LOUCKS ASSOCIATES

MEMORANDUM

TO: **Steve Maki – Community Planning and Economic Development**
City of Minneapolis

FROM: **Jeffery A. Shopek, P.E.**
Eric W. Beazley, P.E.

DATE: **August 27, 2008**

SUBJECT: **Grainbelt Office Building Drainage Study**
Loucks Project No.: 05-051B

Mr. Maki,

The purpose of this memo is to summarize our analysis, evaluation and potential corrective measures for the drainage problems at the Grainbelt Office Building located at 1215 Marshall St. NE. In general, the project consisted of evaluating drainage problems resulting in water entering the basement of the building.

The initial hypothesis pertaining to the causes of drainage problems are as follows:

- Perched groundwater seeping into the building
- Surface runoff from the site draining towards the building
- Faulty roof gutters discharging at the building foundation
- Lack of window well drainage
- Storm sewer backup from downstream piping systems

The goal of the project is to recommend potential options for solutions to identified problems. While Loucks' objective is to evaluate drainage outside of the building, our determinations include recommendations for further analysis internal to the building, which may require an architect's/mechanical engineer's opinion. The project was broken into three phases. Phase 1 was the project initiation phase, and primarily consisted of data gathering. Phase 2 was the site analysis and evaluation phase, which consisted of analyzing the data gathered in phase 1. The third and final phase involved combining the results of phase 1 and phase 2 to determine potential corrective measures for the drainage problems at the Grainbelt office building.

Phase 1 – Project Initiation

The first phase of the project involved two site visits, a compilation of existing documentation (e.g., surveys, geotechnical studies, utility record drawings, etc.) and an inquiry of historical downstream flooding issues and/or restrictive downstream capacity issues.

The first site visit completed by Loucks included a review of accessible portions of the building. The review included documentation in the form of site plan notes and photographs. The second site visit included personnel from Loucks and Utility Mapping Services (UMS) evaluating various storm sewer pipes for traceability potential. Loucks and UMS utilized various methods, such as hand held augers to determine if the targeted storm sewer pipes were blocked. It was concluded that some of the pipes would need to be cleaned prior to tracing the pipe routes and evaluating pipe functionality. Note that tracing and/or mapping of the storm sewer system was not completed as part of this project, as this work was outside the scope and budget.

Research of existing documentation unveiled existing boundary and topographic surveys of the Grainbelt office building site and portions of the surrounding properties. City as-built utility drawings (i.e., sanitary sewer, storm sewer and watermain) and City GIS databases were also reviewed for Marshall St. NE, Main St. NE and 13th Ave. NE.

Based on comments received from the City of Minneapolis, the existing City storm sewer infrastructure in Main St. NE and Marshall St. NE are undersized and over capacity. As such, during larger storm events localized flooding has been observed adjacent to the Grainbelt Office Building site. Loucks was unable to physically witness the street flooding as part of this project. This back up on the storm sewer system could potentially cause storm water to back up onto the Grainbelt site and spill into various openings (e.g., doorways, window wells, etc.) in the building.

Phase 2 – Site Analysis and Evaluation

SURFACE DRAINAGE

The surface drainage analysis consisted of identifying sub-basins draining onsite to offsite, and sub-basins that drain offsite to onsite. In addition, sub-basins were delineated for storm sewer inlets/outlets, roof gutters, window wells and relevant offsite drainage. See the existing drainage area map in Exhibit A. The result of this analysis shows that a large portion of the site, and smaller portions offsite, drain directly towards the building. Only one catch basin on the north side of the building is in place to capture this relatively large amount of runoff. There are three main resulting problems with this condition. First, the catch basin is only able to capture a portion of the site runoff due to its location. Second, the grate capacity of this catch basin is approximately one (1) cfs while the drainage to the basin in the 100-year event is approximately 13 cfs[1]. Third the rim elevation of the catch basin is only slightly lower (i.e., 0.48 feet) than the openings to adjacent window wells. Thus, due to lack of grate capacity onsite flooding may occur, which could subsequently spill over in the adjacent window wells. The sidewalk elevations on Marshall St. NE are only 0.25 feet lower than the rim elevation of 816.15 of this catch basin, and the sidewalk lies approximately 180 feet away from the catch basin, thus providing very little emergency overflow capacity for the larger storms.

WATERSHED

The project site is located within the Mississippi Watershed, which is governed by the Mississippi Watershed Management Organization. Within the watershed there are many subcatchments. The Grainbelt site is located in the southwest quadrant of its

[1] Assuming the grate is 50% clogged.

subcatchment, which is near the outlet. The outlet is located near Broadway and flows to the Mississippi River[2].

EXISTING FEATURES

There are several features of the existing site condition that may be of concern with regards to the drainage problems. Please refer to the site plan shown in Exhibit A while reading this section.

Because of physical constraints, scope and budget limitations it was not feasible to conclusively determine some as-built information of the onsite storm sewer, window well and roof drainage system. A summary of the known and undetermined information and associated assumptions is as follows:

- Catch basin along the north side of the site (Labeled as Feature A)
    - This catch basin is of primary concern, as a large portion of the site and approximately half of the office building drain to the basin. There are several pipes entering and exiting the catch basin. See Exhibit B for a detail of the structure. It is recommended that a dye test be performed on the catch basin to determine where the pipes come from and lead. The catch basin manhole on the north side of the building has three pipes entering from undetermined originations, and one pipe exiting to an undetermined destination. It is assumed the pipes entering the manhole are from directly connected roof drains. The invert elevation of the outlet pipe is approximately 805.6 and the storm sewer depth in Marshall is only 810.3. Therefore, it appears the storm sewer pipe s not connected to the storm sewer system in Marshall. The only pipe deep enough in Marshall to accept drainage from this catch basin is the 78-inch sanitary sewer pipe.
- Rain Leaders (Labeled as Feature B)
    - Several rain leaders drain the roof of the office building on the north and south sides. The rain leaders on the south side of the building drain from the roof to the south side of the retaining wall. The water exiting these leaders discharges directly at the edge of the wall and is slowly eroding the soil and the concrete wall. These roof drains also leak water at the building foundation, and are in need of repair.
    - Rain leaders draining the roof on the north side of the building are either directly connected to the previously described catch basin or surface drain to the catch basin labeled Feature A. Again, these roof drains leak water at the building foundation, and are in need of repair.
- Window wells (Labeled as Feature C)
    - Several windows wells surround the building, which provide access to basement windows. Most of these window wells are drained by grates. however, it is unknown where the pipes connect. The wells vary in depth from two feet to six feet, and in general contain leaves and other debris preventing efficient drainage. Please note the following assumptions:
        - The existing storm sewer capturing rain water entering the window wells along the south and east sides of the building are directed to

[2] Reference: City of Minneapolis Local Storm Water Management Plan

the public sewer system via 1) the catch basin on the north side of the building 2) a manhole structure on the south side of the building (labeled as feature G), or 3) via a direct connection.

    - Certain window wells drain via pipe that runs underneath of the building.
    - The existing underground roof/window well drainage system is old, potentially broken and clogged.

- Retaining wall (Labeled as Feature D)
  - A large concrete retaining wall runs along the south side of the building. The wall varies in height from zero feet to sixteen feet. The window wells along the southeast side of the building tie into this wall. Three rain leaders are discharging at the top side of the wall and are causing the surrounding soil and the actual concrete to erode or spall.
- Existing sanitary sewer connection to the building (Labeled as Feature E)
  - The pipe shown as Feature "E" on Exhibit A is the assumed sanitary sewer service connection to the building. However, there was no visual evidence of the pipe during site visits and where this pipe actually enters the building, and if other pipes (such as roof drains or the outlet from Feature A) tie into the sanitary sewer service line.
- Sump Pump (Labeled as Feature F)
  - A sump pump is located inside the building along the north wall and towards the east end of the building. Connections to, and from, the pump could not be seen upon removing the sump pump cover in the basement due to standing water in the pump basin. Potential connections include draintile and window well drains.
- Manhole on South Side of Building (Labeled as Feature G)
  - A 21-inch Manhole exists on the south side of the office building in the third window well from the southeast corner of the building. Investigation of this manhole revealed at least two feet of standing water, sludge and skim oil in the bottom. As a result, no pipes entering or exiting the structure could be seen.
- Storm Sewer in Marshall St. NE(Labeled as Feature H)
  - A high point exists in Marshall St. NE (Marshall) north of the Grainbelt building, approximately halfway between the Grainbelt Office Building and 13th Ave. NE. (13th). Stormwater draining north from this high point is collected in the public storm sewer system at the intersection of Marshall and 13th, which ultimately drains westerly towards the Mississippi River. Stormwater draining south from the high point is collected by a public storm sewer system immediately adjacent to the Grainbelt building. See Exhibit C for the following discussion.
    - **Existing CBMH I** – An eight (8") inch PVC pipe exits CBMH I to the southwest. It is unknown where this pipe leads.
      - RIM=814.82
      - INV=810.32

- **Existing CBMH II** – A six (6") inch PVC pipe enters CBMH II from the southeast. A ten (10") clay pipe exits CBMH II to the west. The 10-inch clay pipe leads to CBMH III. The Grainbelt building is located northeast of this catch basin.
    - RIM=814.77
    - INV=811.07

  Note that this catch basin is the most logical connection for drains from the window wells along the south side of the building. However, window well bottom elevations along the south side of the building are between approximately 813.0'± and 814.0'±. A hypothesis can be made that the manhole (labeled as Feature G) connects to this CBMH either directly or indirectly.
- **Existing CBMH III** – A ten (10") inch clay pipe from CBMH II enters CBMH III from the west. A nine (9") inch clay pipe exits CBMH III to the east and connects CBMH III to MH IV.
    - RIM=814.72
    - INV=809.77
- **Existing MH IV** – An eight (8") inch pipe enters MH IV from the north. The upstream connection of this pipe could not be determined. It could be speculated that this eight inch pipe is connected to existing CBMH I, but this could not be determined. A nine (9") inch clay pipe enters MH IV from the east from CBMH III. A six (6") inch PVC pipe enters MH IV from the west. The upstream connection of this pipe could not be determined. A fifteen (15") inch pipe exits MH IV to the south.
    - RIM=815.22
    - INV=809.22

GROUNDWATER

- A geotechnical report prepared by Stork Twin City Testing Corporation dated July 27, 2005 is attached in Exhibit D. The important features of the geotechnical report for this study are the soil borings and the recommended building perimeter draintile design. Of particular importance are borings B-1, B-2 and B-3, as these are in closest proximity to the building. The following table summarizes the existing surface elevation and groundwater elevation at each of these borings.

Boring #	Existing Surface Elevation (ft)	Groundwater Elevation (ft)	Depth to Groundwater ft)	Soil Type Above GW	Soils Type Below GW
B-1	816.9	807.1	9.8	Sand and Silty Sand	Clay
B-2	818.4	812.4	6.0	Sand and Silty Sand	Silty Sand
B-3	817.7	813.2	4.5	Sand	Clay

Note that the finish floor elevation of the first floor is 820.44 feet and the finish floor elevation of the basement is approximately 810.0± feet. See Exhibit B for a cross section of the site showing the surface elevation and groundwater elevation in relation to the building floor elevations.

This groundwater system is a perched collection of groundwater that drops approximately six feet in elevation from the east side of the building to the west side. This allows the groundwater to flow below the west portion of the structure. The aquifer generally drains across the site from east to west (i.e., Main St. NE to Marshall St. NE). The high groundwater elevations may be one of the causes of the wet basement issues on the east side of the Grainbelt Office building.

Phase 3 – Potential Corrective Measures

As noted in the beginning of this report each of the following hypothesized conditions contribute to the drainage problems at the Grainbelt Office Building:

- Perched groundwater seeping into the building
- Surface runoff from the site draining towards the building
- Faulty roof gutters discharging at the building foundation
- Lack of window well drainage
- Storm sewer backup from downstream piping systems

It is not one of these conditions that are causing the water problems at the Grainbelt site, but each of them is causing problems in different ways. As such, no one solution will work to alleviate the drainage problems at the Grainbelt Office Building. Rather, a combination of actions should be implemented.

It is not one condition that is causing all of the water problems at the Grainbelt site, but a combination of conditions are causing problems in different ways. As such, no one solution will work to alleviate the drainage problems at the Grainbelt Office Building. Overall is appears there is no easy, quick solution to resolve the water problems at the Grainbelt site. Multiple potential design remedies have been identified to mitigate the drainage problems at the Grainbelt Office building. Some of the following design solutions are temporary in nature and some are considered permanent. A temporary solution is defined as that may be changed or removed as part of future development. It is important to note that these recommendations may be implemented individually or as a combination of one or more. In addition, an effectiveness rating has been given to each of the following potential solutions. See Exhibit E for a summary of the effectiveness rating for each potential solution within several categories. The effectiveness rating is based on a scale of one (1) to five (5), with 5 being the most effective. Several categories have been evaluated for each alternative solution and given a mutually exclusive effectiveness rating. Exhibit F contains a concept design for each of the remedies described below.

A – Surface Runoff Management (Temporary or Permanent)

Purpose: Provide storm water storage to slow the rate of discharge from the site, thereby more closely matching the capacity of the existing storm sewer infrastructure.

A-1 Dry Pond with Clay Lined Bottom

- Description
  - A two foot deep dry pond may be constructed at the northeast corner of the existing office building. The pond typical section will generally consist of two feet of sand underlain by draintile wrapped in a geotextile sock. The draintile would be connected to the existing storm sewer manhole/catch basin along the north side of the building. This catch basin is assumed to

drain to Marshall Street NE. In addition, an emergency overflow outlet would be designed as part of the pond. The soil borings (see Exhibit D) in the area show that a dry pond has potential for groundwater recharge in the area. Recharging the aquifer is actually not desirable. The elevation of the groundwater is approximately two to three feet above the basement floor elevation probably causing groundwater to seep into the building. Adding volume to the existing perched aquifer would only exacerbate the current situation. Therefore, this solution would be most effective if used in combination with re-grading the site and lining the bottom of the pond with clay to minimize infiltration.

- Evaluation of positive aspects of installing a pond
  - Strategically placing a dry pond at the northeast corner of the building would work to capture a significant portion of the site runoff that currently drains toward the building.
  - If necessary, it is relatively inexpensive to relocate the pond through grading.
  - A temporary pond only needs to be designed for the existing pervious/impervious conditions on the site, therefore a temporary pond would be smaller/cheaper than a permanent pond.
  - The pond and outlet could be designed to accommodate future development, which may work as a potential selling point for future development.
  - Given elevation restriction of downstream connection points, a dry pond would likely function better than a wet pond or underground storage.
  - Designing a temporary facility would allow more flexibility (in terms of site planning) for future development.
  - Designing a permanent facility is more expensive, but is only a one time cost versus a temporary facility, which may need to be replaced or improved.
- Evaluation of negative aspects of constructing a pond
  - Designing a permanent pond for an assumed future development carries risk in choosing future design parameters. Thus, the pond may need to be changed or removed to accommodate future developments.
  - The costs associated with designing and constructing a temporary facility may be lost when future development occurs.
  - Groundwater elevations in this area are such that fluctuations in groundwater elevations during wet periods may inundate the pond and not allow it to completely drain.
  - Storm water quality and storm water quantity management from the actual office building would be only minimally accommodated by the pond.
  - Dry ponds are not intended to meet NURP standards.

A-2 Stormwater wet pond

- Description
  - Similar to construction of a dry pond, a wet pond would be constructed near the northeast corner of the building. An outlet structure draining to the existing public storm sewer in Marshall St. NE would be constructed. A wet pond would be most effective if used in combination with re-grading the entire site.

- Evaluation of positive aspects
    - A wet pond could be sized to meet NURP standards for water quality and could also be sized to accommodate rate control requirements.
    - Designing a temporary facility would allow more flexibility (in terms of site planning) for future development.
    - Designing a permanent facility is more expensive but is only a one time cost versus a temporary facility, which may need to be replaced or improved.
- Evaluation of negative aspects
    - Sizing the pond to accommodate a future development may be difficult.
    - A wet pond would be larger than a dry pond.
    - The pond would likely be inundated with groundwater most of the year. Therefore, since the base of the window wells (on the east side of the building) are likely at or below the groundwater elevation a wet pond may not be an effective outlet for drainage from the window wells along the building.
    - A pond would minimize the amount of surface drainage reaching the office building, but storm water quality and storm water quantity management of runoff from the actual office building site to the public storm sewer would be only minimally accommodated by the pond.
    - Given elevation restrictions of downstream connection points, a wet pond may not be practical in terms of outlet functionality. Designing a permanent pond for an assumed future development carries risk in choosing future design parameters. Thus, the pond may need to be changed or removed to accommodate future developments.
    - The costs associated with designing and constructing a temporary facility may be lost when future development occurs.

A-3 Underground Stormwater Management System

- Description
    - An underground stormwater management system would likely consist of pipes, structures, granular material and an impermeable liner surrounding the entire system, which are sized to accommodate water quantity and/or water quality management requirements.
- Evaluation of positive aspects
    - Driving surfaces or open space can be constructed over the system.
- Evaluation of negative aspects
    - Given elevation restrictions of downstream connection points and capacity issues with the storm sewer in Marshall, an underground system would likely need to outlet at the intersection of Marshall and 13th. Constructing an outlet of this type would be expensive because of conflicts with the Orth ruins and with multiple large utilities.
    - The geometrics of the site indicate the east side of the building would be most practical for accommodating an underground system. However, if placed in this location the underground system would probably be below groundwater elevation. Thus, significantly minimizing, or even eliminating system functionality for water quantity and water quality treatment.
    - A small underground system could be installed on the northwest portion of the site. However, because the invert of the existing catch basin manhole on the north side of the site is well below the public storm sewer invert

elevations in Marshall, an underground system would not be able to capture discharge from this structure.
  - An underground system would minimize the amount of surface drainage reaching the office building, but storm water quality and storm water quantity management of runoff from the actual office building site to the public storm sewer would be only minimally accommodated by the pond.
  - Designing a permanent facility for an assumed future development carries risk in choosing future design parameters. Thus, the facility may need to be changed or removed to accommodate future developments.
  - The costs associated with designing and constructing a temporary facility may be lost when future development occurs.
  - Encasing the system with an impermeable liner to avoid negative interactions with groundwater is expensive and carries long term operations and maintenance issues.
  - Plumbing code does not allow buildings to be constructed over an underground system.
  - The cost of underground systems are typically five to 10 times more than surface ponds.

B – Lower a portion of the berm and reconstruct retaining walls

Purpose: To more effectively manage storm water runoff, and remove a portion of the crumbling retaining wall on the south side of the building.

- Description
  - A large retaining wall runs parallel along the south side of the building. The wall varies in height from zero to 16 feet. The area between the retaining wall and the existing building is segmented into window wells of various sizes and depths. The window well walls are perpendicular to the large retaining wall and may provide structural support. As shown in Exhibit F the area between the Grainbelt office building and the existing bank could be re-graded to reduce the height of the wall to a maximum of six feet in height. Because the window wells are below street grade the retaining wall can not be completed eliminated. Drainage from within these window wells can be managed through installation of new catch basins, or reparations to existing drainage grates and outlets. The large retaining wall is exhibiting structural damage from years of exposure to the elements. The soil along the retaining wall is eroding and water is infiltrating behind the wall creating hydrostatic pressure and erosion. This action is causing the wall to slowly fail. The berm created by the retaining wall, which lies between the Grainbelt building and the bank serves no purpose. Currently, the berm reaches an elevation of over 829 feet adjacent to the building, and basement floor elevation is approximately 810.0 feet.
- Evaluation of positive aspects
  - Drainage along the south side of the building would be more effectively managed by drainage swales that run parallel to the building.
  - An indirect benefit is that more natural light will enter the building. Note that this option requires analysis and design by a licensed structural engineer.
- Evaluation of negative aspects
  - Only partially relieves drainage issues along one side of the building.

- o Requires temporary construction easements and approval from the adjacent business.
- o In general, this solution does not address storm water drainage reaching the building directly.

C – Re-grade and construct valley gutter along the north side of the building

Purpose: To provide minimal overland emergency overflow.

- Description
  - o This option is described as re-grading a portion of the area along the northwest side of the building. Re-grading the area between the building and the property line in the northwest portion of the site would more effectively direct storm water runoff to Marshall Ave. NE. Along with re-grading, a two foot-concrete valley gutter could be constructed from a high point along the north side of the building to Marshall Ave. NE. Currently, the pavement along the north side undulates and pockets storm water. The pooled water eventually disappears from the site either through infiltration into the ground, infiltration into the building, slow drainage to the street or drainage to the existing catch basin or evaporation. The existing pavement along the north side of the building is in poor condition and is need of repair or replacement.
- Evaluation of positive aspects
  - o Regrading the north side of the building would also allow landscaped areas to be installed along the building.
  - o Would provide a positive slope to Marshall and minimize the standing surface water which may migrate to the basement via groundwater.
- Evaluation of negative aspects
  - o Only a small fraction of the overall drainage problem on the site would be remedied with this solution. Therefore, this is not a stand alone solution.
  - o If Marshall Ave. NE is inundated during a storm event, the grading and valley gutter would not function as intended.

D – Upgrade public storm sewer

Purpose: To increase the capacity of the public storm sewer system adjacent to the Grainbelt office building and/or to provide an adequate outlet for window wells on the south side of the building.

- Description
  - o This solution was included because it probably is not a realistic option to redesign the public storm sewer system on a large scale basis. The public storm sewer system adjacent to the site is undersized and unable to effectively drain large storm events. As a result, localized flooding has been observed to occur in Marshall Street NE. and various sites upstream of the outlet (such as the Grainbelt Office Building site) are unable to properly drain during certain events. However, it may be feasible to consider reconstructing the connection from CBMH II to CBMH III (see Exhibit C) to allow a connection from the window wells on the south side of the building. At a minimum this would provide a direct outlet for water entering the window wells and significantly reducing the potential of this water seeping into the building.

E – Redesign Onsite Storm Sewer and Redesign the Roof Drainage System

Purpose: To repair/re-route faulty roof drainage systems and window well drains.

- Description
  - o Prior to implementing this solution a dye test should be completed to trace the route of various storm drains on the site. Specifically, this solution includes 1) rerouting/repairing window well storm drain connections as direct outlets to the public storm sewer system and 2) rerouting/repairing roof gutter and roof drain outlets. It is important to note that this solution will likely need to be done in conjunction with solution D in terms of redesigning/reconstructing the connection from existing CBMH II to existing CBMH III in Marshall (see Exhibit C). At a minimum the roof drainage system should be repaired to the minimize leakage of storm water at the building foundation.
- Evaluation of positive aspects
  - o Eliminates possibly draining storm water underneath the building potentially causing undesirable interactions with high groundwater.
  - o New, separate connections to the public storm sewer may allow for more effective drainage.
  - o The old, potentially non-functional roof drainage system would be repaired to a functioning state.
- Evaluation of negative aspects
  - o May require trenching new storm sewer within the public right of way.
  - o If the public storm sewer does not function properly the benefits of this solution are significantly diminished.
  - o Significant site work would be required on the south side of the building.

F – Install Draintile Around the Building

Purpose: To lower groundwater at the east end of the building.

- Description
  - o The geotechnical report included in Exhibit D provides a geotechnical engineer's recommendation for a perimeter draintile system. If this solution is desirable, further analysis would be required by a geotechnical or hydro-geological engineer to determine if either an inside or outside draintile system or and under slab system would be the most beneficial to alleviating the negative effects of relatively high groundwater elevations.
- Evaluation of positive aspects
  - o If installed correctly draintile systems have been proven as an effective solution for minimizing water problems in basements.
  - o The draintile system may not need to extend throughout the entire building as the groundwater elevation on the west end of the building is generally lower than the basement floor elevation.
- Evaluation of negative aspects
  - o Significant site work would be required to implement this solution.
  - o A pumping system may be required to be installed as part of this system.
  - o Lateral lines under the floor slab may be required to be installed with any type of draintile system to prevent groundwater mounding.

G – French Drain with Pumping Extraction System

Purpose: To lower groundwater at the east end of the building.

- Description
  - A French drain system could be installed along the east end of the building to lower the groundwater below the basement elevation before reaching the building. A French drain system consists of digging a trench around a portion of the building to a depth that is lower than the basement floor elevation. The trench is filled with rock and a pumping extraction system is installed to lift the water into the adjacent storm sewer system. As water generally flows along the path of least resistance the purpose of the French Drain would be to capture groundwater flowing towards the building and minimizing the volume of water seeping into the basement.
- Evaluation of positive aspects
  - A French Drain would work well to augment a draintile system.
- Evaluation of negative aspects
  - The south side of the building would require alternate solutions, as the French drain could only be constructed on the east and north sides of the building.
  - A French drain should not be considered as a standalone solution. It would be most effective if used in conjunction with a draintile system.

An engineer's opinion of probable construction and design costs for each solution is shown in the following table. See Exhibit G for graphical representations of what is included in each solution. Note that these cost opinions are based only on conceptual solutions. A detailed analysis and design of each solution will be required to more closely approximate the actual cost of implementing each solution.

Engineer's Opinion of Probable Construction Costs

Solution	Cost Opinion
A. Dry Pond Site Grading	$105,000
A1. Site Grading	$50,000
B. Lower Berm, Rebuild Retaining Walls (south side of building), and Grade Northeast portion of the Site	$180,000
B1. Lower Berm and Retaining Wall on South Side of the Building	$40,000
C. Regrade Along North Side of the Building, Construct a 2-foot Concrete Valley Gutter	$8,000
D. Up-Grade Public Storm Sewer and the Private Storm Sewer Along the South Side of the Building	$245,000
E. Reconstruct the Roof Drainage System	$19,000
F1. Install Perimeter Draintile Around a Portion of the Building	$240,000
F2. Install Draintile Below the Building Foundation (connect to sump pump)	$68,000
F3. Install Draintile Below the Building Foundation (connect to public storm sewer)	$245,000
G. Install French Drain and Sump Pump with Manhole	$36,000

FURTHER INVESTIGATION AND TESTING

In order to more positively identify the cause of water/drainage problems at the Grainbelt site, and subsequently determining which of the above solutions should be given implementation priority, the following three additional actions are recommended:

- o First, it is our recommendation that a dye test be completed to trace the route of various storm drains on the site.
- o Second, we recommend installing piezometers on the site to monitor groundwater elevation throughout the year.
- o Third, upon selecting one or more solutions a detailed design and cost opinion should be completed to further assist in selecting the best option.

RECOMMENDATIONS

As noted in the beginning of this report each of the following hypothesized conditions contribute to the drainage problems at the Grainbelt Office Building:

- Perched groundwater seeping into the building
- Surface runoff from the site draining towards the building
- Faulty roof gutters discharging at the building foundation
- Lack of window well drainage
- Storm sewer backup from downstream piping systems

It is not one of these conditions that are causing the water problems at the Grainbelt site, but each of them is causing problems in different ways. As such, no one solution will work to alleviate the drainage problems at the Grainbelt Office Building. Rather, a combination of actions should be implemented. The following table breaks down each of the hypothesized drainage problems and identifies a combination of solutions to mitigate the problem.

Cause of Drainage Problems	**Potential Solutions**
Perched groundwater seeping into the building	• F – Draintile • G – French Drain
Surface runoff from the site draining towards the building	• A – Runoff • B – Berm • C – Valley Gutter • D – Public STS
Faulty roof gutters discharging at the building foundation	• C – Valley Gutter • D – Public STS • E – Roof Drainage
Lack of window well drainage	• B – Berm • E – Roof Drainage
Storm sewer backup from downstream piping systems	• A – Runoff • D – Public STS • E – Roof Drainage

LEGEND:

A. Temporary or Permanent surface runoff management (**Runoff**)
B. Lower a portion of the berm and reconstruct retaining walls (**Berm**)

C. Re-grade and construct valley gutter along the north side of the building (**Valley Gutter**)
D. Upgrade public storm sewer (**Public STS**)
E. Redesign onsite storm sewer and the roof drainage system (**Roof Drainage**)
F. Install draintile around the building (**Draintile**)
G. French drain with pumping extraction system (**French Drain**)

The preferred recommendation would be to evaluate implementing a combination of solutions listed above. Therefore, along with further investigation and testing, and the likelihood that the perched groundwater is directly linked to the water problems at the Grainbelt building, it is our engineer's recommendation the City further evaluate the following options, as these have the most potential for alleviating water problems at the Grainbelt Office Building in the short term:

- Re-grading the site to minimize surface surcharges draining towards the building. This solution includes raising surface elevation of the site along the east and north sides of the building to allow for positive drainage to Marshall St. NE.
- Redesign/repair the onsite storm sewer and the roof drainage system.
- Dig a test pit along the east side of the building and complete a groundwater pump test to determine appropriate design criteria for a French drain and pumping extraction system.
- Install a French Drain system at the east end of the building.
- Perform general housekeeping duties on a routine basis. This includes cleaning debris out the window wells and roof/window well drainage pipes.

Finally, note that the retaining wall on the south side of the building is showing signs of potential failure. Although lower/rebuilding the retaining wall on the south side of the building probably may not greatly improve the drainage issues on the site, a structural engineer should be retained to evaluate the structural integrity of the wall.

Loucks Associates thanks you for the opportunity to work with you on this project, and we would be grateful for the opportunity to further discuss/study any, or all, of the solutions listed in this report. Please feel free to call if you have any questions, comments or concerns at 763-424-5505.

Sincerely,

LOUCKS ASSOCIATES

Jeffrey A. Shopek, P.E.
Principal Engineer

Eric W. Beazley, P.E.
Project Manager

Loucks Associates is an Equal Opportunity Employer

Exhibit A
Existing Features and Drainage Areas

Exhibit B
Existing Catch Basin Detail and Site Cross Section

Exhibit C
Existing Storm Sewer in Marshall St. NE

Exhibit D
Geotechnical Report

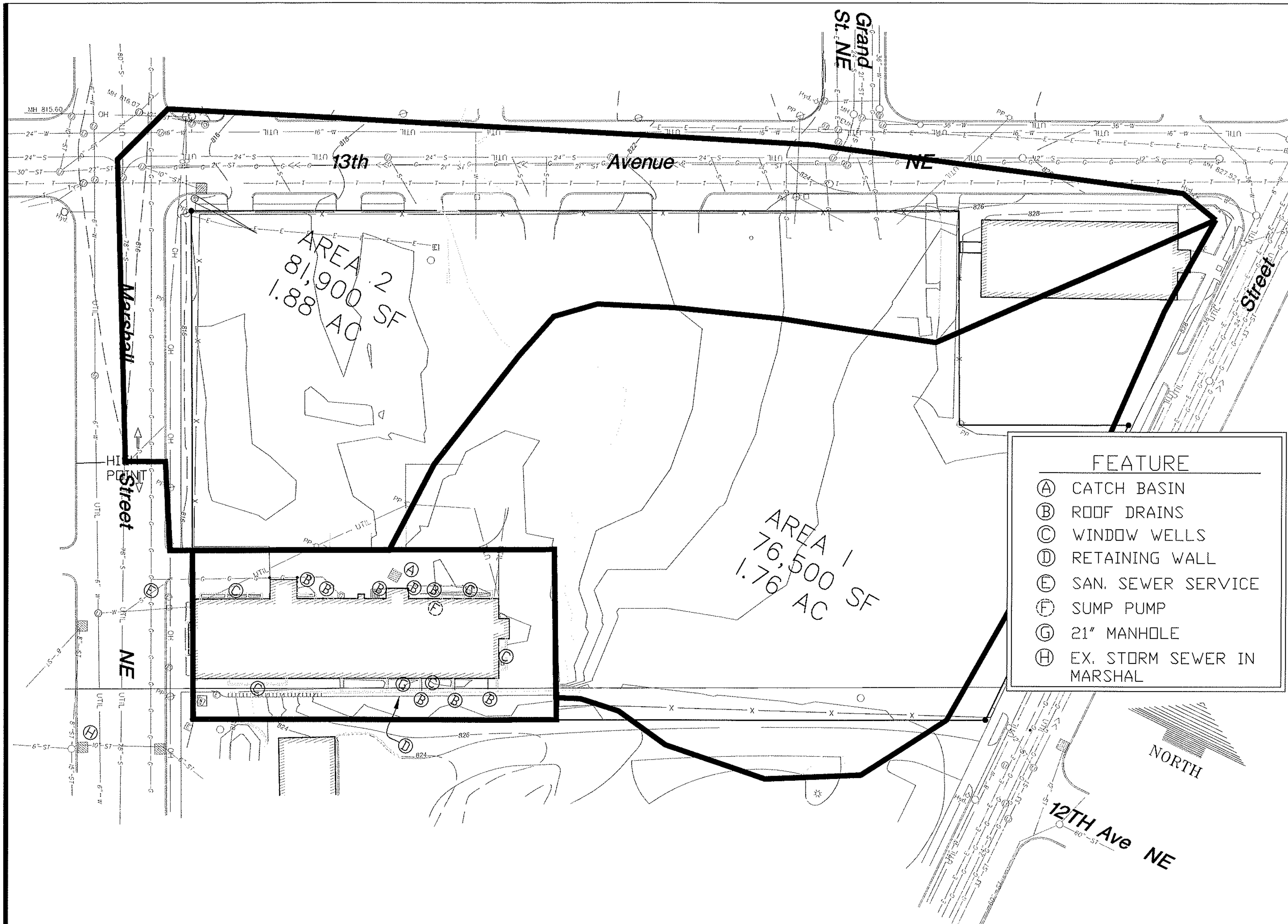
Exhibit E
Effectiveness Rating

Category	**Effectiveness Rating (1 = Worst 5 = Best)**							
	A-1, A-2 Dry or Wet Pond	A-3 Underground	B Lower Berm	C Valley Gutter	D Public Storm Sewer	E Roof Drainage	F Draintile System	G French Drain
Implementation Difficulty	4	5	5	3	5	4	3	3
Time to Complete	2	3	3	2	5	4	3	3
Resulting Impact on correcting drainage problems	4	2	2	4	5	5	5	5
Value added to office building	5	2	4	4	5	5	5	5
Value added for future development	5	2	1	3	5	1	1	2
Public benefit	5	2	3	1	5	2	1	2
Safety	5	2	5	NA	5	5	1	2
Impact on Orth Ruins	2	2	4	4	1	2	1	1
Architectural Design Required	No	No	No	No	No	Yes	Yes	No
Mechanical Design Required	No	No	No	No	No	Yes	Yes	No
Structural Design Required	No	No	Yes	No	No	Yes	Yes	No
Soils Design Required	No	No	Yes	No	No	No	Yes	Yes
Civil Design Required	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No

The effectiveness rating is based on a scale of one (1) to five (5), with 5 being the most effective. Several categories have been evaluated for each alternative solution and given a mutually exclusive effectiveness rating.

Exhibit F
Concept Design Solutions

Exhibit G
Cost Opinion Graphics



Project Name:

GRAINBELT OFFICE DRAINAGE STUDY

Minneapolis, Minnesota

Owner/Developer Name:

City of Minneapolis

1215 Marshall St. NE
Minneapolis, MN 55413

Professional Services:

LOUCKS ASSOCIATES

Planning • Civil Engineering • Land Surveying
Landscape Architecture • Environmental

7200 Hemlock Lane - Suite 300
Minneapolis, Minnesota 55369
Telephone: (763)424-5505
Fax: (763)424-5822
www.LoucksAssociates.com

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Submittal:

Professional Signature:

Quality Control:

EWB | DPM

Project Lead: | Drawn By:

Checked By: | Review Date:

Sheet Title:

EXISTING FEATURES

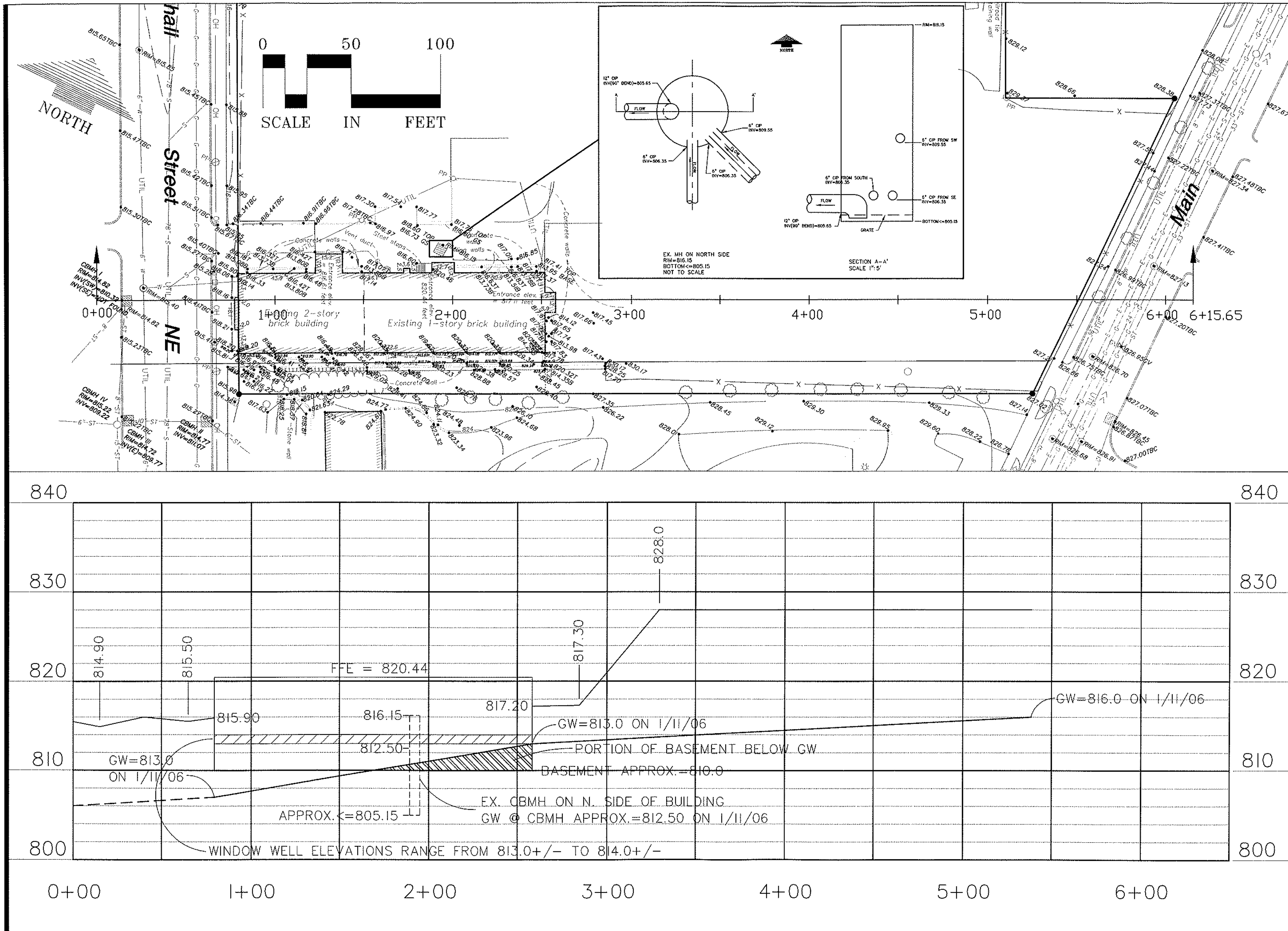
03/20/08

Project No.:

05051B

Sheet No.:

EXHIBIT A



Project Name:

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Minneapolis, Minnesota

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Submittal:

Professional Signature:

Quality Control:

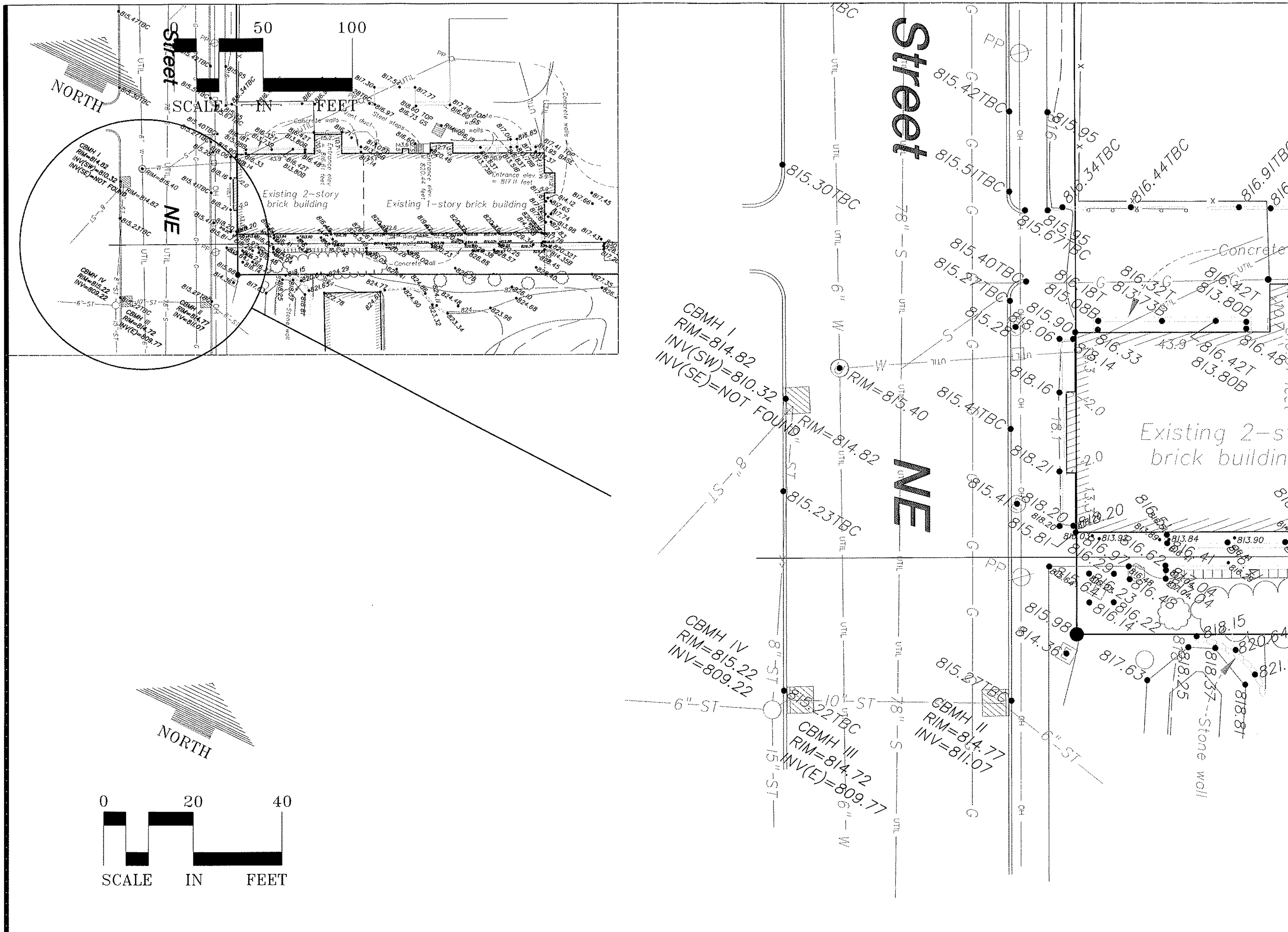
Project Lead: EWB	Drawn By: DPM
Checked By:	Review Date:

Sheet Title:

Project No.: 05051B

Sheet No.:

EXHIBIT B



Project Name:

GRAINBELT OFFICE DRAINAGE STUDY

Minneapolis, Minnesota

Owner/Developer Name:

City of Minneapolis

1215 Marshall St. NE
Minneapolis, MN 55413

Professional Services:

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Fax: (763)424-5822
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CADD Qualification:

Submittal:

Professional Signature:

Quality Control:

Project Lead	EWB	Drawn By	DPM
Checked By		Review Date	

Sheet Title:

Project No.: 05051B

Sheet No.: EXHIBIT C

FROM BEASLEY - 1.16.06

R.J.Rykken Consulting, Inc.
3330 Fremont Circle N.W.
Prior Lake, MN 55372
Phone/Fax: (952) 447-6505

RJR

RECEIVED
JAN 12 2006
ELNESS SWENSON GRAHAM ARCHITECTS, INC.

Transmittal

To: Michael Ryan, ESG

From: Bob Rykken

Date: January 11, 2006

Re: Grain Belt

Enclosed is a copy of a geotechnical report prepared by Stork Twin City Testing Corporation dated July 27, 2005.

662 Cromwell Avenue
St. Paul, MN 55114
USA

Telephone : (651) 645-3601
Telefax : (651) 659-7348
Website : www.storktct.com

July 27, 2005

R. J. Rykken Consulting, Inc.
Attn: Mr. Robert J. Rykken, P.E., P.G.
3330 Fremont Circle N.W.
Prior Lake, MN 55372

RBUFNFO. ESQ.
JAN 13, 2006.

RE: Grain Belt Area Development Project
Minneapolis, Minnesota
Twin City Testing Project #315052

1.0 INTRODUCTION

This report concerns our most recent geotechnical exploration program at the site of the Phase 1 Grain Belt Area Development project in Minneapolis, Minnesota. We were retained by R. J. Rykken Consulting, Inc. to perform the geotechnical work. We understand a geotechnical exploration program was required to depict the subsurface conditions in the proposed new building areas and provide preliminary recommendations for site preparation and foundation design for the proposed construction.

1.1 Scope of Work

We recently performed a geotechnical exploration program in general accordance with our proposal dated June 7, 2005. The scope of our work for the project was as follows:

1. Arrange to have buried public utilities marked through the Gopher State One-Call system.
2. Explore the subsurface conditions by performance of ten (10) standard penetration test borings to unit depths of 15' to 35' in the Phase 1 development area.
3. Perform visual classification of the soil samples and run cursory laboratory tests of selected samples.

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twin city testing corporation — Stork Twin City Testing Corporation is an operating unit of Stork Materials Technology B.V., Amsterdam, The Netherlands, which is a member of the Stork group

4. Prepare a geotechnical report which includes the following information:
   a. Logs of soil test borings showing the soil and groundwater data.
   b. A site plan showing the approximate boring locations.
   c. Written description of encountered soil and groundwater conditions.
   d. Preliminary recommendations for site preparation, allowable bearing capacity, backfill pressures and other geotechnical considerations.

2.0 FIELD TESTING PROGRAM

2.1 Soil Borings

A total of ten (10) soil test borings were put down on the site on July 11-12, 2005. The planned boring locations are shown on the attached site plan. The location and number of test borings was determined by others. The borings were field staked by others prior to our drilling. The surface elevations at the borings were provided by R.J. Rykken Consulting.

The standard penetration borings were performed with a truck mount rotary drill rig using split-barrel sampling procedures. Water level observations were made in the boreholes during and upon completion of the drilling and sampling operations. During the field operations, the drill crew maintained logs of the subsurface conditions including changes in stratigraphy and the observed groundwater levels. The boring logs are attached.

After completion of the drilling operations, the boreholes were backfilled in accordance with MDH regulations.

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Sampling and classification of soils were performed in general accordance with American Standards for Testing and Materials (ASTM) procedures, and are described on an attached sheet.

2.2 Surface Conditions

Existing buildings and a large retaining wall were present in the exploration area at the time of our drilling. Bituminous or concrete surfacing was present along with some grass areas. The ground surface elevations at the borings on the higher eastern portion of the site varied from 824.7' at boring B9 to 828.7' at boring B6. In the lower western zone, west of the existing retaining wall and large one-story building, the surface elevations at the borings varied from 816.9' at boring B1 to 820.4' at boring B10.

2.3 Subsurface Conditions

The subsurface conditions encountered at the test boring locations are shown on the test boring logs. The boring logs also indicate the possible geologic origin of the materials encountered. We wish to point out that the subsurface conditions at other times and locations on the site may differ from those found at our test locations. If different conditions are encountered during construction, it is necessary that you contact us so that our recommendations can be reviewed.

The borings indicated a generalized soil profile consisting of fill underlain by coarse alluvium and fine alluvium.

Fill was encountered at the surface of the borings. The fill thickness varied from 2' at boring B2 to 7' at boring B8. The fill was comprised of silty sand and sand with some organic (black) inclusions. Based on the penetration values, the fill appeared to have variable density.

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Coarse alluvium was encountered in all test holes. This included sand with silt (SP-SM), sand (SP) and silty sand (SM). Lenses and layers of lean clay were typically encountered in the thick, very fine to fine grained silty sand layers. The coarse alluvium was in a very loose to medium dense condition, based on the penetration values.

Fine alluvium was encountered in the test borings. This consisted of lean clay, silt and sandy silt. The fine alluvium was found to be of very soft to firm consistency, based on the N values.

2.4 Water Level Conditions

Water level observations were made during and immediately after completion of the drilling operations. In addition, several bore holes were left open overnight to allow the water to rise and facilitate additional recordings. Groundwater was encountered in most of the borings and the data is shown on the logs. Based on our borings together with results of previous borings done by others on this site, it is our opinion that the water levels reflect a perched water condition resulting from wet weather conditions and the presence of slow draining soils.

In general, water levels may fluctuate throughout the year depending on variations in the amount of precipitation, degree of evaporation, surface run-off characteristics and other related hydrogeological factors.

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3.0 LABORATORY TESTING

The soil samples obtained during the drilling operations were logged, labeled, sealed and delivered to our laboratory for further review. The soil samples were classified in general conformance with ASTM Standards by a Twin City Testing geotechnical engineer. Selected samples were submitted to the laboratory for performance of certain tests including determination of moisture content and density, Atterberg Limits and mechanical analysis. The test results are shown on the logs opposite the samples tested.

4.0 ENGINEERING REVIEW

4.1 Project Data

We understand that proposed construction will include lofts and retail stores. A large portion of the construction will include below-grade parking. We were informed the column loads in this portion of the construction will be up to 250 kips per column. For the purposes of our review, we will assume the maximum wall loads in the building areas with underground garage construction will not exceed 5 kips per foot. We anticipate the remaining construction (e.g., Retail Stores) would have lower wall and column loadings; e.g., not exceeding 4 kips per lineal foot on bearing walls and 120 kip columns loads.

4.2 Discussion

In our opinion, it should be feasible to support the proposed buildings on normal spread footing foundation system. It does appear that subcutting to underground garage grade will penetrate the fill and expose inorganic natural soils. The existing fill is unsuitable for support of slabs and footings and should be removed as part of site preparation for the other buildings. Unusually loose/soft silty sands and clays should also be removed

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below all foundations to limit post-construction settlement. Low areas could then be brought to final grade using suitable site borrow or imported sands as engineered fill.

4.3 Site Preparation

We recommend the site preparation for the planned building involving the below-grade garage include excavation to six inches below bottom of garage slab grade, after removal of all existing construction and related backfill. At the test borings, this should expose coarse alluvium such as silty sand or sand. Also, a layer of fine alluvium might be encountered near final subgrade elevation. Unusually soft fine alluvium and very loose sands should be removed below foundations if encountered within four feet of bottom of footing. That is, we recommend removal of fine alluvium or coarse alluvium with N values less than 9 blows per foot below the foundation. The minimum required subcut depths at the test boring locations could be estimated when actual footing elevations are determined.

In the slab on grade building areas, all existing construction and fill soils should be removed. At the test borings, this excavation would expose coarse alluvial sands and silty sands. Unusually loose clean sands encountered at final subcut elevation should be thoroughly surface densified prior to engineered fill or footing placement. Where unusually loose very fine to fine grained silty sands are encountered, the soils should be removed and replaced with cleaner sands.

The actual depth of excavation may vary between boring locations and should be determined in the field at the time of construction. The geotechnical engineer or engineering assistant should be retained to observe the exposed soils and document the condition of the excavation bottoms prior to fill or footing placement.

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Where excavation extends below the bottom elevation of the foundations, we recommend that the excavation at the footing locations be laterally oversized at least one foot for each foot (i.e., 1:1 lateral oversizing) it extends below footing bottom. A drawing showing the recommended lateral oversizing is attached.

After the recommended excavation, engineered fill should be placed to attain final grades in low areas within the building area. We recommend the use of granular fill having no more than 12% passing the #200 sieve. Soil used as fill should be non-plastic and free of organics, rubble or debris. We would not recommend using the fine grained silty sands for fill to support footings. Compaction tests should be performed to verify that proper compaction is achieved in the fill. The fill should be compacted to a minimum of 98% of the Standard Proctor value in footing areas. The minimum compaction level could be reduced to 95% in areas supporting floor slab only. The moisture content of the fill should be maintained within 2% of optimum as determined by the Standard Proctor test, at the time of placement.

4.4 Foundations

After the recommended site preparation is performed, the footings may be designed for a net allowable bearing pressure of up to 3000 pounds per square foot (psf). This bearing pressure includes a factor of safety of at least three against shear failure of foundations. In our judgement, total and differential settlement should not exceed about one inch and one-half inch, respectively.

All perimeter foundations in heated building space should be placed at a minimum depth of 42 inches below exterior grades for frost protection. Interior footings may be placed at any convenient depth below the floor slab. In unheated areas where deeper frost penetration may occur, we recommend that the foundations have a minimum soil cover of 60 inches for frost protection.

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4.5 Floor Slab Recommendations

After the building area has been prepared as recommended in Section 4.3, it is our opinion the engineered fill and competent natural soils should be suitable to support the floor slab loadings. All backfill placed to support the slab, including within utility runs, should be compacted to at least 95% of the Standard Proctor. We recommend the upper six inches of the subgrade immediately below the floor consist of free draining sand containing less than 5% passing the #200 sieve. The sand will help reduce capillary moisture transmission to the slab.

4.6 Below Grade Garage Walls and Lateral Earth Pressures

Backfill placed against the below grade walls will exert lateral loads on these walls. The lateral loads could be minimized if free-draining granular soils are used as backfill immediately against the walls. This would include sands classified as SP or SP-SM, containing no more than 10% material passing the #200 sieve, and preferably no more than 50% passing the #40 sieve. The clean sand backfill should extend out two feet and then outward at a 30-degree angle to the surface. In areas that will support structures such as sidewalks or slabs, the exterior fill should be compacted to 95% of the Standard Proctor. Backfill under paved areas should be compacted to 100% of the Standard Proctor value in the upper three feet and at least 95% below three feet.

Using free-draining backfill, it is our opinion the sands may transmit a lateral pressure to the foundation equivalent to that of a fluid having a density of 50 pounds per cubic foot in the at-rest condition, respectively.

The design and construction should include proper surface drainage away from the buildings, waterproofing and exterior drain tile systems to prevent water infiltration into below-grade portions of the structures. The details of one such system is attached to this report.

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4.7 Underground Utilities

The mineral soils encountered in the borings appear to be generally suitable for support of typical buried utilities. If loose/soft soils are encountered in the bottom of utility trenches, some subcutting or recompaction of the soils may be required. Fill placed as utility bedding should be either crushed rock or clean, well-graded granular soil.

All backfill in underground utility trenches should be placed and compacted as recommended in Section 4.3 of this report. Utility trench backfill in paved areas should be compacted to 100% of the Standard Proctor value.

4.8 Subsurface Water Control

As indicated in Section 2.4 of this report, the observed groundwater levels in the soil borings depend on normal variations in precipitation and surface runoff amounts. The clays, silts and very fine grained silty sands at this site are slow-draining and perched water may be encountered in the upper portion of the soil profile during a wet season. The earthwork contractor should be aware that some dewatering with portable pumps may be required to facilitate earthwork operations in the building areas. Surface water should be controlled by maintaining positive surface drainage away from the building and paved areas.

4.9 General Comments

We recommend that all geotechnically-related work, including foundation construction, subgrade preparation, and engineered fill placement, be observed by the project geotechnical engineer or their representatives. The geotechnical engineer will perform appropriate testing to verify the geotechnical conditions that have been anticipated during preparation of this report.

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5.0 CONSTRUCTION CONSIDERATIONS

5.1 Excavation Safety

All excavations should comply with applicable O.S.H.A. standards. Excavation safety is the responsibility of the contractor.

5.2 Cold Weather Construction

Construction during cold weather should be exercised with care. We have included a sheet entitled "Precautions for Excavating and Refilling During Cold Weather".

5.3 Soil Sensitivity

The silty and clayey soils are susceptible to disturbance from construction traffic, especially in wet conditions. If the soils become disturbed, additional excavation may be required. Therefore, proper excavation equipment should be used to minimize the potential for disturbance.

5.4 Field Observations and Testing

As variations in soil conditions may exist at locations and elevations other than those of our borings, we recommend the geotechnical engineer be retained to observe the soil conditions during site preparation. We recommend in-place field compaction tests be performed in the compacted fill.

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Grain Belt Area Development
R. J. Rykken Consulting, Inc.
Twin City Testing Project #315052

6.0 REMARKS

The soil testing and geotechnical engineering services performed by Stork Twin City Testing for this project have been conducted in a manner with the level of skill and care ordinarily exercised by other members of the profession currently practicing in this area under similar budgetary and time constraints. No warranty, express or implied, is made.

This report was:

Prepared by ______________________
Leonard A. Rasmussen, P.E.
Senior Geotechnical Engineer
MN Reg. No. 12678

Reviewed by: ______________________
Mark Straight, P.E.
Senior Project Engineer
MN Reg. No. 41658

Attachments:
- Soil Boring Location Plan (1 page)
- Soil Boring Logs #B1 to #B10 (10 pages)
- Symbols & Terminology on Test Boring Logs (1 page)
- Field Exploration Procedures (1 page)
- Prerequisites for Sound Engineering Practice (1 page)
- Excavation Oversizing (1 page)
- Exterior Drain Tile System (1 page)
- Construction Observations and Testing (1 page)
- Cold Weather Precautions (1 page)

F:\BMC\2005CME\315052\GRAINBELTGEO REPORT.doc

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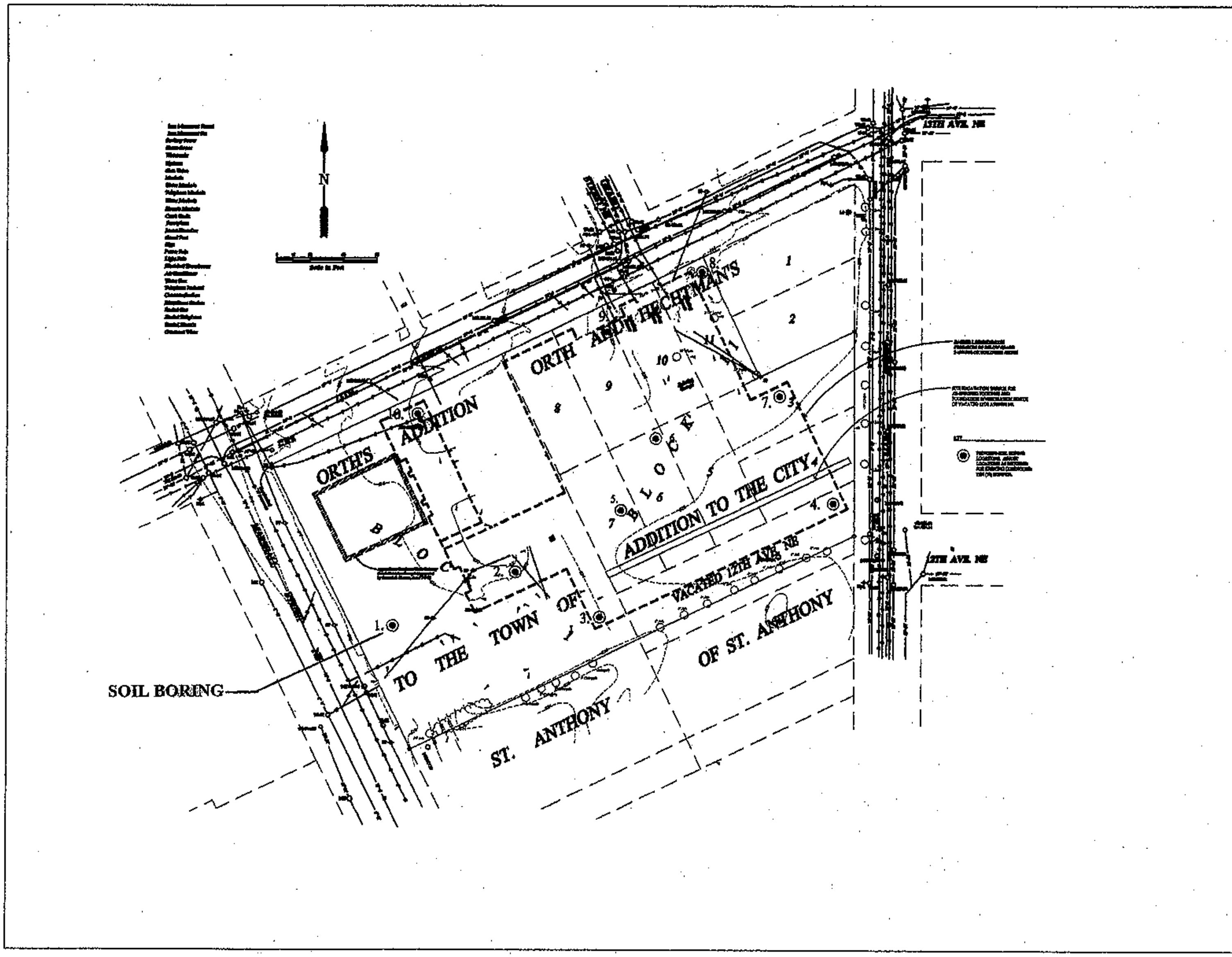

GRAIN BELT BREWERY LOFTS

esc

SCHEMATIC PRICING SET

06/22/05

A0.0

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B1

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

SURFACE ELEVATION 816.9'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, sand and silty sand, dark brown, 2" of bituminous at surface	Fill	12		1	SB					
3.5			4		2	SB					
	SILTY SAND, fine grained, brown, loose (SM)	Coarse Alluvium	8		3	SB					
7.0											
8.5	SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM)		11		4	SB					
	SILTY SAND, fine grained, gray, moist, loose, lenses of lean clay (SM)		8	▼	5	SB					
12.0											
	LEAN CLAY, gray, moist, very soft to soft, lenses of silty sand (CL)	Fine Alluvium	4		6	SB	24		28	19	
16.0			8		7	SB					
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-12-05	5:15pm		14.5'			14.5'
7-12-05	5:30pm			14'		13'
7-13-05	10:00am					9.5'

START 7-12-05 COMPLETE 7-12-07 @ 5:30pm

METHOD 3 1/4" Hollow Stem Auger to 14.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B2

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

SURFACE ELEVATION 818.4'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
2.0	FILL, sand, dark brown to brown, 6" concrete at surface	Fill	6		1	SB					
6.0	SILTY SAND, fine grained, brown, moist, loose (SM) may be fill	Coarse Alluvium or Fill	5		2	SB					
			11	▼	3	SB					
8.5	SAND WITH SILT, fine grained, brown, moist, medium dense (SP-SM)	Coarse Alluvium	10		4	SB					
16.0	SILTY SAND, very fine to fine grained, gray, moist, loose to medium dense, lenses and layers of lean clay (SM)		9		5	SB					
			16		6	SB					
			11		7	SB					
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-12-05	4:15pm		14.5'			none
7-12-05	4:30pm			13'		11'
7-13-05	10:00am					6'

START 7-12-05 COMPLETE 7-12-05 @ 4:30pm

METHOD 3 1/4" Hollow Stem Auger to 14.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

twin city testing

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B3

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL — SURFACE ELEVATION 817.7'	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, mostly sand, dark brown to brown, 6" concrete at surface	Fill	4		1	SB					
			9		2	SB					
4.5				▼							
	SILTY SAND, very fine to fine grained, gray, moist to wet, loose to medium dense, lenses of lean clay (SM)	Coarse Alluvium	10		3	SB					
			12		4	SB					
			17		5	SB					
			6		6	SB					
13.5											
	LEAN CLAY, gray, moist, soft to firm, lenses of wet sand and silty sand (CL)	Fine Alluvium	7		7	SB	20	94			
			10		8	SB					
			9		9	SB					
			7		10	SB					
			9		11	SB					
			6		12	SB					
			6		13	SB					
			6		14	SB					
			6		15	SB					
36.0											
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-12-05	3:00pm		27'			27'
7-12-05	3:30pm			32'		18'
7-13-05	10:00am					4'

START 7-12-05 COMPLETE 7-12-05 @ 3:30pm

METHOD 3 1/4" Hollow Stem Auger to 34.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. **B4**

PROJECT **GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA**

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 827.1')	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
4.5	FILL, sand and silty sand, black to brown, gravel, moist	Fill	10		1	SB					
			11		2	SB					
9.5	SAND WITH SILT, fine grained, grayish-brown, moist, loose to medium dense (SP-SM)	Coarse Alluvium	8		3	SB					
			14		4	SB					
14.0	SILTY SAND, very fine to fine grained, gray, waterbearing, medium dense, lenses of lean clay (SM)		11	▽	5	SB					
			13		6	SB					
36.0	LEAN CLAY, gray, moist, firm to soft, lenses and laminations of silty sand and sand (CL)	Fine Alluvium	8		7	SB	20	104			
			7		8	SB					
			8		9	SB					
			9		10	SB					
			2		11	SB					
			6		12	SB					
			4		13	SB					
			6		14	SB					
			5		15	SB					
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-12-05	10:00am		12'			11'
7-12-05	11:30	36'		8' 3"		none

START 7-12-05	COMPLETE 7-12-05 @ 11:30am
METHOD 3 1/4" Hollow Stem Auger to 34.5'	
NORTH:	EAST:
CREW CHIEF T. Aldrich	

twin city testing

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B5

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 828.5')	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, silty sand and sand, gravel, black to dark brown to brown, moist	Fill	16		1	SB					
			11		2	SB					
5.0	SILTY SAND, very fine to fine grained, grayish-brown to gray, moist to wet, medium dense to dense, lenses of lean clay (SM)	Coarse Alluvium	8		3	SB					
			12		4	SB				30% -#200	
			9	▼	5	SB					
			13		6	SB					
			14		7	SB					
			16		8	SB					
			16		9	SB					
			18		10	SB					
			20		11	SB					
26.0	LEAN CLAY, gray, moist, firm to soft, lenses of silty sand (CL)	Fine Alluvium	11		12	SB					
			10		13	SB					
			8		14	SB					
			7		15	SB					
36.0	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-12-05	12:30pm		17'			17'
7-12-05	1:30pm	36'	--	28'		none
7-12-05	5:30pm					12'
7-13-05	10:00am					11'

START 7-12-05 COMPLETE 7-12-05 @ 11:30am

METHOD 3 1/4" Hollow Stem Auger to 34.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B6

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

SURFACE ELEVATION 828.7'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, silty sand and sand, dark brown to brown, moist	Fill	12		1	SB					
			7		2	SB					
6.0			13		3	SB					
	SAND with a little gravel, fine grained, brown, moist, medium dense (SP)	Coarse Alluvium	13		4	SB					
11.0			16		5	SB					
	SILTY SAND, very fine to fine grained, gray, moist to wet, medium dense, lenses and layers of lean clay (SM)		11		6	SB					
			14		7	SB					
				▽							
			11		8	SB					
			14		9	SB					
			15		10	SB					
			14		11	SB					
28.0			8		12	SB					
	LEAN CLAY, gray, moist, firm (CL)	Fine Alluvium	11		13	SB					
			8		14	SB					
36.0			8		15	SB					
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-11-05	5:00pm	--	20'			17'
7-11-05	5:00pm	36'		11' 4"		none

START 7-11-05 COMPLETE 7-11-05 @ 5:00pm

METHOD 3 1/4" Hollow Stem Auger to 34.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

twin city testing

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. **B7**

PROJECT **GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA**

SURFACE ELEVATION **828.3'**

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, sand and silty sand, black to dark brown	Fill	10		1	SB					
3.5			8		2	SB					
	SAND WITH SILT, fine grained, dark brown, moist, loose to medium dense (SP-SM) may be fill	Fill or Coarse Alluvium	20		3	SB					
7.0	SAND, fine grained, brown, moist, medium dense to loose (SP)	Coarse Alluvium	12		4	SB				4.5%-200	
11.0			7		5	SB					
	SILTY SAND, very fine to fine grained, gray, moist to wet, loose to medium dense, lenses of lean clay (SM)		8	▽	6	SB					
			12		7	SB					
			15		8	SB					
			10		9	SB					
23.0			10		10	SB					
	LEAN CLAY, gray, moist, firm to soft, lenses of silt (CL)	Fine Alluvium	9		11	SB					
			8		12	SB					
			7		13	SB					
			6		14	SB					
36.0			6		15	SB					
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-12-05	8:00am	13.5'				12'
7-12-05	9:30am		34.5'	9' 8"		none

START **7-12-05** COMPLETE **7-12-05** @ **9:30am**

METHOD **3 1/4" Hollow Stem Auger to 34.5'**

NORTH: EAST:

CREW CHIEF **T. Aldrich**

twin city testing

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. **B8**

PROJECT **GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA**

SURFACE ELEVATION **826.3'**

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, mostly silty sand, some silt, black to brown, moist, 1" bituminous at surface	Fill	4		1	SB					
			8		2	SB					
7.0			7		3	SB					
	SILTY SAND, fine grained, brown, moist, medium dense, lenses of silt (SM)	Coarse Alluvium	11		4	SB					
12.0			12		5	SB					
	SANDY SILT, grayish-brown, moist, firm to soft (ML)	Fine Alluvium	9		6	SB					
			9	▽	7	SB					
18.5			7		8	SB					
	SILTY SAND, very fine grained, gray, moist to wet, medium dense, lenses of silt and lean clay (SM)	Coarse Alluvium	13		9	SB					
			12		10	SB					
			19		11	SB					
			18		12	SB					
			15		13	SB					
33.5			11		14	SB					
	LEAN CLAY, gray, moist, firm (CL)	Fine Alluvium	13		15	SB					
36.0	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-11-05	12:30pm	18.5'				16'
7-11-05	12:30pm		34.5'	12' 2"		none

START 7-11-05 COMPLETE 7-11-05 @ 1:00pm

METHOD 3 1/4" Hollow Stem Auger to 34.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

twin city testing

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B9

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

SURFACE ELEVATION 824.7'

DEPTH IN FEET	DESCRIPTION OF MATERIAL	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, mixture sand and silty sand, black to brown, moist, 4" concrete at surface	Fill	9		1	SB					
4.5			14		2	SB					
	SAND with a little gravel, fine to medium grained, brown, moist, medium dense (SP)	Coarse Alluvium	12		3	SB					
8.0			15		4	SB					
9.5	SAND WITH SILT, very fine grained, brown, moist, medium dense (SP-SM)										
	SILTY SAND, fine grained, gray and brown mottled, moist, loose, lenses of lean clay (SM)		7		5	SB					
			6		6	SB					
16.0			9		7	SB					
	SILT, gray, moist, soft (ML)	Fine Alluvium		▽							
18.5			10		8	SB					
	SILTY SAND, very fine grained, gray, moist to wet, loose to medium dense, lenses of silt and lean clay (SM)	Coarse Alluvium	9		9	SB					
			14		10	SB					
			22		11	SB					
			13		12	SB					
			14		13	SB					
			23		14	SB					
36.0			20		15	SB					
	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-11-05	1:40pm	18.5'				17'
7-11-05	3:00pm		34.5'			none
7-11-05	5:00pm		--			none

START 7-12-05 COMPLETE 7-12-05 @ 3:00pm

METHOD 3 1/4" Hollow Stem Auger to 34.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

twin city testing

LOG OF TEST BORING

JOB NO. 315052 VERTICAL SCALE 1" = 5' BORING NO. B10

PROJECT GRAIN BELT DEVELOPMENT AREA MINNEAPOLIS, MINNESOTA

DEPTH IN FEET	DESCRIPTION OF MATERIAL (SURFACE ELEVATION 820.41')	GEOLOGIC ORIGIN	N or CR	WL	SAMPLE NO.	SAMPLE TYPE	W	D	LL	PL	Qu or RQD
	FILL, sand and silty sand, brown, moist, 2" of bituminous at surface	Fill	8		1	SB					
			9		2	SB					
4.5	SAND WITH SILT, very fine grained, brown, moist, loose to medium danse, lenses of silt (SP-SM)	Coarse Alluvium	10		3	SB					
			11		4	SB					
			10		5	SB					
			9	▼	6	SB					
14.0	SILTY SAND, fine grained, gray, moist, loose to medium dense, layers and lenses of silt (SM)		6		7	SB					
			11		8	SB					
			5		9	SB					
			7		10	SB					
24.0	SAND WITH SILT, gray, moist, medium dense (SP-SM)		17		11	SB					
26.0	SILTY SAND, very fine to fine grained, gray, moist to wet, medium dense, lenses of silt (SM)		15		12	SB					
			11		13	SB					
			15		14	SB					
			18		15	SB					
36.0	End of Boring										

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	BAILED DEPTHS	WATER LEVEL
7-11-05		13.5'				12'
7-11-05	10:30am		34.5'			none

START 7-11-05 COMPLETE 7-11-05 @ 10:30am

METHOD 3 1/4" Hollow Stem Auger to 34.5'

NORTH: EAST:

CREW CHIEF T. Aldrich

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SYMBOLS AND TERMINOLOGY ON TEST BORING LOGS

SYMBOLS

Drilling and Sampling

Symbol	Description
HSA	3-1/4" I.D. hollow stem auger
_FA	4", 6" or 10" diameter flight auger
_HA	2", 4" or 6" hand auger
_DC	2-1/2", 4", 5" or 6" steel drive casing
_RC	Size A, B or N rotary casing
PD	Pipe drill or cleanout tube
CS	Continuous split barrel sampling
DM	Drilling mud
JW	Jetting water
SB	2" O.D. split barrel sampling
_L	2-1/2" or 3-1/2" O.D. SB liner sample
_T	2" or 3" thin walled tube sample
3TP	3" thin walled tube using pitcher sampler
_TO	2" or 3" thin walled tube suing Osterberg sampler
W	Wash sample
B	Bag sample
P	Test pit sample
_Q	BQ, NQ, or PQ wireline system
_X	AX, BX, or NX double tube barrel
N	Standard penetration test, blows per foot
CR	Core recovery, percent
WL	Water level
⊻	Water level
NMR	No measurement recorded, primarily due to the presence of drilling or coring fluid

Laboratory Testing

Symbol	Description
W	Water content, % (ASTM:D2216)**
D	Dry density, pcf
LL	Liquid limit (ASTM:D4318)
PL	Plastic limit (ASTM:D4318)
	--- Inserts in Last Column (Qu or RQD) ---
Qu	Unconfined compressive strength, psf (ASTM:D2166)
Pq	Penetrometer reading, tsf (ASTM:D1558)
Ts	Torvane reading, tsf
G	Specific gravity (ASTM:D854)
SL	Shrinkage limits (ASTM:D427)
OC	Organic content – Combustion method (ASTM:D2974)
SP	Swell pressure, tsf (ASTM:D4546)
PS	Percent swell under pressure (ASTM:D4546)
FS	Free swell, % (ASTM:D4546)
SS	Shrink swell, % (ASTM:D4546)
pH	Hydrogen ion content – Meter Method (ASTM:D4972)
SC	Sulfate content, parts/million or mg/l
CC	Chloride content, parts/million, or mg/l
C*	One dimensional consolidation (ASTM:D2435)
Qc*	Triaxial compression (ASTM:D2850 and D4767)
D.S.*	Direct shear (ASTM:D3080)
K*	Coefficient of permeability, cm/sec (ASTM:D2434)
P*	Pinhole test (ASTM:D4647)
DH*	Double hydrometer (ASTM:D4221)
MA*	Particle size analysis (ASTM:D422)
R	Laboratory electrical resistivity, ohm-cm (ASTM:G57)
E*	Pressuremeter deformation modulus, tsf (ASTM:D4719)
PM*	Pressuremeter test (ASTM:D4719)
VS*	Field vane shear (ASTM:D2573)
IR*	Infiltrometer test (ASTM:D3385)
RQD	Rock quality designation, percent

* Results shown on attached data sheet or graph
** ASTM designates American Society for Testing and Materials

TERMINOLOGY

Particle Sizes

Type	Size Range
Boulders	> 12"
Cobbles	3" – 12"
Coarse gravel	3/4" – 3"
Fine gravel	#4 sieve – 3/4"
Coarse sand	#4 - #10 sieve
Medium sand	#10 - #40 sieve
Fine sand	#40 - #200 sieve
Silt	100% passing #200 sieve and > 0.005 mm
Clay	100% passing #200 sieve and < 0.005 mm

Soil Layering and Moisture

Term	Visual Observation
Lamination	Up to 1/4" thick stratum
Varved	Alternating laminations of any combination of clay, silt, fine sand, or colors
Lenses	Small pockets of different soils in a soil mass
Stratified	Alternating layers of varying materials or colors
Layer	1/4" to 12" thick stratum
Dry	Powdery, no noticeable water
Moist	Damp, below saturation
Waterbearing	Pervious soil below water
Wet	Saturated, above liquid limit

Gravel Content

Coarse-Grained Soils

% Gravel	Description
2 – 15	A little gravel
16 – 49	With gravel

Fine-Grained Soils

% Gravel	Description
< 5	Trace of gravel
5 – 15	A little gravel
16 – 30	With gravel
31 – 49	Gravelly

Standard Penetration Resistance

Cohesionless Soils

N-Value	Relative Density
0 – 4	Very loose
5 – 10	Loose
11 – 30	Medium dense
31 – 50	Dense
> 50	Very dense

Cohesive Soils

N-Value	Consistency
0 – 4	Very soft
5 – 8	Soft
9 – 15	Firm
16 – 30	Hard
> 30	Very hard

FIELD EXPLORATION PROCEDURES

Soil Sampling

Soil sampling was performed in accordance with ASTM D 1586-99. Using this procedure, a 2" O.D. split barrel sampler is driven into the soil by a 140 pound weight falling 30". After an initial set of 6", the number of blows required to drive the sampler an additional 12" is known as the penetration resistance, or N value. The N value is an index of the relative density of cohesionless soils and the consistency of cohesive soils. Thin wall tube samples were obtained according to ASTM D 1587-00 where indicated by the appropriate symbol on the boring logs. Rock core samples, if taken, were obtained by rotary drilling in accordance with ASTM D 2113-99. Power auger borings, if performed, were done in general accordance with ASTM D 1452-00.

Soil Classification

As the samples were obtained in the field, they were visually and manually classified by the crew chief in accordance with ASTM D 2488-00. Representative portions of the samples were then returned to the laboratory for further examination and for verification of the field classification. Logs of the borings indicating the depth and identification of the various strata, the N value, the laboratory test data, water level information and pertinent information regarding the method of maintaining and advancing the drill holes are attached. The descriptive terminology and symbols used on the boring logs are also attached.

PREREQUISITES FOR SOUND ENGINEERING PRACTICE

In order to properly evaluate the foundation soils at a building site, it is imperative for our firm to know exactly where the building will be placed, its size, and the elevation of the foundation elements. Without this information, a judgment regarding the adequacy of the preparatory foundation earthwork is not possible.

This project data is especially critical in situations when the excavation extends below the footing grade and compacted fill is required to attain building elevations. In these situations, the excavation would require lateral oversizing to provide suitable lateral distribution of the footing loads.

Offset batter boards of the building lines stakes provide the best on-site verification of the building location and size. It must be recognized that Twin City Testing does not practice in the field of surveying. Therefore, we must rely on staking by others. If Twin City Testing is required to perform the survey, we will retain a licensed surveyor and invoice our client for the amount per our current fee schedule. Provision of the building foundation plans is also important so that we may properly perform our engineering judgments.

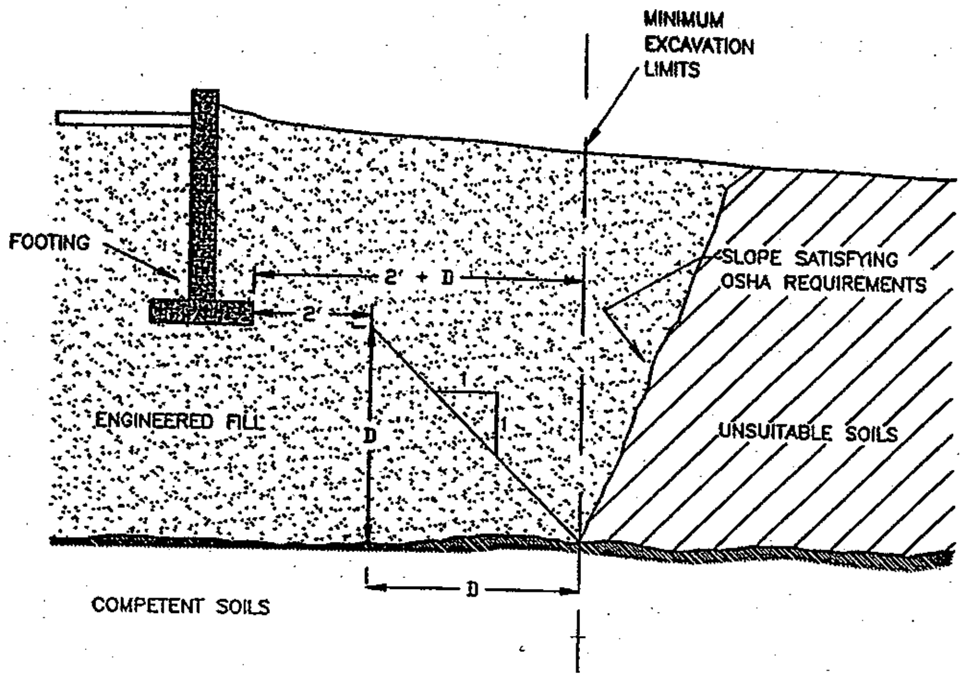
If the construction is redesigned or otherwise moved subsequent to our work, we should be informed so our firm can assess if additional engineering observation is required or suggest sound engineering alternatives. We cannot be responsible for any soil foundation system if the structure has been relocated with respect to the excavation subsequent to our observations.

GENERAL OVERSIZE REQUIREMENTS

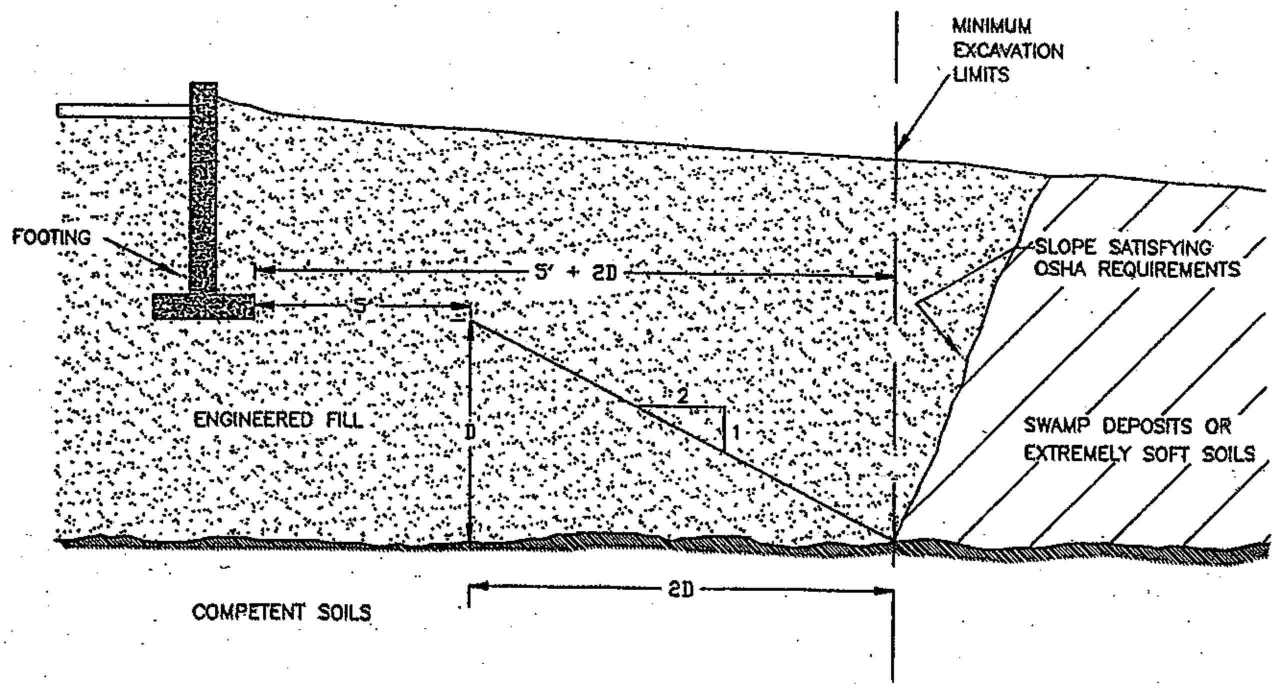
Because of the lateral distribution of foundation pressures with depth, lateral oversizing is required in an excavation where unsuitable soils extend below planned footing grade. The lateral oversize scheme provides compacted fill materials beyond the exterior footing limits where fill is required below footing elevation. The degree of lateral oversizing is dependent upon the surrounding soil's ability to resist lateral movement. Although we generally recommend the lateral oversize be at least 2' plus the depth of fill below bottom of footing elevation, each project must be evaluated separately. For example, in extremely compressible swamp or organic soils, the oversize should be increased to 5' plus twice the depth of excavation below footing grade. Due to the variations in the required oversize, an engineering judgment must be made to establish the necessary extent of the oversizing. Diagrams illustrating typical oversizing dimensions are included in this report.

EXCAVATION OVERSIZING

NORMAL EXCAVATION



SWAMP OR EXTREMELY SOFT SOIL EXCAVATION



C:\GEODWGS\GEOTECH\OVERSIZE

NOT TO SCALE

CONSTRUCTION OBSERVATIONS AND TESTING

The recommendations made in this report have been made based on the subsurface conditions found in the borings. It is possible that there are soil and water conditions on site that were not represented by the borings. Consequently, on-site observation during construction is considered integral to the successful implementation of the recommendations. We believe that qualified field personnel need to be on site at the times outlined below to observe the site conditions and effectiveness of the construction.

We recommend that the completed excavation and prepared subgrade be observed and tested by a soils engineer/technician prior to fill placement or construction of any foundation elements. These observations would be necessary to judge if all unsuitable materials have been removed from within the planned construction area and that an appropriate degree of lateral oversize has been provided for in those areas where fill will be placed below the bottom of foundation grade.

We recommend a representative number of field density tests be taken in all engineered fill placed to aid in judging its suitability. We suggest that at least one density test be performed for at least every 2500 square feet of engineered fill placed for every 2' of fill depth. Additional tests should be taken where confined areas are compacted. Any proposed fill material should be submitted to the laboratory for tests to check compliance with our recommendations and project specifications.

PRECAUTIONS FOR EXCAVATING AND REFILLING DURING COLD WEATHER

The winter season in this area presents specific problems for foundation construction. Soils that are allowed to freeze undergo a moisture volume expansion, resulting in loss of density. These frost-expanded soils will consolidate upon thawing, causing settlement of any structure supported on them. To prevent this settlement, frost should not be allowed to penetrate into the soils below any proposed structure.

Ideally, winter excavation should be limited to areas small enough to be refilled to grade higher than footing grade on the same day. Typically, these areas should be filled to floor grade. Trenching back down to unfrozen soils for foundation construction can then be performed just prior to footing placement. The excavated trenches should be protected from freezing by means of insulating or heating during foundation construction. Backfilling of the foundation trenches should be performed immediately after the below-grade foundation construction is finished. In addition, any interior footings or footings designed without frost protection should be extended below frost depth, unless adequate precautions are taken to prevent frost intrusion until the building can be enclosed and heated.

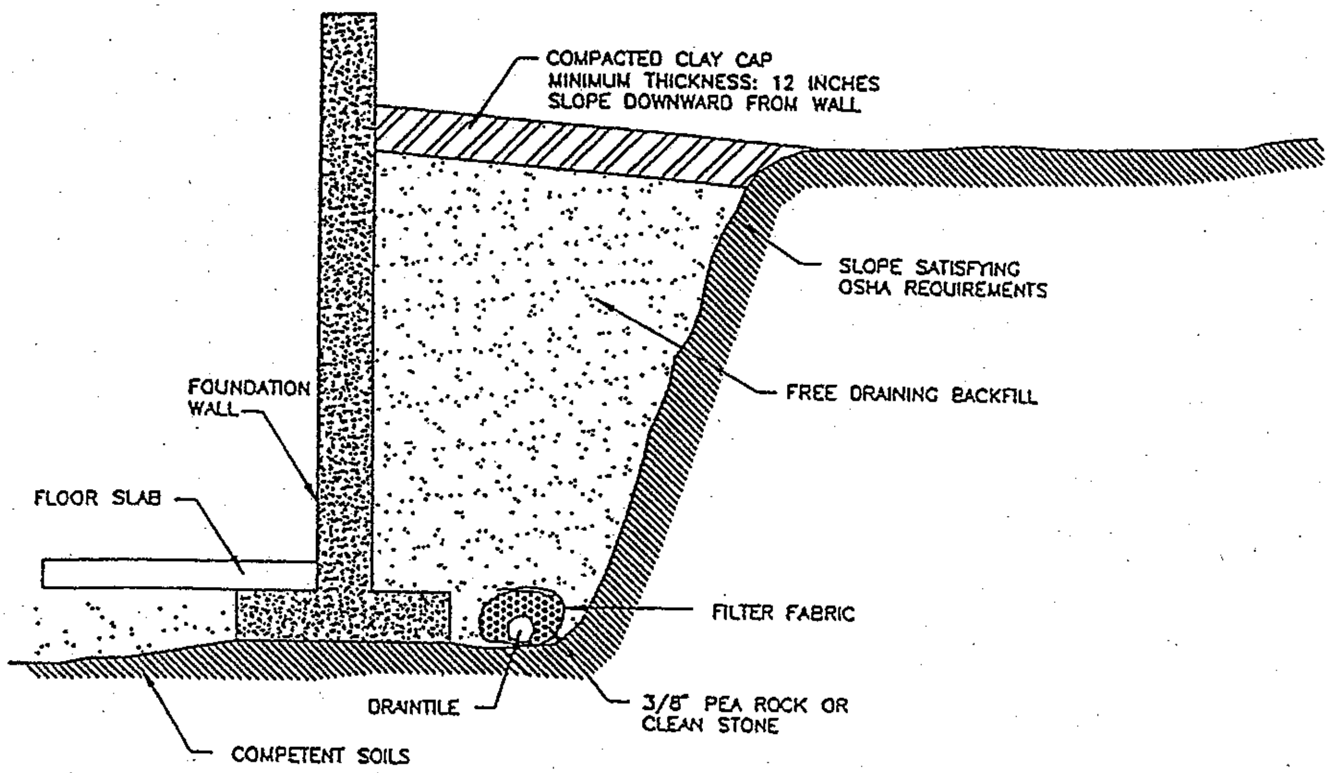
In many cases, final grade cannot be attained in one day's time, even though small areas are worked. In the event final grade cannot be attained in one day's time, frost can be expected to develop overnight. Leaving a layer of loose soil on top of the compacted material overnight can minimize the depth of frost penetration. However, any frost that forms in this loose layer, or snow that accumulates, should be completely removed from the fill area prior to compaction and additional soil placement. Frozen soils or soils containing frozen material or snow should never be used as fill material.

After the structure has been enclosed, all floor slab areas should be subjected to ample periods of heating to allow thawing of the soil system. Alternatively, the frozen soil can be completely removed and be replaced with an engineered fill. The floor slab areas should be checked at random and representative locations for remnant areas of frost and density tests should be performed to document fill compaction to slab placement.

Due to the potential problems associated with fill placement during cold weather, a full-time, on-site soils technician should monitor any filling operations. Full-time monitoring aids in detecting areas of frozen material, or potential problems with frozen material within the fill, so the appropriate measures can be taken. The choice of fill material is particularly important during cold weather, since clean granular fill material can be placed and compacted more efficiently than silty and clayey soils. In addition, greater magnitudes of heaving can be expected with freezing of the more frost susceptible silts and clays.

If more specific frost information or cold weather data concerning other construction materials is required, please contact us.

TYPICAL EXTERIOR DRAINTILE SYSTEM



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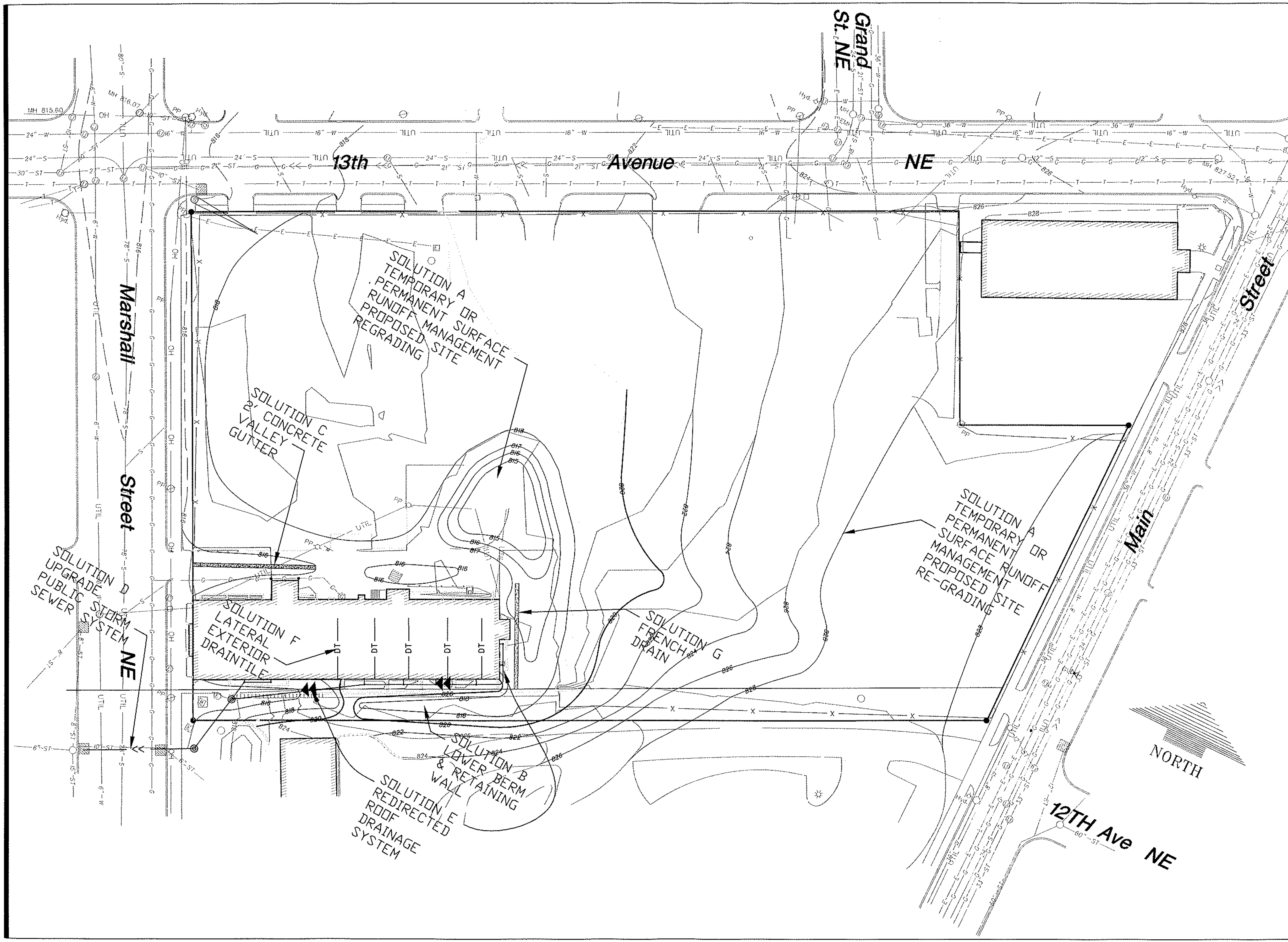

Project Name:

GRAINBELT OFFICE DRAINAGE STUDY

Minneapolis, Minnesota

Owner/Developer Name:

City of Minneapolis

1215 Marshall St. NE
Minneapolis, MN 55413

Professional Services:

LOUCKS ASSOCIATES

Planning • Civil Engineering • Land Surveying
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Checked By:	Review Date:

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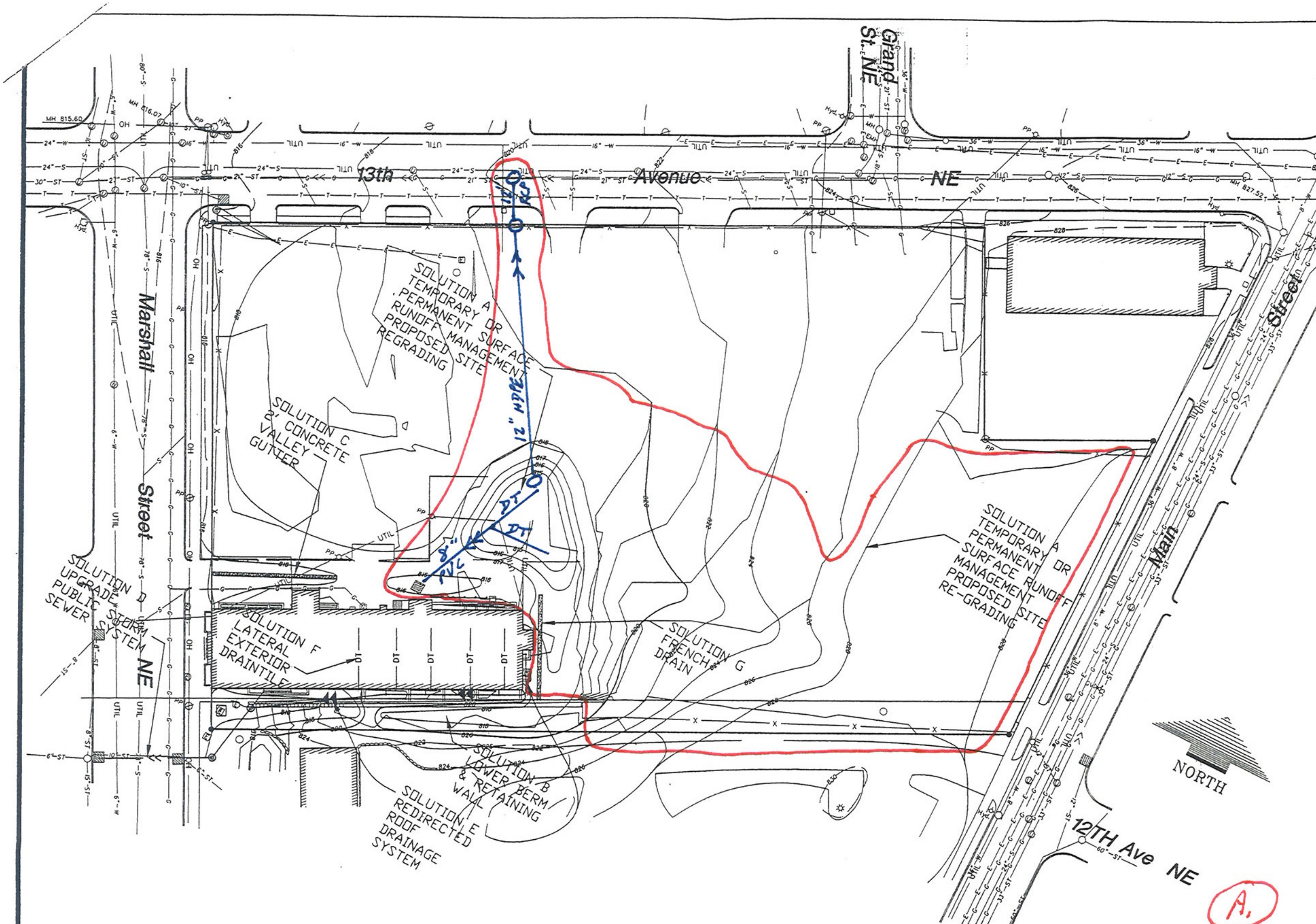

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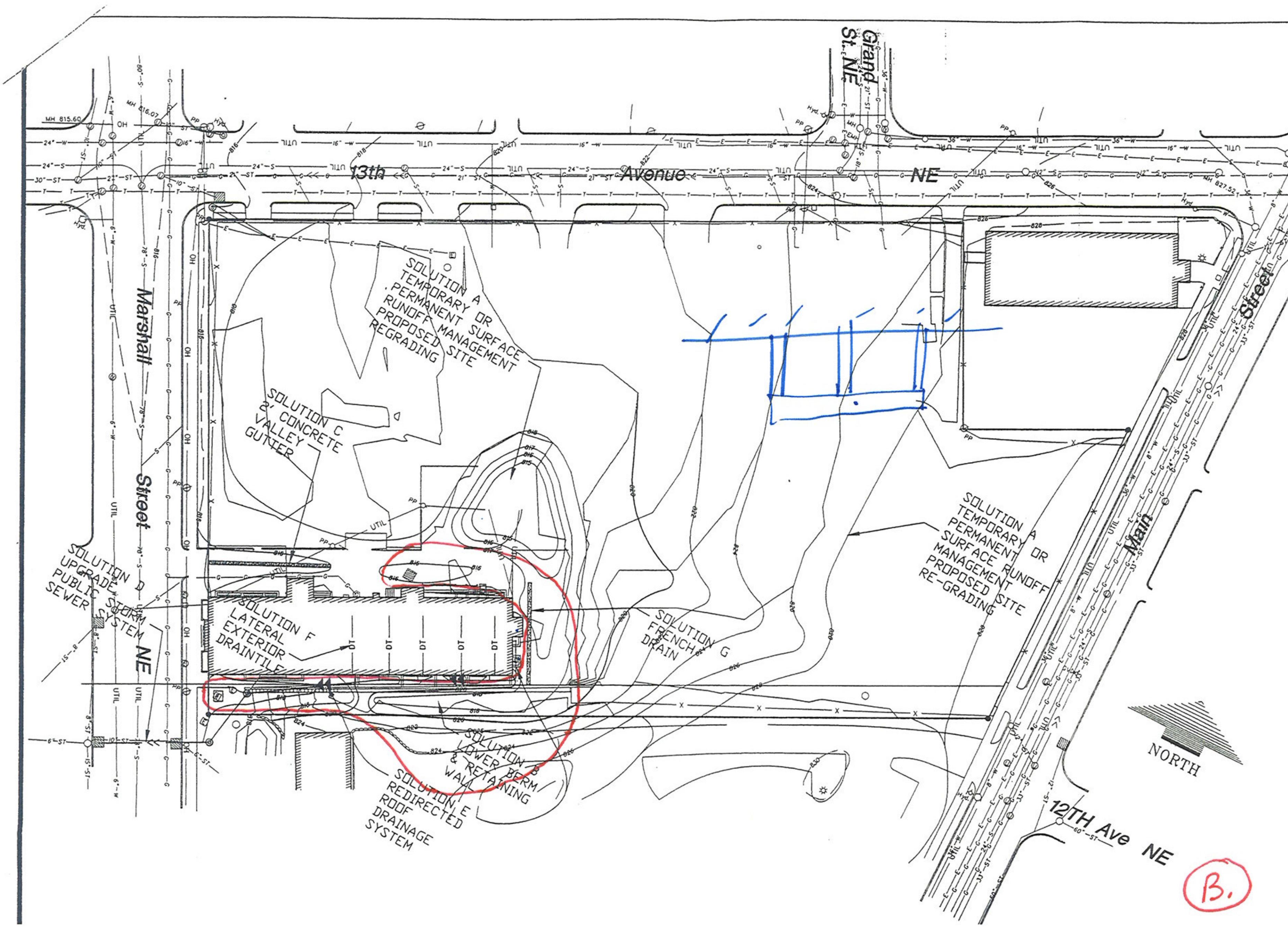

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Planning • Civil Engineering • Land Surveying
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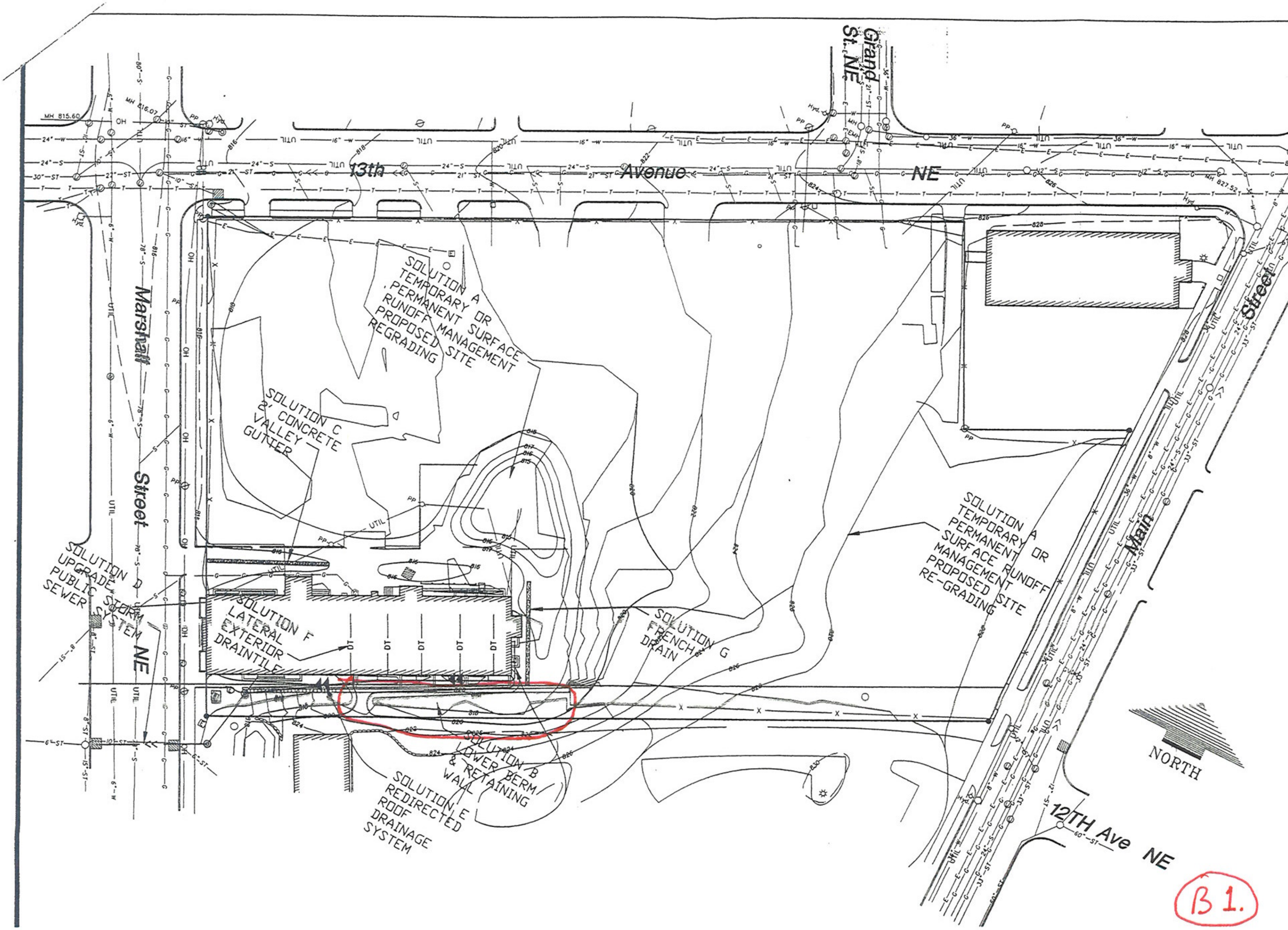

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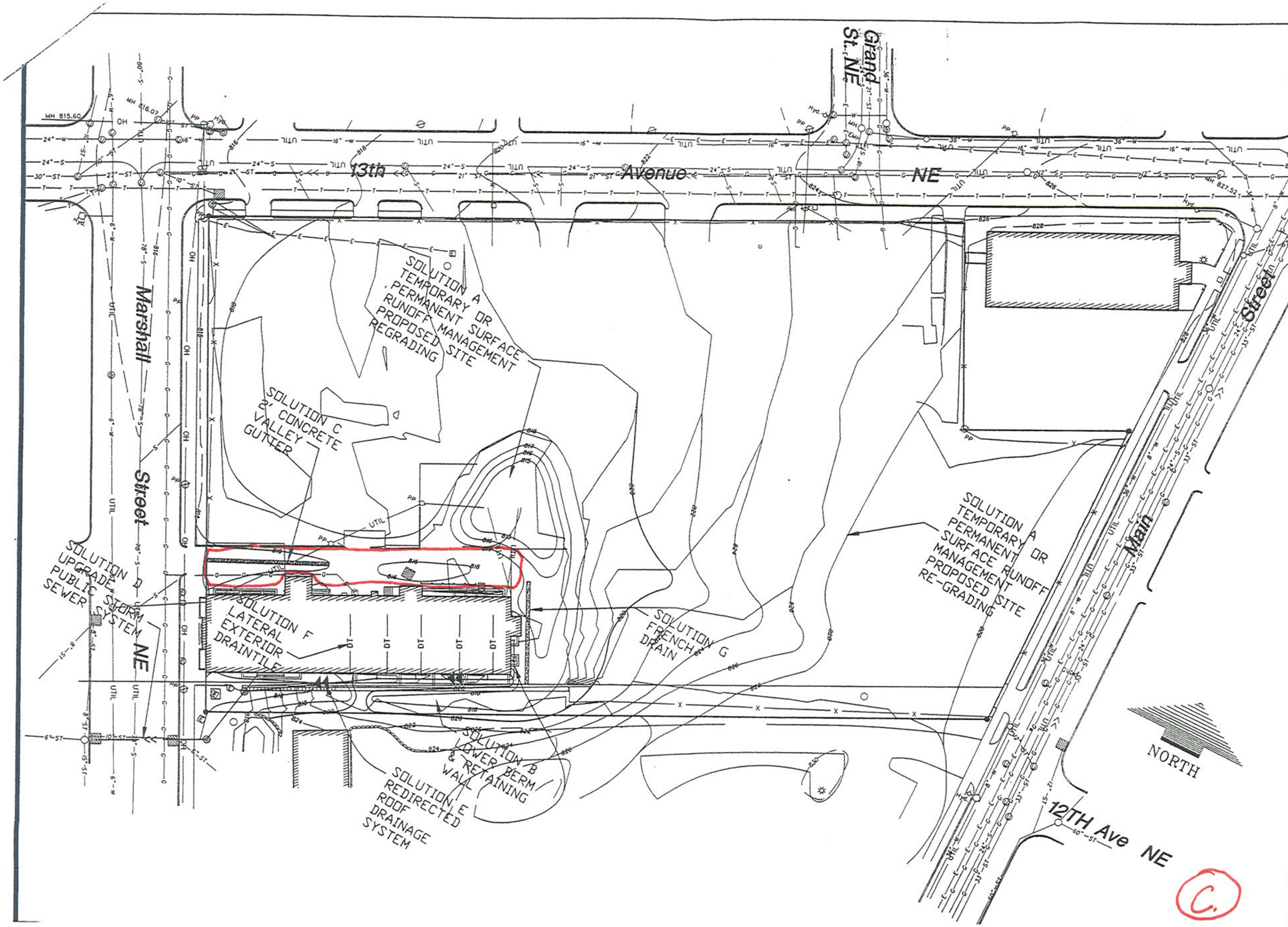

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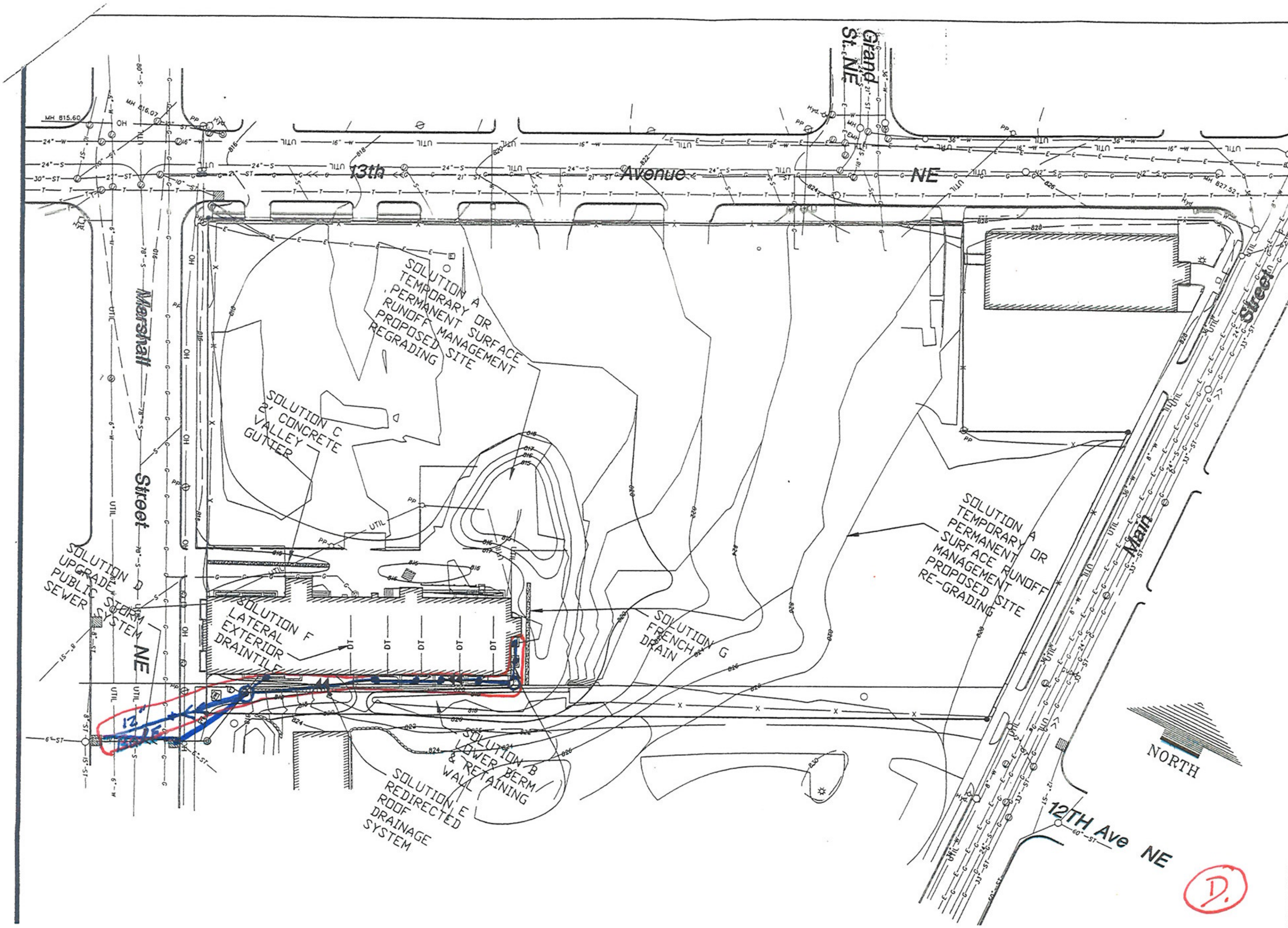

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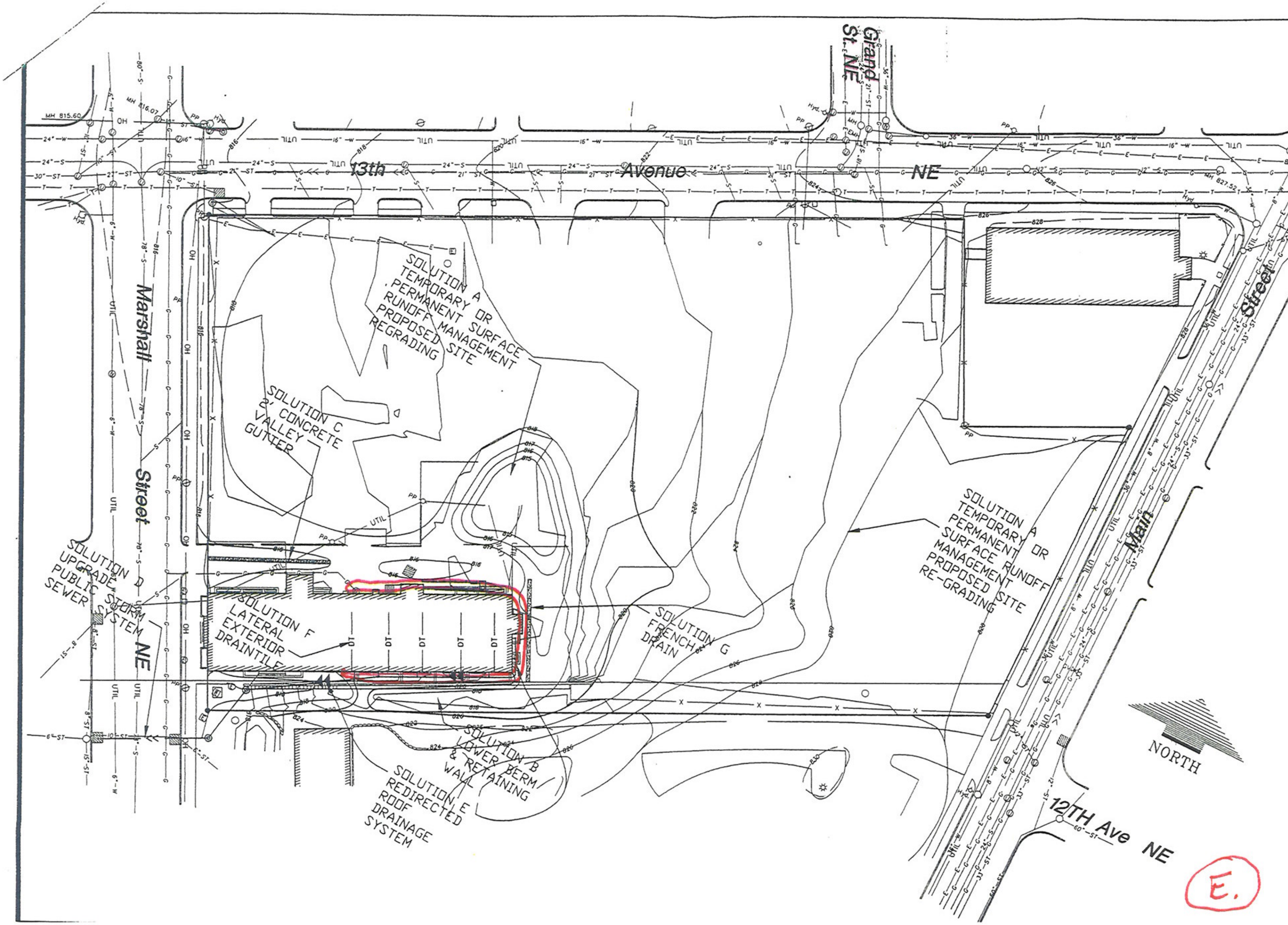

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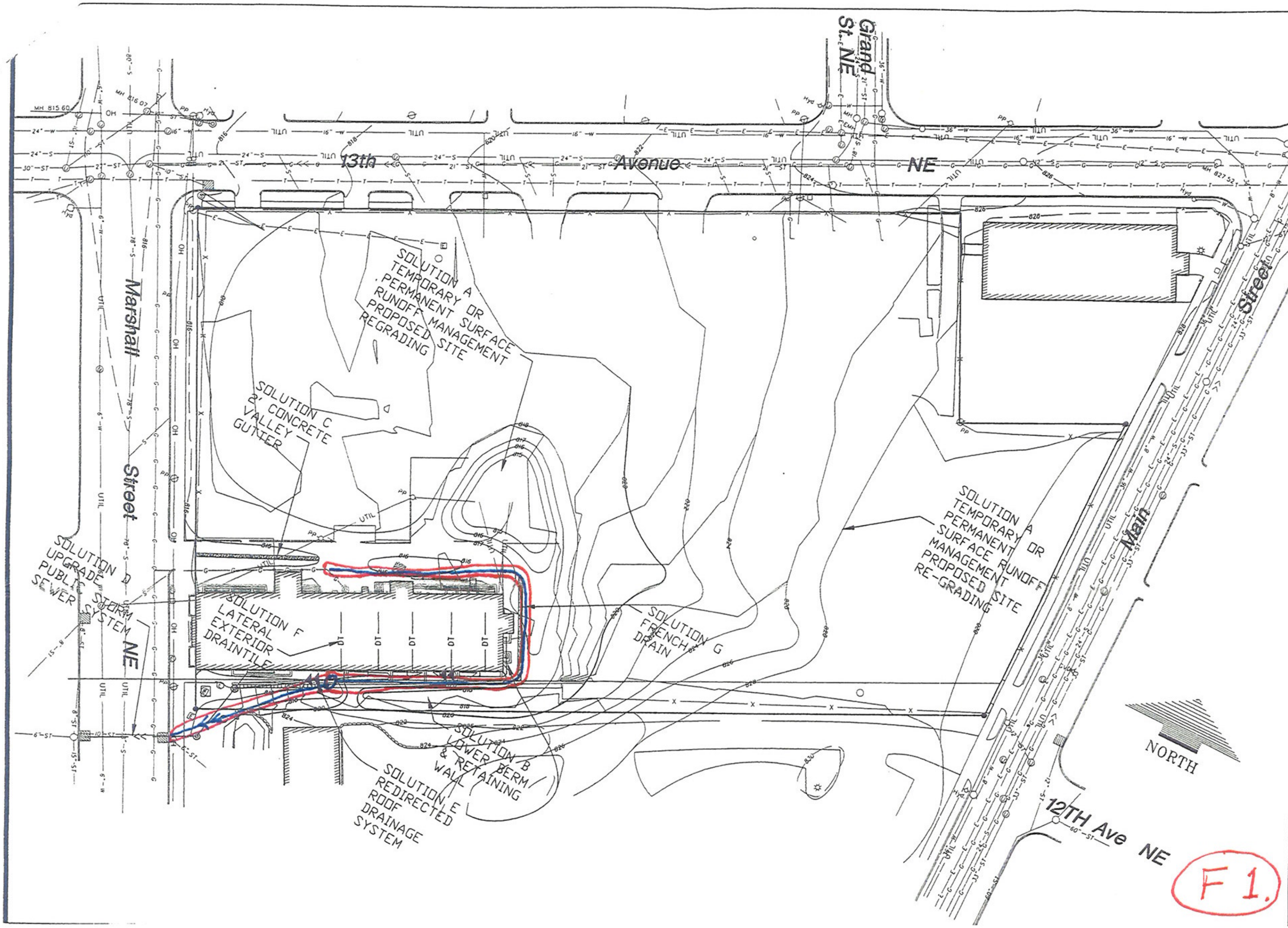

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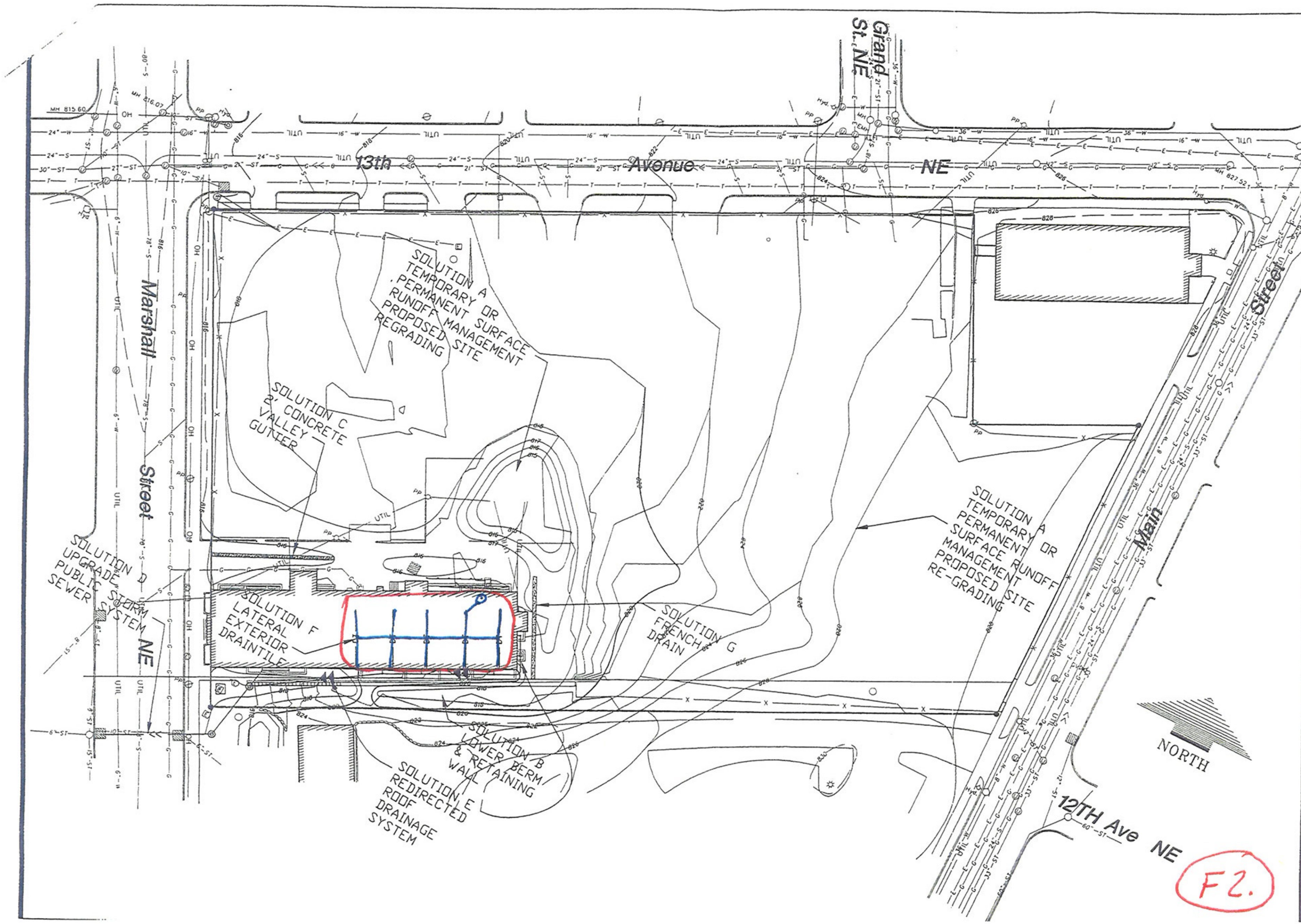

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Minneapolis, Mi

Owner/Developer Name:

City of Minnea

1215 Marshall S
Minneapolis, MN

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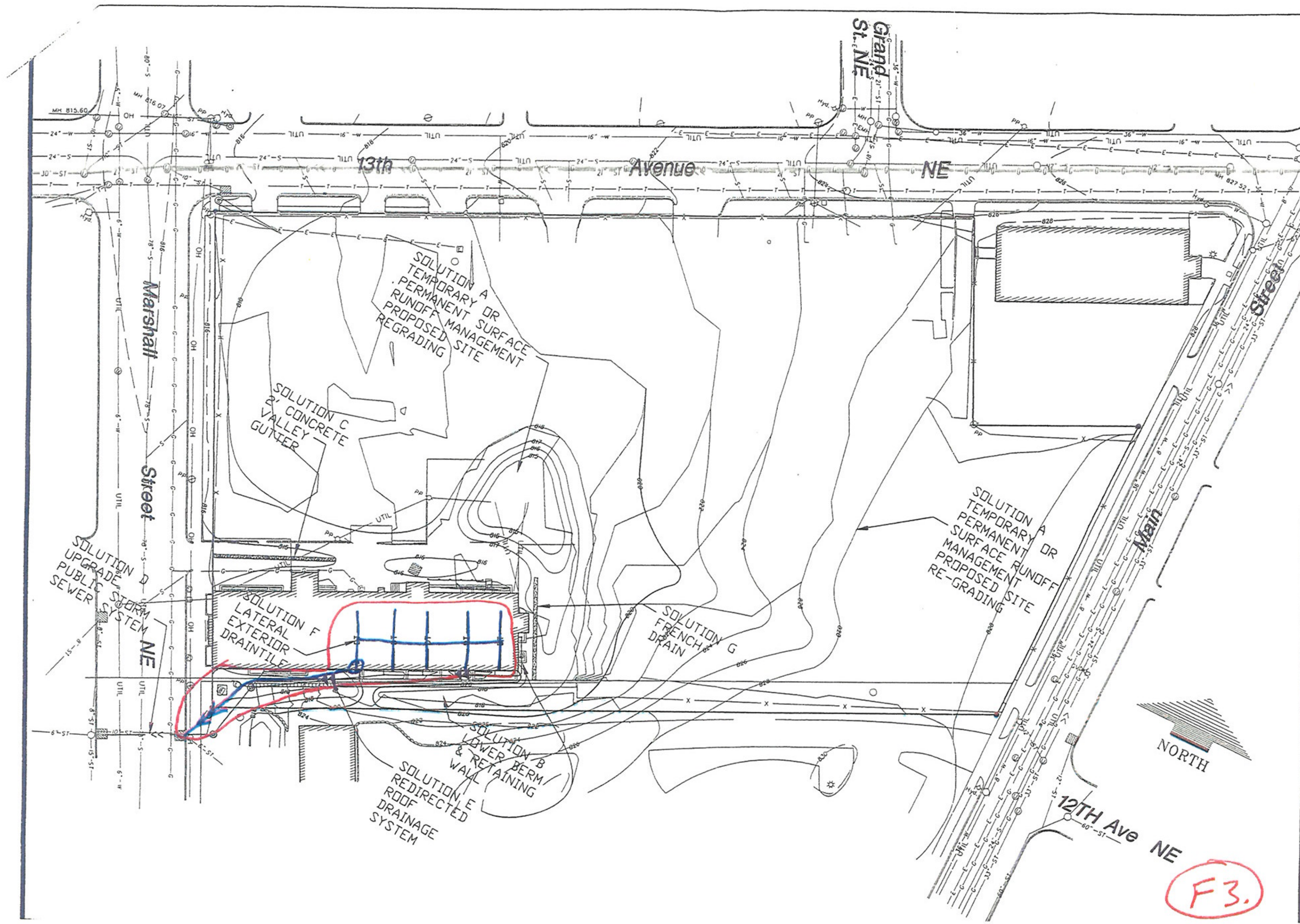

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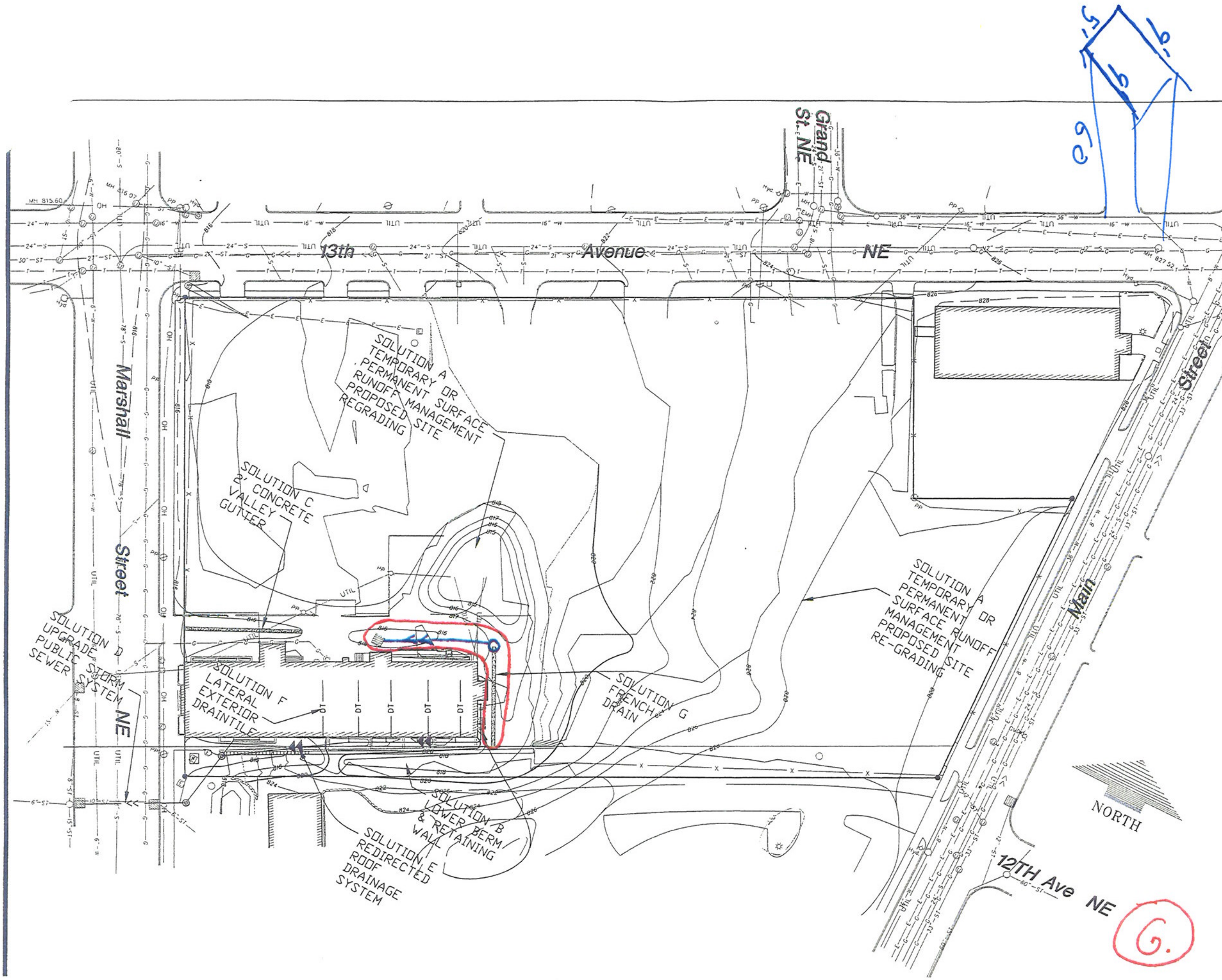

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City of Minnea
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