D

MATERIAL STAGING AND SYSTEM PREFABRICATION

Gouverneur Healthcare Services Prefabrication Take-Offs

Table 39: Prefabrication Schedule Reduction Take-Offs

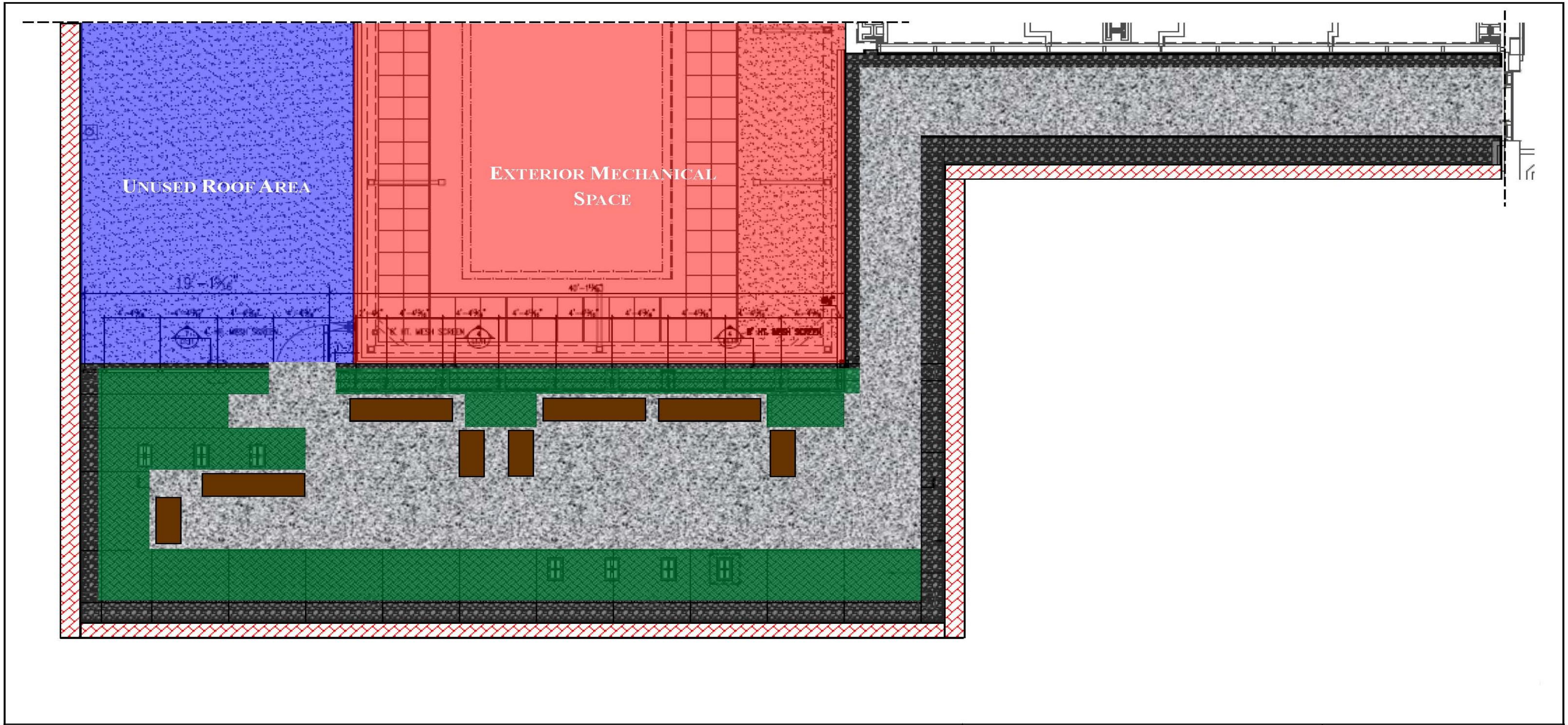
Location	Installation Activity	Original Installation Duration	Prefabrication Installation Duration	Duration Reduction
Second Floor	Mechanical Installation			
	Supply Air Ductwork AHU 6	11	7	4
	Return Air Ductwork AHU 6	11	7	4
	Supply Air Ductwork AHU 7	11	7	4
	Return Air Ductwork AHU 7	11	7	4
	Exam Room Ductwork Branches	6	4	2
	Mechanical System Piping	6	4	2
	Electrical Installation			
	Power Conduit and Wiring	11	7	4
	Lighting Conduit and Wiring	11	7	4
	Nurse Call Conduit and Wiring	5	3	2
	AHU Component Conduit and Wiring	5	3	2
	Plumbing Installation			
	Soil, Waste, and Sanitary Piping	34	22	12
	Domestic Hot and Cold Water Piping	23	15	8
	Fire Protection Installation			
	Sprinkler Piping	16	11	5
	Total			
	-	161	106	55
Third Floor	Mechanical Installation			
	Supply Air Ductwork AHU 6	11	7	4
	Return Air Ductwork AHU 6	11	7	4
	Supply Air Ductwork AHU 7	11	7	4
	Return Air Ductwork AHU 7	11	7	4
	Exam Room Ductwork Branches	6	4	2
	Mechanical System Piping	6	4	2
	Electrical Installation			
	Power Conduit and Wiring	11	7	4
	Lighting Conduit and Wiring	11	7	4
	Nurse Call Conduit and Wiring	5	3	2
	AHU Component Conduit and Wiring	5	3	2
	Plumbing Installation			
	Soil, Waste, and Sanitary Piping	34	22	12
	Domestic Hot and Cold Water Piping	23	15	8
	Fire Protection Installation			
	Sprinkler Piping	16	11	5
	Total			
	-	161	106	55
Fourth Floor	Mechanical Installation			
	Supply Air Ductwork AHU 6	10	7	4
	Return Air Ductwork AHU 6	10	7	4
	Supply Air Ductwork AHU 7	10	7	4
	Return Air Ductwork AHU 7	10	7	4
	Mixed-Use Ductwork Branches	5	3	2
	Mechanical System Piping	5	3	2

	Electrical Installation			
	Power Conduit and Wiring	18	12	6
	Lighting Conduit and Wiring	18	12	6
	Nurse Call Conduit and Wiring	8	5	3
	AHU Component Conduit and Wiring	8	5	3
	Plumbing Installation			
	Soil, Waste, and Sanitary Piping	39	26	13
	Domestic Hot and Cold Water Piping	39	26	13
	Medical Gas Piping	52	34	18
	Fire Protection Installation			
	Sprinkler Piping	26	17	9
	Total			
	-	261	172	89
Fifth Floor	Mechanical Installation			
	Supply Air Ductwork AHU 6	15	10	5
	Return Air Ductwork AHU 6	15	10	5
	Supply Air Ductwork AHU 7	15	10	5
	Return Air Ductwork AHU 7	15	10	5
	Consult Room Ductwork Branches	8	5	3
	Mechanical System Piping	8	5	3
	Electrical Installation			
	Power Conduit and Wiring	11	7	4
	Lighting Conduit and Wiring	11	7	4
	Nurse Call Conduit and Wiring	5	3	2
	AHU Component Conduit and Wiring	5	3	2
	Plumbing Installation			
	Soil, Waste, and Sanitary Piping	18	12	6
	Domestic Hot and Cold Water Piping	12	8	4
	Fire Protection Installation			
	Sprinkler Piping	15	10	5
	Total			
	-	153	101	52
Total		737	486	250

APPENDIX E

SUSTAINABLE GREEN ROOF GARDEN

Gouverneur Healthcare Services Original Green Roof Design



Legend

🟩 Planting Bed; Aluminum Edging & Intensive Light-Weight Planting Medium
▒ 2" Thick Precast Concrete Pavers on Expanded Shale Aggregate Base
▨ Roof Parapet
🟫 Metal Bench
⬛ Roof Ballast
🟥 Exterior Mechanical Space
🟦 Unused Roof Area

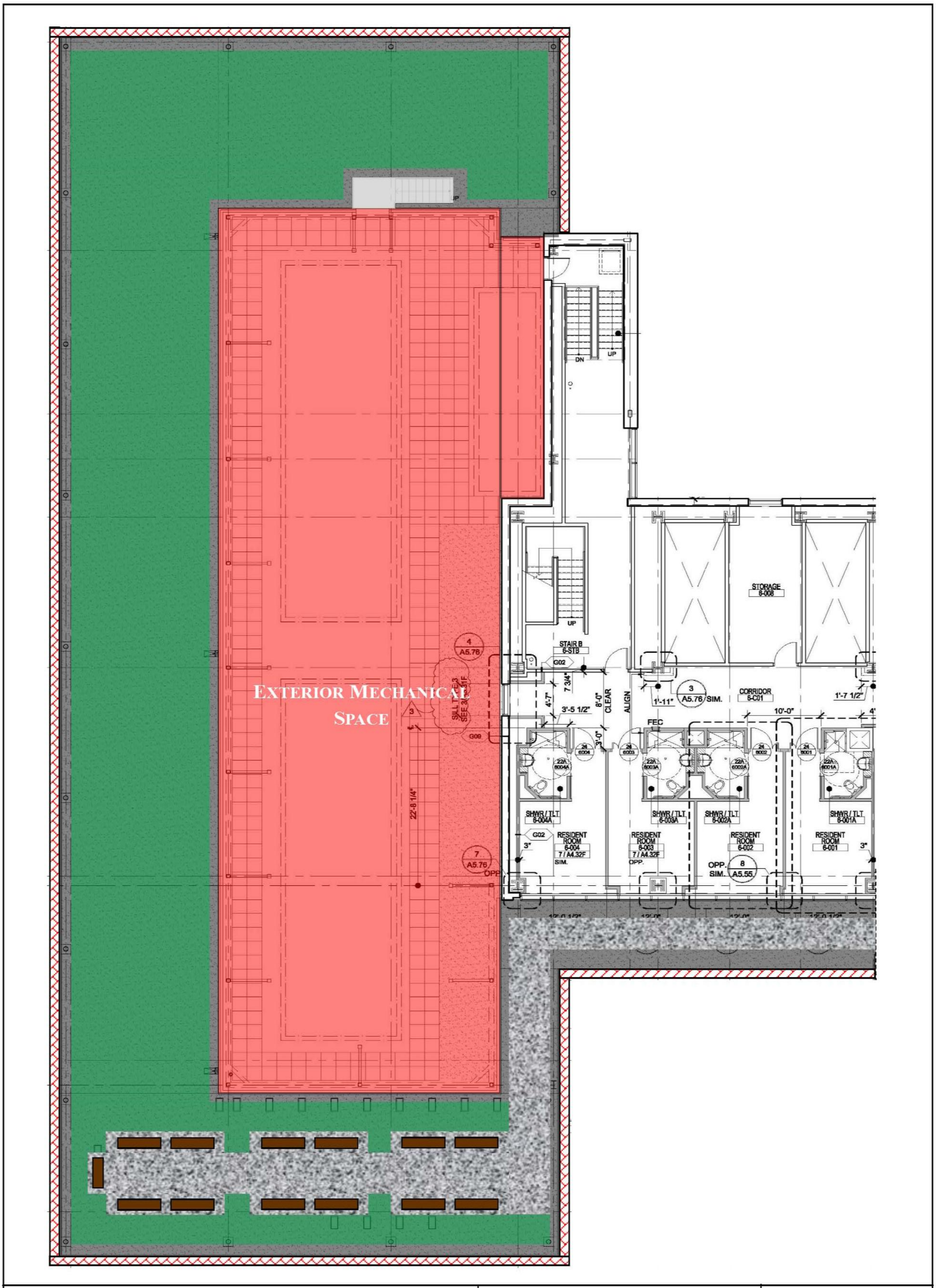
Drawn By: Alex Despotovich
Date: April 4, 2012

Original Green Roof
Scale: Not to Scale

Gouverneur Healthcare Services Project
227 Madison Street, New York, NY, 10002

Drawing L-001

GOUVERNEUR HEALTHCARE SERVICES PROPOSED GREEN ROOF DESIGN



LEGEND

🟩 GroRoof 4.5" Extensive Green Roof Modules

▨ GroRoof Paver Platforms

⬛ Roof Ballast

🟫 Metal Bench

▨ Roof Parapet

🟥 Exterior Mechanical Space

Drawn By: Alex Despotovich

Date: April 4, 2012

Gouverneur Healthcare Services Project

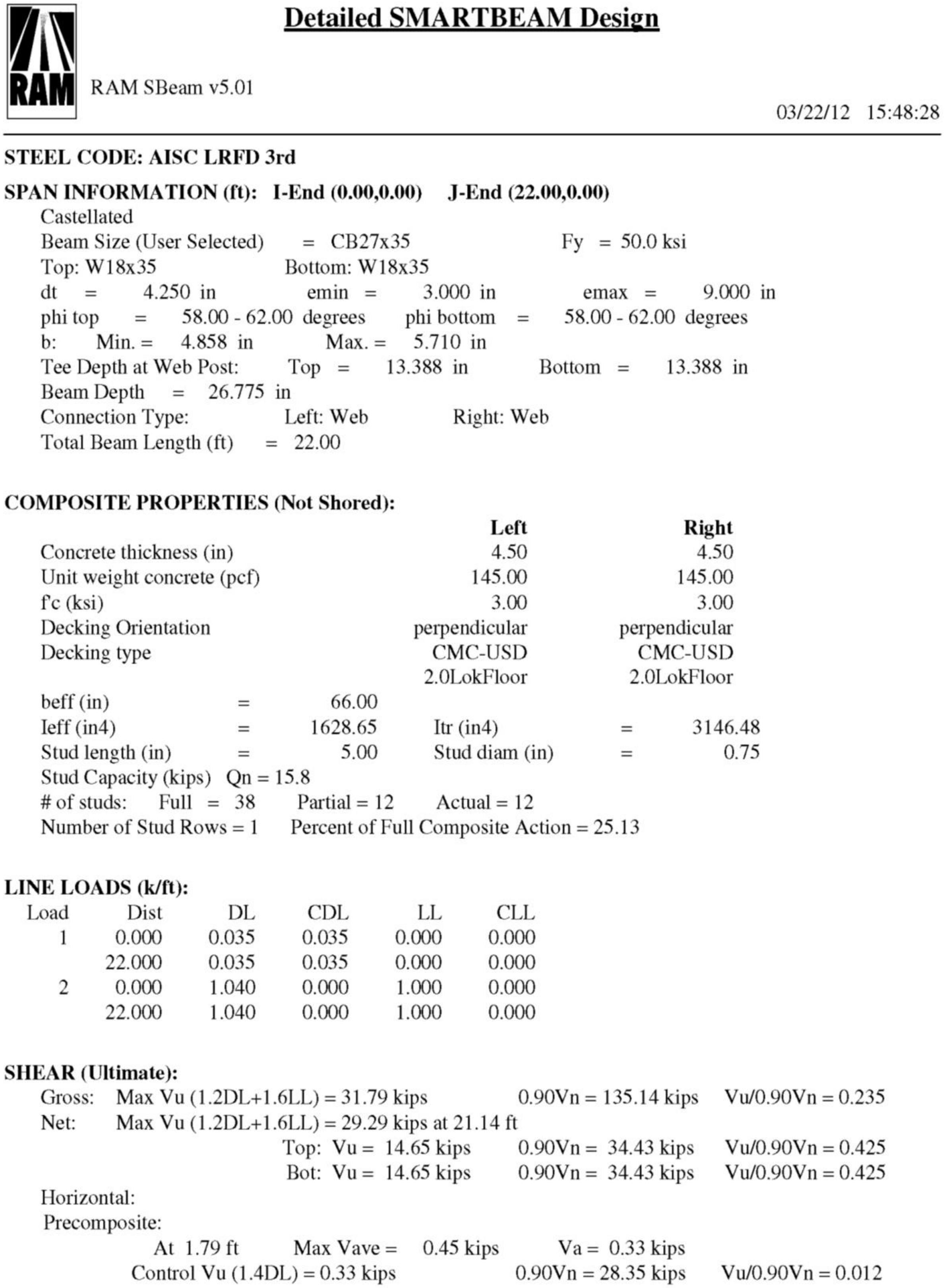
227 Madison Street, New York, NY, 10002

Proposed Green Roof

Scale: Not to Scale

Drawing L-002

GOUVERNEUR HEALTHCARE SERVICES CASTELLATED BEAM ANALYSIS



Detailed SMARTBEAM Design

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RAM SBeam v5.01
                                                              03/22/12   15:48:28

STEEL CODE: AISC LRFD 3rd
SPAN INFORMATION (ft):  I-End (0.00,0.00)   J-End (22.00,0.00)
    Castellated
    Beam Size (User Selected)    =  CB27x35              Fy  =  50.0 ksi
    Top: W18x35               Bottom: W18x35
    dt    =     4.250  in          emin  =     3.000  in        emax  =     9.000  in
    phi top     =     58.00 - 62.00  degrees     phi bottom    =    58.00 - 62.00  degrees
    b:     Min. =    4.858  in         Max. =    5.710  in
    Tee Depth at Web Post:      Top   =    13.388  in          Bottom   =    13.388  in
    Beam Depth    =    26.775  in
    Connection Type:             Left: Web            Right: Web
    Total Beam Length (ft)     =   22.00

COMPOSITE PROPERTIES (Not Shored):
                                                    Left                  Right
    Concrete thickness (in)                         4.50                   4.50
    Unit weight concrete (pcf)                    145.00                 145.00
    f'c (ksi)                                       3.00                   3.00
    Decking Orientation                    perpendicular          perpendicular
    Decking type                                 CMC-USD                CMC-USD
                                              2.0LokFloor            2.0LokFloor
    beff (in)               =          66.00
    Ieff (in4)              =        1628.65     Itr (in4)            =       3146.48
    Stud length (in)        =           5.00     Stud diam (in)       =          0.75
    Stud Capacity (kips)   Qn = 15.8
    # of studs:     Full   =   38      Partial = 12      Actual = 12
    Number of Stud Rows = 1      Percent of Full Composite Action = 25.13

LINE LOADS (k/ft):
   Load      Dist        DL        CDL        LL        CLL
      1      0.000      0.035      0.035      0.000      0.000
            22.000      0.035      0.035      0.000      0.000
      2      0.000      1.040      0.000      1.000      0.000
            22.000      1.040      0.000      1.000      0.000

SHEAR (Ultimate):
    Gross:   Max Vu (1.2DL+1.6LL) = 31.79 kips             0.90Vn = 135.14 kips    Vu/0.90Vn = 0.235
    Net:     Max Vu (1.2DL+1.6LL) = 29.29 kips at 21.14 ft
                                  Top:  Vu =  14.65 kips   0.90Vn =  34.43 kips    Vu/0.90Vn = 0.425
                                  Bot:  Vu =  14.65 kips   0.90Vn =  34.43 kips    Vu/0.90Vn = 0.425
    Horizontal:
     Precomposite:
                 At  1.79 ft       Max Vave =    0.45 kips        Va =  0.33 kips
               Control Vu (1.4DL) = 0.33 kips              0.90Vn = 28.35 kips     Vu/0.90Vn = 0.012
```

Detailed SMARTBEAM Design

```
RAM SBeam v5.01                                                    Page  2/48
                                                            03/22/12  15:48:28
   Composite Max Vu (1.2DL+1.6LL) = 13.90 kips at 19.71 ft
                                          0.90Vn = 24.30 kips     Vu/0.90Vn = 0.572

WEB POST BUCKLING:
  Precomposite Max Vu (1.4DL) = 0.30 kips at 1.54 ft
                Mu        Mp       Mocr      phib     phiMn      Mu/phiMn
             kip-ft    kip-ft    kip-ft              kip-ft
     Top:      0.23     52.54     18.48      0.90     16.63         0.014
     Bot:      0.23     52.54     18.48      0.90     16.63         0.014

  Composite Max Vu (1.2DL+1.6LL) = 14.32 kips at 20.46 ft
                Mu        Mp       Mocr      phib     phiMn      Mu/phiMn
             kip-ft    kip-ft    kip-ft              kip-ft
     Top:     10.90     52.54     18.48      0.90     16.63         0.655
     Bot:     10.90     52.54     18.48      0.90     16.63         0.655

VIERENDEEL:
  Precomposite:
  Beam:       Vu =  0.45 kips             Mu =   0.87 kip-ft at  1.76 ft (1.4DL)
  Top Tee:    Pu =    0.42 kips           Mu = 0.00 + 0.09 = 0.09 kip-ft
              0.85Pn =  159.63 kips       0.9Mn = 5.56 kip-ft
                                                   H1-1b:  0.001 + 0.015 = 0.017
  Beam:       Vu =  0.45 kips             Mu =   0.87 kip-ft at  1.76 ft (1.4DL)
  Bot Tee:    Pu =    0.42 kips           Mu = 0.00 + 0.09 = 0.09 kip-ft
              0.90Pn =  169.51 kips       0.9Mn = 5.56 kip-ft
                                                   H1-1b:  0.001 + 0.015 = 0.017

  Composite:   Vc = 16.34 kips
  Beam:       Vu = 26.70 kips             Mu =  51.50 kip-ft at 20.24 ft (1.2DL+1.6LL)
  Top Tee:    Pu =    5.09 kips           Mu = 0.00 + 1.94 = 1.94 kip-ft
              0.85Pn =  159.63 kips       0.85Mn = 5.25 kip-ft
                                                   H1-1b:  0.016 + 0.370 = 0.386
  Beam:       Vu = 26.70 kips             Mu =  51.50 kip-ft at 20.24 ft (1.2DL+1.6LL)
  Bot Tee:    Pu =   20.25 kips           Mu = 0.00 + 1.94 = 1.94 kip-ft
              0.90Pn =  169.51 kips       0.90Mn = 5.56 kip-ft
                                                   H1-1b:  0.060 + 0.349 = 0.409

MOMENTS (Ultimate):
  Span      Cond        LoadCombo          Mu        @
                                       kip-ft       ft
  Center    PreCmp      1.4DL             3.0     11.0
  Center    InitDL      1.4DL             3.0     11.0
            Max +       1.2DL+1.6LL     174.8     11.0
```

Detailed SMARTBEAM Design

```
RAM SBeam v5.01
                                                              03/22/12   15:53:15

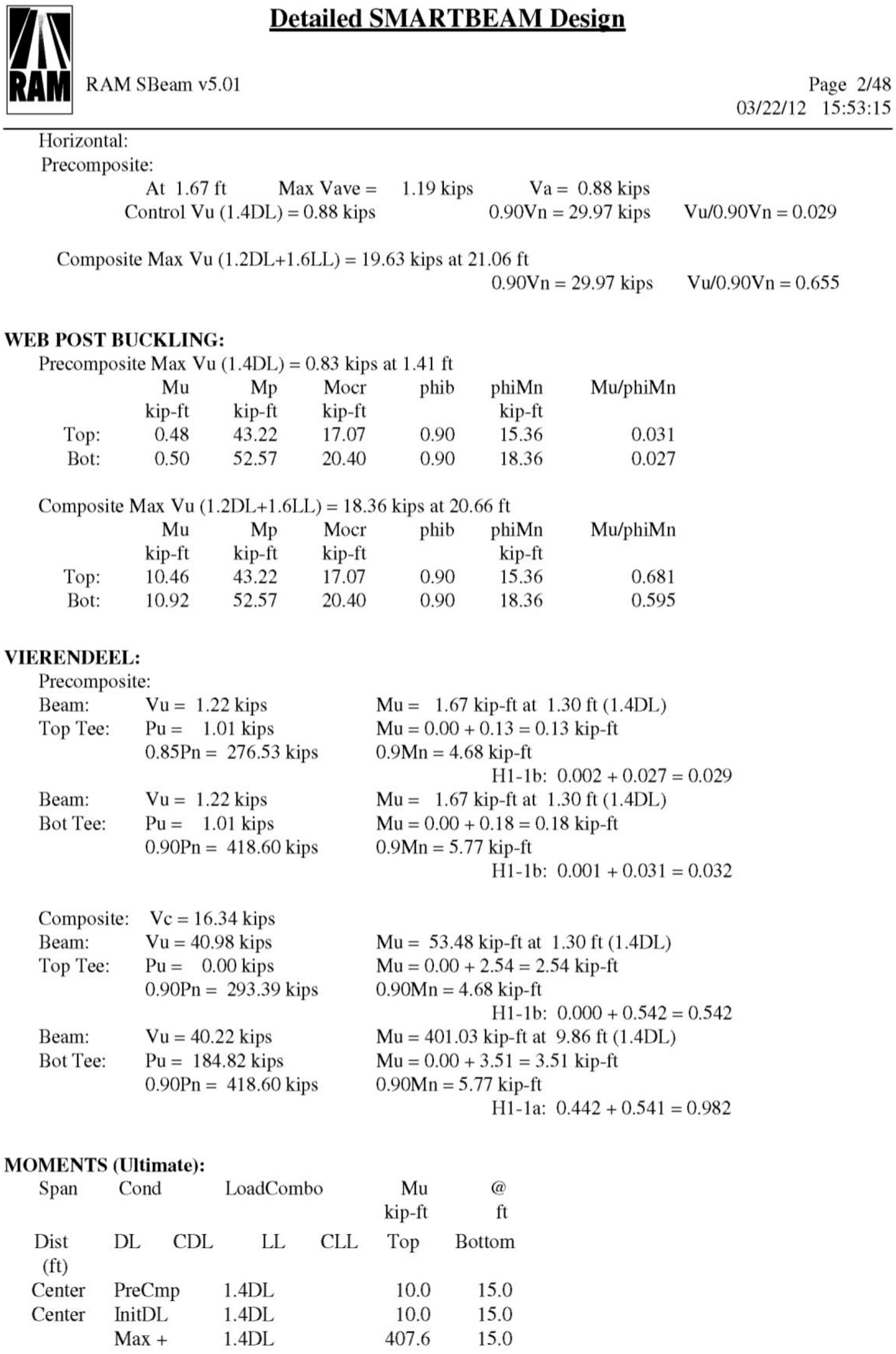
STEEL CODE: AISC LRFD 3rd
SPAN INFORMATION (ft):   I-End (0.00,0.00)    J-End (30.00,0.00)
   Castellated
   Beam Size (User Selected)     =  CB21x53/74             Fy  =  50.0 ksi
   Top: W14x53                 Bottom: W14x74
   dt     =      3.500  in          emin   =     3.000  in          emax   =     6.000  in
   phi top     =     58.00 - 60.97  degrees     phi bottom    =    59.10 - 62.00  degrees
   b:       Min. =      3.795  in          Max. =     4.273  in
   Tee Depth at Web Post:        Top    =     10.337  in          Bottom    =     10.637  in
   Beam Depth     =    20.975  in
   Connection Type:              Left: Web              Right: Web
   Total Beam Length (ft)      =   30.00

COMPOSITE PROPERTIES (Not Shored):
                                                      Left                  Right
   Concrete thickness (in)                            4.50                  4.50
   Unit weight concrete (pcf)                       145.00                145.00
   f'c (ksi)                                          3.00                  3.00
   Decking Orientation                       perpendicular         perpendicular
   Decking type                                   CMC-USD               CMC-USD
                                                2.0LokFloor           2.0LokFloor
   beff (in)               =           45.00
   Ieff (in4)              =         3025.12      Itr (in4)             =        4033.50
   Stud length (in)        =            5.00      Stud diam (in)        =           0.75
   Stud Capacity (kips)  Qn[1] = 15.8   Qn[2] = 21.0
   # of studs:      Full   =  52        Partial = 52        Actual = 52
   Number of Stud Rows = 2      Percent of Full Composite Action = 100.00

POINT LOADS (kips):
                                                Flange Bracing
  Dist (ft)      DL      CDL       LL      CLL    Top     Bottom
   10.000     28.40     0.00     0.00     0.00    No        No
   20.000     28.40     0.00     0.00     0.00    No        No

LINE LOADS (k/ft):
    Load       Dist        DL        CDL        LL        CLL
      1       0.000      0.064     0.064     0.000     0.000
             30.000      0.064     0.064     0.000     0.000

SHEAR (Ultimate):
   Gross:   Max Vu (1.4DL) = 41.10 kips                   0.90Vn = 232.52 kips    Vu/0.90Vn = 0.177
   Net:     Max Vu (1.4DL) = 40.98 kips at 1.30 ft
                                  Top:  Vu =  16.89 kips   0.90Vn =  34.97 kips    Vu/0.90Vn = 0.483
                                  Bot:  Vu =  24.09 kips   0.90Vn =  42.52 kips    Vu/0.90Vn = 0.567
```



Detailed SMARTBEAM Design

```
RAM SBeam v5.01                                                         Page  2/48
                                                                 03/22/12   15:53:15
Horizontal:
 Precomposite:
            At  1.67 ft       Max Vave =    1.19 kips        Va =  0.88 kips
          Control Vu (1.4DL) = 0.88 kips               0.90Vn = 29.97 kips     Vu/0.90Vn = 0.029

  Composite Max Vu (1.2DL+1.6LL) = 19.63 kips at 21.06 ft
                                                       0.90Vn = 29.97 kips     Vu/0.90Vn = 0.655

WEB POST BUCKLING:
   Precomposite Max Vu (1.4DL) = 0.83 kips at 1.41 ft
                 Mu        Mp        Mocr      phib      phiMn      Mu/phiMn
               kip-ft    kip-ft    kip-ft               kip-ft
     Top:       0.48     43.22     17.07     0.90      15.36         0.031
     Bot:       0.50     52.57     20.40     0.90      18.36         0.027

   Composite Max Vu (1.2DL+1.6LL) = 18.36 kips at 20.66 ft
                 Mu        Mp        Mocr      phib      phiMn      Mu/phiMn
               kip-ft    kip-ft    kip-ft               kip-ft
     Top:      10.46     43.22     17.07     0.90      15.36         0.681
     Bot:      10.92     52.57     20.40     0.90      18.36         0.595

VIERENDEEL:
   Precomposite:
   Beam:       Vu =  1.22 kips              Mu =   1.67 kip-ft at  1.30 ft (1.4DL)
   Top Tee:    Pu =    1.01 kips            Mu = 0.00 + 0.13 = 0.13 kip-ft
               0.85Pn =  276.53 kips        0.9Mn = 4.68 kip-ft
                                                      H1-1b:  0.002 + 0.027 = 0.029
   Beam:       Vu =  1.22 kips              Mu =   1.67 kip-ft at  1.30 ft (1.4DL)
   Bot Tee:    Pu =    1.01 kips            Mu = 0.00 + 0.18 = 0.18 kip-ft
               0.90Pn =  418.60 kips        0.9Mn = 5.77 kip-ft
                                                      H1-1b:  0.001 + 0.031 = 0.032

   Composite:   Vc = 16.34 kips
   Beam:       Vu = 40.98 kips              Mu =  53.48 kip-ft at  1.30 ft (1.4DL)
   Top Tee:    Pu =    0.00 kips            Mu = 0.00 + 2.54 = 2.54 kip-ft
               0.90Pn =  293.39 kips        0.90Mn = 4.68 kip-ft
                                                      H1-1b:  0.000 + 0.542 = 0.542
   Beam:       Vu = 40.22 kips              Mu = 401.03 kip-ft at  9.86 ft (1.4DL)
   Bot Tee:    Pu =  184.82 kips            Mu = 0.00 + 3.51 = 3.51 kip-ft
               0.90Pn =  418.60 kips        0.90Mn = 5.77 kip-ft
                                                      H1-1a:  0.442 + 0.541 = 0.982

MOMENTS (Ultimate):
   Span      Cond          LoadCombo          Mu          @
                                            kip-ft        ft
  Dist      DL      CDL         LL      CLL      Top      Bottom
   (ft)
  Center    PreCmp         1.4DL               10.0        15.0
  Center    InitDL         1.4DL               10.0        15.0
            Max +          1.4DL              407.6        15.0
```

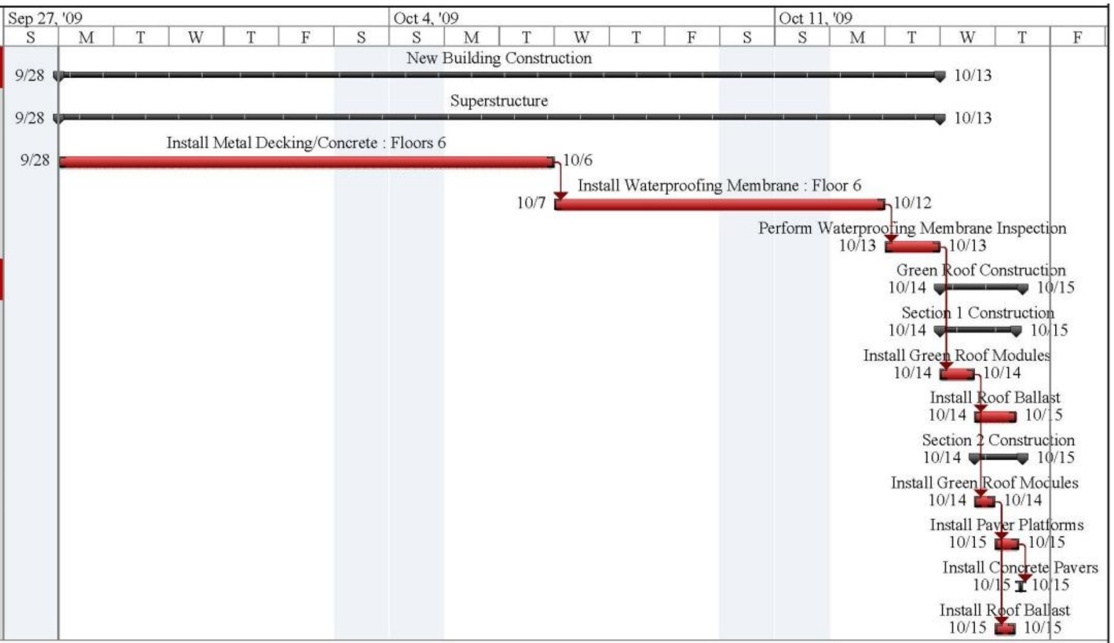
Gouverneur Healthcare Services Green Roof Life-Cycle Cost Analysis

Table 40: Life-Cycle Cost Analysis

Year	Annual Cost Savings	Life-Cycle Cost
1	$ 3,745.58	$ (74,189.42)
2	$ 3,745.58	$ (70,443.84)
3	$ 3,745.58	$ (66,698.26)
4	$ 3,745.58	$ (62,952.68)
5	$ 3,745.58	$ (59,207.10)
6	$ 3,745.58	$ (55,461.52)
7	$ 3,745.58	$ (51,715.94)
8	$ 3,745.58	$ (47,970.36)
9	$ 3,745.58	$ (44,224.78)
10	$ 3,745.58	$ (40,479.20)
11	$ 3,745.58	$ (36,733.62)
12	$ 3,745.58	$ (32,988.04)
13	$ 3,745.58	$ (29,242.46)
14	$ 3,745.58	$ (25,496.88)
15	$ 3,745.58	$ (21,751.30)
16	$ 3,745.58	$ (18,005.72)
17	$ 3,745.58	$ (14,260.14)
18	$ 3,745.58	$ (10,514.56)
19	$ 3,745.58	$ (6,768.98)
20	$ 3,745.58	$ (3,023.40)
21	$ 3,745.58	$ 722.18
22	$ 3,745.58	$ 4,467.76
22	$ 3,745.58	$ 8,213.34
23	$ 3,745.58	$ 11,958.92
24	$ 3,745.58	$ 15,704.50
25	$ 3,745.58	$ 19,450.08
26	$ 3,745.58	$ 23,195.66
27	$ 3,745.58	$ 26,941.24
28	$ 3,745.58	$ 30,686.82
29	$ 3,745.58	$ 34,432.40
30	$ 3,745.58	$ 38,177.98
31	$ 3,745.58	$ 41,923.56
32	$ 3,745.58	$ 45,669.14
33	$ 3,745.58	$ 49,414.72
34	$ 3,745.58	$ 53,160.30
35	$ 3,745.58	$ 56,905.88
36	$ 3,745.58	$ 60,651.46
37	$ 3,745.58	$ 64,397.04
38	$ 3,745.58	$ 68,142.62
39	$ 3,745.58	$ 71,888.20
40	$ 3,745.58	$ 75,633.78
41	$ 3,745.58	$ 79,379.36
42	$ 3,745.58	$ 83,124.94
43	$ 3,745.58	$ 86,870.52
44	$ 3,745.58	$ 90,616.10
45	$ 3,745.58	$ 94,361.68
46	$ 3,745.58	$ 98,107.26
47	$ 3,745.58	$ 101,852.84
48	$ 3,745.58	$ 105,598.42
49	$ 3,745.58	$ 109,344.00
50	$ 3,745.58	$ 113,089.58

GOUVERNEUR HEALTHCARE SERVICES GREEN ROOF CONSTRUCTION SCHEDULE

ID	Task Name	Duration	Start	Finish
1	**New Building Construction**	**12 days**	**Mon 9/28/09**	**Tue 10/13/09**
2	**Superstructure**	**12 days**	**Mon 9/28/09**	**Tue 10/13/09**
3	Install Metal Decking/Concrete : Floors 6	7 days	Mon 9/28/09	Tue 10/6/09
4	Install Waterproofing Membrane : Floor 6	4 days	Wed 10/7/09	Mon 10/12/09
5	Perform Waterproofing Membrane Inspection	1 day	Tue 10/13/09	Tue 10/13/09
6	**Green Roof Construction**	**1.5 days**	**Wed 10/14/09**	**Thu 10/15/09**
7	**Section 1 Construction**	**1.15 days**	**Wed 10/14/09**	**Thu 10/15/09**
8	Install Green Roof Modules	0.75 days	Wed 10/14/09	Wed 10/14/09
9	Install Roof Ballast	0.4 days	Wed 10/14/09	Thu 10/15/09
10	**Section 2 Construction**	**0.75 days**	**Wed 10/14/09**	**Thu 10/15/09**
11	Install Green Roof Modules	0.25 days	Wed 10/14/09	Wed 10/14/09
12	Install Paver Platforms	0.3 days	Thu 10/15/09	Thu 10/15/09
13	Install Concrete Pavers	0.2 days	Thu 10/15/09	Thu 10/15/09
14	Install Roof Ballast	0.1 days	Thu 10/15/09	Thu 10/15/09



Gouverneur Healthcare Services
Alex Despotovich
April 4, 2012

Task	▬	Project Summary	▬	Inactive Milestone	◇	Manual Summary Rollup	▬	Deadline	⇩
Split	┈┈┈	External Tasks	▬	Inactive Summary	▭	Manual Summary	▬	Progress	▬
Milestone	◆	External Milestone	◆	Manual Task	▬	Start-only	[		
Summary	▬	Inactive Task	▭	Duration-only	▬	Finish-only	]		

Appendix F