# Chrysler Museum Culvert Inspection

Presented to:

City of Norfolk

Public Works Department

*November 1, 2013*

Prepared by:

moffatt & nichol

800 World Trade Center

Norfolk, Virginia 23510

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# EXECUTIVE SUMMARY

This report summarizes findings from the inspection of the Chrysler Museum Culvert. This inspection was performed under the City of Norfolk Department of Public Works Contract No. 13298B, Task Order 10. The services under this task order involved inspection of the stormwater drainage culvert from the underground junction box near the intersection of Olney Road and Duke Street to Smith Creek, a tributary of the Elizabeth River.

The Chrysler Museum Culvert is approximately 600 LF in length and consists of two (2) circular precast reinforced concrete pipes. The north and south barrels are approximately 72" in diameter. No as-builts or construction drawings of the culvert were available from the City of Norfolk.

Moffatt & Nichol's (M&N) objectives for this inspection included:

- Completing a Level I & Level II inspection of the double pipe culvert to determine the overall condition
- Figure preparation showing approximate culvert alignment and location of deficiencies
- Recommendations for repairs/replacement and conceptual cost estimate for noted deficiencies

Overall, the Chrysler Museum Culvert is in **FAIR** condition based on the condition rating system defined in the American Society of Civil Engineers Manuals and Reports on Engineering Practice No. 101 "Underwater Inspection Standard Practice Manual". M&N has identified three priority repair recommendations, two of which are near the pipe outfalls at Smith Creek. In addition to the priority actions, M&N has also identified one (1) routine repair recommendation in the North Barrel and seven (7) routine repair recommendations in the South Barrel. M&N recommends the City setup a routine maintenance contract for sediment removal from the culvert barrels. There was approximately 82 cubic yards (CY) of sediment in the South Barrel and 317 CY in the North Barrel. This routine maintenance dredging/cleaning will help restore the hydraulic capacity of the culvert and may mitigate localized flooding in this area.

The priority recommendations include:

- Defect N2: Repair of a pipe joint in the North Barrel at STA 0+16 N. The upstream pipe invert at the joint is 4" lower than the downstream. Penetration up to 8" was achieved in the gap. The differential settlement of the pipes at this joint has allowed soil to infiltrate resulting in a void adjacent to and above the barrel. Evidence of this settlement can be seen from the topside where excessive settlement and cracking was noted in the sidewalk and a 2'-6" diameter x 1" deep sinkhole was noted in the roadway adjacent to the sidewalk. The topside deficiencies are shown in Photo Nos. 4 through 6 in Appendix A.
- Defect S2: Repair of a pipe joint in the South Barrel at STA 0+16 S, shown in Photo No. 13 in Appendix A. There is a 4" gap between the pipes at the joint location. Penetration up to 3" was achieved in the gap. The gap between the pipes at this joint has allowed soil to infiltrate

resulting in a void adjacent to and above the barrel. Evidence of this settlement can be seen from the topside where excessive settlement and cracking was noted in the sidewalk and a 2'-6" diameter x 1" deep sinkhole was noted in the roadway adjacent to the sidewalk. The topside deficiencies are shown in Photo Nos. 4 through 6 in Appendix A.

- Defect S22: Repair of a pipe joint in the South Barrel at STA 5+98 S, shown in Photo Nos. 17 through 18 in Appendix A. The downstream pipe invert at the joint is 4" lower than the upstream. Penetration up to 12" was achieved in the gap. The differential settlement of the pipes at this joint has allowed sediment to infiltrate resulting in a void adjacent to and above the barrel. No signs of a sinkhole were noted on the lawn above.

These priority actions should take precedence over all other repairs and are needed to prevent further deterioration and more significant future repairs.

The routine repair recommendations typically consist of gaps up to 3" wide at pipe joints with minimal penetration in the gap as well as differential settlement of pipes at joints with up to a 2" difference in elevation between the adjacent inverts. If not addressed, these routine repairs will not compromise the structural integrity of the culvert; however, delaying the repairs may result in additional damage and increased repair costs.

A summary of these recommendations is presented in Table E-1 with an Opinion of Probable Cost (OPC) for each repair recommendation. All costs associated with the OPC are in 2013 dollars a breakdown of each recommendation is included in Appendix B.

**TABLE E-1**

**SUMMARY OF OPINION OF PROBABLE COST**

| Recommendation | Opinion of Probable Cost |
|---|---|
| Priority Repair Actions | Option 1: $21,875<br>Option 2: $53,859 |
| Routine Repair Actions | $37,500 |
| Routine Maintenance Cleaning of Culvert and Sediment Removal including Mobilization | $81,109 |

# 1. SCOPE OF WORK AND INSPECTION PROCEDURE

## 1.1. Scope of Work

During October 2013, Moffatt & Nichol performed a baseline condition assessment of the stormwater drainage culvert from the underground junction box near the intersection of Olney Road and Duke Street to Smith Creek, a tributary of the Elizabeth River.

The condition assessment included a 100% visual and minimum 10% hands-on inspection of all accessible portions of the north and south barrels of the culvert. The hands-on inspection included selective cleaning and sounding of the concrete with a masonry hammer to identify soundness of the concrete and potential interior spalls. In addition, sediment accumulation measurements were taken at variable intervals within the culvert and at the mouth of the culvert.

This report provides an overall condition rating of the structure as assigned by the American Society of Civil Engineers (ASCE) Manuals and Reports on Engineering Practice No. 101. M&N has also included general repair recommendations and additional inspection and maintenance recommendations based on the deficiencies identified during the inspection.

## 1.2. Structure Description

The Chrysler Museum Culvert is approximately 600 LF in length and consists of two (2) circular precast reinforced concrete pipes. The north and south barrels are approximately 72" in diameter. No as-builts or construction drawings of the culvert were available from the City of Norfolk; therefore, all culvert drawings and descriptions in this report are shown as accurately as possible based on approximate field measurements.

## 1.3. Inspection Procedure

### 1.3.1. Surface Supplied Air Underwater Diving

On October 15th and 16th, M&N performed an underwater inspection of the culverts in accordance with Association of Diving Contractors International (ADCI) and EM-385-1-1 requirements. The inspection was performed utilizing surface-supplied air diving equipment. The team consisted of four Professional Engineer-Divers and one additional engineer diver. The five divers on-site were responsible for the following tasks:

- Diver 1 – responsible for completing the inspection.
- Diver 2 – located at the opening of the pipe culvert and assisted with tending Diver 1 while also acting as the rescue diver.
- Diver 3 – located on topside and responsible for tending Diver 2.
- Diver 4 – located on topside and responsible for assisting Diver 3 and considered back-up diver for Diver 1 if required.

- Diver 5 – located on topside and considered Dive Supervisor and responsible for Divers 1-4 health and safety.

All diving was completed with hard-wire communications and was staged from land via a dive truck and dive station. An underwater inspection was required because head clearance during low tidal periods was insufficient for use of confined space gear. Access to the structure was obtained through the pipe outfalls at Smith Creek and through a manhole over an underground junction box near the intersection of Olney Road and Duke Street.

## 1.4. Condition Assessment Rating Systems

### 1.4.1. Structure Condition Rating

The overall rating of the structure is based on the condition assessment rating system defined in the ASCE Manuals and Reports on Engineering Practice No. 101 "Underwater Investigations Standard Practice Manual". A description of each applicable rating condition is provided below. It should be noted that only one rating condition applies to the overall structure of the Chrysler Museum Culvert. The Chrysler Museum Culvert based on the assessment rating below is considered to be in **FAIR** condition.

**Good** No visible damage or only minor damage is noted. Structural elements may show very minor deterioration, but no overstressing is observed. No repairs are required.

**Satisfactory** Limited minor to moderate defects or deterioration are observed, but no overstressing is observed. No repairs are required.

**Fair** All primary structural elements are sound, but minor to moderate defects or deterioration is observed. Localized areas of moderate to advance deterioration may be present but do not significantly reduce the load-bearing capacity of the structure. Repairs are recommended, but the priority of the recommended repairs is low.

**Poor** Advanced deterioration or overstressing is observed on widespread portions of the structure but does not significantly reduce the load-bearing capacity of the structure. Repairs may need to be carried out with moderate urgency.

**Serious** Advanced deterioration, overstressing, or breakage may have significantly affected the load-bearing capacity of the primary structural components. Local failures are possible and loading restrictions may be necessary. Repairs may need to be carried out on a high-priority basis with urgency.

**Critical** Very advanced deterioration, overstressing, or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur, and load restrictions should be implemented as necessary. Repairs may need to be carried out on a very high priority basis with strong urgency.

### 1.4.2. General Repair/Action Recommendations

Repair recommendations are typically provided following an inspection in order to determine the order of magnitude for cost estimates. General actions for noted deficiencies are broken down into three groups and are presented below.

**Priority** — Priority actions are required to maintain the structure in a safe operating condition, and/or prevent deterioration from continuing to a point where the future repairs will be significantly more costly.

**Routine** — Routine actions are required for conditions requiring further investigation or remedial work, which can be undertaken as part of a scheduled maintenance program, other scheduled project, or routine facility maintenance, depending on the action required.

**No Action** — Recommended when no further action is necessary for the noted deficiency and will be re-evaluated at the next scheduled inspection.

In addition to the repair recommendations for noted deficiencies, other recommendations such as additional inspections or engineering analysis may be proposed. A description of each are provided below.

**Additional Inspection** — Additional inspection work should be recommended when more information is needed to better determine the overall structural condition, develop repair plans, or determine the cause of significance of non-typical deterioration.

**Engineering Analysis** — An engineering analysis should be recommended when damage or defects are encountered which require a structural investigation or evaluation to determine if repairs required and what method of repairs is appropriate.

# 2. DETAILED INSPECTION FINDINGS AND RECOMMENDATIONS

## 2.1. Inspection Findings

Overall, the Chrysler Museum Culvert is in **FAIR** condition. The priority and routine repairs are identified in the report for action to prevent further deterioration and to restore the culvert to **SATISFACTORY** condition. Approximately 5" diameter holes were found in the top of the concrete pipes at the mid-span of several pipes. The holes were sealed on the exterior of the pipe and appeared to be in good condition without allowing sediment to enter the pipe. These holes were likely used for installation purposes and are not a structural concern. A typical hole is shown in Photo No. 11 in Appendix A. Sediment accumulation was also measured at various locations within the culvert. Typical sedimentation depths are summarized in Table 2-1. There was approximately 82 cubic yards (CY) of sediment in the South Barrel and 317 CY in the North Barrel.

**TABLE 2-1**

**DEPTH OF SEDIMENT IN BARRELS**

| Station Range | Depth of Sediment |
|---|---|
| **North Barrel:** | |
| STA 0+00 to 6+06 | 3'-0" |
| **South Barrel:** | |
| STA 0+00 to 2+10 | 6" |
| STA 2+10 to 2+15 | 3'-0" |
| STA 2+15 to 2+90 | 6" |
| STA 2+90 to 3+10 | 1'-0" |
| STA 3+10 to 3+50 | 2'-0" |
| STA 3+50 to 3+70 | 1'-0" |
| STA 3+70 to 4+80 | 2'-0" |
| STA 4+80 to 5+10 | 0" |
| STA 5+10 to 5+60 | 2'-0" |
| STA 5+60 to 6+06 | 6" |

Noted deficiencies and general observations are provided in Figure C-1 through C-4 of Appendix C. These figures provide a general alignment of the culvert, locations of associated manholes and also include station locations and observations noted during the inspection. Photographs of these deficiencies and other general observations are provided in Appendix A.

## 2.2. Recommendations

M&N has identified three priority repair recommendations, two of which are near the pipe outfalls to Smith Creek. Priority repair actions should take precedence over all other repairs and are needed to prevent further deterioration and more significant future repairs. In addition to the priority actions, M&N has also identified one (1) routine repair recommendation in the North Barrel and seven (7) routine repair recommendations in the South Barrel. The routine repair recommendations typically consist of gaps up to 3" wide at pipe joints with minimal penetration in the gap as well as differential settlement of pipes at joints with up to a 2" difference in elevation between the adjacent inverts. If not addressed, these routine repairs will not compromise the structural integrity of the culvert; however, delaying the repairs may result in additional damage and increased repair costs.

M&N recommends the City setup a routine maintenance contract for sediment removal from the culvert barrels. There was approximately 82 cubic yards (CY) of sediment in the South Barrel and 317 CY in the North Barrel. This routine maintenance dredging/cleaning will help restore the hydraulic capacity of the culvert and may mitigate localized flooding in this area.

Table 2-2 and Table 2-3 below provide the location, station, current condition and repair recommendation for the identified priority and routine repairs associated with the culvert. A cost estimate for these identified repair actions is presented in Appendix B.

## TABLE 2-2

## PRIORITY LEVEL RECOMMENDATIONS

| DEFECT NUMBER | STATION | OBSERVED DEFICIENCY | RECOMMENDATION | PHOTO NUMBER |
|---|---|---|---|---|
| N2 | 0+16 N | The upstream pipe invert at the joint is 4" lower than the downstream. Penetration up to 8" was achieved in the gap. The differential settlement of the pipes at this joint has allowed soil to infiltrate, resulting in a void adjacent to and above the barrel. Evidence of this void can be seen from the topside where excessive settlement and cracking was noted in the sidewalk and a 2'-6" diameter x 1" deep sinkhole was noted in the roadway adjacent to the sidewalk. | Option 1*: Repair joint from inside of pipe by applying a joint filler or approved underwater grout.<br><br>Option 2: Demolish roadway and sidewalk over joint, excavate down to joint, re-set both pipes for proper alignment and re-seal joint. | Topside: 4-6 |
| S2 | 0+16 S | There is a 4" gap between the pipes at the joint location. Penetration up to 3" was achieved in the gap. The gap between the pipes at this joint has allowed soil to infiltrate, resulting in a void adjacent to and above the barrel. Evidence of this void can be seen from the topside where excessive settlement and cracking was noted in the sidewalk and a 2'-6" diameter x 1" deep sinkhole was noted in the roadway adjacent to the sidewalk. | Option 1*: Repair joint from inside of pipe by applying a joint filler or approved underwater grout.<br><br>Option 2: Demolish roadway and sidewalk over joint, excavate down to joint, re-set both pipes for proper alignment and re-seal joint. | Topside: 4-6<br><br>Culvert: 13 |
| S22 | 5+98 S | The downstream pipe invert at the joint is 4" lower than the upstream. Penetration up to 12" was achieved in the gap. The differential settlement of the pipes at this joint has allowed soil to infiltrate, resulting in a void adjacent to and above the barrel. No signs of a sinkhole were noted on the lawn above. | Option 1*: Repair joint from inside of pipe by applying a joint filler or approved underwater grout.<br><br>Option 2: Excavate down to joint, re-set both pipes for proper alignment and re-seal joint. | 17-18 |

***Option 1 does not address differential settlement or voids adjacent to culvert. This repair option only limits the amount of future soil infiltration.**

## TABLE 2-3

## ROUTINE LEVEL RECOMMENDATIONS

| DEFECT NUMBER | STATION | OBSERVED DEFICIENCY | RECOMMENDATION | PHOTO NUMBER |
|---|---|---|---|---|
| N14 | 6+02 N | There is a 1" gap between the pipes at the joint. Penetration up to 5" was achieved in the gap. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | N/A |
| S3 | 0+24 S | There is a 3" gap between the pipes at the bottom of the joint. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | N/A |
| S4 | 0+32 S | There is a 1-1/2" gap between the pipes at the joint. The downstream pipe invert at the joint is 1" lower than the upstream. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | 14 |
| S5 | 0+40 S | There is a 2" gap between the pipes at the top of the joint. The downstream pipe invert at the joint is 1" lower than the upstream. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | 15 |
| S7 | 0+56 S | There is a 2" gap between the pipes at the top of the joint. The downstream pipe invert at the joint is 1" lower than the upstream. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | 16 |
| S18 | 5+66 S | There is a 1-1/2" gap between the pipes at the joint on the west side. Penetration up to 3" was achieved in the gap. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | N/A |
| S20 | 5+82 S | The upstream pipe invert at the joint is 2" lower than the downstream. Penetration up to 6" was achieved in the gap. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | N/A |
| S21 | 5+90 S | There is a 3" gap between the pipes at the bottom of the joint with missing joint filler and a 1/2" gap on the side walls. | Repair joint from inside of pipe by applying a joint filler or approved underwater grout. | N/A |

# Appendix A: Culvert Inspection Photos

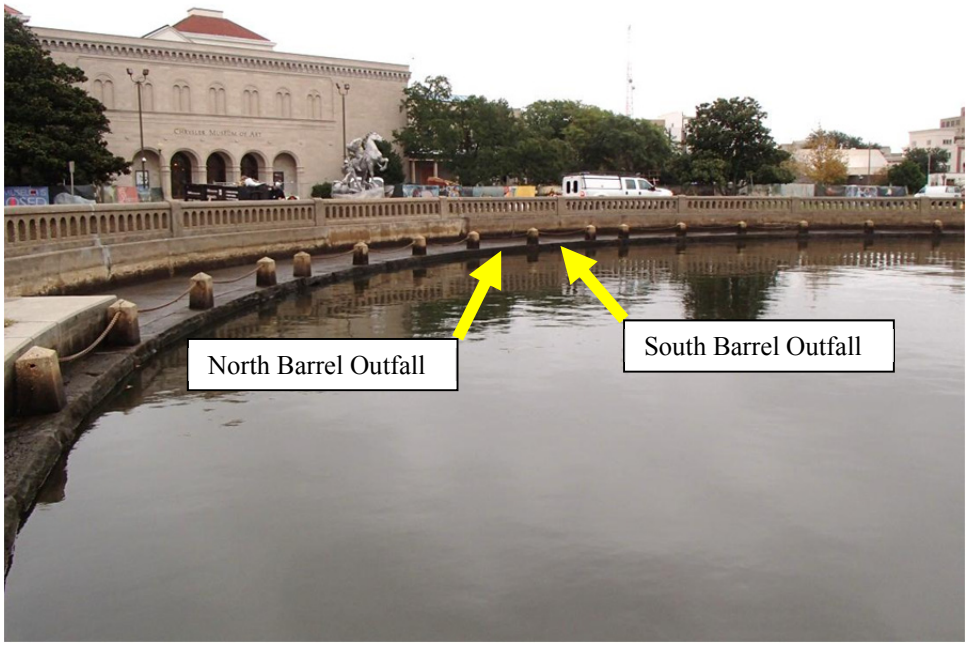


**Photo No.:** 1

**Location:**

Looking east at North and South Barrel outfalls that flow into Smith Creek on the southwest side of the Chrysler Museum

**Description:**

Outfall locations for 72" diameter circular concrete barrels

**No Action**

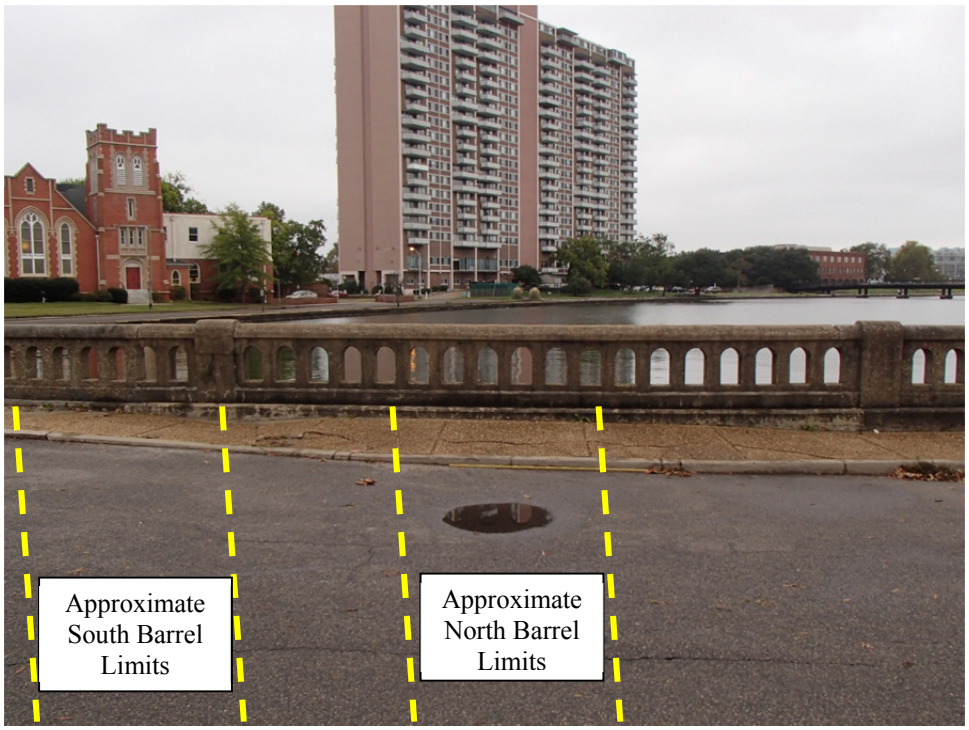


**Photo No.:** 2

**Location:**

Looking southwest at street level over North and South Barrels

**Description:**

Outfall locations for 72" diameter circular concrete barrels

**No Action**


**Photo No.:** 3

**Location:**

Looking northwest at street level above North and South Barrels

**Description:**

Street level above North and South Barrels

**No Action**

**Photo No.:** 4

**Location:**

Looking southeast at sidewalk above culverts

**Description:**

Excessive settlement and cracking in sidewalk above culvert

**Priority Repair**

**Photo No.:** 5

**Location:**

Looking southeast at sidewalk above culverts between North and South Barrels

**Description:**

Excessive settlement and cracking in sidewalk above culvert

**Priority Repair**

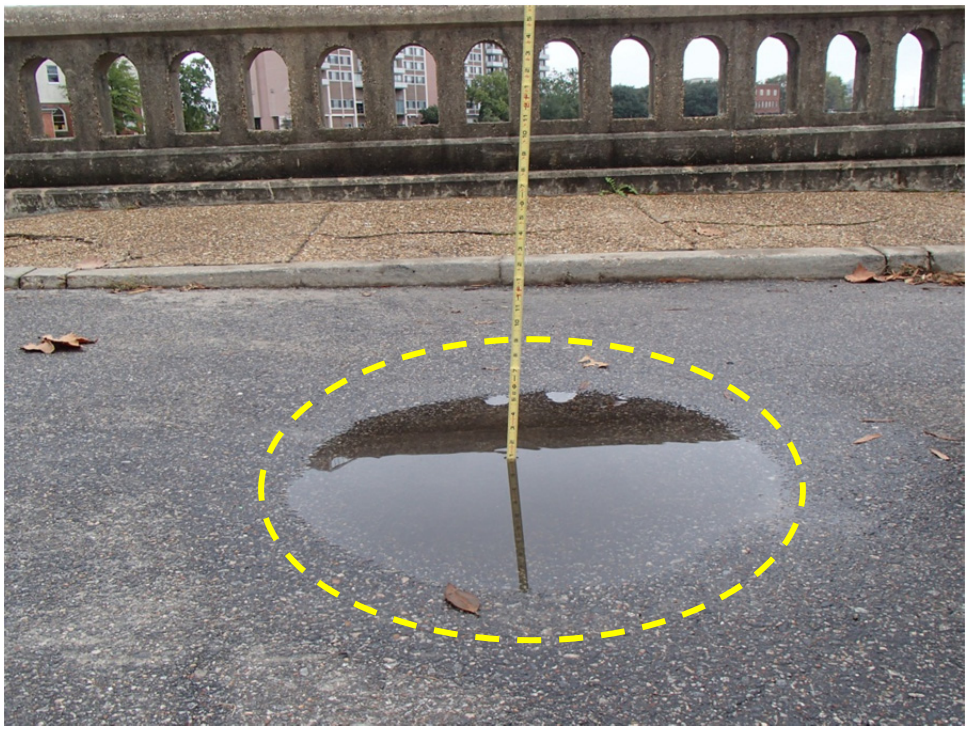

**Photo No.:** 6

**Location:**

Looking southwest at roadway above North Barrel at STA 0+16 N

**Description:**

2'-6" diameter x 1" deep sinkhole in roadway above North Barrel

**Priority Repair**


**Photo No.:** 7

**Location:**

Looking northwest at 30” diameter manhole located on the lawn on the northeast side of the Chrysler Museum

**Description:**

30” diameter manhole used to access underground concrete junction box below

**No Action**

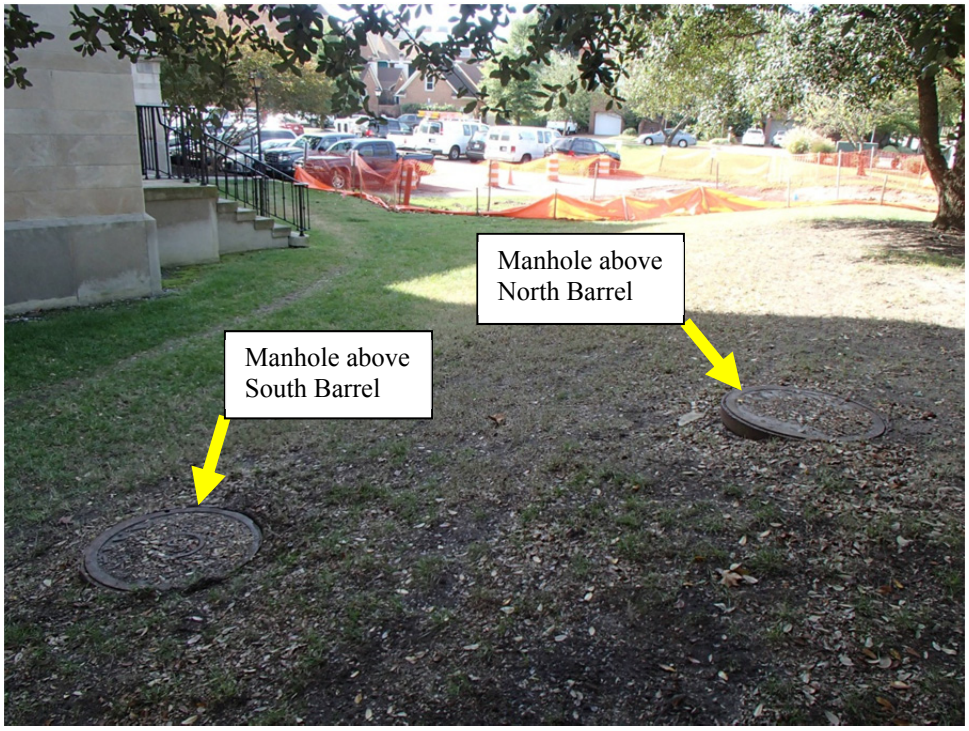


**Photo No.:** 8

**Location:**

Looking west at 30” diameter manholes located on the lawn on the north side of the Chrysler Museum at STA 5+20

**Description:**

Manholes used to access North and South Barrels

**No Action**

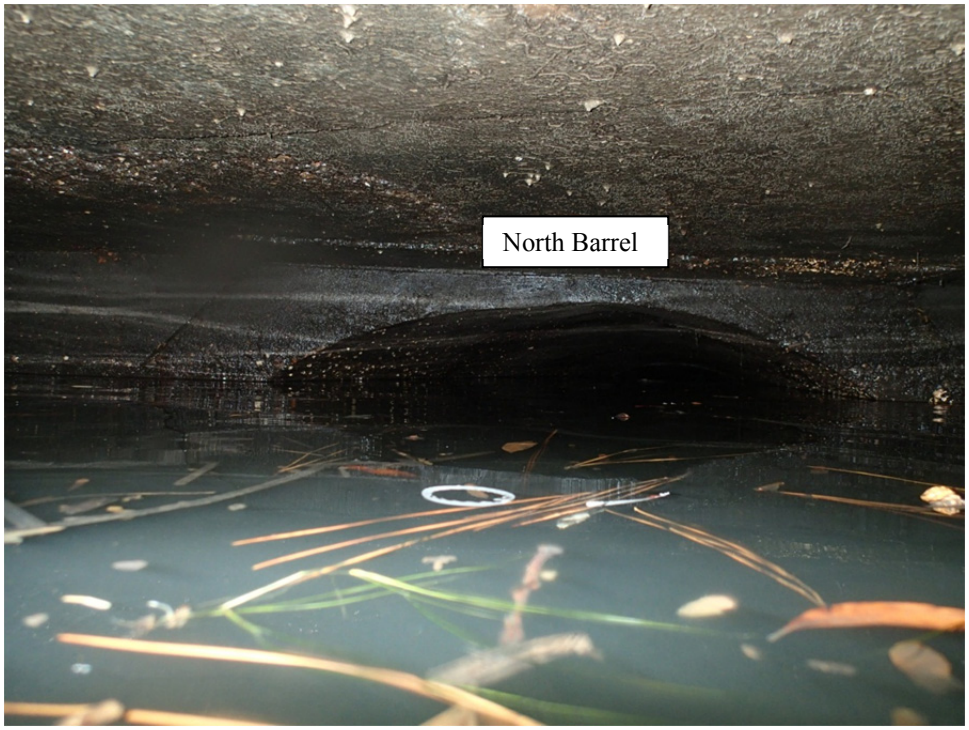


**Photo No.:** 9

**Location:**

Looking west (downstream) at North Barrel entrance from underground concrete junction box at STA 6+06 N

**Description:**

North Barrel entrance from underground junction box

**No Action**

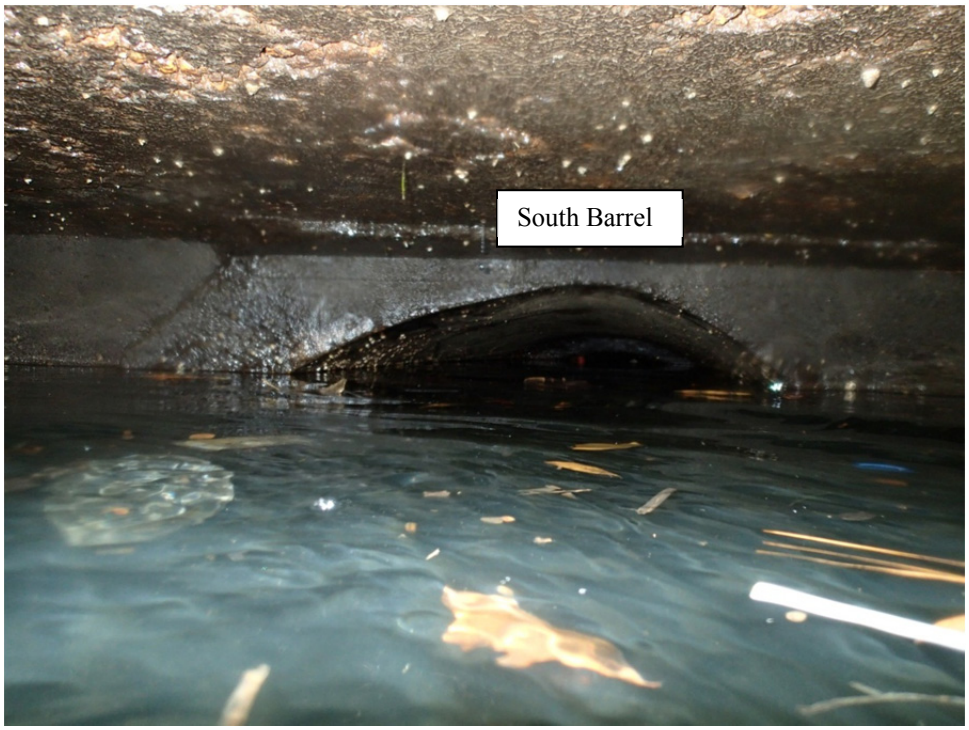


**Photo No.:** 10

**Location:**

Looking west (downstream) at South Barrel entrance from underground concrete junction box at STA 6+06 S

**Description:**

South Barrel entrance from underground junction box

**No Action**

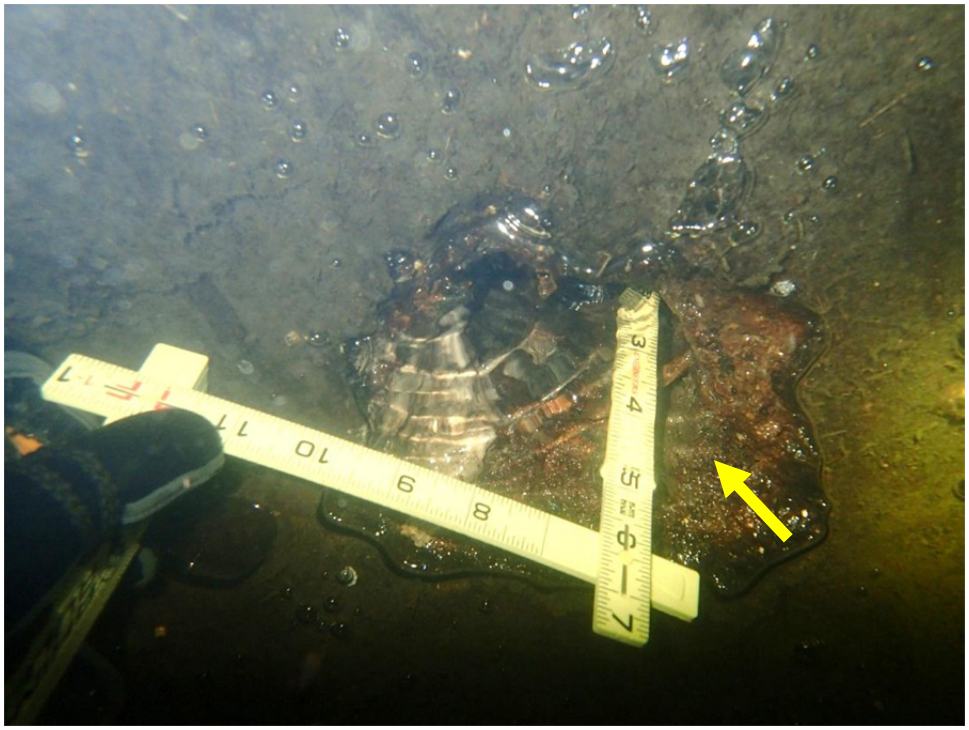

**Photo No.:** 11

**Location:**

South Barrel at STA 4+95 S

**Description:**

Typical 5” diameter hole in top of barrel at midspan. Hole is sealed on exterior of pipe and appeared to have been used for installation purposes. No signs of additional sediment.

**No Action**

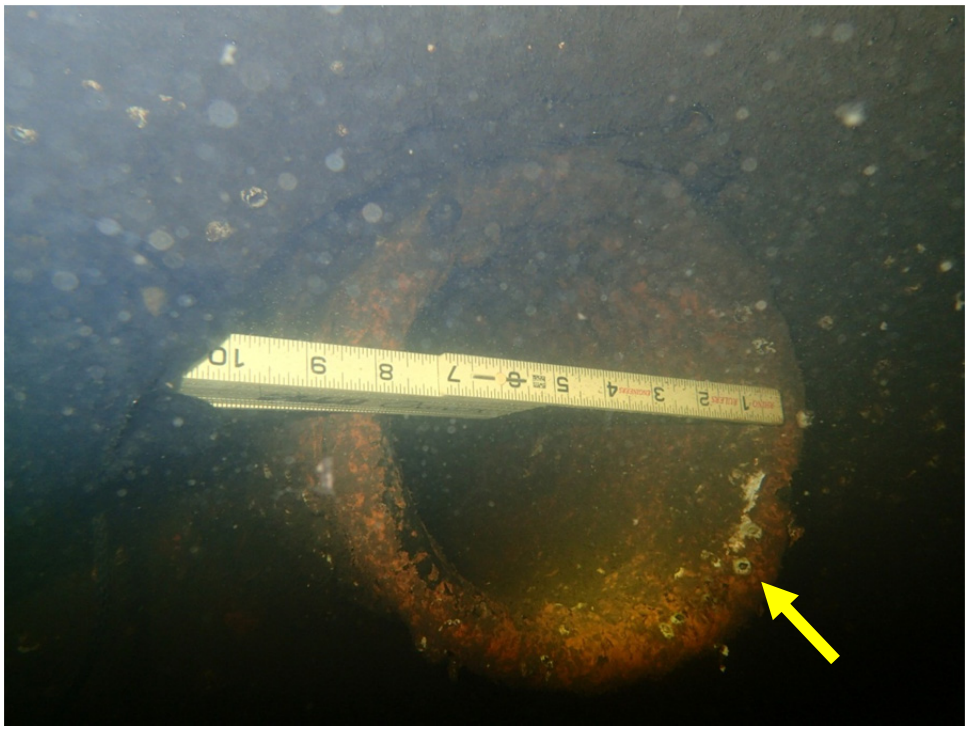

**Photo No.:** 12

**Location:**

Looking south in South Barrel at STA 5+05 S

**Description:**

8” diameter lateral ductile iron pipe that penetrates wall in South Barrel

**No Action**

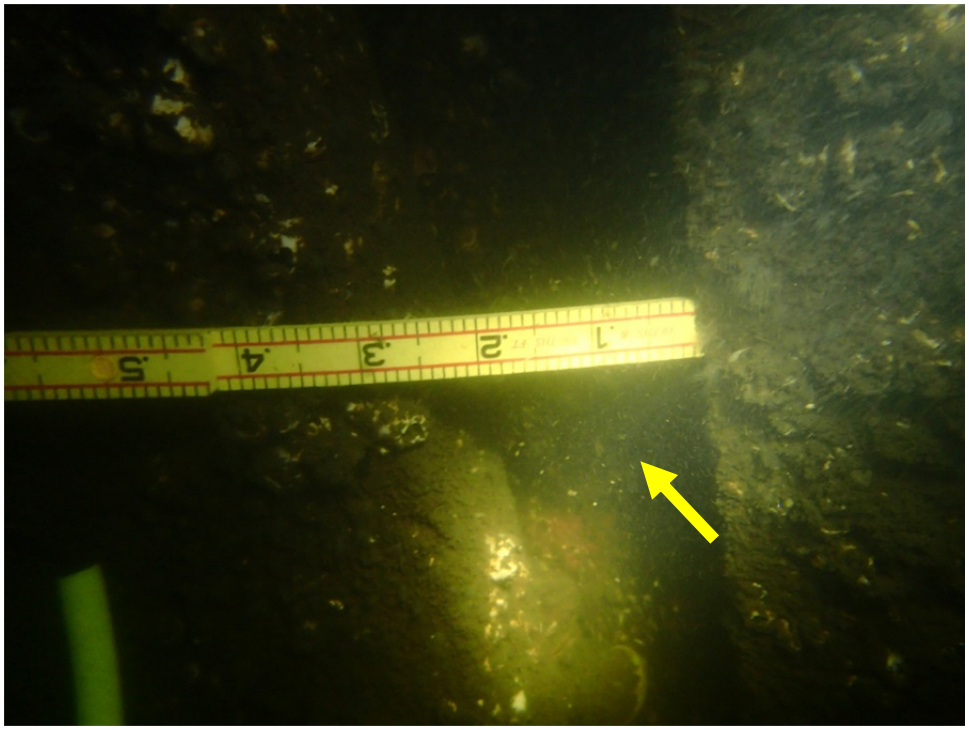

**Photo No.:** 13

**Location:**

South Barrel at STA 0+16 S

**Description:**
Defect S2: 4" gap between pipes at joint. Penetration up to 3" was achieved in gap. Gap has allowed soil to infiltrate. Evidence of loss of soil on topside in Photo 4-6.

**Priority Repair**

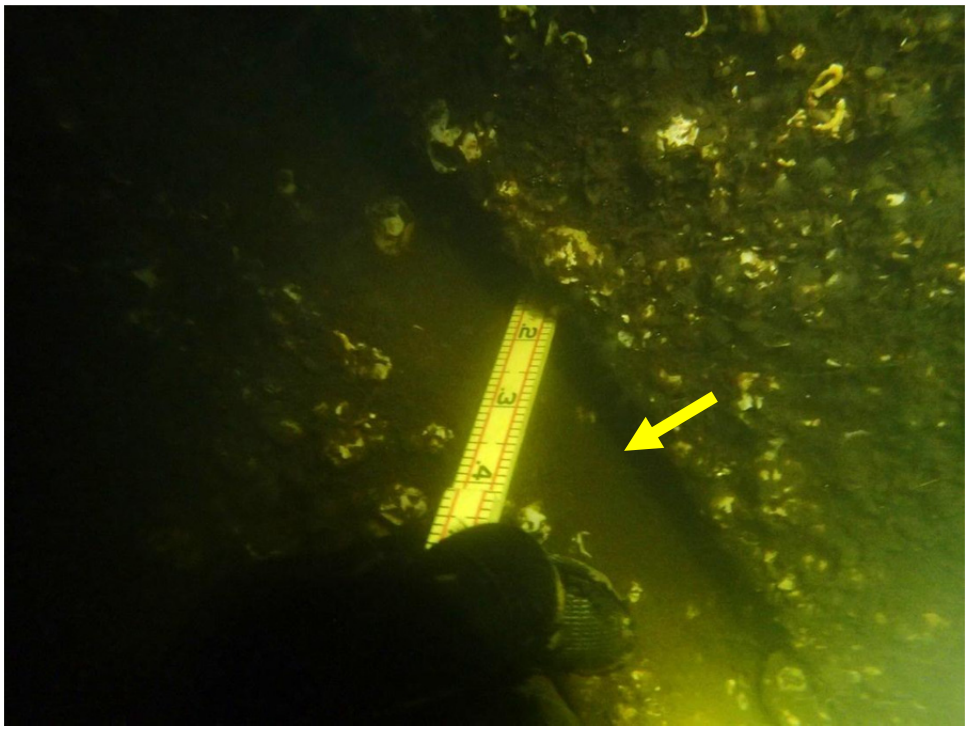

**Photo No.:** 14

**Location:**

South Barrel at STA 0+32 S

**Description:**

Defect S4: 1-1/2" gap between pipes at joint. Downstream pipe invert at joint is 1" lower than the upstream invert (not shown in photo).

**Routine Repair**

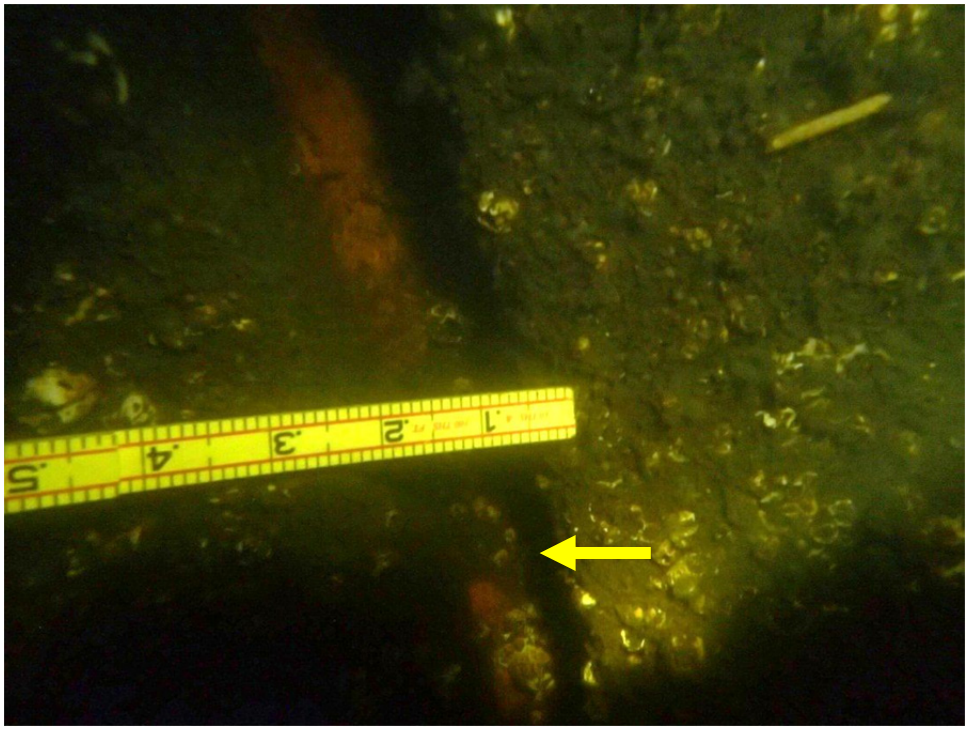

**Photo No.:** 15

**Location:**

South Barrel at STA 0+40 S

**Description:**

Defect S5: 2" gap between pipes at top of joint. Downstream pipe invert at joint is 1" lower than upstream invert (not shown in photo).

**Routine Repair**

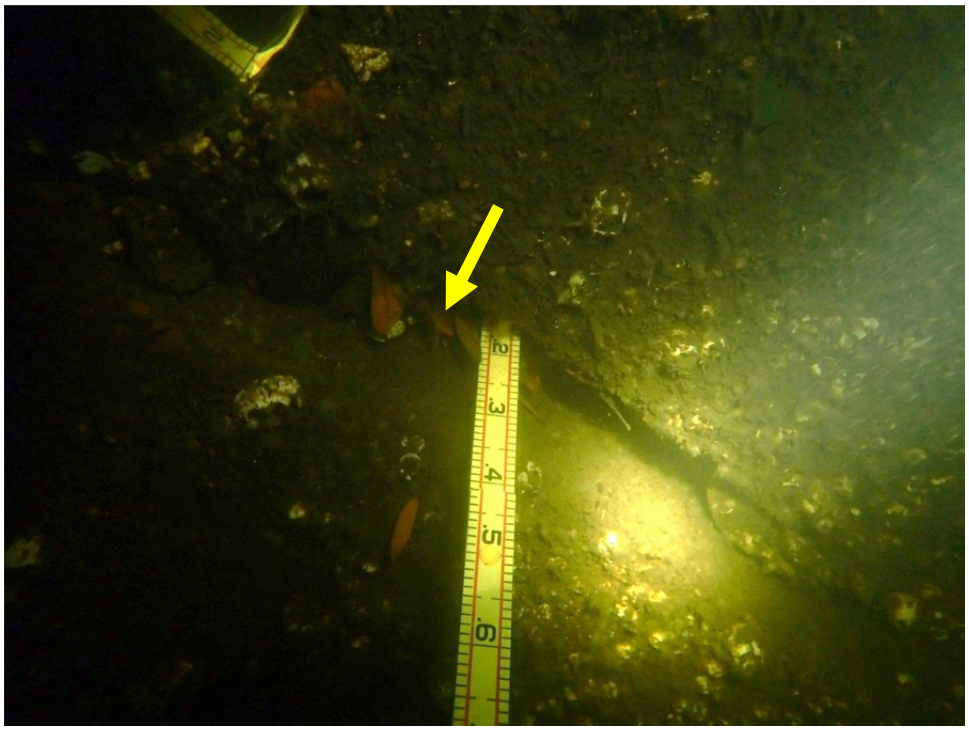

**Photo No.:** 16

**Location:**

South Barrel at STA 0+56 S

**Description:**

Defect S7: 2" gap between pipes at top of joint. Downstream pipe invert at joint is 1" lower than upstream invert (not shown in photo).

**Routine Repair**

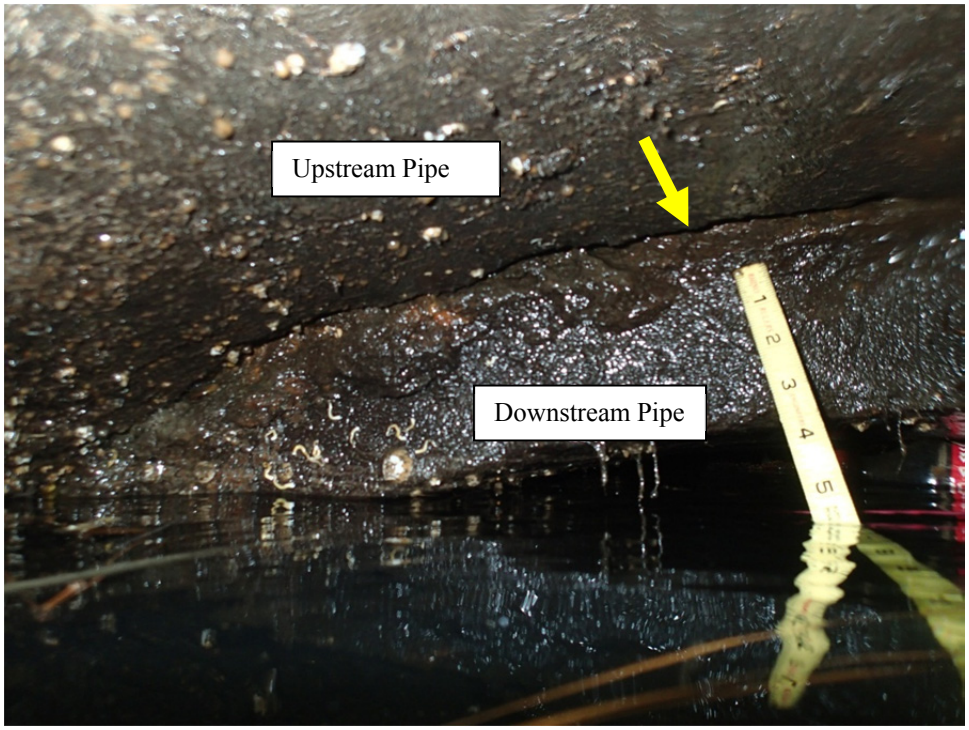


**Photo No.:** 17

**Location:**

South Barrel at STA 5+98 S

**Description:**

Defect S22: Downstream pipe invert at joint is 4" lower than upstream invert. Differential settlement has allowed soil to infiltrate resulting in a void around culvert.

**Priority Repair**

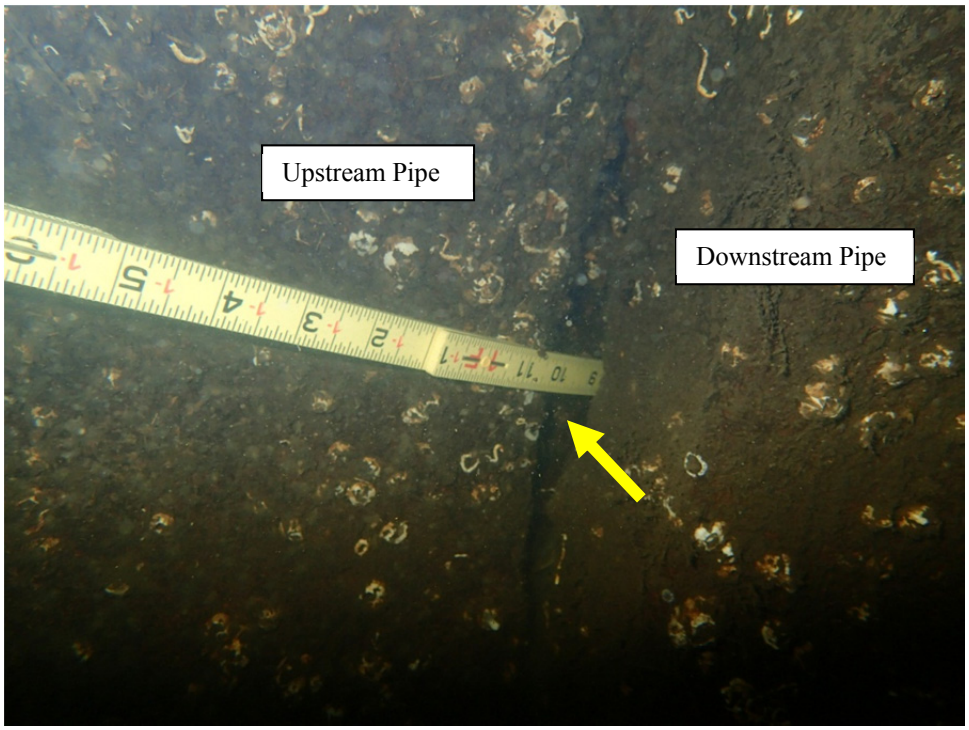


**Photo No.:** 18

**Location:**

South Barrel at STA 5+98 S

**Description:**

Defect S22: Penetration up to 12" deep was achieved in gap at pipe joint. Differential settlement has allowed soilt to infiltrate resulting in a void around culvert.

**Priority Repair**

# Appendix B: Opinion of Probable Cost

moffatt & nichol

Date: November 1, 2013



## OPINION OF PROBABLE COST - CHRYSLER MUSEUM CULVERT INSPECTION

| ITEM DESCRIPTION | QUANTITY NUMBER | QUANTITY UNIT | ENGINEERING ESTIMATE UNIT COST | ENGINEERING ESTIMATE TOTAL |
|---|---|---|---|---|
| **PRIORITY RECOMMENDATIONS FOR CHRYSLER MUSEUM CULVERT (OPTION 1)** | | | | |
| ***Mobilization for Priority Repairs*** | 1 | LS | $2,500.00 | $2,500 |
| ***Additional Labor Working Around Tide cycles*** | 1 | LS | $5,000.00 | $5,000 |
| ***Traffic Control (Option 1)*** | 1 | LS | $2,500.00 | $2,500 |
| | | | | |
| ***North Barrel Defect N2 - Station 0+16 N*** | | | | |
| ***Option 1:*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S2 - Station 0+16 S*** | | | | |
| ***Option 1:*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S22 - Station 5+98 S*** | | | | |
| ***Option 1:*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| Subtotal for Priority Recommendations (Option 1) | | | | $17,500 |
| Contingency | 25% | | | $4,375 |
| | | | | |
| **TOTAL FOR PRIORITY RECOMMENDATIONS (OPTION 1)** | | | | **$21,875** |

moffatt & nichol

Date: November 1, 2013



## OPINION OF PROBABLE COST - CHRYSLER MUSEUM CULVERT INSPECTION

| ITEM DESCRIPTION | QUANTITY NUMBER | QUANTITY UNIT | ENGINEERING ESTIMATE UNIT COST | ENGINEERING ESTIMATE TOTAL |
|---|---|---|---|---|
| **PRIORITY RECOMMENDATIONS FOR CHRYSLER MUSEUM CULVERT (OPTION 2)** | | | | |
| ***Mobilization for Priority Repairs*** | 1 | LS | $2,500.00 | $2,500 |
| ***Additional Labor Working Around Tide cycles*** | 1 | LS | $5,000.00 | $5,000 |
| ***Traffic Control (Option 2)*** | 1 | LS | $10,000.00 | $10,000 |
| | | | | |
| ***North Barrel Defect N2 - Station 0+16 N*** | | | | |
| ***Option 2:*** | | | | |
| - Pavement Demolition | 100 | SF | $3.00 | $300 |
| - Sidewalk Demolition | 75 | SF | $1.50 | $113 |
| - Curb & Gutter Demolition | 15 | LF | $6.00 | $90 |
| - Excavation | 32 | CY | $27.00 | $875 |
| - Re-set Both Pipes at Joint for Proper Alignment | 1 | LS | $3,000.00 | $3,000 |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,000.00 | $2,000 |
| - Backfill - #57 Stone | 32 | CY | $32.00 | $1,037 |
| - Pavement | 4 | Tons | $95.00 | $344 |
| - New Sidewalk | 75 | SF | $4.00 | $300 |
| - New Curb & Gutter | 15 | LF | $28.00 | $420 |
| | | | | |
| ***South Barrel Defect S2 - Station 0+16 S*** | | | | |
| ***Option 2:*** | | | | |
| - Pavement Demolition | 100 | SF | $3.00 | $300 |
| - Sidewalk Demolition | 75 | SF | $1.50 | $113 |
| - Curb & Gutter Demolition | 15 | LF | $6.00 | $90 |
| - Excavation | 32 | CY | $27.00 | $875 |
| - Re-set Both Pipes at Joint for Proper Alignment | 1 | LS | $3,000.00 | $3,000 |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,000.00 | $2,000 |
| - Backfill - #57 Stone | 32 | CY | $32.00 | $1,037 |
| - Pavement | 4 | Tons | $95.00 | $344 |
| - New Sidewalk | 75 | SF | $4.00 | $300 |
| - New Curb & Gutter | 15 | LF | $28.00 | $420 |
| | | | | |
| ***South Barrel Defect S22 - Station 5+98 S*** | | | | |
| ***Option 2:*** | | | | |
| - Excavation | 59 | CY | $27.00 | $1,600 |
| - Re-set Both Pipes at Joint for Proper Alignment | 1 | LS | $3,000.00 | $3,000 |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,000.00 | $2,000 |
| - Backfill - #57 Stone | 59 | CY | $32.00 | $1,896 |
| - Grading & Grass | 22 | SY | $6.00 | $133 |
| | | | | |
| Subtotal for Priority Recommendations (Option 2) | | | | $43,087 |
| Contingency | 25% | | | $10,772 |
| | | | | |
| **TOTAL FOR PRIORITY RECOMMENDATIONS (OPTION 2)** | | | | **$53,859** |

moffatt & nichol

Date: November 1, 2013



## OPINION OF PROBABLE COST - CHRYSLER MUSEUM CULVERT INSPECTION

| | QUANTITY | | ENGINEERING ESTIMATE | |
|---|---|---|---|---|
| ITEM DESCRIPTION | NUMBER | UNIT | UNIT COST | TOTAL |
| **ROUTINE RECOMMENDATIONS FOR CHRYSLER MUSEUM CULVERT** | | | | |
| ***Mobilization for Priority Repairs*** | 1 | LS | $2,500.00 | $2,500 |
| ***Additional Labor Working Around Tide cycles*** | 1 | LS | $5,000.00 | $5,000 |
| ***Traffic Control*** | 1 | LS | $2,500.00 | $2,500 |
| | | | | |
| ***North Barrel Defect N14 - Station 6+02 N*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S3 - Station 0+24 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S4 - Station 0+32 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S5 - Station 0+40 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S7 - Station 0+56 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S18 - Station 5+66 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S20 - Station 5+82 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| ***South Barrel Defect S21 - Station 5+90 S*** | | | | |
| - Install Internal Joint Seal with Pipe Grout | 1 | EA | $2,500.00 | $2,500 |
| | | | | |
| Subtotal for Routine Recommendations | | | | $30,000 |
| Contingency | 25% | | | $7,500 |
| | | | | |
| **TOTAL FOR ROUTINE RECOMMENDATIONS** | | | | **$37,500** |

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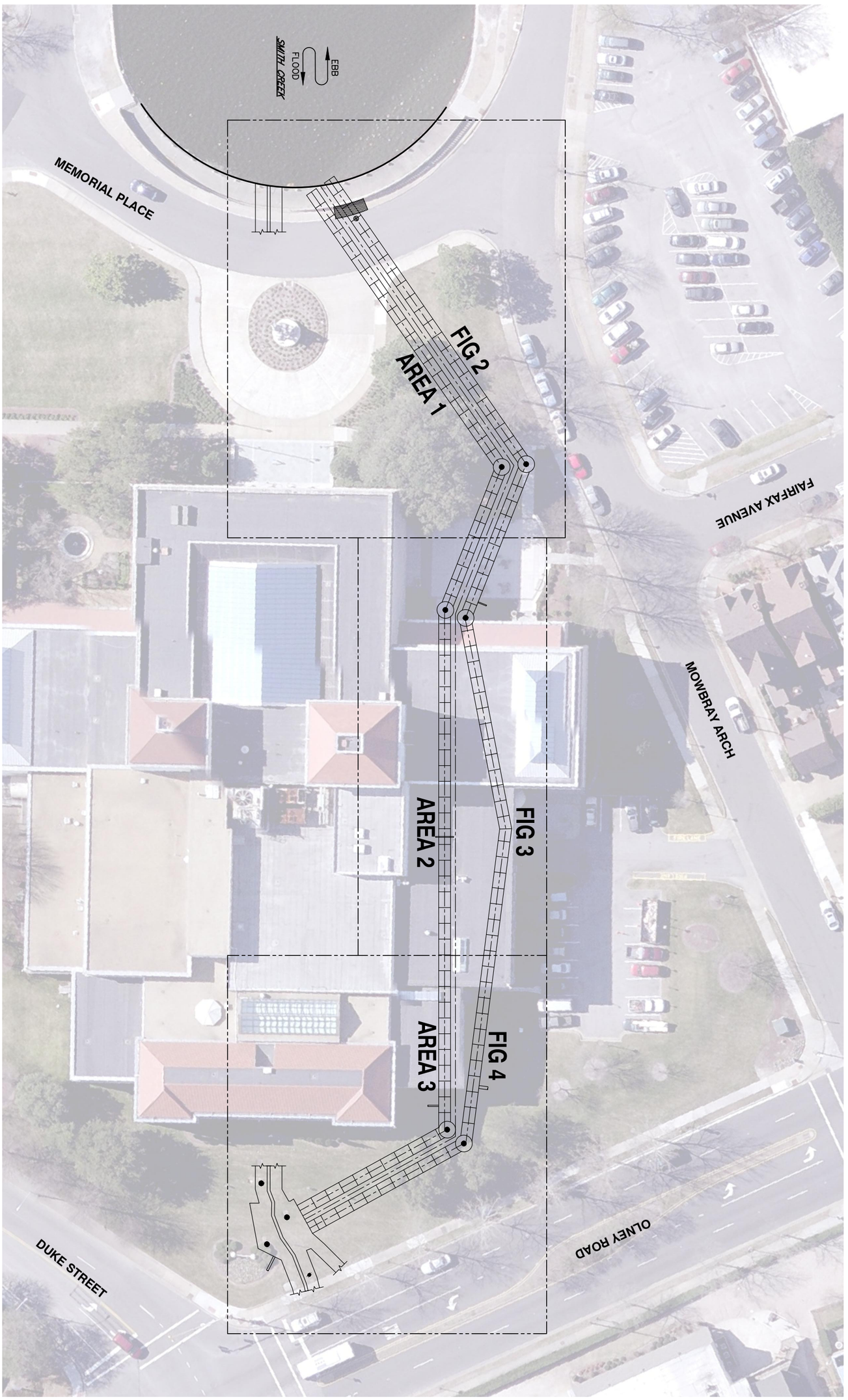
Date: November 1, 2013



## OPINION OF PROBABLE COST - CHRYSLER MUSEUM CULVERT INSPECTION

| | QUANTITY | | ENGINEERING ESTIMATE | |
|---|---|---|---|---|
| ITEM DESCRIPTION | NUMBER | UNIT | UNIT COST | TOTAL |
| | | | | |
| | | | | |
| **ROUTINE MAINTENANCE CLEANING AND SEDIMENT REMOVAL** | | | | |
| ***Mobilization for Culvert Cleaning*** | 1 | LS | $20,000.00 | $20,000 |
| | | | | |
| ***North Barrel Cleaning*** | | | | |
| - Sediment Removal (Approx. 3'-0" Deep) | 317 | CY | $87.50 | $27,738 |
| - Disposal Fee | 317 | CY | $25.00 | $7,925 |
| | | | | |
| ***South Barrel Cleaning*** | | | | |
| - Sediment Removal (Depth Varies 6" to 3'-0" Deep) | 82 | CY | $87.50 | $7,175 |
| - Disposal Fee | 82 | CY | $25.00 | $2,050 |
| | | | | |
| Subtotal for Culvert Cleaning | | | | $64,888 |
| Contingency | 25% | | | $16,222 |
| | | | | |
| **TOTAL FOR ROUTINE MAINTENANCE CLEANING & SEDIMENT REMOVAL** | | | | **$81,109** |

# Appendix C: Chrysler Museum Culvert Inspection Drawings




# CHRYSLER MUSEUM CULVERT INSPECTION

FIGURE C-1 – OVERALL CULVERT PLAN

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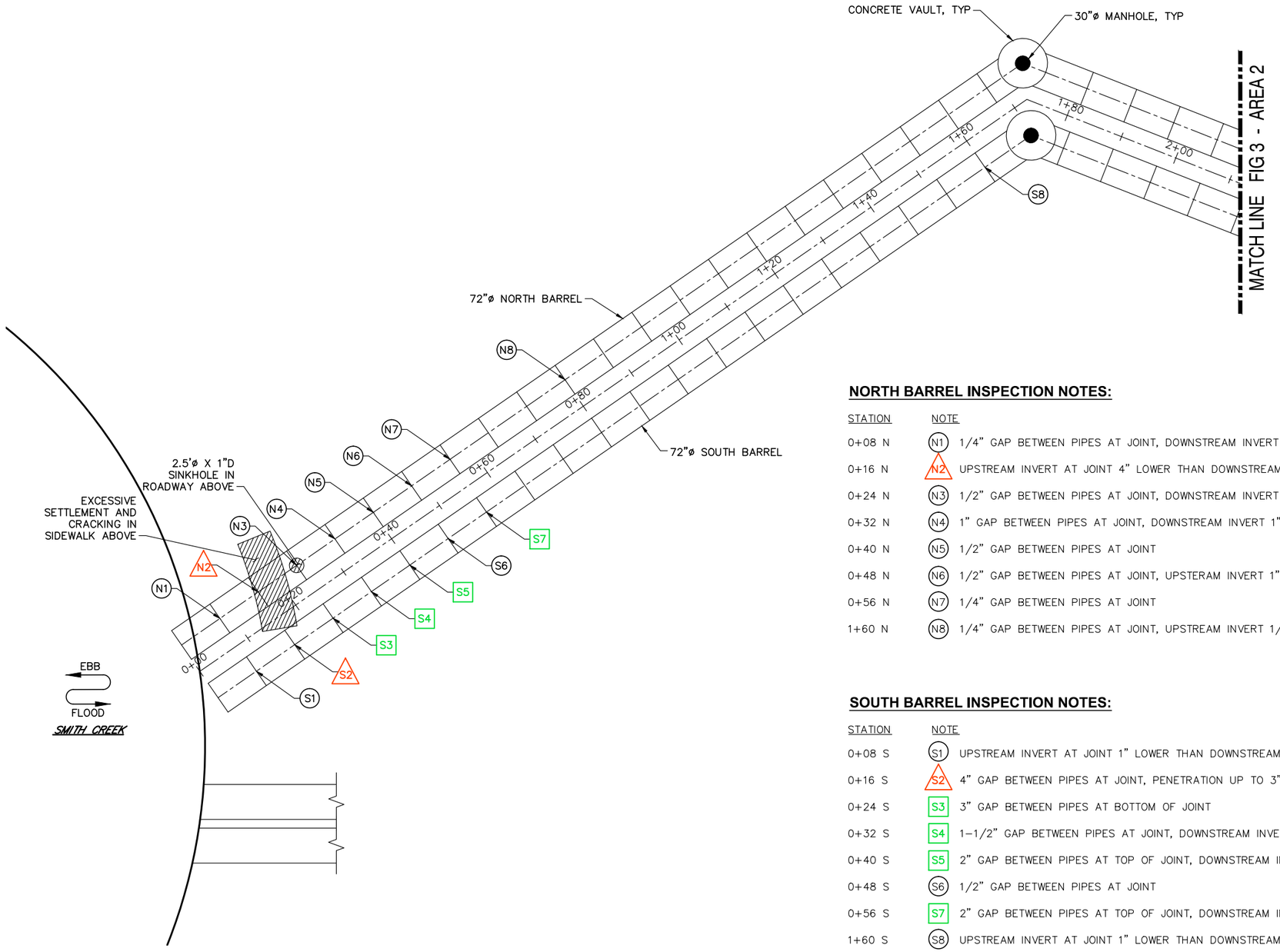


## NORTH BARREL INSPECTION NOTES:

| STATION | NOTE | |
|---|---|---|
| 0+08 N | N1 | 1/4" GAP BETWEEN PIPES AT JOINT, DOWNSTREAM INVERT 1/2" LOWER THAN UPSTREAM |
| 0+16 N | N2 | UPSTREAM INVERT AT JOINT 4" LOWER THAN DOWNSTREAM, PENETRATION UP TO 8" DEEP |
| 0+24 N | N3 | 1/2" GAP BETWEEN PIPES AT JOINT, DOWNSTREAM INVERT 1/2" LOWER THAN UPSTREAM |
| 0+32 N | N4 | 1" GAP BETWEEN PIPES AT JOINT, DOWNSTREAM INVERT 1" LOWER THAN UPSTREAM |
| 0+40 N | N5 | 1/2" GAP BETWEEN PIPES AT JOINT |
| 0+48 N | N6 | 1/2" GAP BETWEEN PIPES AT JOINT, UPSTERAM INVERT 1" LOWER THAN DOWNSTREAM |
| 0+56 N | N7 | 1/4" GAP BETWEEN PIPES AT JOINT |
| 1+60 N | N8 | 1/4" GAP BETWEEN PIPES AT JOINT, UPSTREAM INVERT 1/2" LOWER THAN DOWNSTREAM |

## SOUTH BARREL INSPECTION NOTES:

| STATION | NOTE | |
|---|---|---|
| 0+08 S | S1 | UPSTREAM INVERT AT JOINT 1" LOWER THAN DOWNSTREAM |
| 0+16 S | S2 | 4" GAP BETWEEN PIPES AT JOINT, PENETRATION UP TO 3" DEEP |
| 0+24 S | S3 | 3" GAP BETWEEN PIPES AT BOTTOM OF JOINT |
| 0+32 S | S4 | 1-1/2" GAP BETWEEN PIPES AT JOINT, DOWNSTREAM INVERT 1" LOWER THAN UPSTREAM |
| 0+40 S | S5 | 2" GAP BETWEEN PIPES AT TOP OF JOINT, DOWNSTREAM INVERT 1" LOWER THAN UPSTREAM |
| 0+48 S | S6 | 1/2" GAP BETWEEN PIPES AT JOINT |
| 0+56 S | S7 | 2" GAP BETWEEN PIPES AT TOP OF JOINT, DOWNSTREAM INVERT 1" LOWER THAN UPSTREAM |
| 1+60 S | S8 | UPSTREAM INVERT AT JOINT 1" LOWER THAN DOWNSTREAM |

## GENERAL NOTES:

1. CULVERT ALIGNMENT, MANHOLE LOCATIONS, AND DEFICIENCY LOCATIONS ARE APPROXIMATE. FIGURES ARE ONLY REPRESENTATIVE OF RELATIVE LOCATIONS. CITY OF NORFOLK GIS DATABASE (2009) WAS UTILIZED TO SHOW APPROXIMATE LOCATIONS OF CULVERT ALIGNMENT AND MANHOLE LOCATIONS.
2. SEDIMENT DEPTH VARIED BETWEEN 6" AND 2'-6" IN THE SOUTH BARREL AND WAS CONSISTENT AT A DEPTH OF 2'-6" IN THE NORTH BARREL. QUANTITY BREAKDOWNS ARE PRESENTED IN THE BODY OF THIS INSPECTION REPORT.

## REPAIR LEGEND:

- NO ACTION REQUIRED
- ROUTINE REPAIR
- PRIORITY REPAIR

N

10' 0' 10' 20'

SCALE: 1"=20'

# CHRYSLER MUSEUM CULVERT INSPECTION

FIGURE C-2 - CULVERT PLAN VIEW - AREA 1

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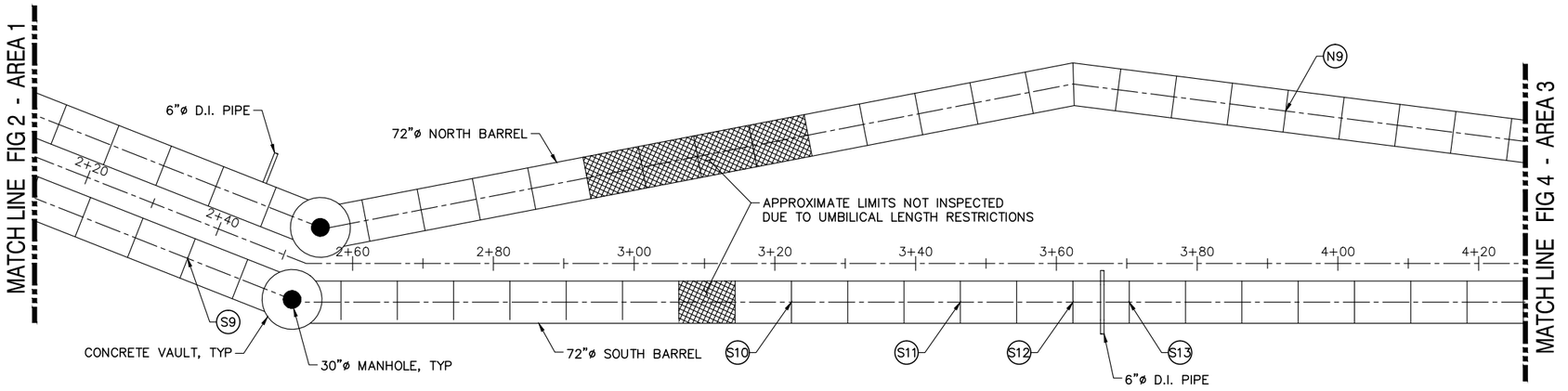


## NORTH BARREL INSPECTION NOTES:

| STATION | NOTE |
|---|---|
| 3+92 N | (N9) 1/4" GAP BETWEEN PIPES AT JOINT |

## SOUTH BARREL INSPECTION NOTES:

| STATION | NOTE |
|---|---|
| 2+38 S | (S9) UPSTREAM INVERT AT JOINT 1/2" LOWER THAN DOWNSTREAM |
| 3+22 S | (S10) UPSTREAM INVERT AT JOINT 1" LOWER THAN DOWNSTREAM |
| 3+46 S | (S11) UPSTREAM INVERT AT JOINT 1" LOWER THAN DOWNSTREAM |
| 3+62 S | (S12) UPSTREAM INVERT AT JOINT 1-1/2" LOWER THAN DOWNSTREAM |
| 3+70 S | (S13) UPSTREAM INVERT AT JOINT 1/2" LOWER THAN DOWNSTREAM |

## GENERAL NOTES:

1. CULVERT ALIGNMENT, MANHOLE LOCATIONS, AND DEFICIENCY LOCATIONS ARE APPROXIMATE. FIGURES ARE ONLY REPRESENTATIVE OF RELATIVE LOCATIONS. CITY OF NORFOLK GIS DATABASE (2009) WAS UTILIZED TO SHOW APPROXIMATE LOCATIONS OF CULVERT ALIGNMENT AND MANHOLE LOCATIONS.
2. SEDIMENT DEPTH VARIED BETWEEN 6" AND 2'-6" IN THE SOUTH BARREL AND WAS CONSISTENT AT A DEPTH OF 2'-6" IN THE NORTH BARREL. QUANTITY BREAKDOWNS ARE PRESENTED IN THE BODY OF THIS INSPECTION REPORT.
3. AT THE TIME OF THE INSPECTION, CONSTRUCTION TO EXTEND THE CHRYSLER MUSEUM WAS TAKING PLACE AT STA 2+50. THEREFORE, THE LOCATIONS OF THE MANHOLES AT THIS LOCATION COULD NOT BE VERIFIED BASED ON THE CITY OF NORFOLK GIS DATABASE (2009).

## REPAIR LEGEND:

- NO ACTION REQUIRED
- ROUTINE REPAIR
- PRIORITY REPAIR

N

10' 0' 10' 20'

SCALE: 1"=20'

# CHRYSLER MUSEUM CULVERT INSPECTION

FIGURE C-3 - CULVERT PLAN VIEW - AREA 2

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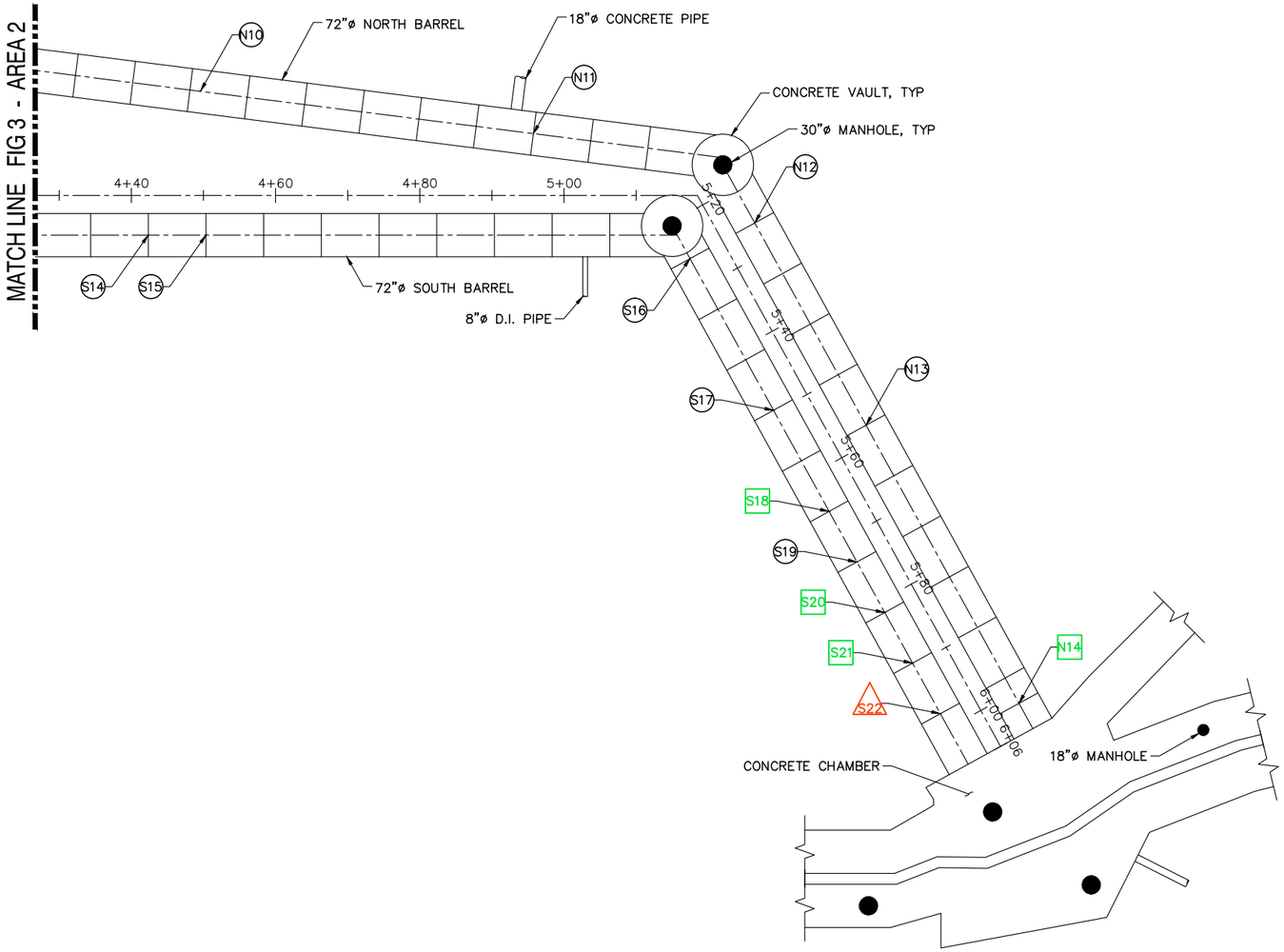


## NORTH BARREL INSPECTION NOTES:

| STATION | NOTE |
|---|---|
| 4+50 N | (N10) 13"ø OPENING IN TOP OF PIPE, PENETRATION UP TO 1' DEEP ABOVE, NO FILL PRESENT |
| 4+96 N | (N11) 1/4" GAP BETWEEN PIPES AT TOP OF JOINT, DOWNSTREAM INVERT 1" LOWER THAN UPSTREAM |
| 5+26 N | (N12) 1/2" GAP BETWEEN PIPES AT TOP OF JOINT |
| 5+58 N | (N13) 1" GAP BETWEEN PIPES AT TOP OF JOINT, UPSTREAM INVERT 1" LOWER THAN DOWNSTREAM |
| 6+02 N | [N14] 1" GAP BETWEEN PIPES AT JOINT, PENETRATION UP TO 5" DEEP |

## SOUTH BARREL INSPECTION NOTES:

| STATION | NOTE |
|---|---|
| 4+42 S | (S14) 1" GAP BETWEEN PIPES AT JOINT ON WEST SIDE, PENETRATION UP TO 3" DEEP, UPSTREAM INVERT 1" LOWER THAN DOWNSTREAM AT TOP OF JOINT |
| 4+50 S | (S15) 3/4" GAP BETWEEN PIPES AT TOP OF JOINT |
| 5+34 S | (S16) UPSTREAM INVERT 1" LOWER THAN DOWNSTREAM AT TOP OF JOINT |
| 5+50 S | (S17) UPSTREAM INVERT 1" LOWER THAN DOWNSTREAM AT JOINT |
| 5+66 S | [S18] 1-1/2" GAP BETWEEN PIPES AT JOINT ON WEST SIDE, PENETRATION UP TO 3" DEEP |
| 5+74 S | (S19) UPSTREAM INVERT 1" LOWER THAN DOWNSTREAM AT TOP OF JOINT |
| 5+82 S | [S20] UPSTREAM INVERT 2" LOWER THAN DOWNSTREAM AT JOINT, PENETRATION UP TO 6" DEEP |
| 5+90 S | [S21] 3" GAP BETWEEN PIPES AT BOTTOM OF JOINT WITH MISSING JOINT FILLER, ½" GAP ON SIDE WALLS |
| 5+98 S | <S22> DOWNSTREAM INVERT 4" LOWER THAN UPSTREAM AT JOINT, PENETRATION UP TO 1' DEEP |

## GENERAL NOTES:

1. CULVERT ALIGNMENT, MANHOLE LOCATIONS, AND DEFICIENCY LOCATIONS ARE APPROXIMATE. FIGURES ARE ONLY REPRESENTATIVE OF RELATIVE LOCATIONS. CITY OF NORFOLK GIS DATABASE (2009) WAS UTILIZED TO SHOW APPROXIMATE LOCATIONS OF CULVERT ALIGNMENT AND MANHOLE LOCATIONS.
2. SEDIMENT DEPTH VARIED BETWEEN 6" AND 2'-6" IN THE SOUTH BARREL AND WAS CONSISTENT AT A DEPTH OF 2'-6" IN THE NORTH BARREL. QUANTITY BREAKDOWNS ARE PRESENTED IN THE BODY OF THIS INSPECTION REPORT.

## REPAIR LEGEND:

- ◯ NO ACTION REQUIRED
- ▢ ROUTINE REPAIR
- △ PRIORITY REPAIR

N

10' 0' 10' 20'
SCALE: 1"=20'

CHRYSLER MUSEUM CULVERT INSPECTION

FIGURE C-4 – CULVERT PLAN VIEW – AREA 3

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