Thesis Proposal - Revised

Marriott Hotel at Penn Square and Lancaster County Convention Center

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Executive Summary

The following proposal outlines issues and changes that will be analyzed to add value, decrease schedule and cost to the project. Three technical issues will be analyzed and one industry issue will be researched and applied towards the Marriott Hotel and Convention Center Project. All of the following issues will be addressing construction difficulties that arose in the southern half of the project, in particularly the convention entry level of the project. These technical and industry issues include:

Breadth #1 - Structural Redesign

The structural system of the convention entry and museum levels will be redesigned from a cast in place concrete floor slab and concrete structure to a composite steel joist structural system with W-shape columns and girders. Additionally, cantilevered retaining walls will be designed using Ivany block to replace the pinned cast-in-place concrete retaining walls utilized.

Breadth #2 – Mechanical/Plumbing Redesign

The original groundwater lift station system will be redesigned to account for additional water flow required; due to the discovery of a natural underground spring encountered during the excavation process.

Depth #1 - Construction Sequencing

An equivalent micro-pile foundation system will be designed to support the required loads that the current caissons support. This system will also be evaluated as an alternative to decrease the schedule for the foundation work. In large part, the convention entry (south end of the site) will be evaluated and re-sequenced to implement the proposed changes of the foundation system, retaining walls and superstructure structural system construction.

Research - BIM Implementation

A specific BIM processes that will be researched for this project will include the effectives and advantages of implementing a 3D electronic survey of existing conditions into a BIM model/3D model of the structure. The existing buildings on site made it difficult to design and construct the new Marriott Hotel and Convention Center with traditional surveying techniques. The costs and limited availability of the new technology will be evaluated against the advantages in time savings and in having the 3D electronic survey available for incorporation into a 3D model of the superstructure to avoid conflicts.

Analysis Descriptions

Introduction:

The convention entry level for The Marriott Hotel and Convention Center Project faced construction delays due to unforeseen site conditions and requirements in sequencing to place a reinforced concrete slab. The Analysis Description section of this report will focus primarily on the convention entry area of the convention center portion of the project, see figure 3 below for a visual representation of the area.

Problem Background:

- Dewatering System Redesign

During the excavation in the lowest part of the site, the museum level, a natural spring was discovered. This spring provided significantly larger water flows then what the current permanent dewatering system could handle. A delay in construction was encountered while a redesign was finalized for the dewatering system.

- Convention Entry Level

The convention entry level is the level above the museum level in the convention center. The museum level, as mentioned above, encountered unexpected delays with the discovery of a natural spring. The museum level also encountered issues and delays with the unearthing of historical artifacts and structures near the Kleiss Saloon (in particular a brick floor). The delays encountered in the museum level directly affect the ability to proceed with the convention entry level, as in concrete construction the slab below needs to be complete to enable the forming of the slab above.

Proposed Solutions:

- **Structural System**

Problem Statement:

The convention entry level is a cast in place concrete structure; can the load requirements for this area be met with a structural steel system, specifically a composite metal joist system? With a structural steel frame, what sequencing delays and how much of a delay could have been avoided due the required sequential steps in placing an elevated concrete structural slab that could was not met due to unforeseen issues in the lowest level of the building (museum level)?

Can the currently implemented cast-in-place concrete pinned foundation walls will be redesigned to a cantilevered retaining wall using a 16" Ivany block system? Can the Ivany block wall support the loads of the joists that will be framed directly into it? What are tangible advantages in utilizing a block retaining wall system that almost eliminates the need for formwork (faster construction) and allows for complete backfill of the wall before the floor system is in place?

Proposed Solution:

A composite metal joist framing system will be designed to support the required loads of the exhibit level without changing the current column grid, see figure 2 below for a detail of a composite joist system. The majority of the convention center is already a steel structure and in designing the convention entry to be steel, schedule reduction can be achieved. See figure 1 Convention Entry below for a picture of the convention entry level concrete with the exhibit level steel being erecting above it. A cast-in-place concrete structure mandates a specific sequence of construction activities and any delay to a part of the sequence will delay the entire process. A steel structure offers more flexibility for the sequence of construction and most importantly does no rely on the museum level or under slab work to be totally complete. As mentioned previously, the museum level faced unforeseen issues and redesign issues creating delays in the completion of the underslab and slab work. Due to these issues in the museum level the entire convention center superstructure was delayed. A steel structure would have been very beneficaial to break the schedule ties between the museum level and the rest of the superstructure and significant time could be saved and construction sequencing would greatly improve. See Appendix A for floor plans of the Museum, Convention Entry and Exhibit Levels, the elevated structural concrete is highlighted in yellow. A 24" deep composite joist system will adequately support the loads of the exhibit hall. The 30'x30' column grid currently used for the concrete structure will be revised to 20'x40' to provide more efficiency in the steel system, limit the girder depth by using a smaller span, and avoid the most architectural conflicts in using a 20'x40' instead of a 20'x30', 25'x40' etc… The floor plan of the convention entry level will be analyzed for the incorporation of the proposed column grid and resolution to the conflicts will be proposed.

Figure 1 Convention Entry

Research Steps:

1. Gather loading requirements for the floor systems in the spaces of interest.
2. Determine the best steel alternative for the space allotted (composite joists)
3. Design the proposed steel structure
4. Design a complete structural system for the area
5. Calculate a detailed costs for the structural system and compare to the cast-in place concrete structure

6. Develop a schedule for the erection of the steel and compare to the schedule for concrete
7. Analyze the architectural conflicts in changing from a 30’x30’ bay size to 20’x40’
8. Design the Ivany block cantilever retaining wall to replace the exisiting cast-in-place concrete pinned foundation wall utilizing ‘RAM Advance’ retaining wall designer.
9. Compare the cost of the proposed block foundation wall system.

Sources of Information:

1. Baker Ingram & Associates
2. Providence Engineering Corporation
3. Uzun and Case Engineers
4. 1st Ed. CJ Series Standard Specifications for Composite Joists; Weight table and bridging tables code of standard practice by SJI (Steel Joist Institute)
5. RAM Advance
6. http://ivanyblock.com/
7. Steel Construction Manual, Thirteenth Ed.

- **Plumbing Redesign:**

Problem Statement:

In the Museum Level, the lowest level, of the project a natural underground spring was encountered during the excavation process. The additional water adds additional requirements to the original ground water lift stations designed.

Proposed Solution:

The existing groundwater lift stations will be redesigned to accommodate the additional loads of the underground spring. See Appendix B for a plan of the existing ground water lift station design.

Research Steps:

1. Obtain a copy of the hydro-geological study reports.
2. Analyze the existing groundwater lift station design.
3. Design a new lift station system to accommodate the required loads.
4. Compare new design to the original.

Sources of Information

1. W.G. Tomko the plumbing contractor.
2. Jordan and Skala Engineers the mechanical/plumbing engineers.
3. Mechanical and Electrical Equipment for Building by Stein and Reynolds, 9th Ed.
4. The hydro-geological study report.

- **Construction Sequencing/Planning**

Problem Statement:

In using mini-piles for the foundation system instead of caissons will there be cost savings and schedule reduction? In switching the convention entry structure to a steel frame can the construction sequence be reworked to accelerate work in this area, and what will be the schedule savings?

Proposed Solution:

Mini-piles require more holes to be drilled then caissons but the holes are much smaller and can be drilled considerably faster. The mini-piles also use less material then caissons and can provide cost savings also. The load requirements for the area can be met with a mini-pile system.

In redesigning the convention entry level to be a steel structure there will no longer be a need for shoring and reshoring in the area and the flow of materials and workers will be improved. The steel structure can be erected in this area regardless of the unforeseen conditions in the museum level, and can be independent of the progress in that area to a certain extent. Overall, a steel structural system for the convention entry level will save time and provide a less crowded work site. See figure 2 below for an aerial view of the museum, convention entry and exhibit levels.

With the implementation of all proposed changes the south end of the site will be a cleaner more efficient work area that will also reduce the schedule. In utilizing a steel structure it will allow for the super structure to be erected prior to all underground work and unforeseen issues being completed in the museum and convention entry levels.

Research Steps:

1. Determine the load requirements for the foundations in this area
2. Calculate an equivalent minipile system to support these loads
3. Calculate the cost for the mini-pile system and compare to the caisson cost
4. Evaluate the sequence of construction activities in this area
5. Develop a new sequence of activities to include activities related around the excavation, minipile construction thru steel erection
6. Compare the cost, schedule and site access to that of the existing design.

Sources of Information:

1. Shelley Drilling for minipile and caisson information
2. Contact Walter Schneider (PSU foundation professor) about information on the design of micro-piles
3. Reynolds Construction Management for scheduling and sequencing information
4. Mechanical and Electrical Building Construction by Hettema

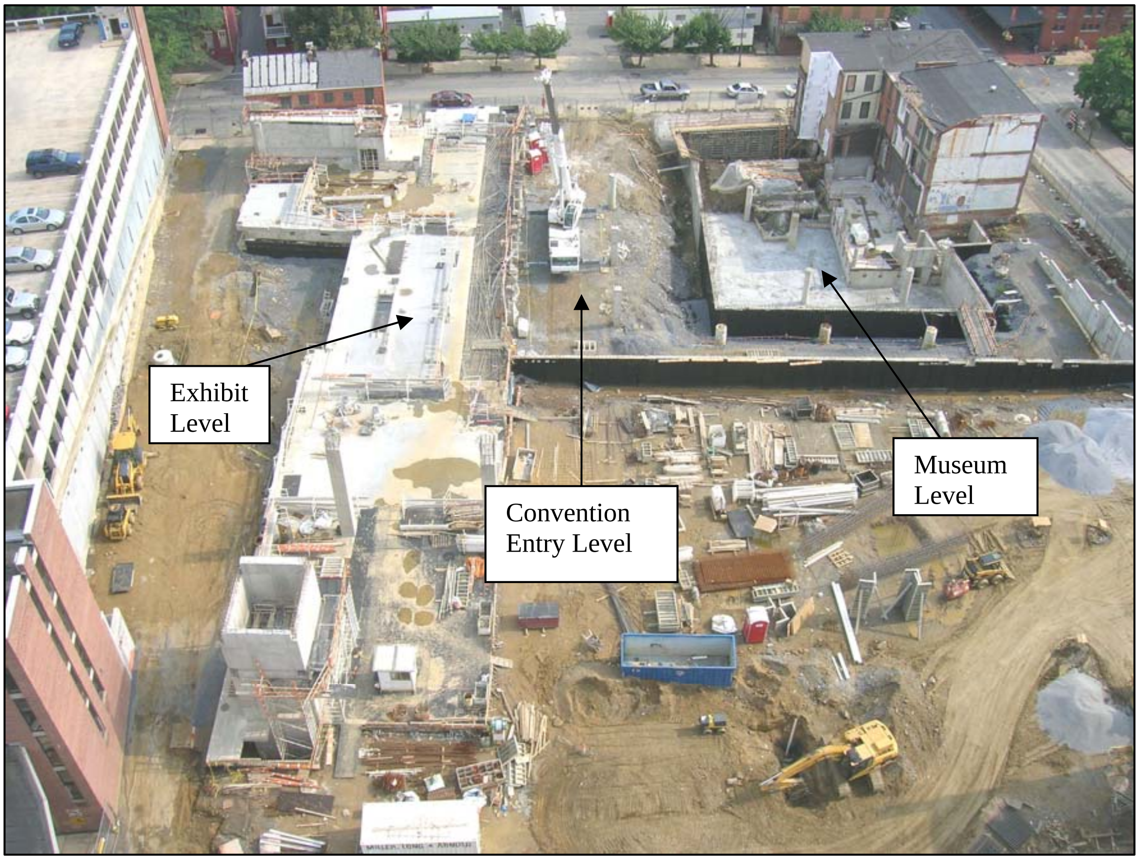

Figure 2 View from Tower Crane of Southern Half of Site

Critical Issues Research Method – Minipile

Background

On any project site work is on the critical path. The time spent on the construction of the foundations directly affects the overall schedule of the project. It is very important for the success of a project to be able to identify the best appropriate foundation system to be used. There are two main types of foundation systems, shallow and deep. Among the deep foundation systems there are caissons, piles and minipiles. A critical issue researched further in this report is the minipile system and the opportunities available in using the system.

The first patent for the minipile (or micropile) foundation system was obtained in 1952 by Dr. Lizzi of Naples, Italy[1]. Minipiles are small diameter piles typically ranging from 5-12" diameters while macropiles range from 12-24". Alternatively, caisson diameters can range from 24" up to 90+". Today minipile systems are generally thought of as a foundation system primarily for confined spaces such as building additions, underpinning and inside existing structures though minipiles are able to support large compressive loads and large uplift loads thus making them applicable to new construction. The term pile in minipile is misleading as minipiles are drilled into the ground like a caisson and not driven into the ground like a standard pile. The minipiles are drilled in clusters of 2, 3, 4, or 6+ and then capped with a pile cap to distribute the load between each pile. The smaller diameters of the micropiles enable them able to be drilled much faster then caisson holes. Also the machines required to drill micropiles are smaller then caisson drill rigs and thus provides more room on site.

The information researched in this paper is beneficial to developers, engineers, and contractors alike to become educated about the option of micropiles and can then consider using the method on further projects. It is important to for developers and geotechnical engineers to be aware of the potential construction advantages of micropiles as then they themselves can propose the system on their next project to the engineer. The ultimate goal is to improve the construction industry by implementing new techniques.

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Problem Identification

Currently in the United States, micropiles are not commonly used even though they have some distinct advantages. Why are minipiles not used more frequently? In which new building applications do minipiles provide the largest advantage? Is there significant schedule saving to justify a potentially higher cost to use minipiles? Will the cost of minipiles decrease as they become better known and used more frequently?

The Marriott Hotel and Convention Center is located in central Pennsylvania, the study of minipiles in this report will be focused on this region and immediate surrounding areas.

Caisson Construction

The Convention Center project utilizes 200 caissons for the foundation system of the structure. In the specifications intact rock requirements needed to be met for each caisson drilled. Many of the caissons also required special requirements to account for uplift forces; such as drilling a smaller diameter caisson deeper through the bottom of a larger hole and the use of rock anchors at the bottom of the caissons. For theses caissons the caisson contractor needed to set up the drill rig for a large diameter caisson, reach the required depth then switch to a smaller diameter bit to continue to drill for the same caisson, then further drilling is required by the concrete contractor to install the rock anchors. Additionally, for several of the caissons rock was encountered at a very shallow depth, approximately 10 feet, and the structural engineer still required the depth to be increased, thus the caisson contractor spend significant time drilling large diameter holes in rock. In an effort to save money from drilling large holes in rock, the foundations for some of the caissons were redesigned to be large spread footings, which decreased the rock removal required but also took significantly longer then to drill caissons.

Karst Topography

The central Pennsylvania region has karst topography. The term karst is defined as an area of limestone terrane characterized by sinks, ravines, and underground streams.[2] Figure 3 below outlines the areas of karst topography in Pennsylvania. Karst topography makes it difficult to meet intact rock requirements for large diameter holes, as the rock drops off suddenly, can be fractured and can also be layered, see figure 4 Karst Topography Cross Section below. A key reason why minipiles offer greater flexibility in karst then caissons is that minipiles resist forces by skin friction and are not end bearing. The skin friction design allows for the piles to spread out the load over several small sections of rock rather then specifying a certain amount of competent rock to bear on. In this regard, the existence of a major karstic feature just under the pile tip should not adversely affect the minipile performance, as it would of a large-diameter end bearing caisson.[4]

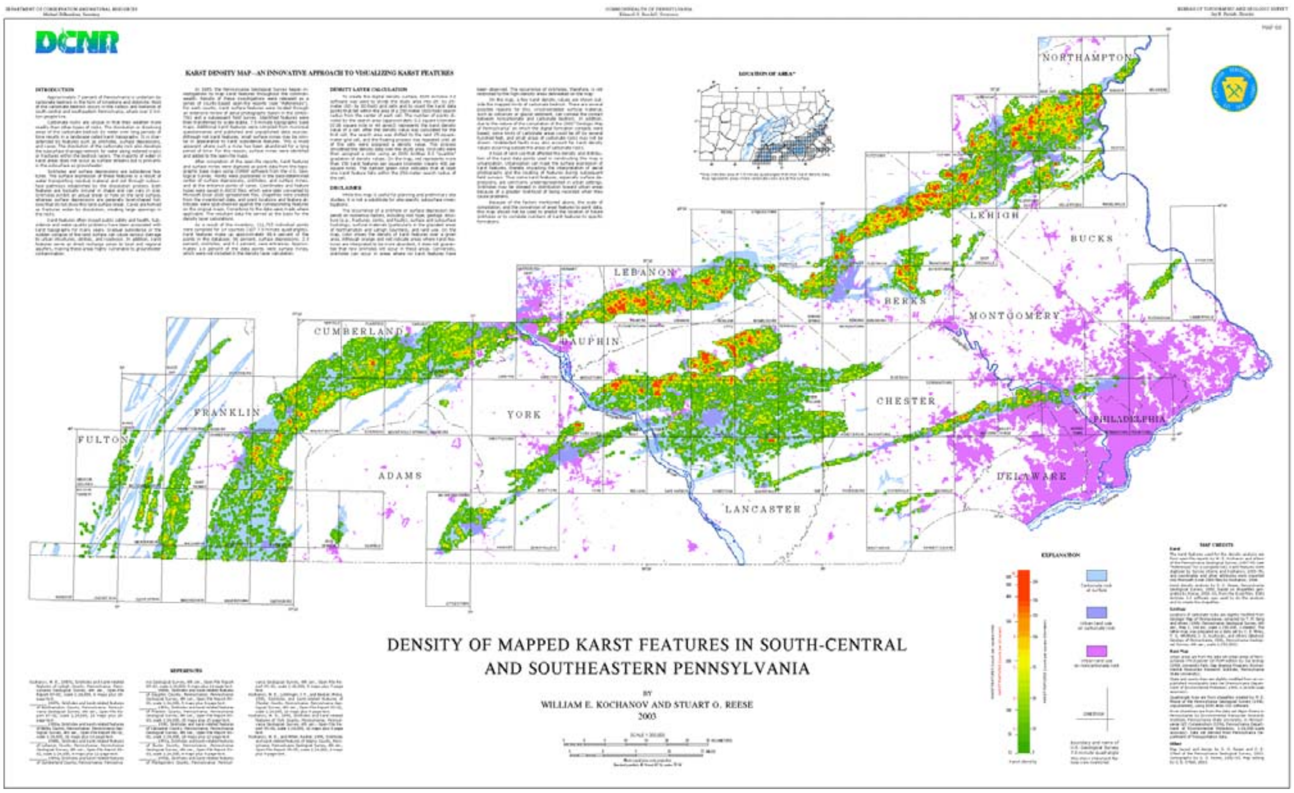

Figure 3 Pennsylvania Karst Topography Map

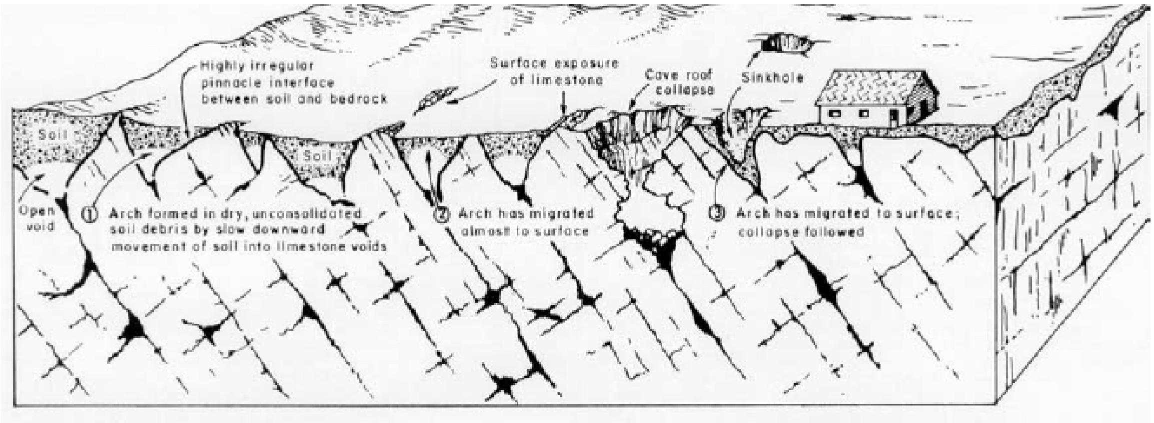

Figure 4 Karst Topography Cross Section

Proposed Solution

Minipiles have distinct advantages, they are conducive for small spaces such as interior renovations (low head room situations), can also be drilled at an angle for lateral loads, support of excavation and underpinning. Advances in minipiles have enables them to be designed to carry significant loads which allows them to also be used for new construction applications. The smaller diameter hole the minipile requires poses advantages over caissons in rock situations and karst topography where the rock is fractured and uneven.

Research Steps

The following steps were followed to research the minipile foundation system:

1. Research further information about micropile systems from ISM (International Society for micropiles), IWM (International Workshop on Micropiles) and related code, design and guideline manuals for micropiles.
2. Assembled cost and schedule information from case studies of projects that have utilized micropiles.
3. Gather input from developers, construction managers, general contractors and specialty contractors and specialty design engineers on their experiences (or lack of) with minipile construction. High Real Estate, Reynolds Construction Management, Clark Foundations, Hayward Baker

Geotechnical Consults, HAAS Engineers, Schnabel Foundation Engineers, and Shelly Foundations contributed to the input and data for the case study analysis.

Apply the research and data to the Marriott Hotel and Lancaster County Convention Center project.

Critical Issues Research Method – 3D Laser Scan Survey

Background

The use and implementation of laser scan surveys is a relatively new practice considering laser scan technology was developed in the mid 1990's. Simply, laser scan technology enable the setup of a small machine on a tripod to rotate and scan to gather enough information to accurately produce drawings or a 3D model of the building or structure. Traditional survey techniques require a survey crew to measure distances, angles and elevations. The process of surveying using traditional techniques is far more time consuming and also has larger tolerances then that of laser scanning.

Problem Identification

As mentioned previously, the project maintains and utilizes the existing façade of the Watt & Shand department store into the new building. The façade is 4 stories above grade and approximately 900 ft. long. Parts of the façade are over 100 years old. Extensive stabilization and façade monitor processes have been implemented on the project, though a lack of detail was taken in locating the exact dimensions and makeup of the façade. The lack of knowledge as to the specific location of the façade led to a major structural redesign as all of the caissons needed to be relocated to accommodate the drill rig near the façade to drill the required holes.

Structural Redesign

The locations of the interior concrete columns were designed too close to the existing façade to allow the caisson rig to drill the caissons in the required location. A major structural redesign took place to move the concrete columns in from the façade one foot as to avoid the conflict. At the surface it sounds like a simplistic solution that should be a major conflict though, in moving the location of the caissons the columns through the entire 19 stories of the structure needed to be adjusted to accommodate the change. The contractors need drawings to build off, thus waiting for reissued correct drawings created a major delay for the project along with increased cost. The caisson and column relocations changed dimensions on almost every page of the architectural and structural drawings (hundreds of sheets).

Additionally, a few of the conflict caissons were also redesigned into large spread footings to accommodate site conditions of bearing under the existing façade. Significant time was spent by the architect and structural engineer to complete the required redesign. The construction of the spread footing (while cheaper then the caissons) took significantly longer and added delays.

Traditional Survey

Surveying has advanced significantly within the past few years, as total stations are very common. Total stations allow for the user to input a CADD drawing of the building and perform layout very accurately, fast and with few individuals – though this does not help to document an existing building or façade. An EDM is still required to document an existing structure. The EDM can shoot and record points accurately by the user; though it only records the points inputted by the user and can be a lengthy process depending on the amount of detail required. This method collects data one point at a time.

Laser Scan Surveys

The machine seen in figure 5 Laser Scanning Equipment, illustrates a typical laser scan machine used by an individual to gather data on the location of an existing structure.

Figure 5 Laser Scanning Equipment (Cyrax 2500)

The laser scanner works on similarly to the EDM but collects data at a much more rapid rate. Instead of a point-and-press EDM collecting measurements one at a time, a laser scanner automatically and rapidly captures a vast swath of points, horizontally and vertically to build up a 3D image.[3] The machine is able to obtain points as far as 200 feet away, horizontally or vertically, thus the need for a hoist or lift can be eliminated.

Within a few minutes a laser scan machine can obtain enough data points to create a drawing or model in Figure 6 Laser Scan Façade Output. The machine collects

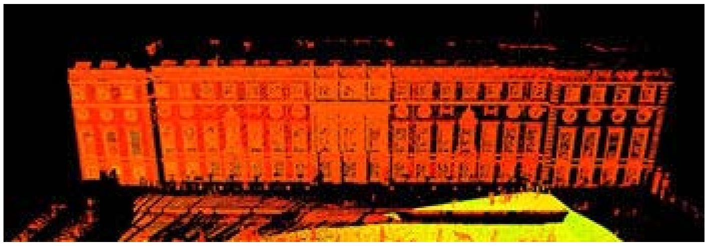

Figure 6 Laser Scan Façade Output

enough data to accurately dimension the facades features, such as window reveals, mullions, soffits, and cornices.[3]

Proposed Solution

The accuracy, quantity and speed to collect data with laser scanning techniques will pay for its self by avoiding conflicts and redesign issues on a project with existing structures to remain, especially with the integration of a historical façade.

Research Steps

The following steps were followed to research laser scan surveys:

1. Review case studies of projects that utilized laser scan surveys.
2. Contact contractors that provide laser scan services.
3. Review and obtain cost and time impacts of redesign issues due to lack of knowledge pertaining to façade location.
4. Obtain costs for a laser scan survey for the project and analyze the benefits against the costs.

Concluding Remarks

This proposal outlines issues and changes that will be analyzed to add value, decrease schedule and cost to the project. The museum level of the project encountered several unforeseen conditions including a freshwater spring that created water issues and redesign issues, along with the discovery of a historic floor that is to be preserved and incorporated into the new building along with other issues. The groundwater lift station redesign will account for additional considerations brought about by the discovery of an underground spring during excavation. The issues encountered in the museum level directly effected the progress on the entire project due to the required sequence of activities to form and place a concrete structure. Incorporating the new structural system for the convention entry level it would mitigate the delays of the unforeseen issues in the museum level by being able to erect steel without a slab placed beneath it. Incorporated in the structural redesign, the Ivany block wall retaining walls will be designed to allow for the joists to frame into and most importantly allow for complete backfill of the wall before the floor system is in place saving considerable space on site. Additionally, micro-piles will be explored as a potential schedule reducing option to the existing foundation system of caissons. Lastly, the implementation of a 3D electronic survey modeling the historic Watt & Shand building will also be researched into the effectiveness and advantages in incorporating a of existing conditions into the original design to alleviate several unknowns due to an existing building on the project site. Construction sequencing, scheduling and cost will all be analyzed for the proposed changes to quantify potential advantages in using the new systems.

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Weight Matrix

Description	Research	Value Eng.	Const. Rev.	Sched. Red.	Total
Breadth 1 - Structural Redesign		10	20	10	40
Breadth 2 - Plumbing - Ground Water Lift Station Redesign		15			15
Depth Study - Construction Sequencing		5	10	20	35
Analysis 4 - Reasearch - Laser Scan and Minipile	10				10
Total	10	30	30	30	100

References

1. http://www.skylinesteel.com/products/pipe/micro_piles.aspx 15 Nov. 2007.
2. http://dictionary.reference.com/browse/karst 12 Dec. 2007.
3. Stephen Booth. "Measured Building Surveys." The Building Conservation Directory. 2002. *Cathedral Communications*. February 12, 2008. www.buildingconservation.com/articles/measuredbsurveys/measuredbsurveys.htm

Marriott Hotel at Penn Square
and Lancaster County
Convention Center

Spring '08
Thesis Schedule

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AE Consultant: Dr. Horman

				1					2					3					4					5					6	
		1.14	1.15	1.16	1.17	1.18	1.21	1.22	1.23	1.24	1.25	1.28	1.29	1.30	1.31	2.1	2.4	2.5	2.6	2.7	2.8	2.11	2.12	2.13	2.14	2.15	2.18	2.19	2.20	2.21
CM Study		1st Thesis Class of the Semester	Meet with Prof. Horman to discuss Proposal																											
	Laser Scan Survey Research																													
00010	Meet with Prof. Messner											Meeting																		
00011	Research Laser Scan Surveys								Research 3D Elect. Surveys																					
00013	Obtain Designer and Contractor Input											Obtain Designer and Contractor Input																		
00014	Analyze Findings																					Analyze Findings								
00015	Propose Solution																								Propose Solution					
	Micropile Research																													
00020	Meet with Prof. Schneider										Meet																			
00021	Research Micropiles											Research Micropiles																		
00022	Email and Call Foundation Contractors												Email and Call Foundation Contractors																	
00023	Analyze Findings																				Analyze Findings									
00024	Propose Solution																				Propose Solution									
	Resquencing																													
00030	Obtain Production Rates from the Steel C											Obtain Production Rates from the Steel Contractor																		
00031	Develop Graphical Model											Develop Graphical Model																		
00032	Analyze Schedule Reduction																													
00033	Propose Solution																													
Structural Breadth																														
00050	Analyze Loads for Given Bay Size																					Analyze Loads for Typical Bay								
00051	Design Composite Joist System to Suppo																										Design Composite Jois			
00052	Analyze Cost Comparison																													
00053	Propose Solution																													
Mechanical Breadth																														
00070	Obtain Hydro-geological Reports																													
00071	Analyze the Existing System																													
00072	Design New Lift Station System																													
00073	Compare New Design to Original																													
Administrative Tasks																														
00100	Assemble Final Report																Assemble Final Report													
00110	Develop Powerpoint Presentation																													
00115	Practice Presentation																													

Legend
Work Complete

Last Updated: 3.2.08

Marriott Hotel at Penn Square
and Lancaster County
Convention Center

Spring '08
Thesis Schedule

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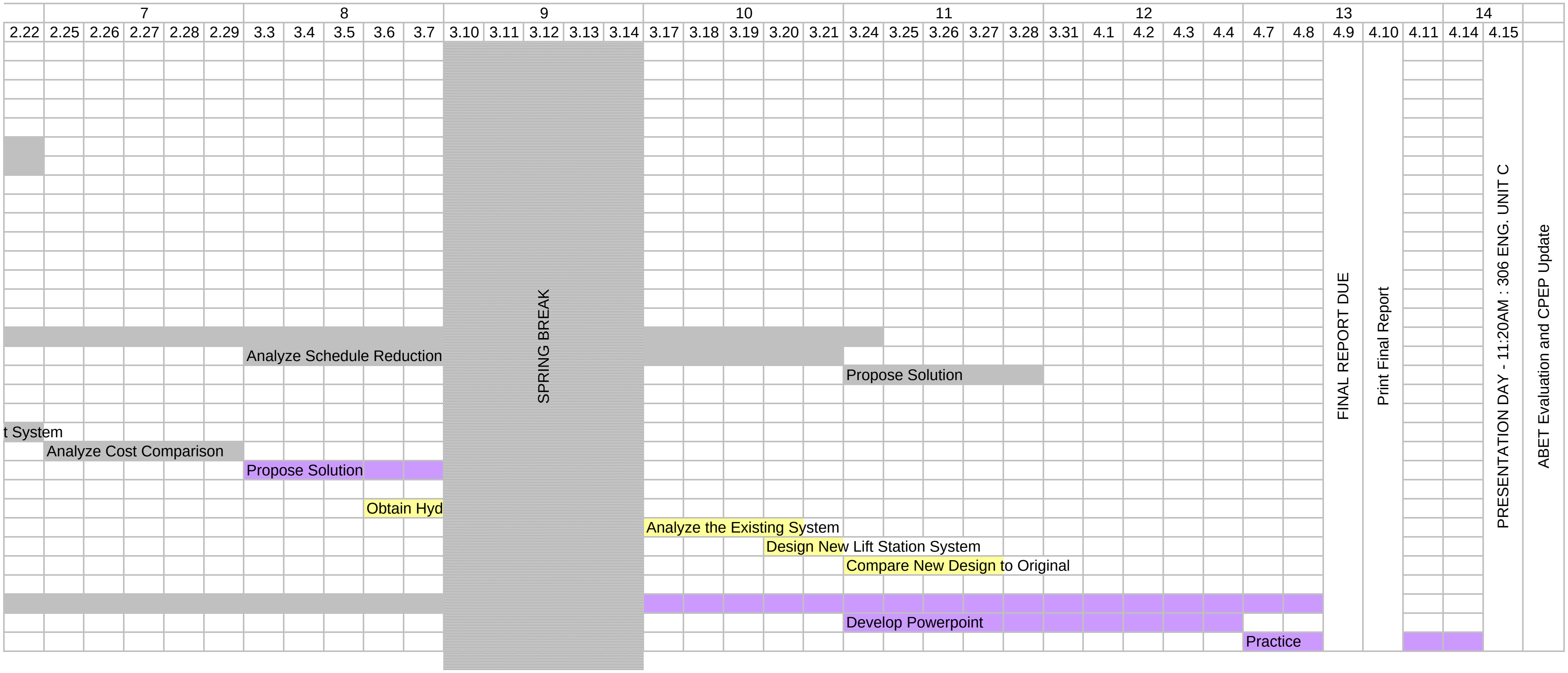

Last Updated: 3.2.08

Schedule

The following schedule will be followed to complete the proposed work during the spring semester.

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Appendix A

See the following pages for highlighted floor plans of the museum, convention entry and exhibit levels showing the elevated structural concrete areas.

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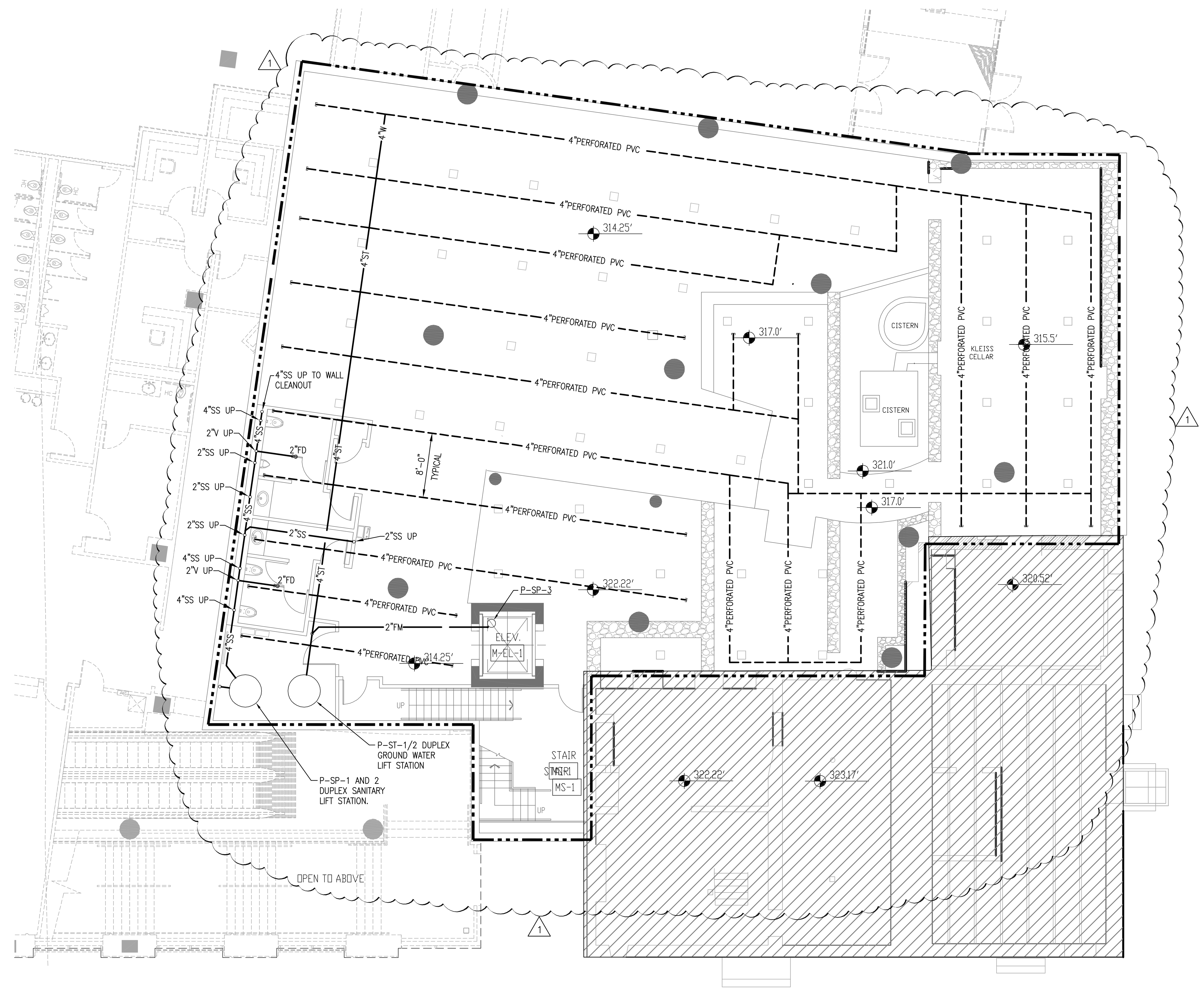
Appendix B

See the following page for a plan of the plumbing ground water lift station system in the museum level.



1 P2.0B ENLARGED PLAN - MUSEUM LEVEL UNDERGROUND PART B - PLUMBING
1/8" = 1'-0"

JORDAN & SKALA ENGINEERS, INC.

5365 OAKBROOK PARKWAY
NORCROSS, GEORGIA 30093
770/447-5547 FAX 770/448-0262
JSE Number - 0410326

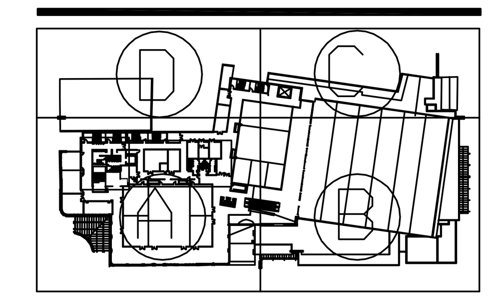
COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
G.M. SKALA
ENGINEER
NO.36028-E

No.	Drawing Issue Description	Date
1	BULLETIN #4	01/29/07

PENN SQUARE CENTER
MARRIOTT HOTEL AND
LANCASTER COUNTY
CONVENTION CENTER

Lancaster, Pennsylvania

PENN SQUARE PARTNERS
LANCASTER COUNTY CONVENTION
CENTER AUTHORITY



ENLARGED PLAN
MUSEUM LEVEL
UNDERGROUND - PART B
PLUMBING

Skala (Principal-in-Charge)	204030 (Project No.)
Haefeli (Project Director)	As Noted (Scale)
Haefeli (Project Manager)	3/21/06 (Date)
Creson (Project Engineer)	

NEW DRAWING ISSUED 1/29/07

File Path

File Plot Date

P2.0B-UG