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Flagstone Culvert Investigation

Final Report
July 16, 2025

Prepared for:
Town Of Lyons
432 5th Ave
P.O Box 49
Lyons, Colorado 80540

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EXECUTIVE SUMMARY

We have completed our investigation of the two culverts that run north to south below grade in the Town of Lyons, Colorado, between 5th Avenue and 4th Avenue, from just north of the alley between Reese Street and Seward Street, at the north end, to the drive lane just north of Broadway, at the south end. The north culvert is approximately 300 feet long and the south culvert is approximately 1,100 feet long with a section of open channel separating the two culverts. The purpose of our investigation was to observe the existing conditions of the culverts, identify damaged areas and potentially hazardous conditions, and to provide recommendations and options for repairs to the culverts. Our work included existing document review, on-site investigations, evaluation of observed conditions, and development of repair options.

A majority of the culverts' construction typically consists of flagstone or concrete slab lids spanning to stacked stone masonry walls. At some locations, the flagstone lid was supported by steel framing. The floor of the culverts typically consists of laid stone or brick masonry of various quality. We observed silt, debris, and rubble throughout the culverts. Several areas of previous repairs and modifications were observed including localized lid replacement, shotcrete walls, and replacement of sections of culvert with precast box culvert. We observed and documented visible pipes, inlets, and other utilities within the culverts.

Overall, the culverts are in good to fair condition with some locations in poor condition. Observations of deterioration and distress have been grouped into areas of High, Medium, and Low Concern. High Concern indicates structural elements have failed or are at risk of failure and pose a potential life-safety concern. Medium Concern indicates structural elements in poor condition and no longer performing their intended purpose that may progress to High Concern if left unaddressed. Low Concern indicates structural elements in fair condition that are performing their intended purpose despite wear or deterioration.

We observed several locations with failed structural elements that we consider as potential life-safety hazards that should be addressed as High Concern actions. The locations and types of deterioration of these High Concern items are as follows:

- Fractured and failed flagstone lids at Stations (S)0+24 to (S)0+28, (S)1+47, (S)2+07, (S)2+43, (S)2+65, (S)2+70, (S)2+76, (S)6+16, and (S)7+15.
- Deteriorated steel framing supporting lids at Stations (S)7+04 to (S)7+07.
- Deteriorated concrete lids at Station (S)3+82.

We have presented repair options and cost estimates for work to be completed at areas noted as High Concern and Medium Concern. Repair options for High Concern items typically consist of excavating the damaged culvert lid, removing and replacing the lid with a new flagstone, reinforced concrete, or precast lid; and then backfilling and replacing landscaping or paving. These repair options vary in cost between $19,000 to $31,000 per location. At locations where excavation is not feasible and work must be performed from within the culvert, repair options include overhead concrete repairs, installing a reinforced concrete lid via shotcrete, or installing supplemental hot dipped galvanized steel framing. These repair options vary in cost between $20,000 to $39,000 per location.

We have also provided discussion of additional recommendations and modifications to improve the overall function of the culvert. Such options include establishing a regular maintenance program, installing a slip lining within the culvert, removing and replacing portions of the culvert, and converting sections of culvert into open channels via removal of the lid.

We appreciate this opportunity to be of service. Please contact us if you have any questions regarding this Report or if you require further assistance.

PURPOSE

We have completed our investigation of the two culverts that run north to south below grade in the Town of Lyons, Colorado, between 5th Avenue and 4th Avenue, from just north of the alley between Reese Street and Seward Street, at the north end, to the drive lane just north of Broadway, at the south end. The purpose of our investigation was to observe the existing conditions of the culverts, identify damaged areas and potentially hazardous conditions, and to provide recommendations and options for repairs to the culverts. Our work included existing document review, on-site investigations, evaluation of observed conditions, and development of repair options. We observed several issues that we considered as potential life-safety hazards that should be addressed as High Concern actions. We present our repair recommendations for work into three levels of concern based on the severity of the item.

BACKGROUND

The focus of our investigation was the two flagstone box culverts that run under a portion of the Town of Lyons, in Boulder County, Colorado. The south culvert is approximately 1,100 feet long and runs north to south below grade in Lyons, between 5th Avenue and 4th Avenue. It runs from the alley between Seward Street and Stickney Street, at the north end, to the drive lane just north of Broadway, at the south end, where it then discharges into a concrete elliptical storm sewer built by the Colorado Department of Transportation (CDOT) in the 1960s. The north culvert is approximately 300 feet long and runs north to south between 5th Avenue and 4th Avenue, from just north of the alley between Reese Street and Seward Street, at the north end, to just south of Seward Street, at the south end, where it discharges into an open channel that leads to the south culvert.

The original culverts are believed to have been built in the late 1800s to early 1900s. They run beneath streets, houses, yards, and businesses. The culverts have been repaired and modified in several areas throughout their life. In 2009, the section of the south culvert below Main Street was replaced with a precast concrete box culvert. Figure 1 and Figure 2 show plan views of the Town of Lyons, Colorado, with the inspected sections of culvert indicated on the maps. The stations indicated by “X+XX” on the plan indicate the distance in feet from the north end of each culvert. References to station numbers throughout this Report are preceded by “(S)” and “(N)” referring to the south and north culvert, respectively.

A culvert is a structure, typically a pipe or tunnel, that allows water to flow underneath a road, railway, building, or other embankment. It serves as a drainage system to redirect stormwater along a desired path, preventing water from accumulating or eroding the structures above. The culverts observed as part of this investigation are off-system, minor structures. In general, according to the CDOT *‘Section 5 – Off-System Bridge Program*,’ “off-system” indicates that the culvert is owned and maintained by a city, county, or other local or regional government, and not CDOT. They are considered “minor” structures because their maximum span length is less than 20 feet, as defined in the ‘*CDOT Office of the Chief Engineer – Section 5 Structures*’ document, dated December 2024.

Prior to our investigation it was reported to us in the Request for Proposal (RFP) documents, dated November 22, 2024, that there were several locations of damage to the flagstone lids and masonry walls, reported from observations dated September 22, 2024. The RFP indicates that some areas of damage have not changed since May 8, 2020, while one area of damage near the north entrance is new since 2020.

As part of our investigation, we performed a preliminary study of the existing hydraulic capacity of the culverts to establish a baseline to understand the impact of proposed repair options. This study was based on measurements taken during our field observations. The underground conveyance infrastructure was modeled using StormCAD 2024, which applies Manning's equation and hydraulic modeling techniques developed by Haestad Methods to estimate conveyance capacity reported in cubic feet per second (cfs).

Based on this study, we determined the overall full flow capacity of the entire south culvert from entrance to outfall is 156 cubic feet per second (cfs). The *average* full flow capacity of the length of south culvert investigated is 350 cfs. The most restrictive segment of the investigated length of the south culvert occurs at the north entrance and has a hydraulic capacity of only 195 cfs. The elliptical pipe at the downstream outfall that starts at the south end of the investigated length (i.e. outside the scope of the investigation) is the most restrictive segment with a capacity of 156 cfs. Although this is the most restrictive segment of the culvert, water would likely surcharge through another inlet or the manhole cover at the south end before exceeding the overall capacity.

The overall full flow capacity of the north culvert from entrance to outfall is 78 cfs. The *average* full flow capacity of the north culvert is 216 cfs. The most restrictive segment of the north culvert occurs at the elliptical pipe running below Reese Avenue.

A review of the 2016 Town of Lyons Stormwater Masterplan, produced by Icon Engineering, Inc., suggests the capacity of the south culvert meets an approximate 5-year storm event, with a flow demand of 108 cfs. This is in line with our results regarding the overall capacity of the south culvert. According to the 2016 Town of Lyons Stormwater Masterplan, the 100-year storm event has a flow demand of 682 cfs, which exceeds the current capacity of both culverts.

Overall photos of the culverts at 50-foot intervals are provided in APPENDIX A.

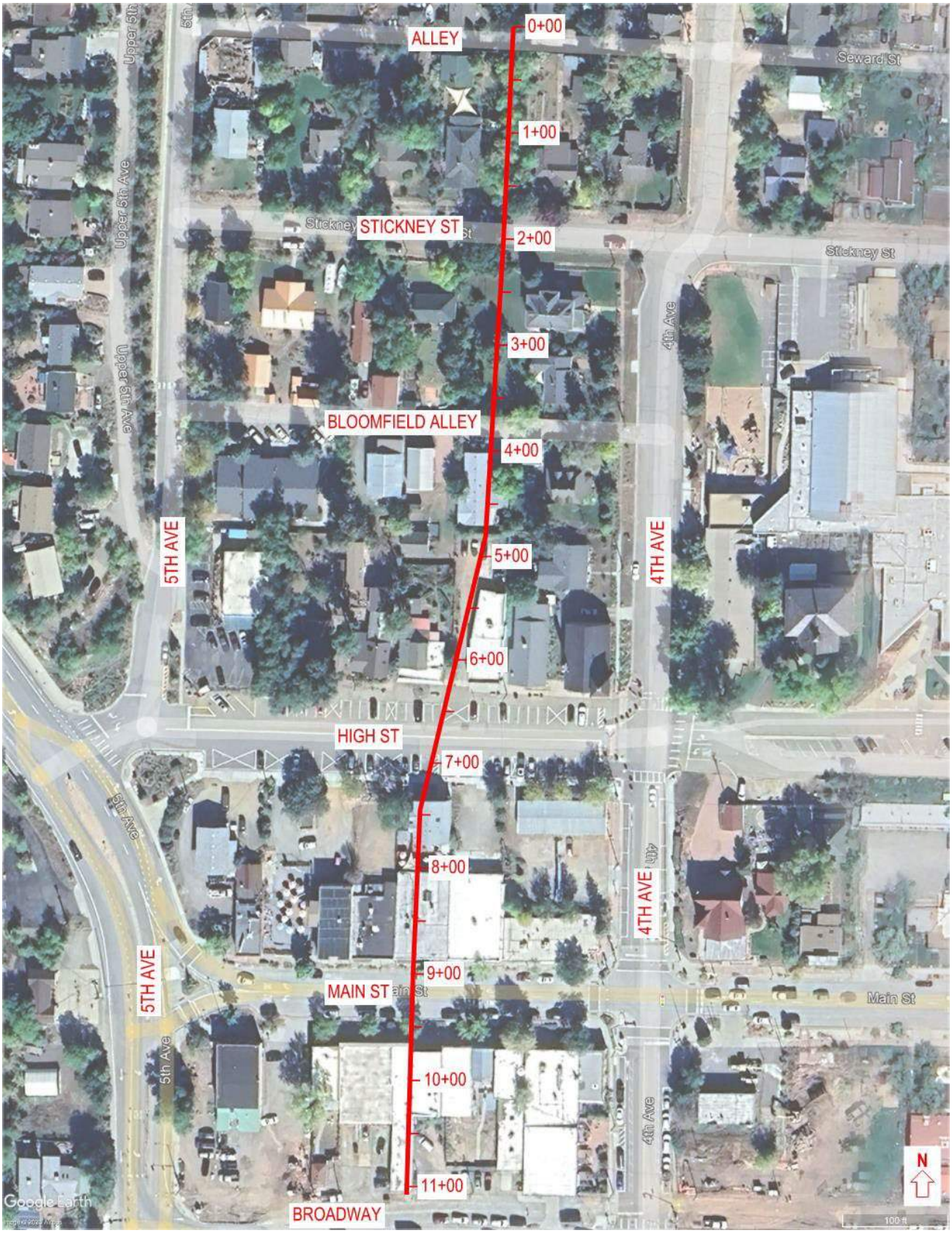

Figure 1: Map of South Culvert

Figure 2: Map of North Culvert

EXISTING CONDITIONS

We observed several typical construction types throughout the length of the culverts, which we have described below. There are several locations where it is unclear whether the conditions were part of the original construction (and thus categorized as a construction type) or installed as repairs. Those conditions are included both in this section and in the 'Previous Repairs' section below. The extents of each construction type are mapped in Figure 3 through Figure 11, for reference, and representative photos of each construction type can be found in APPENDIX B.

Lid Construction Types (Figure 3 through Figure 5):

1. Type L1 (Photo B.1) – Flagstone lids of varying lengths (between 2'-6"-to-6'-0"-long in the direction of the culvert) spanning the width of the culvert; flagstone thickness varies between 4 inches and 8 inches
2. Type L2 (Photo B.2 to Photo B.5) – Flagstone lids of varying lengths spanning the full width of the culvert; flagstone thickness varies between 2 inches and 4 inches; the flagstones are additionally supported by various steel members including railroad rails spaced at 20 inches to 38 inches on-center (sizes vary but are typically 3-1/2-inches-deep and 3-1/2-inches-wide at the flange), 6-inch diameter steel pipes at 2'-0" on-center, and other miscellaneous steel members
3. Type L3 (Photo B.6 to Photo B.8) – Reinforced concrete slab lid; measurable locations are approximately 7 inches thick
4. Type L4 (Photo B.9 and Photo B.10) – Cast-in-place concrete slab with embedded, tightly spaced steel elements of a variety of shapes and sizes
5. Type L5 (Photo B.11) – Precast concrete panels, typically 6-inches-to-7-inches-thick and 3'-10"-to-4'-0"-long in the direction of the culvert
6. Type L6 (Photo B.12 and Photo B.13) –2x10 wood floor joists at 12 inches on-center with plywood decking above; serves as the floor framing of the building above
7. Type L7 (Photo B.14) – Precast concrete box culvert 9'-0"-wide-by-4'-0"-tall with 8'-0" typical section lengths
8. Type L8 (Photo B.15) – Cast-in-place concrete box culvert
9. Type L9 (Photo B.16) – Corrugated pipe culvert, elliptical shaped (3'-6"-wide-by-2'-4"-tall)

Wall Construction Types (Figure 6 through Figure 8):

1. Type W1 (Photo B.17 and Photo B.18) – Dry stacked stone masonry
2. Type W2 (Photo B.19 and Photo B.20) – Stacked stone masonry with mortar in joints
3. Type W3 (Photo B.21) – Shotcrete applied over stacked stone masonry
4. Type W4 (Photo B.22) – Cast-in-place concrete
5. Type W5 (Photo B.23) – Precast box culvert (see Lid Type C7)
6. Type W6 (Photo B.24 and Photo B.25) – Stacked stone masonry with mortar in joints at bottom of wall, and Concrete Masonry Unites (CMU) at top of wall
7. Type W7 (Photo B.26) – Dry stacked stone masonry with 3-inch-thick precast concrete wall panels in front of the stone
8. Type W8 (Photo B.27) – Corrugated pipe culvert, elliptical shaped (3'-6"-wide-by-2'-4"-tall) with cast-in-place concrete headwall and backwall (see Lid Type L9)

Floor Construction Types (Figure 9 through Figure 11):

1. Type F1 (Photo B.28) – Cast-in-place concrete; many locations have rubble / soil / silt covering concrete
2. Type F2 (Photo B.29) – Stone or brick masonry installed in smooth pattern
3. Type F3 (Photo B.30 and Photo B.31) – Rough stone masonry with significant rubble / soil / silt
4. Type F4 (Photo B.32) – Dirt, small rubble, or gravel
5. Type F5 (Photo B.33) – Shotcrete applied to dirt / small rubble
6. Type F6 (Photo B.34) – Precast box culvert (see Lid Type C7)
7. Type F7 (Photo B.36) – Corrugated pipe culvert, elliptical shaped (3’-6”-wide-by-2’-4” tall, see Lid Type L9)

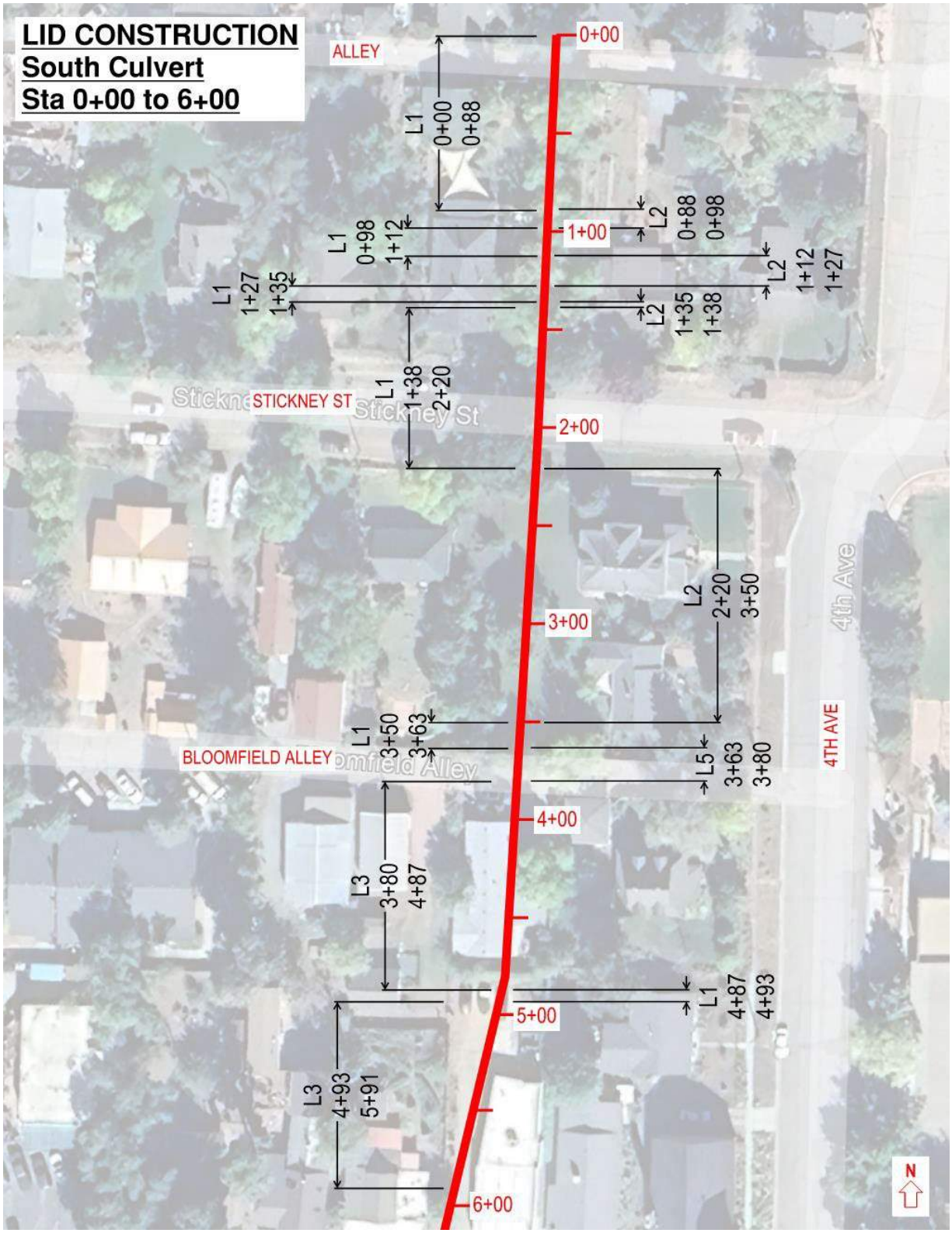

Figure 3: South Culvert Lid Construction Stations (S)0+00 to (S)6+00

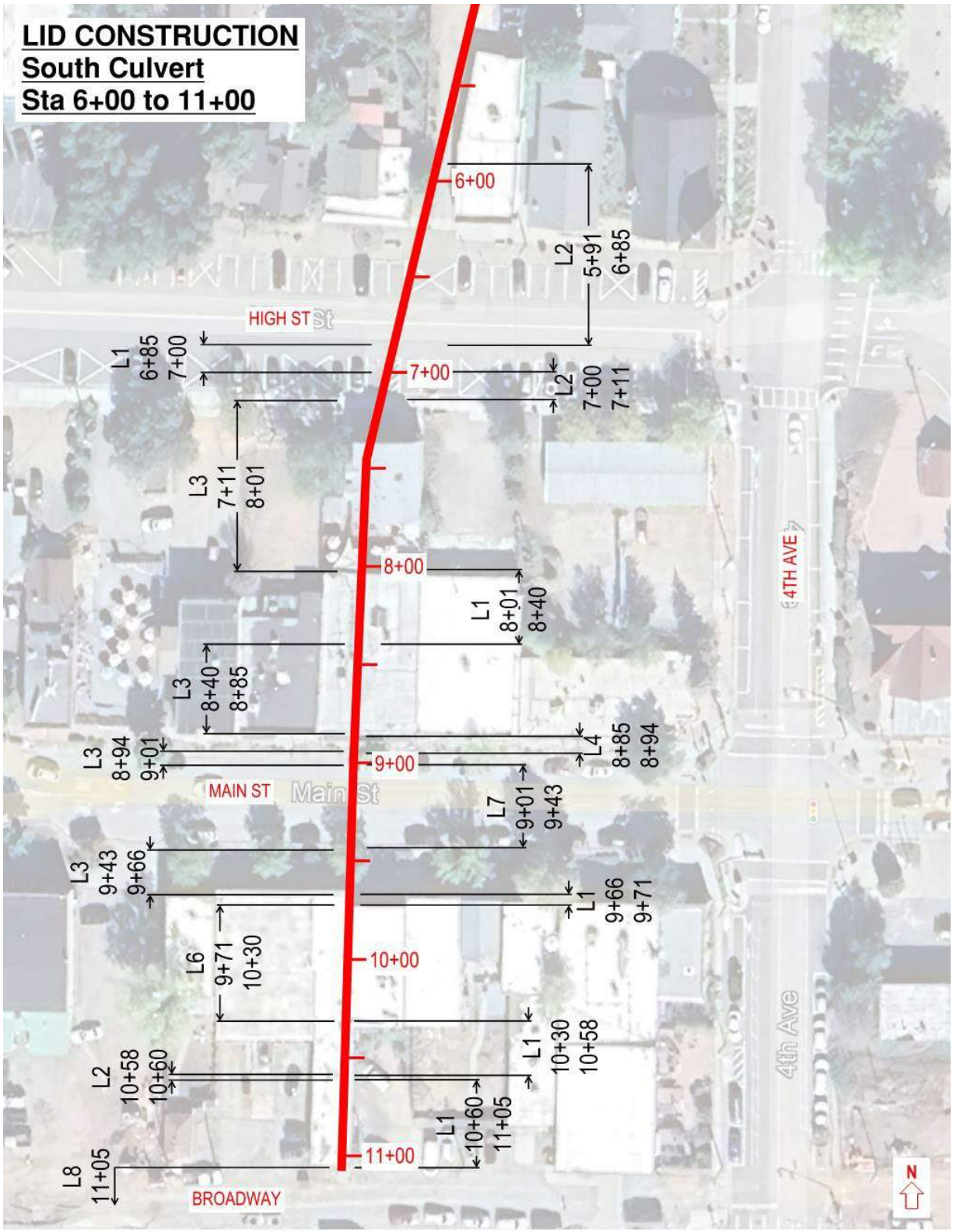

Figure 4: South Culvert Lid Construction Stations (S)6+00 to (S)11+00

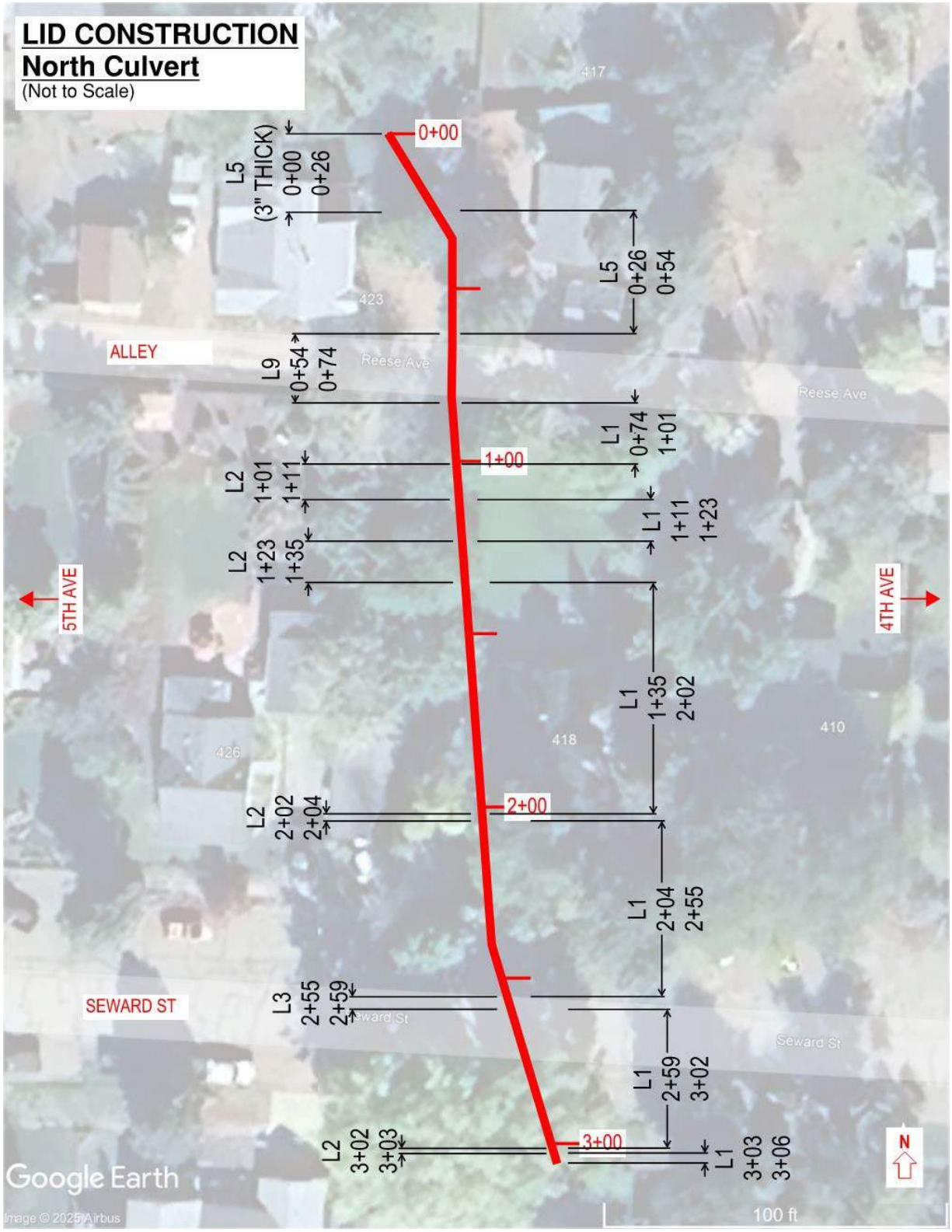

Figure 5: North Culvert Lid Construction

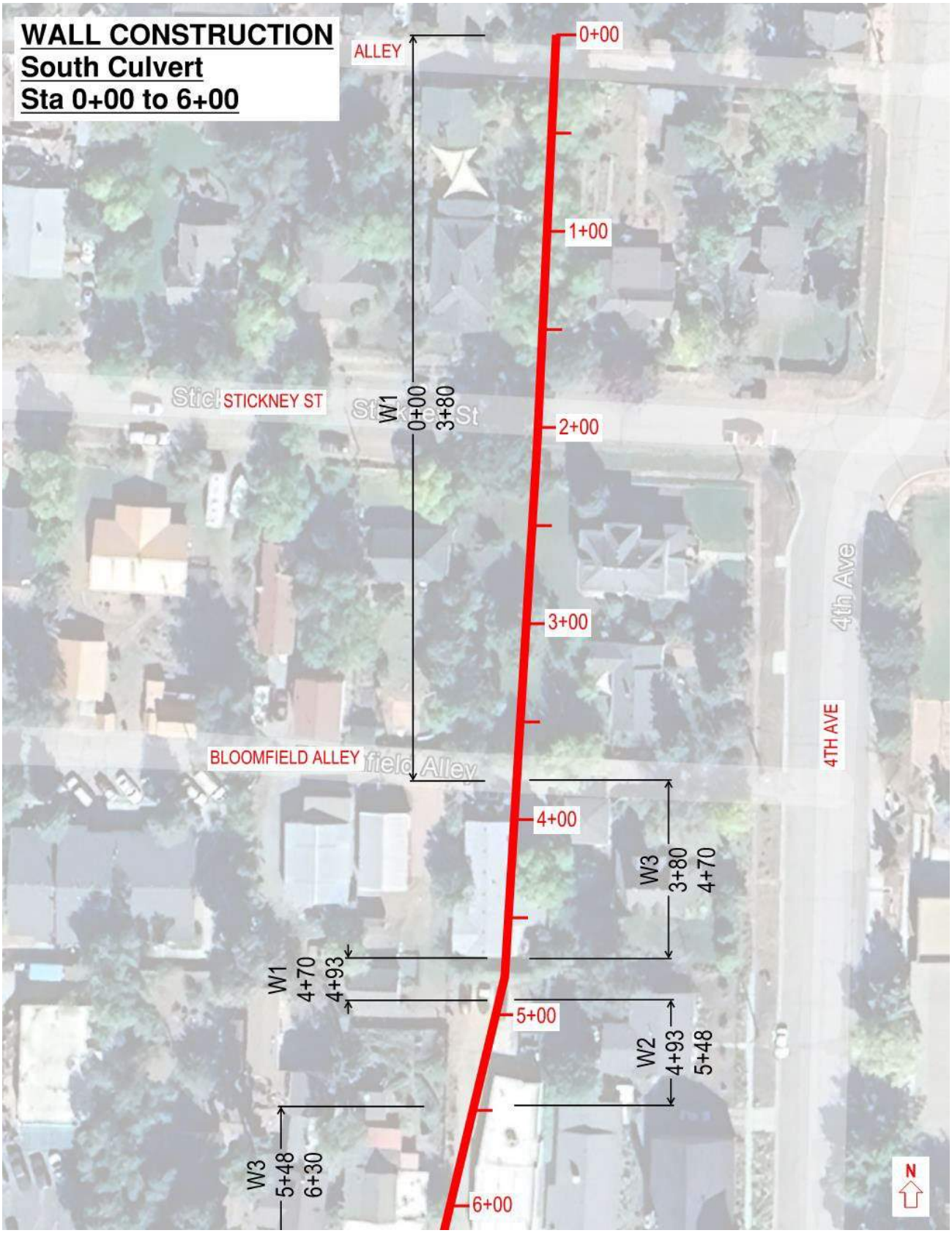

Figure 6: South Culvert Wall Construction Stations (S)0+00 to (S)6+00

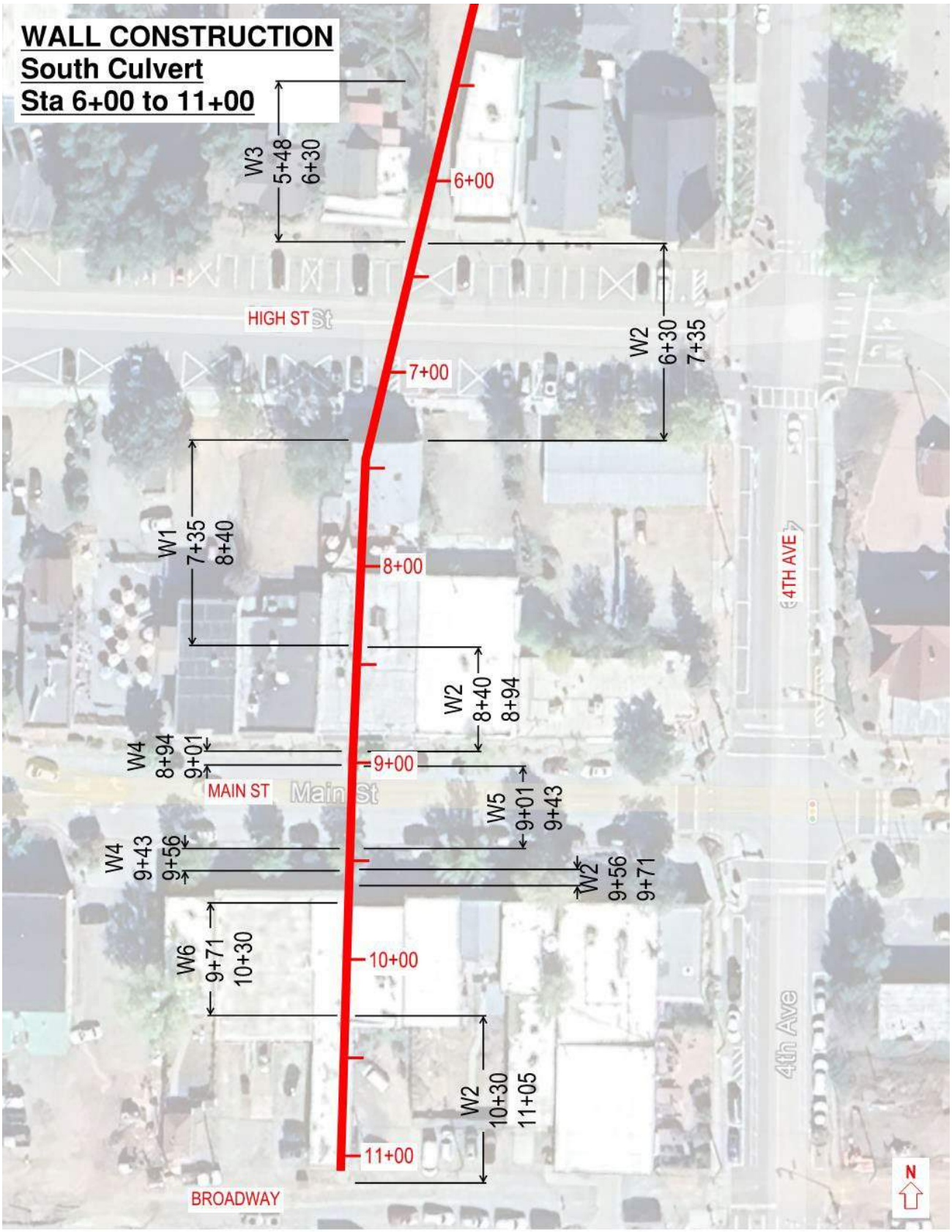

Figure 7: South Culvert Wall Construction Stations (S)6+00 to (S)11+00

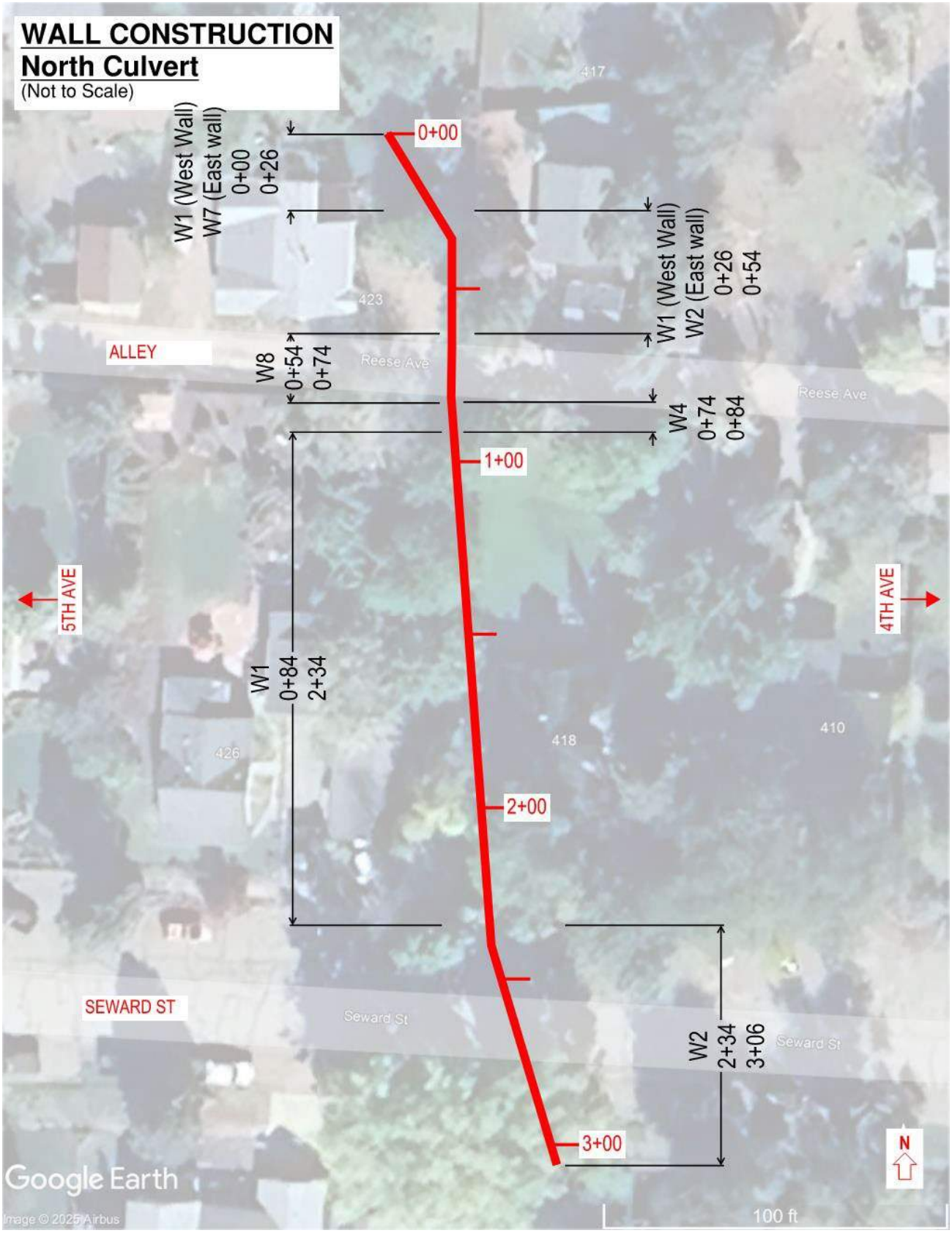

Figure 8: North Culvert Wall Construction

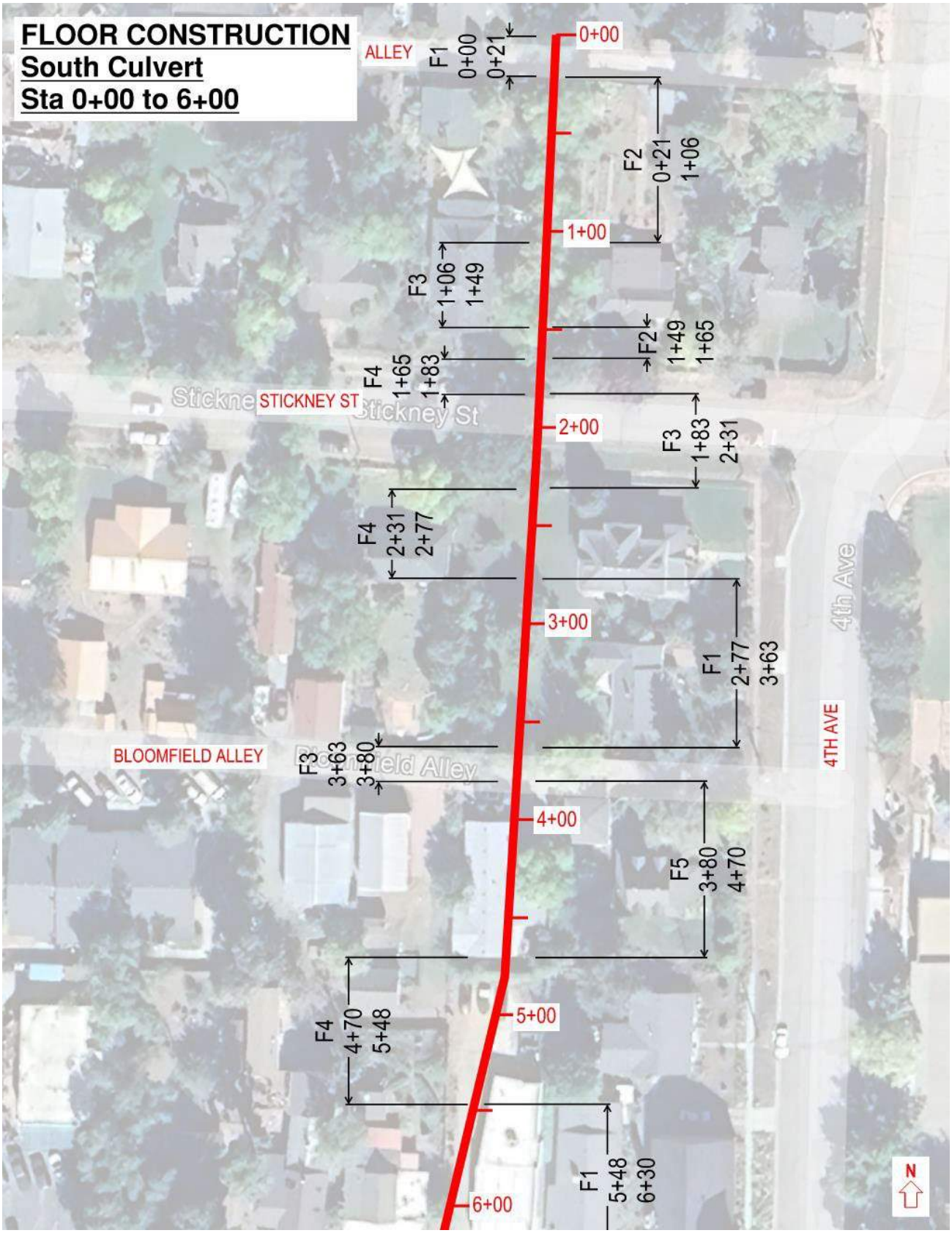

Figure 9: South Culvert Floor Construction Stations (S)0+00 to (S)6+00

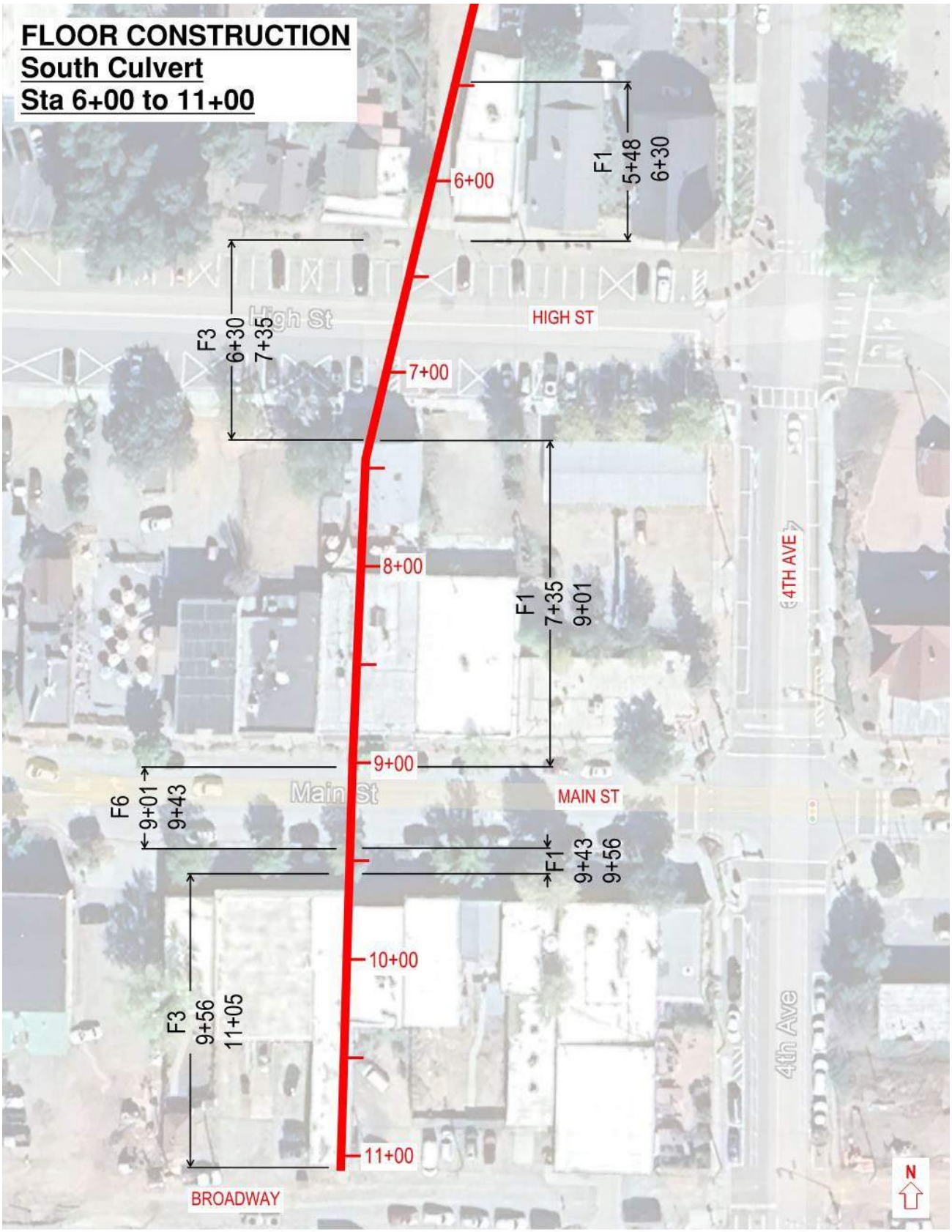

Figure 10: South Culvert Floor Construction Stations (S)6+00 to (S)11+00

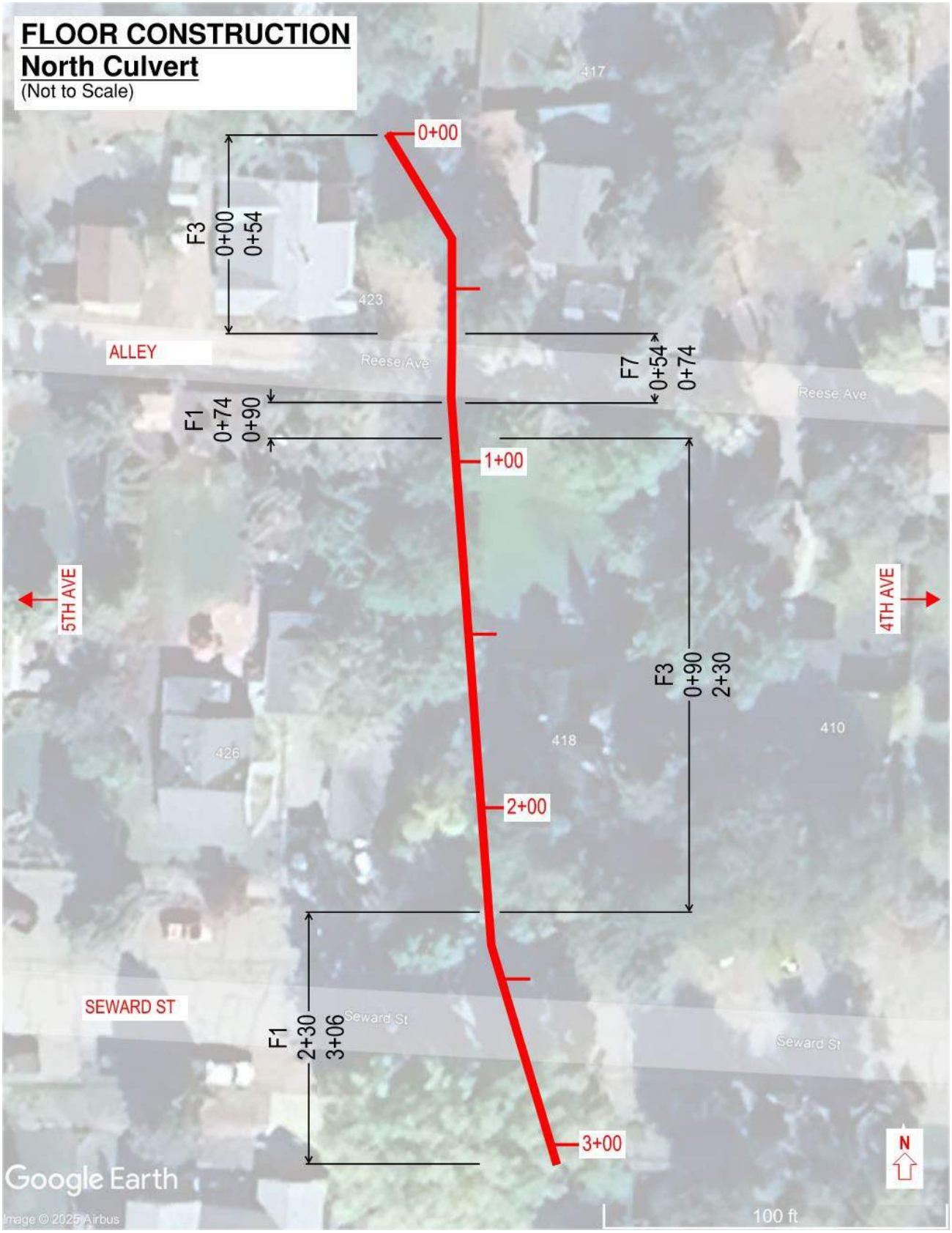

Figure 11: North Culvert Floor Construction

STANDARDS AND CRITERIA

CODES AND STANDARDS

- CDOT Master Item Code Book – Spec Year 05 (Dated April 10, 2025)
- CDOT 2024 Cost Data (Dated April 17, 2024)
- CDOT Colorado Structure Element Level Coding Guide – Version 1.2 (Dated August 20, 2021)

'LEVEL OF CONCERN' DEFINITIONS

High Concern (HC) – This is the highest concern category and indicates sections of the culvert where a structural element has: a) failed or b) is at risk of failure and is in an area where failure would result in a life-safety concern for the public. We recommend that corrective action be taken at these locations within 2 years.

Medium Concern (MC) – Section of culvert where a structural element is in poor condition and is no longer performing its intended purpose or shows signs of deterioration that may progress to High Concern if left unaddressed. We recommend that corrective action be taken at these locations within 2 to 5 years.

Low Concern (LC) – Section of culvert where a structural element is in fair condition. There are signs of wear, failure, or deterioration though the feature is generally structurally sound and performing its intended purpose. We recommend these locations be monitored for change or progressive deterioration.

Sections of the culvert that do not fall within one of the concern categories above are intact, structurally sound, and appear to be performing as intended.

INSPECTION FINDINGS – DETERIORATION AND DAMAGE

We visited the site on March 26, 2025, to observe and document the conditions of the south culvert. We visited the site again on May 19, 2025, to observe and document the conditions of the north culvert. Our overall impression is that the culverts are in good to fair condition, with a few areas in poor condition needing further attention and repairs.

Table 1 describes typical conditions of deterioration and damage observed throughout the culverts. Reference Figure 12 though Figure 14 for mapped locations of each issue and their "level of concern," and APPENDIX C for associated photos.

Map Keynote	Description
A	**Flagstone Lid Fracture** (Photo C.1 to Photo C.14) – Several flagstone lid members (lid construction Type C1) throughout the culvert have fractured or cracked, many of which have deflected to varying degrees exposing the soil above the culvert. Typically, the cracks are parallel to the culvert (perpendicular to the flagstone span direction) or have occurred at the corner of a flagstone. The damage is likely due to loads imposed above the top of the culvert lid, either by vehicular traffic or excessive soil / pavement / flagstones installed since original construction.

Map Keynote	Description
B	**Deteriorated Steel Framing at Lid** (Photo C.15 to Photo C.21) – At isolated locations, the steel framing supporting the flagstone lid members (lid construction Type C2) is deteriorated and/or deflected. A few locations have significant section loss due to corrosion. The locations indicated as High Concern (HC) or Medium Concern (MC) have deflected or damaged flagstones above the deteriorated steel framing. This indicates the steel members are not adequately supporting the flagstone lids above which could eventually lead to structural failure of the lid.
C	**Deteriorated Concrete Lid** (Photo C.22 to Photo C.27) – Some of the concrete lids are deteriorated or cracked and deflected. We observed spalled concrete and corroded reinforcing with section loss. Water is most likely infiltrating the culvert lids at these locations and corroding the steel reinforcing in the concrete slabs. This deterioration will continue to progress, which can eventually lead to structural failure of the lid.
D	**Poor Bearing Condition at Top of Wall** (Photo C.28 to Photo C.36) – At several locations there are loose or missing masonry stones at the top of the walls resulting in a poor lid bearing condition. When the flagstone or concrete lids do not have full bearing on the wall below, it increases the stress in both the lids and the walls, making them more prone to cracking or fracturing.
E	**Missing or Displaced Masonry in Wall** (Photo C.37 to Photo C.49) – At several locations there are one to two masonry stones missing from the wall, or there is displacement of a few stones within the wall. It is unclear whether these issues were from the original construction or if they were caused by soil loads acting on the walls. This is a low structural concern but should be monitored to determine if the conditions are worsening.
F	**Scour, Washout, or Large Drop at Floor** (Photo C.50 to Photo C.56) – Scour (erosion of the soil below the concrete floor caused by flowing water) and washout (erosion and removal of soil and sediment due to water flow) is occurring at a few locations throughout the culvert. Additionally, there are several locations with a drastic drop in the floor elevation, likely due to a change in floor construction resulting in the downstream area degrading more quickly than the adjacent upstream area. These locations cause inconsistent water flow regions and will continue to worsen over time, possibly undermining the foundations of the bearing walls. This could eventually compromise the structural integrity of the walls.
G	**Large Pile of Rubble or Concrete at Floor** (Photo C.57 to Photo C.59) – There are several piles of rubble, concrete, or debris present throughout the floor of the culvert. The rubble piles are likely formed by scour and washout dislodging materials from the culvert walls and floor, depositing them in certain low-flow areas. These piles will continue to trap more rubble and debris, worsening the problem. This issue is a Low Concern in regard to structural integrity; however, it could rapidly become a High Concern issue with a large storm event.

Table 1: Descriptions of Deterioration and Damage

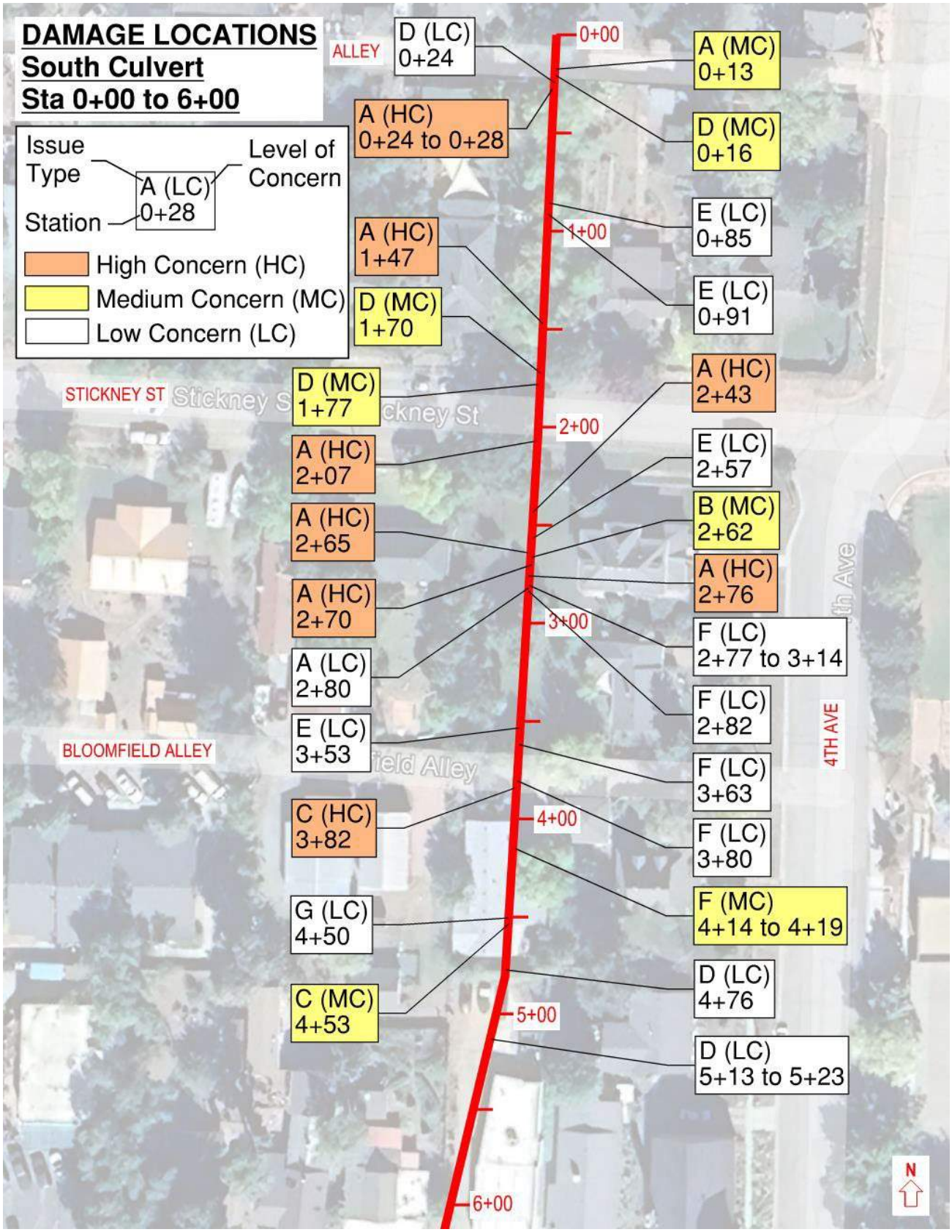

Figure 12: South Culvert Map of Damaged/Deteriorated Areas Stations (S)0+00 to (S)6+00

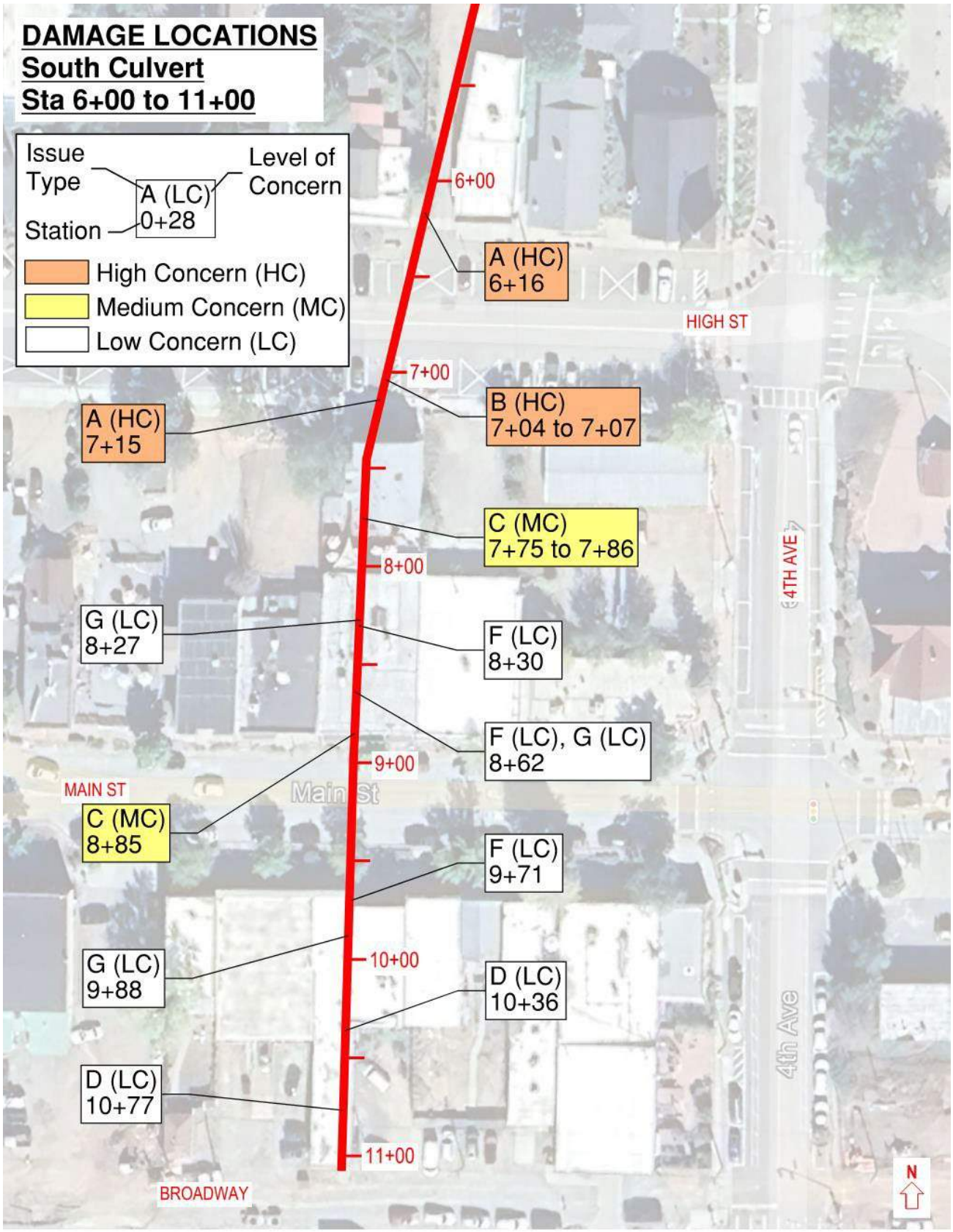

Figure 13: South Culvert Map of Damaged/Deteriorated Areas Stations (S)6+00 to (S)11+00

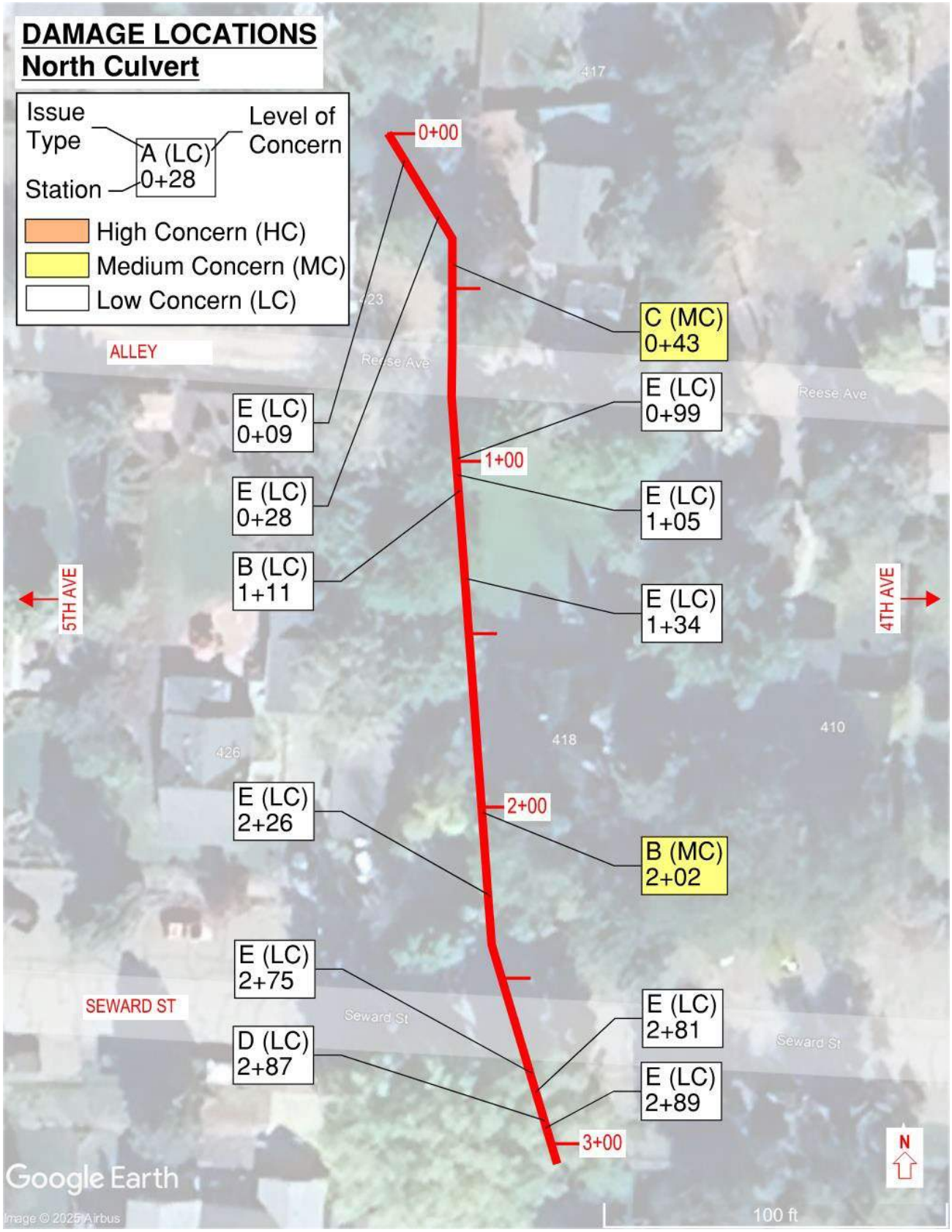

Figure 14: North Culvert Map of Damaged/Deteriorated Areas

REPAIR OPTIONS

Repair options for the areas of High Concern and Medium Concern noted above are provided below along with cost estimates and impact on hydraulic capacity. All repair options provided can be designed to resist HS-20 loading. Sections of culvert with similar deterioration and repair options have been grouped together for simplicity and repair cost estimates have been provided on a per-location basis. No cost estimates have been provided for areas of Low Concern including deterioration Types E and G. Cost estimate breakdowns with CDOT cost item codes are provided in APPENDIX F.

Unit prices used in cost estimates are based on the average bid for work of similar quantity, if available, provided in the CDOT 2024 Cost Data. Some work associated with repairs do not have a CDOT cost item code or cost data available. For work items that do not have a CDOT cost item code or cost data available, a similar work item with available data was selected to provide the cost estimate. Cost estimates include a 15% contingency.

The repair options provided below are only intended to restore the structural integrity of the culvert. They are not intended to improve the culvert's hydraulic efficiency. Given the localized nature of the observed deterioration, the repairs provided in this section are intended to be localized repairs. Discussion of full culvert repair or retrofit is discussed in a later section of this Report.

Costs related to procurement, permitting, engineering, water quality, construction administration, utilities, and other expenses not mentioned are excluded from the Engineer's Estimated Costs stated below and in APPENDIX F.

Deterioration Type: A – Flagstone Lid Fracture (accessible from above)			
Locations (10 total): (S)0+13 (MC), (S)0+24 to (S)0+28 (HC), (S)1+47 (HC), (S)2+07 (HC), (S)2+43 (HC), (S)2+65 (HC), (S)2+70 (HC), (S)2+76 (HC), (S)6+16 (HC), (S)7+15 (HC)			
Repair Option	Description	Cost Estimate	Hydraulic Impact
1	▪ Excavate damaged culvert lid. ▪ Remove and replace-in-kind with Lyons Red Sandstone up to 12" thick. ▪ Backfill and replace landscaping/paving.	$20,000 to $30,000 per location	No change.
2	▪ Excavate damaged culvert lid. ▪ Remove lid and replace with a reinforced precast concrete panel between 6" and 8" thick. ▪ Backfill and replace landscaping/paving.	$21,000 to $31,000 per location	No change.
3	▪ Excavate damaged culvert lid. ▪ Remove lid and replace with a reinforced cast-in-place concrete slab between 6" and 8" thick. ▪ Backfill and replace landscaping/paving.	$19,000 to $29,000 per location	No Change.

Deterioration Type: B – Deteriorated Steel Framing at Lid, C – Deteriorated Concrete Lid (accessible from above)			
Locations: (S)2+62 (MC), (S)3+82 (HC), (S)7+04 to (S)7+07 (HC), (N)0+43 (MC), (N)2+02 (MC)			
Repair Option	Description	Cost Estimate	Hydraulic Impact
1	▪ Excavate damaged culvert lid. ▪ Remove lid and replace with a reinforced precast concrete panel between 6” and 8” thick. ▪ Backfill and replace landscaping/paving.	$21,000 to $31,000 per location	No change.
2	▪ Excavate damaged culvert lid. ▪ Remove lid and replace with a reinforced cast-in-place concrete slab between 6” and 8” thick. ▪ Backfill and replace landscaping/paving.	$19,000 to $29,000 per location	No change.
3	▪ Shore existing lid and remove existing steel framing if present. ▪ Install supplemental hot dipped galvanized steel framing. Bear framing on existing wall. ▪ Grout between top of steel and lid. Grout bearing pockets solid. ▪ Work may be performed from inside the culvert and without excavation above.	$22,000 to $25,000 per location	No change.

Deterioration Type: C – Deteriorated Concrete Lid (not accessible from above)			
Locations: (S)4+53 (MC), (S)7+75 to (S)7+86 (MC), (S)8+85 to (S)8+94 (MC)			
Repair Option	Description	Cost Estimate	Hydraulic Impact
1	▪ Perform partial depth overhead concrete repairs with supplemental reinforcing.	$20,000 to $23,000 per location	No change.
2	▪ Dowel rebar into existing concrete lid. ▪ Install new 6”-to-8”-thick reinforced concrete lid to underside of existing lid via shotcrete. ▪ Note: this will reduce the overall height of the culvert in the repaired area.	$11,000 to $13,000 per location	Sta. (S)4+53 reduced from 436 cfs to 338 cfs Sta. (S)7+75 to (S)7+86 reduced from 388 cfs to 297 cfs
3	▪ Install supplemental hot dipped galvanized steel framing. Bear framing on existing wall. ▪ Grout between top of steel and lid. Grout bearing pockets solid.	$34,000 to $39,000 per location	Sta. (S)4+53 reduced from 436 cfs to 338 cfs Sta. (S)7+75 to (S)7+86 reduced from 388 cfs to 297 cfs

Deterioration Type: D – Poor Bearing Condition at Top of Wall			
Locations: (S)0+16 (MC), (S)0+70 (MC), (S)1+72 (MC), (S)1+77 (MC)			
Repair Option	Description	Cost Estimate	Hydraulic Impact
1	▪ Reset or replace loose or missing masonry stones. ▪ Provide mortar at joints around repaired masonry stone.	$600 to $1,000 per location	No change.
2	▪ Remove loose masonry, if present, and fill void with low shrinkage concrete repair mortar in void.	$1,500 to $2,000 per location	No change.
3	▪ Monitor for change or progressed deterioration as part of regular inspections and maintenance.	None	No change.

Deterioration Type: F – Scour at Culvert Floor			
Locations: (S)4+14 to (S)4+29 (MC)			
Repair Option	Description	Cost Estimate	Hydraulic Impact
1	▪ Remove silt and debris from scoured area. ▪ Fill the scoured area with reinforced concrete to top of existing floor.	$26,000 to $29,000 per location	No change.
2	▪ Remove silt and debris from section of culvert with shotcrete walls and floor (Sta. (S)3+80 to (S)4+70) that encompasses the area of scour. ▪ Place reinforced concrete to raise the floor elevation along section to provide a flat floor that matches the floor elevations at the start and end stations of this section.	$146,000 to $160,000 per location	Reduced from 299 cfs to 289 cfs
3	▪ Monitor for change or progressed deterioration as part of regular inspections and maintenance.	None	No change.

OTHER OPTIONS, MODIFICATIONS, AND RECOMMENDATIONS

We recommend that a regular maintenance program be established. Maintenance would largely consist of removing debris and silt build-up within the culverts. This would improve drainage performance as well as allow for easier observations during inspection. According to the CDOT 2024 Cost Data, the estimated cost to clean the entire length of both culverts would be approximately $61,000 to $65,000. We also recommend that the culverts be inspected every 3 to 4 years to monitor their condition, areas of concern, and determine when and where future repairs are needed.

The repair options provided above only address the structural integrity concerns at the locations where structural deterioration and damage were observed. However, other large-scale or full culvert retrofit and modification options exist that may offer improved strength, performance, and lifespan of the culverts.

One option is to install a slip lining within the culverts, either along large sections or the full length of the culverts. Culvert slip lining involves placing a new, smaller-diameter pipe inside an existing culvert and grouting the annular space around the slip liner. The slip lining system is designed to withstand the loads transmitted through the existing culvert and can be designed to resist HS-20 loading. Slip linings are a specialty product that is typically designed by the supplier. According to CDOT 2024 Cost Data, the estimated cost to install slip linings within the entire length of both culverts would be approximately $2,800,000 to $3,000,000.

Another option to improve strength and longevity would be to replace the sections of culvert below roads with a precast concrete box culvert, similar to the section of culvert below Main Street. This would have the most benefit at roads that see the highest amount of traffic, such as High Street (approximately Sta. (S)6+40 to (S)7+20). Precast box culverts are available in various sizes which can be selected to avoid impacting the overall hydraulic capacity of the culvert. According to CDOT 2024 Cost Data, the estimated cost to replace the section of culvert below High Street would be approximately $380,000 to $420,000.

INSPECTION FINDINGS – OTHER

INCOMING PIPES, INLETS, OR OTHER UTILITIES

Table 2 denotes the location and size of observed pipes, inlets, or utilities coming into or crossing the culverts. Several inlets appeared to be inoperable as noted; however, operability could not be verified. Reference Figure 15 through Figure 17 for mapped locations of each issue and APPENDIX D for associated photos.

Station	Location	Description	Operability
(S)0+98	Top of west wall	5-inch outer diameter pipe	Unknown
(S)1+09	Top of west wall	5-inch outer diameter pipe	Appears to be plugged
(S)1+09	Top of east wall	5-inch outer diameter pipe	Appears to be plugged
(S)1+74	East side of lid, stormwater drain at north side of Stickney Street	8-inch diameter drain; set into 5-inch-thick flagstone with 9 inches of concrete or soil above; grate at street level	Operable
(S)2+07	East side of lid, stormwater drain at south side of Stickney Street	8-inch diameter drain; set into 5-inch-thick flagstone with 9 inches of concrete or soil above; grate at street level	Operable
(S)2+41	Top of east wall	6-inch outer diameter, 4-inch inner diameter pipe	Unknown
(S)2+73	Top of east wall	6-inch outer diameter, 4-inch inner diameter pipe	Unknown
(S)3+63	Stormwater drain at north side of Bloomfield Alley	Full width of culvert and approximately 12 inches wide	Operable
(S)3+75	1’-0” below lid, spans across culvert	2-inch outer diameter pipe / utility, spans across culvert	Unknown
(S)5+25	East wall	4-inch outer diameter PVC pipe	Unknown
(S)5+48	West side of lid	11-inch diameter drain in concrete lid with a grate, covered with board above	Appears Operable
(S)6+38	West wall	8-inch diameter pipe	Inoperable
(S)6+38	East wall	8-inch diameter pipe	Inoperable
(S)6+87	Below lid, spans cross culvert	4-inch diameter pipe/utility	Unknown
(S)6+92	Below lid, spans cross culvert	3-inch diameter pipe/utility	Unknown
(S)7+21	West wall	24-inch diameter segmented concrete pipe with 2-inch-thick wall	Unknown
(S)7+21	East wall	7-inch inner-diameter formed concrete pipe; appears to terminate 2 feet to 3 feet behind the wall	Inoperable
(S)7+85	East wall	15-inch diameter corrugated steel pipe	Unknown
(S)7+90	East wall	Approximately 6-inch diameter, pipe is crushed	Inoperable
(S)7+90	West wall	Approximately 6-inch diameter, pipe is crushed	Inoperable
(S)7+92	East wall	Approximately 6-inch diameter, pipe is crushed	Inoperable
(S)8+00	Stormwater drain	Full width of culvert and 2 feet long	Operable
(S)8+18	East wall	9-inch diameter steel pipe	Unknown
(S)8+22	Base of wall	6-inch diameter steel pipe	Unknown
(S)8+71	Lid, between embedded steel	6-inch diameter pipe	Inoperable
(S)8+98	Lid, at north side of Main Street	Manhole	Operable
(S)9+43	East wall	8-inch diameter PVC pipe	Unknown
(S)9+53	East side of lid, stormwater drain in sidewalk above	8-inch diameter drain	Operable
(S)9+66	East wall	4-inch inner diameter pipe	Unknown
(S)10+20	East wall	1-inch inner diameter pipe	Unknown
(S)10+24	Wall	2-inch diameter pipe	Unknown
(S)11+07	Lid	Manhole	Operable

Table 2: South Culvert Incoming Pipes, Inlets, and other Utilities

Station	Location	Description	Operability
(N)0+04	Lid	4-inch diameter	Inoperable
(N)0+09	Lid	4-inch diameter	Inoperable
(N)0+74	Full width of lid	Lid opening large enough for personnel access	Operable
(N)0+79	East and West walls	(2) cores – one in each wall	Inoperable
(N)1+54	Top of east wall	8-inch-high-x-16-inch-wide inlet	Unknown
(N)1+64	Below lid, spans across culvert	4-inch diameter pipe	Unknown
(N)1+70	Mid-height, spans across culvert	5/8-inch diameter copper pipe, protrudes through mass of foam at east wall	Unknown
(N)2+27	East wall	7-inch-high-x-18-inch-wide inlet	Unknown
(N)2+44	Top of west wall	3-inch diameter inlet	Unknown
(N)2+45	Below lid, spans across culvert	1-inch diameter pipe	Unknown
(N)2+48	Top of east wall	3-inch diameter	Inoperable
(N)2+54	Below lid, spans across culvert	2 ½-inch diameter pipe	Unknown
(N)2+89	Top of west wall	Inlet	Unknown
(N)2+94	Top of east wall	Inlet	Unknown

Table 3: North Culvert Incoming Pipes, Inlets, and other Utilities

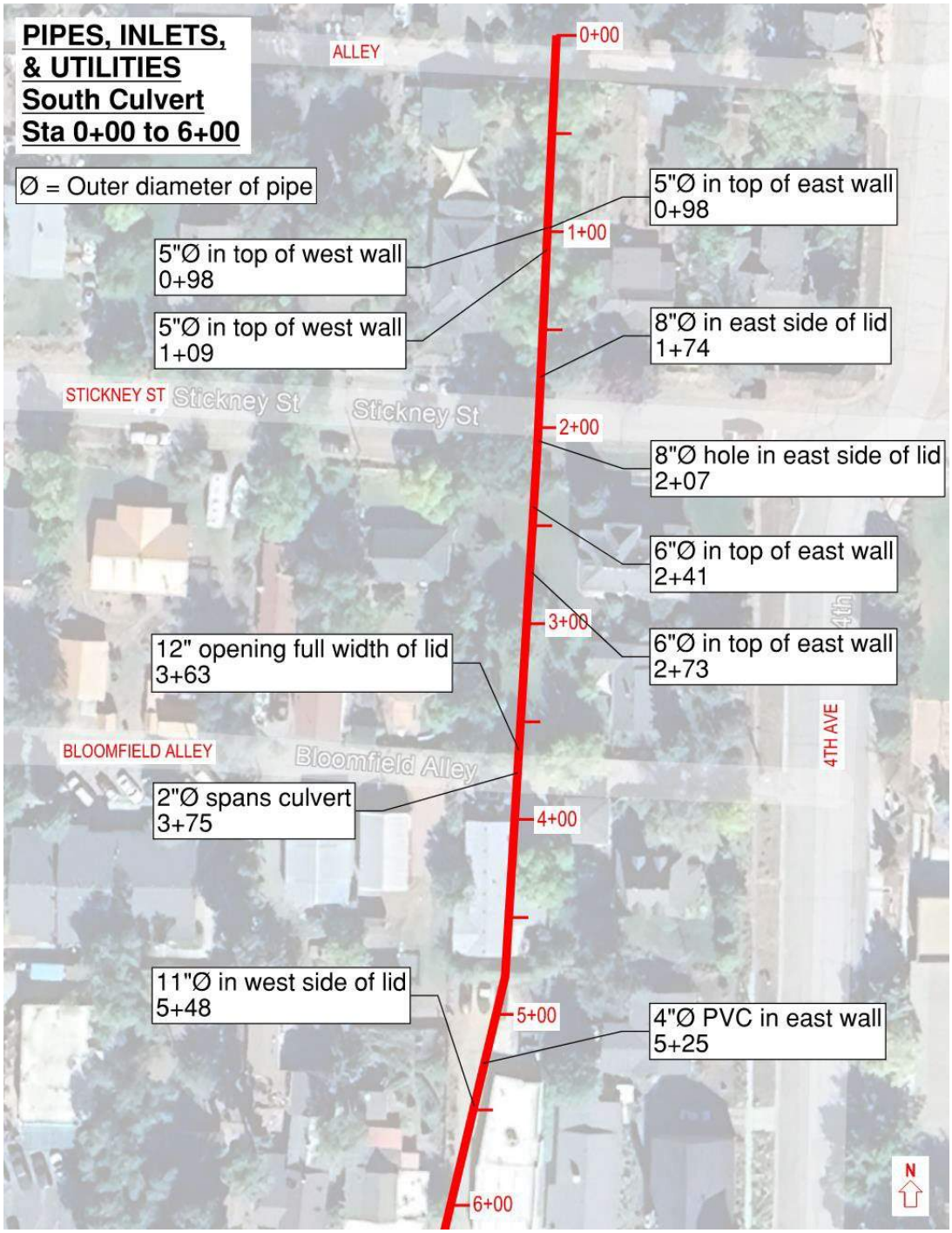

Figure 15: South Culvert Incoming Pipes, Utilities, Inlets Stations (S)0+00 to (S)6+00

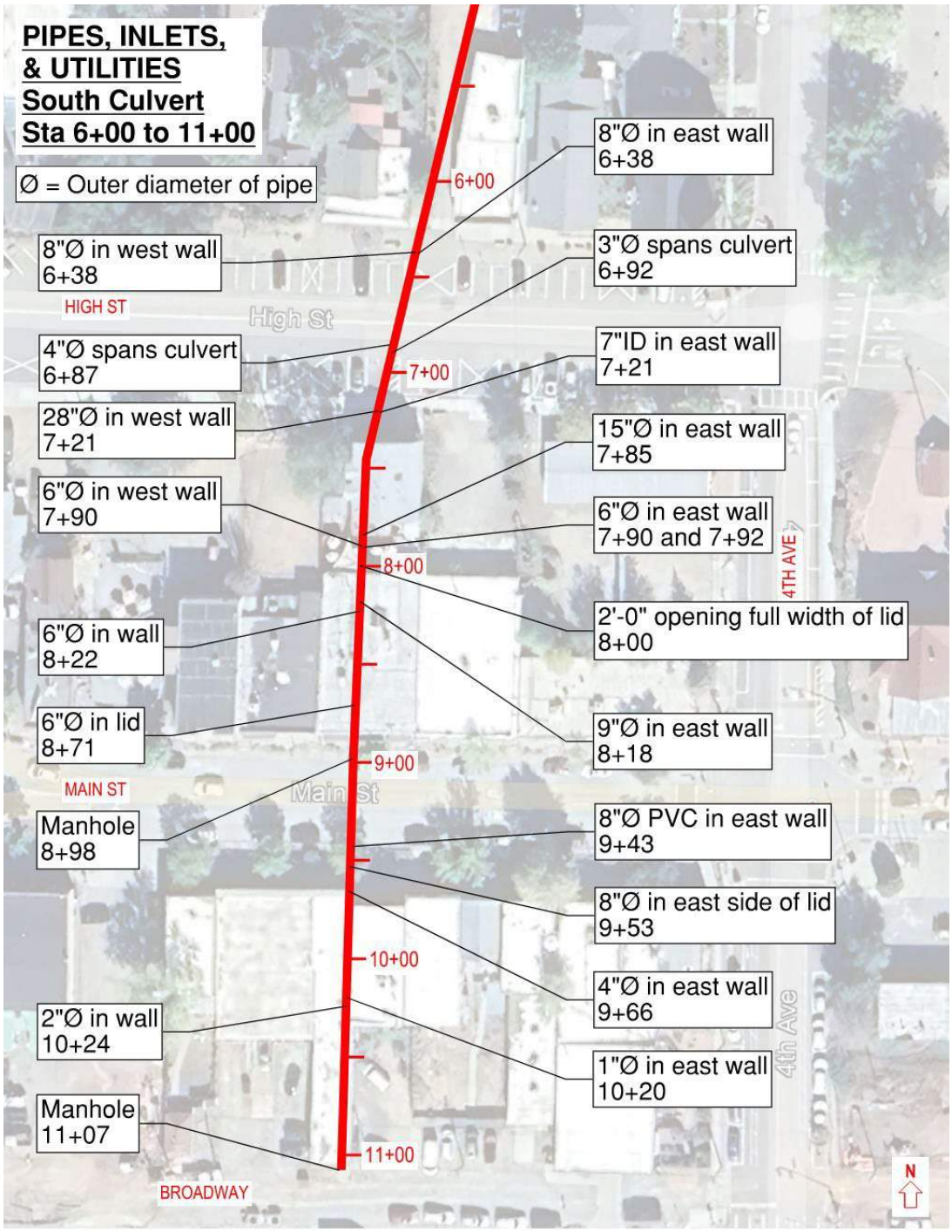

Figure 16: South Culvert Incoming Pipes, Utilities, Inlets Stations (S)6+00 to (S)11+00

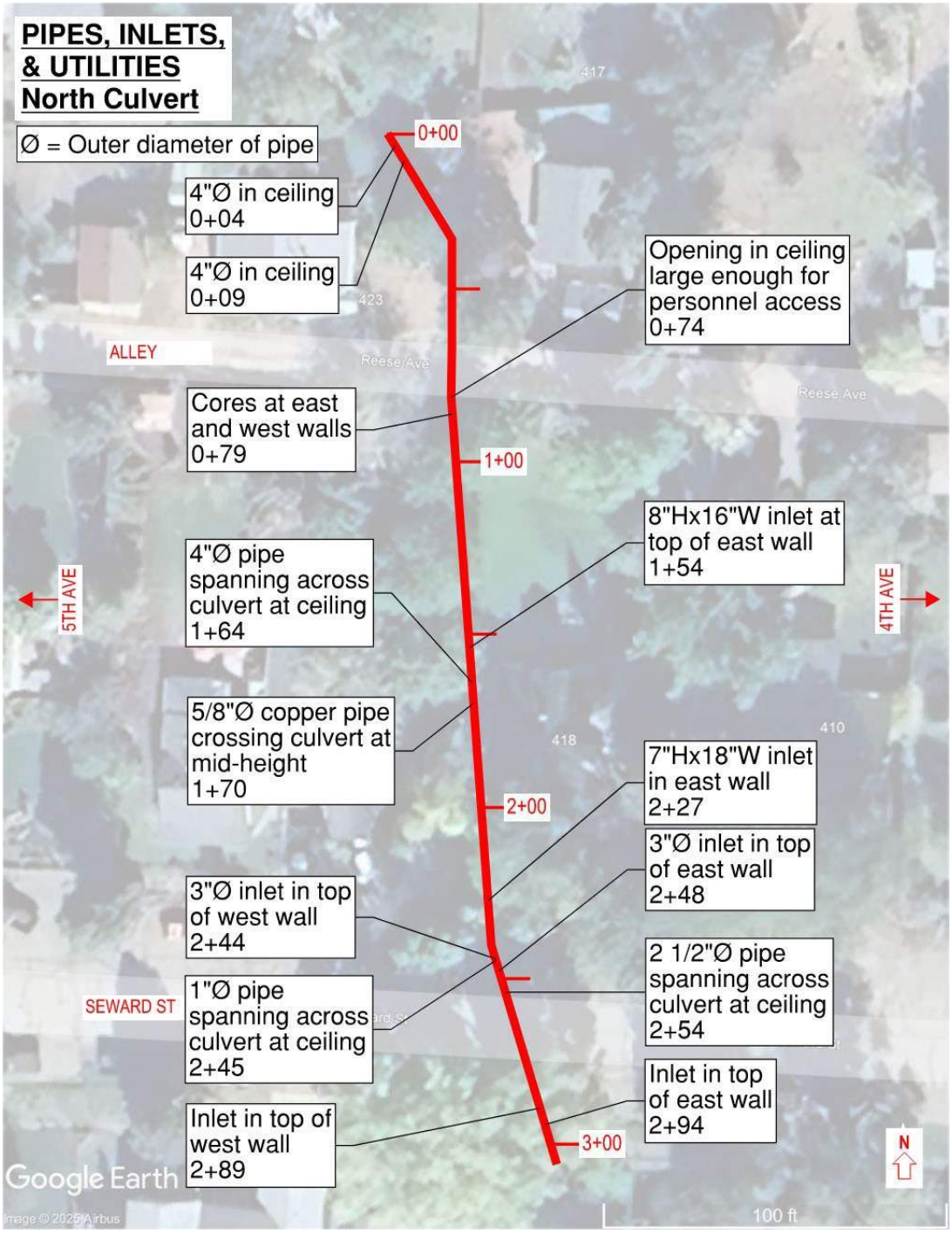

Figure 17: North Culvert Incoming Pipes, Utilities, Inlets

PREVIOUS REPAIRS

Table 4 denotes the locations and descriptions of previous repairs observed in the culvert. There are several locations where it is unclear whether the conditions were part of the original construction (and thus categorized as a construction type) or installed as repairs. Those conditions are included both in this section and in the 'Existing Conditions' section above. The extents of each construction type are mapped in Figure 18 and Figure 19 for reference and photos of each repair can be found in APPENDIX E.

Map Keynote	Repair Description	Station(s)	Photo
PR1	Timber lid framing consisting of five (5) 6x4 beams and one (1) 4x4 beam	0+35 to 0+38	Photo E.1
PR2	Railroad rails and other miscellaneous steel members installed below cracked flagstones to provide additional support (Note: locations indicated in this section differ from the locations indicated in the 'Existing Conditions' section as Construction Type C2; the locations noted in this section appear to have been added as a repair)	1+35 2+62 3+62 7+11	Photo E.2
PR3	Support added below a cracked flagstone stone; support consists of an additional flagstone bearing on two miscellaneous steel members that span the width of the culvert	2+43	Photo E.3
PR4	Shotcrete applied to the stacked masonry walls (Note: locations indicated in this section are also included in the 'Existing Conditions' section as Construction Type W3)	3+80 to 4+70 5+48 to 6+30	Photo E.4
PR5	Cast-in-place concrete lids or walls, or precast concrete lid planks, which appear to have replaced the flagstone lids and masonry walls; these locations are typically found below buildings which may indicate the repairs were completed during building construction (Note: locations indicated in this section are also included in the 'Existing Conditions' section as Construction Types C3, C4, C5, and W4)	3+63 to 4+87 4+93 to 5+91 7+11 to 8+01 8+40 to 9+01 9+43 to 9+66	Photo E.5
PR6	Culvert lid replaced with 2x10 wood floor joists as indicated in the 'Existing Conditions' section as Construction Type C6. This lid serves as the building floor framing above, indicating it was likely installed as part of building renovations	9+71 to 10+30	Photo E.6

Table 4: Previous Repairs

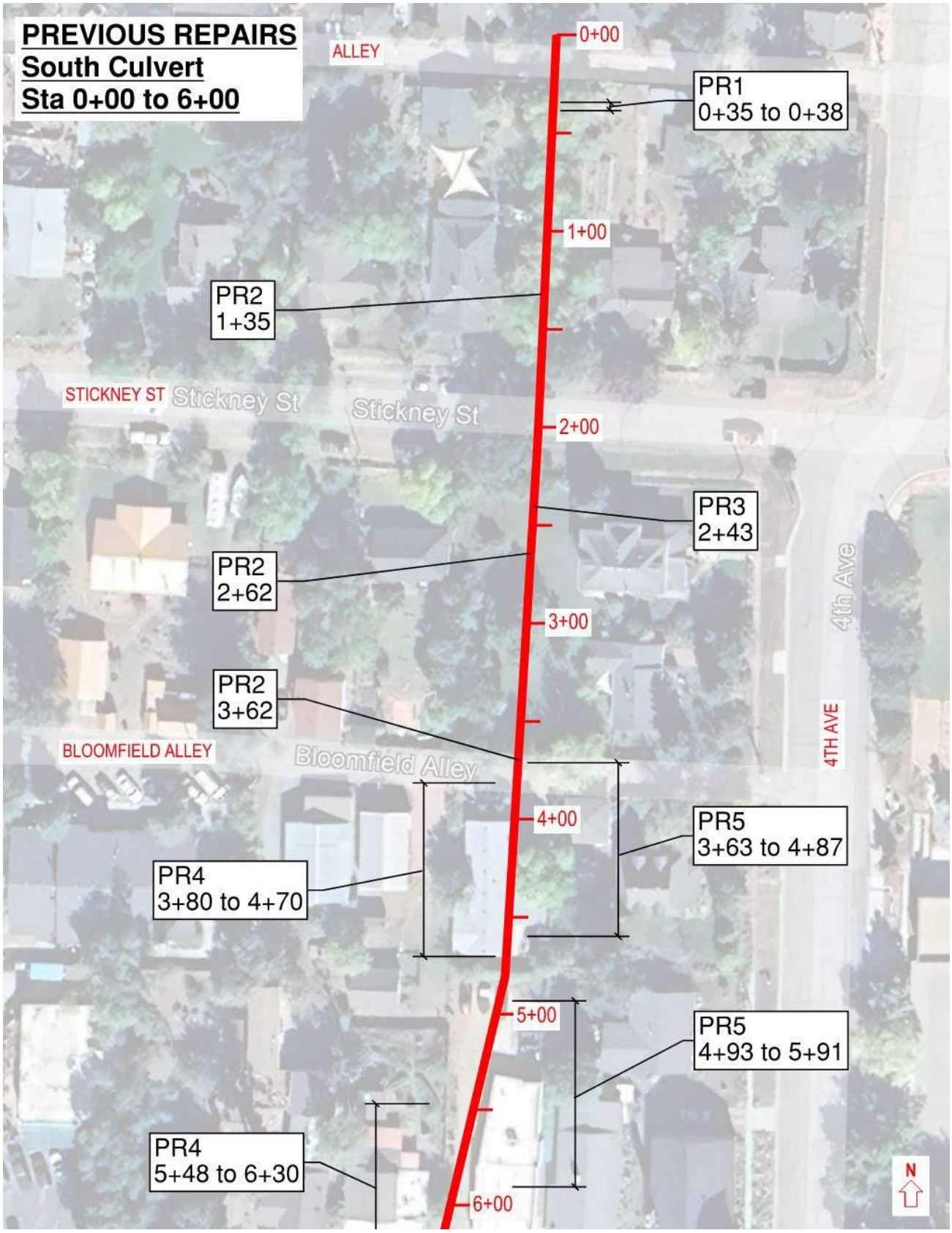

Figure 18: South Culvert Previous Repairs Stations (S)0+00 to (S)6+00

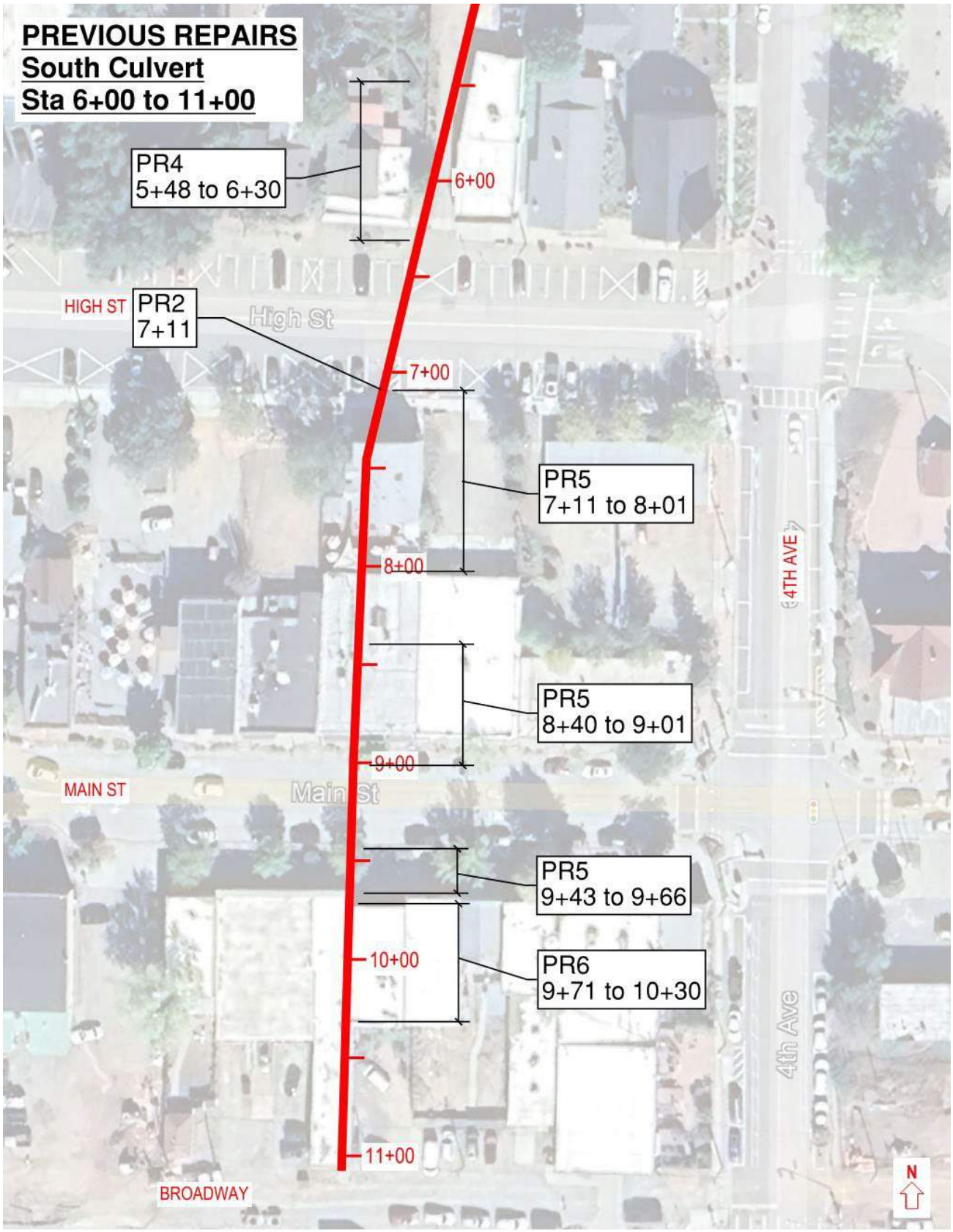

Figure 19: South Culvert Previous Repairs Stations (S)6+00 to (S)11+00

OPEN CHANNEL CONVERSION

The only area of the south culvert that could have the lid removed and converted to an open channel is the section between Stickney Street and Bloomfield Alley (approximately Sta. (S)2+30 to (S)3+60). This section runs through the yards of two residential properties. The only area of the north culvert that could have the lid removed and converted to an open channel is the section between Seward Street and Reese Avenue (approximately Sta. (N)0+80 to (N)1+50). This section also runs through the yard of a residential property.

In order to convert these sections of culvert to an open channel, the soil over the culvert would need to be excavated, the lid components removed, and the height of the walls increased to match grade. We do not recommend converting these sections to open channels. The drawbacks of doing so are that it creates the potential for a fall hazard and provides a path for more debris to enter the culverts. Converting these sections to open channels would allow more stormwater to enter the culverts and be easier to maintain; however, the overall hydraulic capacity of the entire culvert system would remain unchanged and would still be restricted by the north entrances, the elliptical pipe below Reese Avenue, and the elliptical pipe at the south end below Broadway.

LIMITATIONS

Our investigation was limited solely to the structural condition of the two culverts that run north to south below grade in the Town of Lyons, Colorado, between 5th Avenue and 4th Avenue, from just north of the alley between Reese Street and Seward Street, at the north end, to the drive lane just north of Broadway, at the south end, and is based on conditions that were readily observable at the time of our site visits. Some existing drawings were provided for review, and no invasive testing was performed. Repair recommendations are conceptual in nature and are not intended for construction. Neither the investigation nor this Report is intended to cover mechanical, electrical, architectural, or other features beyond those described above. Martin/Martin, Inc. does not accept responsibility for deficiencies not evident during an observation of this type.

Any opinions of probable Project costs or construction costs rendered by Martin/Martin, Inc. represent its reasonable professional engineering opinion and are furnished for general guidance. Martin/Martin, Inc. makes no representation, warranty, or guarantee, either expressed or implied, as to the accuracy of such opinions as compared to bid or actual costs.

We appreciate this opportunity to be of service. Please contact us if you have any questions regarding this Report or if you require further assistance.

Sincerely,

Roger M. Mock, PE
Senior Project Engineer, Investigative Engineering

Meg Riley, PE
Project Engineer, Investigative Engineering

APPENDICES

APPENDIX A
Overall Photos of Culvert at 50-Foot Intervals

SOUTH CULVERT (1100 FT)

Photo A.1: Entrance Station (S)0+00 (looking south)

Photo A.2: Station (S)0+50 (looking southeast)

Photo A.3: Station (S)1+00 (looking south)

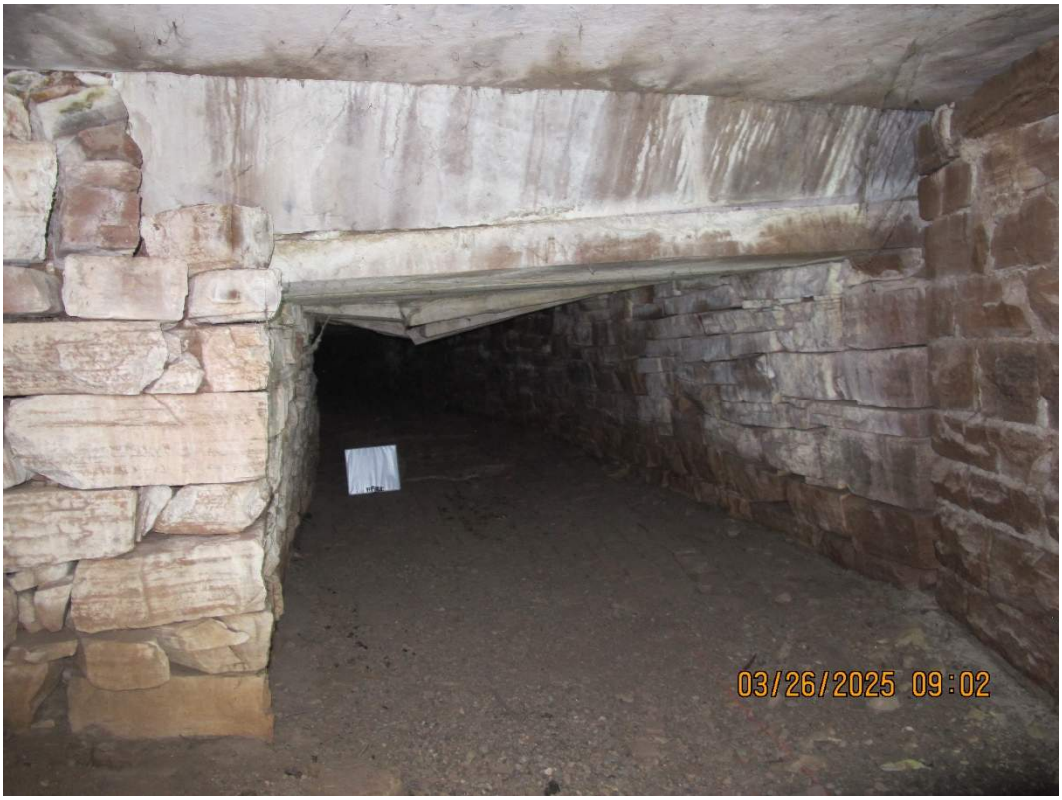

Photo A.4: Station (S)1+50 (looking north)

Photo A.5: Station (S)2+00 (looking south)

Photo A.6: Station (S)2+50 (looking southwest)

Photo A.7: Station (S)3+00 (looking south)

Photo A.8: Station (S)3+50 (looking north)

Photo A.9: Station (S)3+50 (looking south)

Photo A.10: Station (S)4+00 (looking north)

Photo A.11: Station (S)4+00 (looking south)

Photo A.12: Station (S)4+50 (looking south)

Photo A.13: Station (S)5+00 (looking south)

Photo A.14: Station (S)5+50 (looking south)

Photo A.15: Station (S)6+00 (looking south)

Photo A.16: Station (S)6+50 (looking south)

Photo A.17: Station (S)7+00 (looking south)

Photo A.18: Station (S)7+50 (looking south)

Photo A.19: Station (S)8+00 (looking southwest)

Photo A.20: Station (S)8+50 (looking south)

Photo A.21: Station (S)9+00 (looking south)

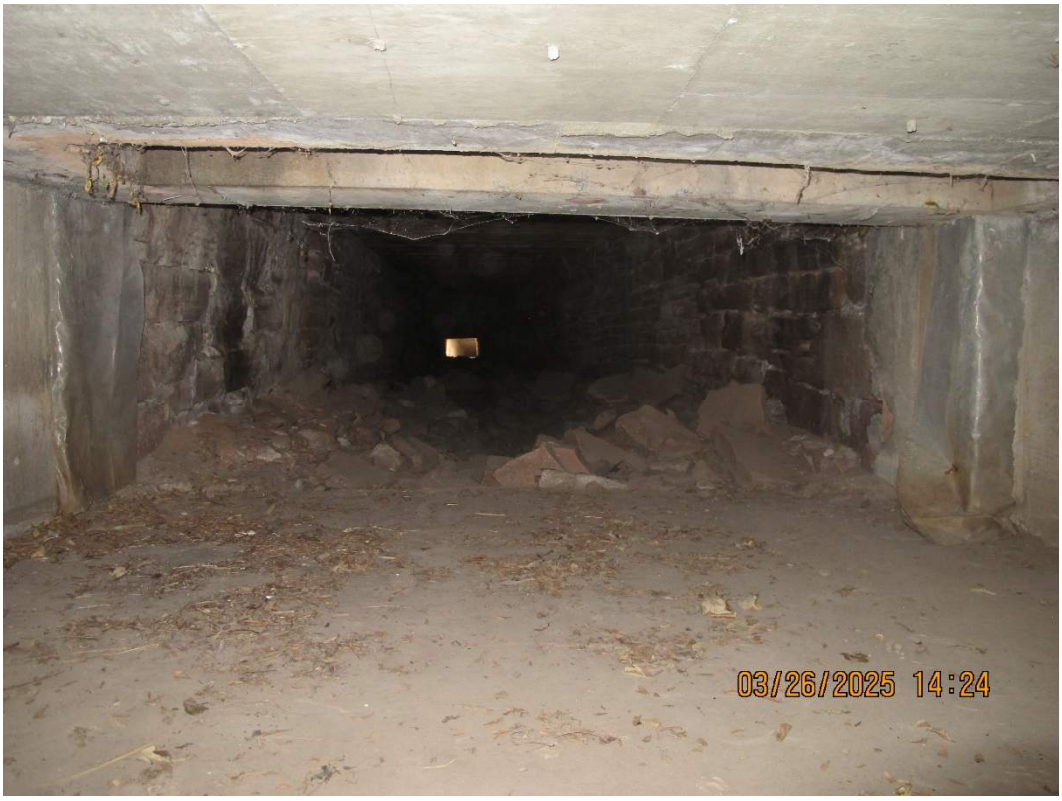

Photo A.22: Station (S)9+50 (looking south)

Photo A.23: Station (S)10+00 (looking south)

Photo A.24: Station (S)10+50 (looking south)

Photo A.25: Station (S)11+00 (looking south)

NORTH CULVERT (300 FT)

Photo A.26: Entrance Station (N)0+00 (looking south)

Photo A.27: Station (N)0+00 (looking south)

Photo A.28: Station (N)0+50 (looking south)

Photo A.29: Station (N)1+00 (looking south)

Photo A.30: Station (N)1+50 (looking south)

Photo A.31: Station (N)2+00 (looking south)

Photo A.32: Station (N)2+50 (looking south)

Photo A.33: Station (N)3+00 (looking north)

Photo A.34: Station (N)3+00 (looking south)

APPENDIX B
Construction Types – Representative Photos

LID CONSTRUCTION REPRESENTATIVE PHOTOS

Photo B.1: Lid Construction Type L1

Photo B.2: Lid Construction Type L2 – Example 1

Photo B.3: Lid Construction Type L2 – Example 2

Photo B.4: Lid Construction Type L2 – Example 3

Photo B.5: Lid Construction Type L2 – Example 4

Photo B.6: Lid Construction Type L3 – Example 1

Photo B.7: Lid Construction Type L3 – Example 2

Photo B.8: Lid Construction Type L3 – Example 3

Photo B.9: Lid Construction Type L4 – Example 1

Photo B.10: Lid Construction Type L4 – Example 2

Photo B.11: Lid Construction Type L5

Photo B.12: Lid Construction Type L6 – Example 1

Photo B.13: Lid Construction Type L6 – Example 2

Photo B.14: Lid Construction Type L7

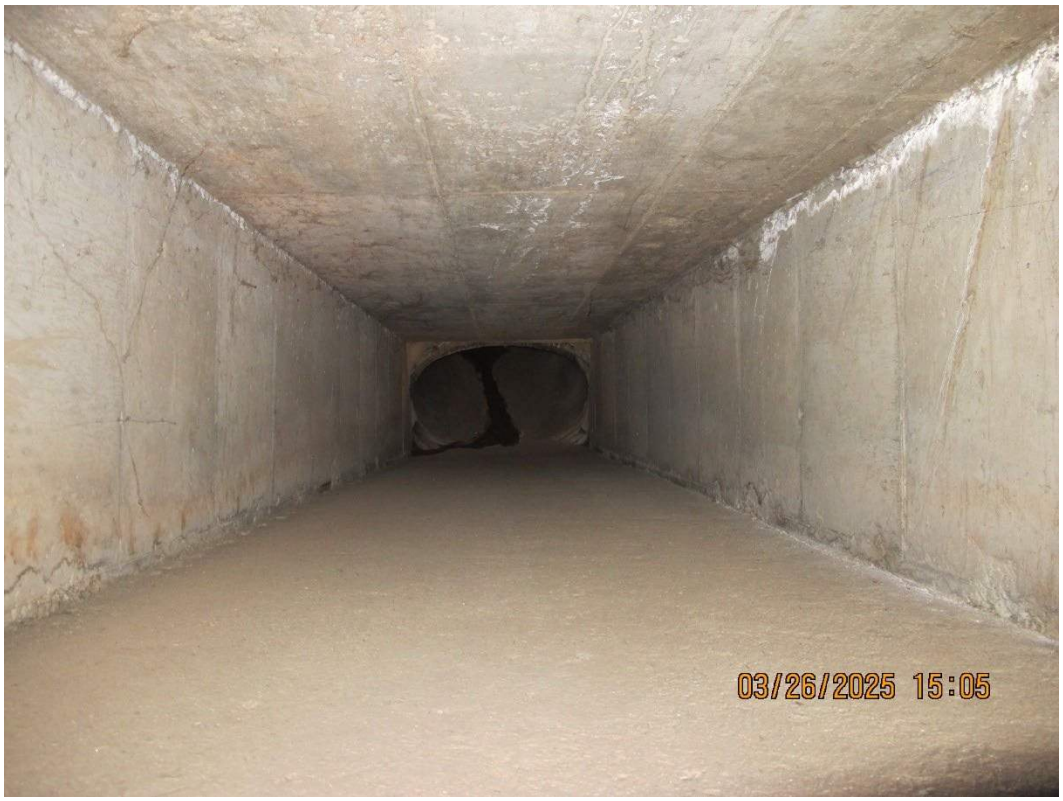

Photo B.15: Lid Construction Type L8

Photo B.16: Lid Construction Type L9

WALL CONSTRUCTION REPRESENTATIVE PHOTOS

Photo B.17: Wall Construction Type W1 – Example 1

Photo B.18: Wall Construction Type W1 – Example 2

Photo B.19: Wall Construction Type W2 – Example 1

Photo B.20: Wall Construction Type W2 – Example 2

Photo B.21: Wall Construction Type W3

Photo B.22: Wall Construction Type W4

Photo B.23: Wall Construction Type W5

Photo B.24: Wall Construction Type W6 – Example 1

Photo B.25: Wall Construction Type W6 – Example 2

Photo B.26: Wall Construction Type W7

Photo B.27: Wall Construction Type W8

FLOOR CONSTRUCTION REPRESENTATIVE PHOTOS

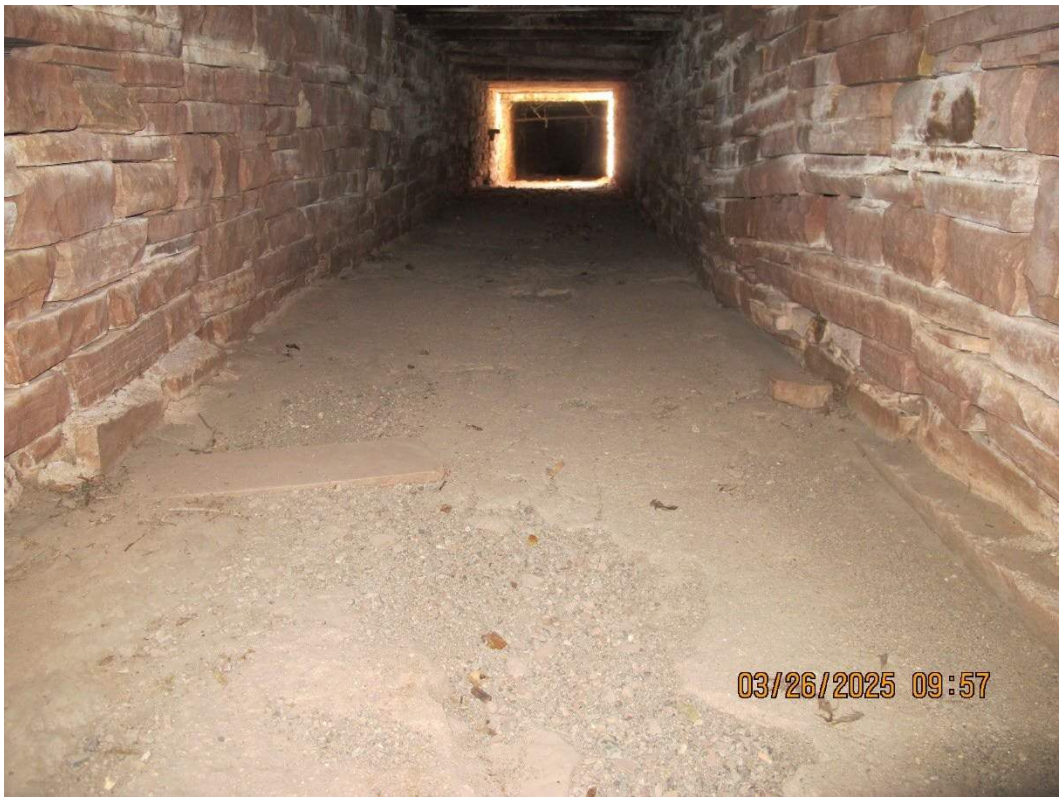

Photo B.28: Floor Construction Type F1

Photo B.29: Floor Construction Type F2

Photo B.30: Floor Construction Type F3 – Example 1

Photo B.31: Floor Construction Type F3 – Example 2

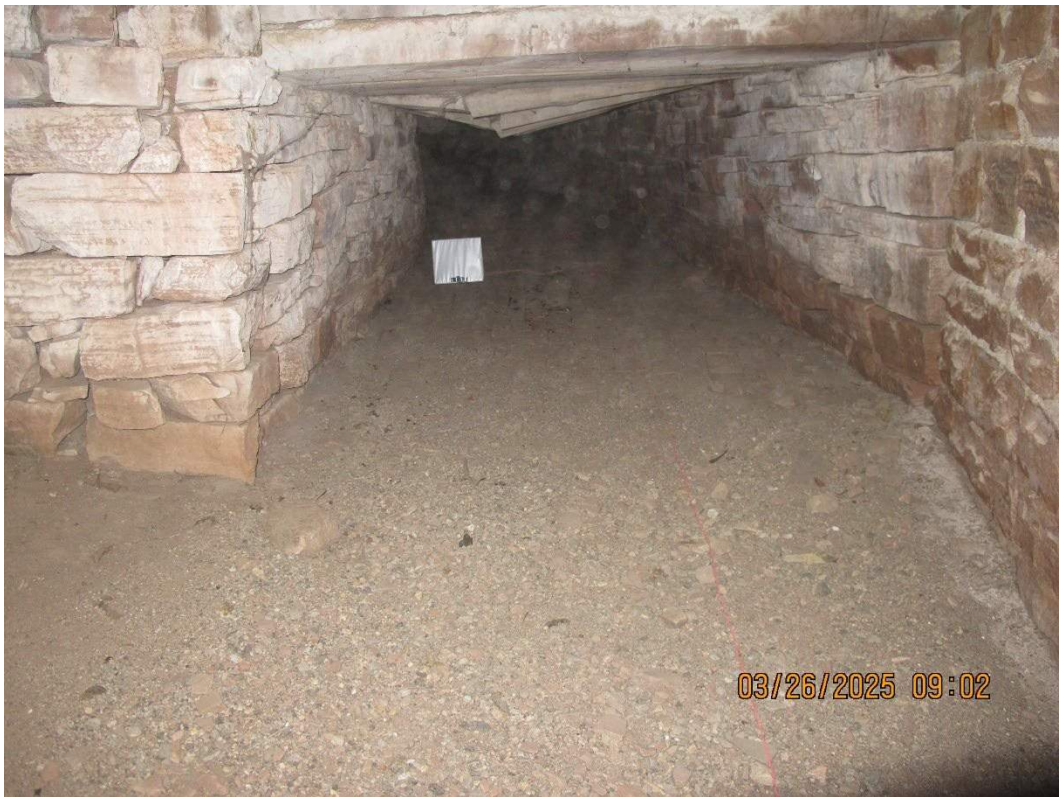

Photo B.32: Floor Construction Type F4

Photo B.33: Floor Construction Type F5

Photo B.34: Floor Construction Type F6

Photo B.35: Floor Construction Type F6

Photo B.36: Floor Construction Type F7

APPENDIX C
Photos of Areas of Damage / Concern

DAMAGE TYPE A (Flagstone Lid Fracture)

Photo C.1 South Culvert Station (S)0+13

Photo C.2: South Culvert Station (S)0+24

Photo C.3: South Culvert Station (S)0+28

Photo C.4: South Culvert Station (S)1+47

Photo C.5: South Culvert Station (S)2+07

Photo C.6: South Culvert Station (S)2+43

Photo C.7: South Culvert Station (S)2+65

Photo C.8: South Culvert Station (S)2+70

Photo C.9: South Culvert Station (S)2+76

Photo C.10: South Culvert Station (S)2+80

Photo C.11: South Culvert Station (S)6+16

Photo C.12: South Culvert Station (S)7+15

Photo C.13: North Culvert Station (N)0+43

Photo C.14: North Culvert Station (N)1+01

DAMAGE TYPE B (Deteriorated Steel Framing at Lid)

Photo C.15: South Culvert Station (S)2+62

Photo C.16: South Culvert Station (S)7+04

Photo C.17: South Culvert Station (S)7+07 (Photo 1)

Photo C.18: South Culvert Station (S)7+07 (Photo 2)

Photo C.19: North Culvert Station (N)1+11

Photo C.20: North Culvert Station (N)2+02

Photo C.21: North Culvert Station (N)2+04

DAMAGE TYPE C (Deteriorated Concrete Lid)

Photo C.22: South Culvert Station (S)3+82

Photo C.23: South Culvert Station (S)4+53

Photo C.24: South Culvert Station (S)7+75

Photo C.25: South Culvert Station (S)7+86 (Photo 1)

Photo C.26: South Culvert Station (S)7+86 (Photo 2)

Photo C.27: South Culvert Station (S)8+85

DAMAGE TYPE D (Poor Bearing Condition at Top of Wall)

Photo C.28: South Culvert Station (S)0+16

Photo C.29: South Culvert Station (S)0+24

Photo C.30: South Culvert Station (S)1+72

Photo C.31: South Culvert Station (S)1+77

Photo C.32: South Culvert Station (S)4+76

Photo C.33: South Culvert Station (S)5+13

Photo C.34: South Culvert Station (S)10+36

Photo C.35: South Culvert Station (S)10+77

Photo C.36: North Culvert Station (N)2+87

DAMAGE TYPE E (Missing or Displaced Masonry in Wall)

Photo C.37: South Culvert Station (S)0+85

Photo C.38: South Culvert Station (S)0+91

Photo C.39: South Culvert Station (S)2+57

Photo C.40: South Culvert Station (S)3+53

Photo C.41: North Culvert Station (N)0+09

Photo C.42: North Culvert Station (N)0+28

Photo C.43: North Culvert Station (N)0+99

Photo C.44: North Culvert Station (N)1+05

Photo C.45: North Culvert Station (N)1+34

Photo C.46: North Culvert Station (N)2+26

Photo C.47: North Culvert Station (N)2+75

Photo C.48: North Culvert Station (N)2+81

Photo C.49: North Culvert Station (N)2+89

DAMAGE TYPE F (Scour, Washout, or Large Drop at Floor)

Photo C.50: South Culvert Station (S)2+77

Photo C.51: South Culvert Station (S)3+63

Photo C.52: South Culvert Station (S)3+80

Photo C.53: South Culvert Station (S)4+14

Photo C.54: South Culvert Station (S)8+30

Photo C.55: South Culvert Station (S)8+62

Photo C.56: South Culvert Station (S)9+71

DAMAGE TYPE G (Large Pile of Rubble or Concrete at Floor)

Photo C.57: South Culvert Station (S)8+27

Photo C.58: South Culvert Station (S)8+62

Photo C.59: South Culvert Station (S)9+88

APPENDIX D
Photos of Incoming Pipes, Inlets, and other Utilities

Photo D.1: South Culvert Station (S)0+98

Photo D.2: South Culvert Station (S)1+09 (West Wall)

Photo D.3: South Culvert Station (S)1+09 (East Wall)

Photo D.4: South Culvert Station (S)1+74

Photo D.5: South Culvert Station (S)2+07

Photo D.6: South Culvert Station (S)2+41

Photo D.7: South Culvert Station (S)2+73

Photo D.8: South Culvert Station (S)3+63

Photo D.9: South Culvert Station (S)3+75

Photo D.10: South Culvert Station (S)5+25

Photo D.11: South Culvert Station (S)5+48

Photo D.12: South Culvert Station (S)6+38 (West Wall)

Photo D.13: South Culvert Station (S)6+38 (East Wall)

Photo D.14: South Culvert Station (S)6+87

Photo D.15: South Culvert Station (S)6+92

Photo D.16: South Culvert Station (S)7+21 (West Wall)

Photo D.17: South Culvert Station (S)7+21 (East Wall)

Photo D.18: South Culvert Station (S)7+85

Photo D.19: South Culvert Station (S)7+90 to (S)7+92 (East Wall)

Photo D.20: South Culvert Station (S)8+18

Photo D.21: South Culvert Station (S)8+22

Photo D.22: South Culvert Station (S)8+71

Photo D.23: South Culvert Station (S)8+98

Photo D.24: South Culvert Station (S)9+43

Photo D.25: South Culvert Station (S)9+53

Photo D.26: South Culvert Station (S)9+66

Photo D.27: South Culvert Station (S)10+20

Photo D.28: South Culvert Station (S)10+24

Photo D.29: North Culvert Station (N)0+04

Photo D.30: North Culvert Station (N)0+09

Photo D.31: North Culvert Station (N)0+74

Photo D.32: North Culvert Station (N)1+54

Photo D.33: North Culvert Station (N)1+64

Photo D.34: North Culvert Station (N)1+70

Photo D.35: North Culvert Station (N)2+27

Photo D.36: North Culvert Station (N)2+44

Photo D.37: North Culvert Station (N)2+45

Photo D.38: North Culvert Station (N)2+48

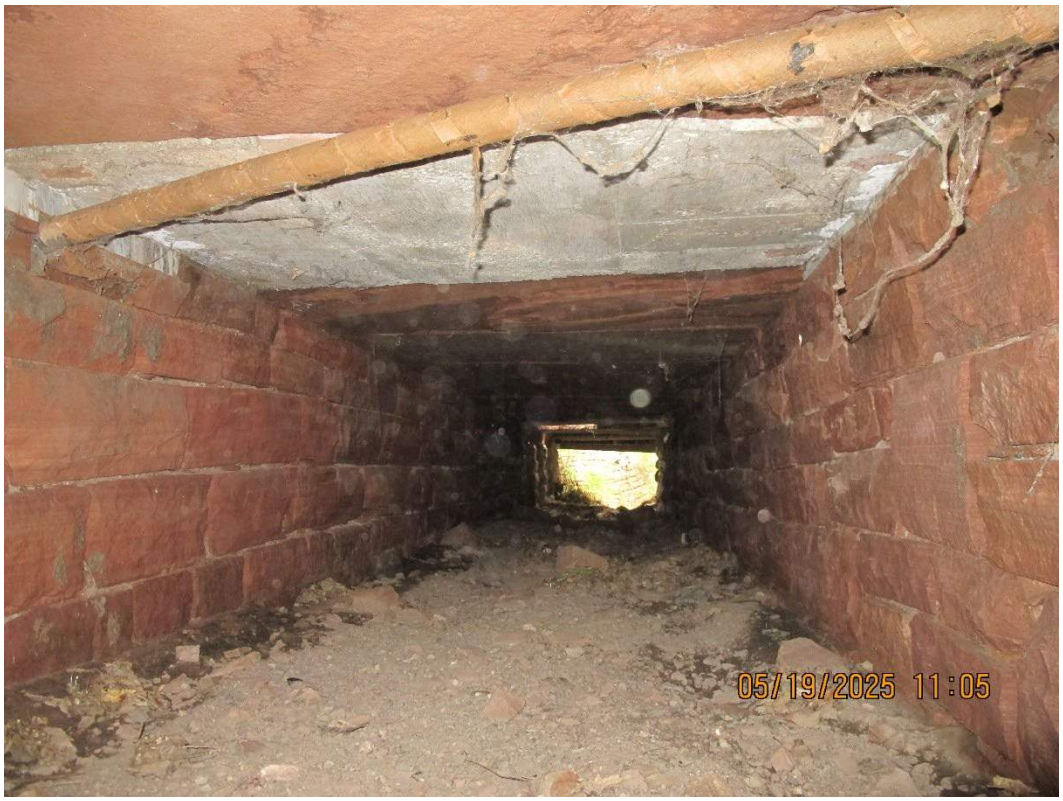

Photo D.39: North Culvert Station (N)2+54

Photo D.40: North Culvert Station (N)2+89

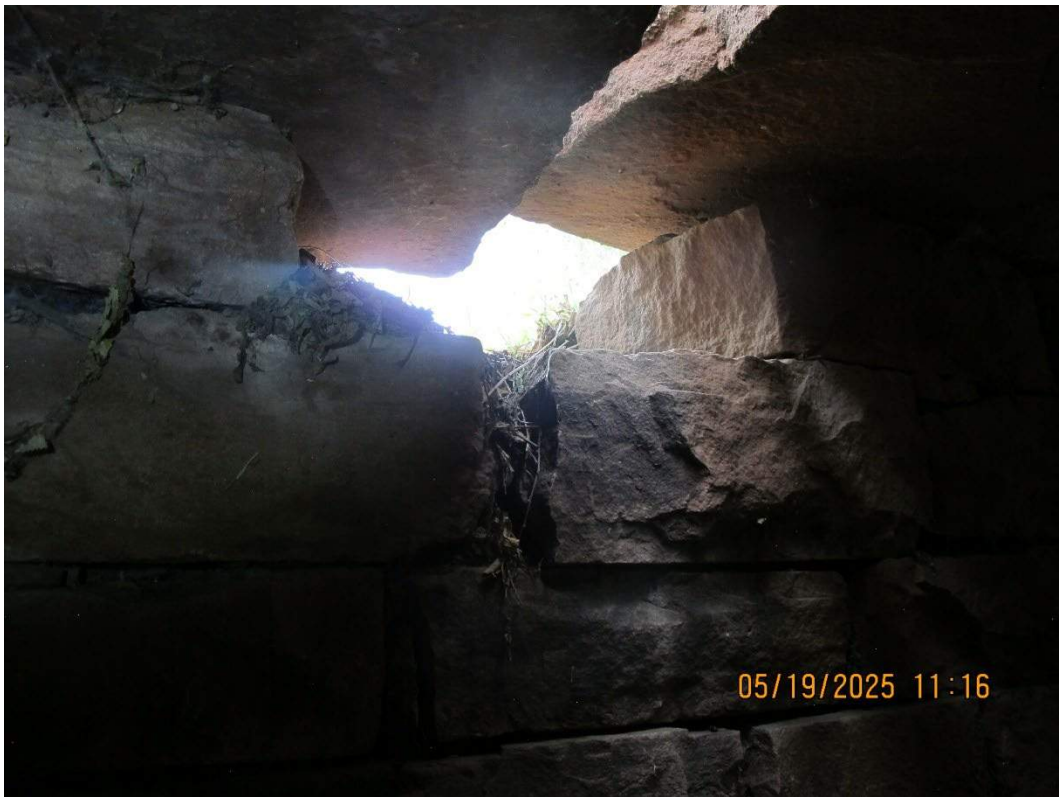

Photo D.41: North Culvert Station (N)2+94

APPENDIX E
Photos of Previous Repairs

Photo E.1: Previous Repair type PR1, South Culvert Station (S)0+35

Photo E.2: Previous Repair Type PR2, South Culvert Station (S)1+35

Photo E.3: Previous Repair Type PR3, South Culvert Station (S)2+43

Photo E.4: Previous Repair Type PR4, South Culvert Station (S)3+80

Photo E.5: Previous Repair Type PR5, South Culvert Station (S)8+94

Photo E.6: Previous Repair Type PR6, South Culvert Station (S)9+71

APPENDIX F
Engineer's Cost Estimates

Deterioration Type A - Flagstone Lid Fracture (accessible from above)

Repair Option 1 - Lyons Red Sandstone Lid[1]

CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-00210[2]	Removal of Concrete Pavement	SY	12	$ 303.22	$ 3,639
206-00000	Structure Excavation	CY	8	$ 197.03	$ 1,576
202-00120	Removal of Concrete Box Culvert	LF	6	$ 162.17	$ 973
601-31001[3]	Lyons Red Sandstone Lid	LF	6	$ 1,991.34	$ 11,948
206-00100	Structure Backfill (Class 1)	CY	8	$ 321.50	$ 2,572
210-03100[2]	Replace Concrete Pavement	SY	12	$ 425.28	$ 5,103
				Subtotal	$ 25,811
				Contingency	15%
				Total	**$ 29,683**

Repair Option 2 - Precast Concrete Lid[1]

CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-00210[2]	Removal of Concrete Pavement	SY	12	$ 303.22	$ 3,639
206-00000	Structure Excavation	CY	8	$ 197.03	$ 1,576
202-00120	Removal of Concrete Box Culvert	LF	6	$ 162.17	$ 973
603-70804	8x4 Foot Concrete Box Culvert (Precast)	LF	6	$ 2,157.84	$ 12,947
206-00100	Structure Backfill (Class 1)	CY	8	$ 321.50	$ 2,572
210-03100[2]	Replace Concrete Pavement	SY	12	$ 425.28	$ 5,103
				Subtotal	$ 26,810
				Contingency	15%
				Total	**$ 30,832**

Repair Option 3 - Cast-in-Place Concrete Lid[1]

CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-00210[2]	Removal of Concrete Pavement	SY	12	$ 303.22	$ 3,639
206-00000	Structure Excavation	CY	8	$ 197.03	$ 1,576
202-00120	Removal of Concrete Box Culvert	LF	6	$ 162.17	$ 973
601-01000	Concrete Class B	CY	2	$ 4,887.50	$ 9,775
602-00000	Reinforcing Steel	LB	270	$ 5.00	$ 1,350
206-00100	Structure Backfill (Class 1)	CY	8	$ 321.50	$ 2,572
210-03100[2]	Replace Concrete Pavement	SY	12	$ 425.28	$ 5,103
				Subtotal	$ 24,988
				Contingency	15%
				Total	**$ 28,736**

Notes:

1 - Repair quantities are based on a 6-foot length of repair along culvert with an excavation depth of 2 feet.

2 - Work item may not be required depending on location. Reflected in cost estimate range.

3 - CDOT Cost Item Code or cost data not available for this item. Unique code created and cost based on discussion with supplier.

Deterioration Type	B - Deteriorate Steel Framing at Lid, C - Deteriorated Concrete Lid (accessible from above)				
Repair Option	1 - Precast Concrete Lid[1]				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-00210[2]	Removal of Concrete Pavement	SY	12	$ 303.22	$ 3,639
206-00000	Structure Excavation	CY	8	$ 197.03	$ 1,576
202-00120	Removal of Concrete Box Culvert	LF	6	$ 162.17	$ 973
603-70804	8x4 Foot Concrete Box Culvert (Precast)	LF	6	$ 2,157.84	$ 12,947
206-00100	Structure Backfill (Class 1)	CY	8	$ 321.50	$ 2,572
210-03100[2]	Replace Concrete Pavement	SY	12	$ 425.28	$ 5,103
				Subtotal	$ 26,810
				Contingency	15%
				Total	**$ 30,832**
Repair Option	2 - Cast-in-Place Concrete Lid[1]				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-00210[2]	Removal of Concrete Pavement	SY	12	$ 303.22	$ 3,639
206-00000	Structure Excavation	CY	8	$ 197.03	$ 1,576
202-00120	Removal of Concrete Box Culvert	LF	6	$ 162.17	$ 973
601-01000	Concrete Class B	CY	2	$ 4,887.50	$ 9,775
602-00000	Reinforcing Steel	LB	270	$ 5.00	$ 1,350
206-00100	Structure Backfill (Class 1)	CY	8	$ 321.50	$ 2,572
210-03100[2]	Replace Concrete Pavement	SY	12	$ 425.28	$ 5,103
				Subtotal	$ 24,988
				Contingency	15%
				Total	**$ 28,736**
Repair Option	3 - Replace/Install Steel Framing				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
206-01750	Shoring	LS	1	$ 1,900.00	$ 1,900
202-00495	Removal of Portions of Present Structure	LS	1	$ 2,500.00	$ 2,500
509-00001	Structural Steel (Galvanized)	LB	350	$ 47.83	$ 16,741
				Subtotal	$ 21,141
				Contingency	15%
				Total	**$ 24,312**

Notes:

1 - Repair quantities are based on a 6-foot length of repair along culvert with an excavation depth of 2 feet.

2 - Work item may not be required depending on location. Reflected in cost estimate range.

Deterioration Type	C - Deteriorated Concrete Lid (not accessible from above)				
Repair Option	1 - Overhead Concrete Repairs[1]				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
601-06150	Concrete (Patching)	SF	60	$ 325.00	$ 19,500
				Subtotal	$ 19,500
				Contingency	15%
				Total	**$ 22,425**
Repair Option	2 - Shotcrete Lid[1]				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
601-01000	Concrete Class B	CY	2	$ 4,887.50	$ 9,775
602-00000	Reinforcing Steel	LB	135	$ 5.00	$ 675
				Subtotal	$ 10,450
				Contingency	15%
				Total	**$ 12,018**
Repair Option	3 - Install Steel Framing				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
509-00001	Structural Steel (Galvanized)	LB	700	$ 47.83	$ 33,481
				Subtotal	$ 33,481
				Contingency	15%
				Total	**$ 38,503**

Notes:
1 - Repair quantities are based on a 10-foot length of repair along culvert.
2 - Work item may not be required depending on location. Reflected in cost estimate range.

Deterioration Type	D - Poor Bearing Condition at Top of Wall				
Repair Option	1 - Replace Masonry Stones				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
504-08050	Stone Landscape Wall	SF	4	$ 125.46	$ 502
				Subtotal	$ 502
				Contingency	15%
				Total	**$ 577**
Repair Option	2 - Fill Void with Repair Mortar				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
601-06150	Concrete (Patching)	SF	4	$ 325.00	$ 1,300
				Subtotal	$ 1,300
				Contingency	15%
				Total	**$ 1,495**
Repair Option	3 - Monitor				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
N/A	N/A	N/A	0	$ -	$ -
				Subtotal	$ -
				Contingency	15%
				Total	**$ -**

Deterioration Type	F - Scour at Culvert Floor				
Repair Option	1 - Fill Scoured Area				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-04008	Clean Culvert	LF	15	$ 37.34	$ 560
601-01000	Concrete Class B	CY	6	$ 2,981.58	$ 17,889
602-00000	Reinforcing Steel	LB	810	$ 5.00	$ 4,050
				Subtotal	$ 22,500
				Contingency	15%
				Total	**$ 25,875**
Repair Option	2 - Raise Floor from Sta. (S)3+80 to (S)4+70				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
202-04008	Clean Culvert	LF	90	$ 37.34	$ 3,361
601-01000	Concrete Class B	CY	34	$ 2,981.58	$ 101,374
602-00000	Reinforcing Steel	LB	4590	$ 5.00	$ 22,950
				Subtotal	$ 127,684
				Contingency	15%
				Total	**$ 146,837**
Repair Option	3 - Monitor				
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*	*Unit Price*	*Cost*
N/A	N/A	N/A	0	$ -	$ -
				Subtotal	$ -
				Contingency	15%
				Total	**$ -**

Other Options, Modifications, and Recommendations

Recommendation	Clean Culverts						
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*		*Unit Price*		*Cost*
202-04008	Clean Culvert (South)	LF	1107	$	37.34	$	41,340
202-04008	Clean Culvert (North)	LF	306	$	37.34	$	11,427
				Subtotal		$	52,767
				Contingency			15%
				Total		**$**	**60,682**
Other Options	Slip Lining						
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*		*Unit Price*		*Cost*
603-00010	Culvert Lining (South)	SF	22140	$	46.92	$	1,038,809
603-00001	Annular Space Grouting	CY	820	$	1,025.00	$	840,500
603-00010	Culvert Lining (North)	SF	6120	$	46.92	$	287,150
603-00001	Annular Space Grouting	CY	227	$	1,025.00	$	232,333
				Subtotal		$	2,398,793
				Contingency			15%
				Total		**$**	**2,758,611**
Other Options	Precast Box Culvert (Sta. (S)6+40 to (S)7+20)						
CDOT Cost Item Number	*Item Description*	*Units*	*Quantity*		*Unit Price*		*Cost*
202-00210	Removal of Concrete Pavement	SY	130	$	303.22	$	39,419
206-00000	Structure Excavation	CY	90	$	197.03	$	17,733
202-00120	Removal of Concrete Box Culvert	LF	80	$	162.17	$	12,974
603-70804	8x4 Foot Concrete Box Culvert (Precast)	LF	80	$	2,157.84	$	172,627
206-00100	Structure Backfill (Class 1)	CY	90	$	321.50	$	28,935
210-03100	Replace Concrete Pavement	SY	130	$	425.28	$	55,286
				Subtotal		$	326,974
				Contingency			15%
				Total		**$**	**376,020**