Stream Daylighting Opportunities Assessment

January 27, 2015

PRESENTED TO

City of Grand Rapids
Environmental Services
1300 Market Avenue SW
Grand Rapids, Michigan 49503

PRESENTED BY

Tetra Tech
401 S. Washington Square
Suite 100
Lansing, Michigan 48933

P +1-517-316-3930
F +1-517-484-8140
tetratech.com

Restriction on Use

This report is intended as a planning document. Drawings herein are not intended to be used for construction.

DRAFT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PHOTOGRAPHS

APPENDICES

ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
cfs	cubic feet per second
FEMA	Federal Emergency Management Agency
MDEQ	Michigan Department of Environmental Quality
USGS	United States Geological Survey

DEFINITIONS

Phrase	Definition
100-year flood / flow rate	the event that would be exceeded, on average, once every 100 years; also known as the 1 percent chance event
daylighting	restoring an enclosure watercourse to an open channel
enclosure	the portion of a watercourse that is conveyed in a pipe
FEMA Flood Zone A	area within the limits of the 100-year flood
FEMA Flood Zone B	the area between the limits of the 100-year flood and 500-year flood
inlet	the location where an open channel enters a pipe
outfall	the location where a pipe discharges to an open channel

EXECUTIVE SUMMARY

Stream daylighting was reviewed as one part of a project to identify green infrastructure opportunities in the City of Grand Rapids. Available data on enclosed portions of intermittent and permanent watercourses in the city were reviewed to identify and provide a conceptual design and opinion of cost of the locations that were most suited for daylighting and storage. This report documents the condition of the watercourses (enclosed versus open channel), opportunities to daylight watercourses, and the costs and benefits associated with specific opportunities.

Opportunities were identified by reviewing data provided by the City that included stream and parcel data. All watercourses that were considered are owned by the City of Grand Rapids or the Kent County Drain Commissioner and are located within Grand Rapids. Public and private property sites were considered. A site visit was also completed to better understand the locations in this report. Some watercourses have more than one daylighting opportunity and some do not have any.

Flow rates were calculated to determine the top width that would be required to fully daylight the channel or, if there were space constraints, to provide an open channel for low flows, while higher flows continue to utilize the pipe.

Qualitative rankings were provided to assess the engineering feasibility of a potential route and the potential benefits of daylighting the watercourse. The opportunities in this report include:

- Coldbrook Creek at Highland Park
- Comstock and Sligh Drain at Riverside Park
- Laraway-Brooklyn Drain at MacKay-Jaycees Park
- Palmer / Leonard Heights Drain at the Kent Country Club
- Palmer / Leonard Heights Drain at Northeast Middle School
- Reeds-Barlow Drain at Highland Golf Course
- Richards Fairplains Drain at Huff Park
- Richland Hills Park Diversion Drain
- West Leonard Drain at Indian Mill Creek

The conceptual level opinion of cost for individual projects ranged from $100,000 (Richards-Fairplains Drain) to $1,960,000 (Palmer / Leonard Heights Drain at the Kent Country Club).

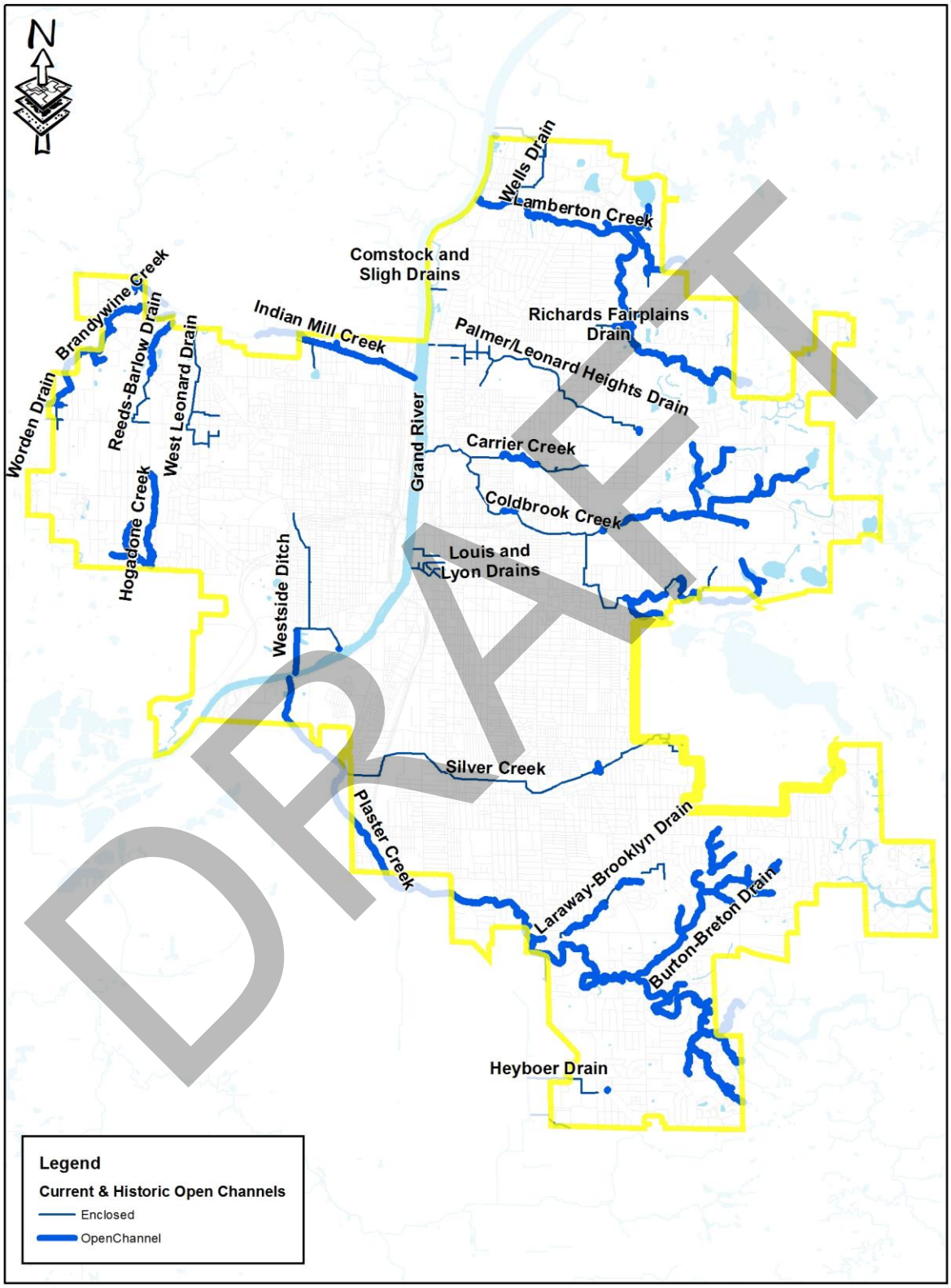
1.0 INTRODUCTION

The green infrastructure opportunity assessment includes identifying locations where natural watercourses that have been enclosed can be daylighted and where storage can be constructed. Daylighting recreates a surface channel for the watercourse and improves habitat along a stream, particularly if an enclosure separates two open channel sections. Storage can reduce peak flow rates and the risk of flooding. Opportunities were assessed using geographical data provided by the City that included enclosed watercourses, land ownership, aerial photography, and topographic data. Peak flow rates were calculated to size the channels and storage volumes. This memorandum summarizes the opportunities and provides conceptual level design and costs.

Several watersheds in Grand Rapids contain natural permanent or intermittent watercourses that have been enclosed in pipes. Geographical data provided by the City and historical mapping were reviewed to determine the watercourses that are currently or were historically open channels. The watercourses reviewed for daylighting and storage opportunities are listed below and shown in Figure 1. The primary watercourses are shown as the major bullet with their tributaries listed following sub-bullets.

- Coldbrook Creek (including South and North Branches)
  - Carrier Creek
- Comstock and Sligh Boulevard Drains
- Heyboer Drain
- Hogadone Creek
- Indian Mill Creek
  - Brandywine Creek
  - Reed Drain
  - West Leonard Drain
  - Worden Drain
- Lamberton Creek
  - Wells Drain
  - Richards Fairbanks Drain
- Louis-Lyon Drain
- Palmer / Leonard Heights Drain
- Plaster Creek
  - Burton-Breton Drain
  - Laraway-Brooklyn Drain
  - Silver Creek
- West Side Ditch

Figure 1: Current and Historic Open Channel Watercourses in Grand Rapids



2.0 CONSTRAINTS AND METHODOLOGY

Several steps were completed to identify and determine the feasible of potential daylighting opportunities from the data collection to understanding details of specific sites. During the initial step, criteria were developed as a basis for locating opportunities. These criteria are listed here:

- Past reports were reviewed and opportunities listed in those reports were included.
- New opportunities must be within the jurisdiction of the Kent County Drain Commissioner or the City of Grand Rapids and within the city boundary.
- Historical open channels based on the City's stormwater collection data, USGS, or other available data were considered. They may be permanent or intermittent watercourses. Local storm sewers were not considered for daylighting opportunities.
- Opportunities were not constrained by pipe size.
- Both public and private open lands were considered for daylighting opportunities, but with the level of development along most of the enclosures parks presented the best opportunities. At the request of the City, drains that would encroach upon cemeteries if daylighted were not considered viable options.

Once potential opportunities were located, flow rates were estimated for several recurrence intervals using MDEQ's *Computing Flood Discharges for Small Ungaged Watersheds* as a basis or by requesting flow rate data directly from MDEQ (Coldbrook Creek only). Flow rates were used to estimate a channel top width for the 100-year design storm to determine if adequate space exists on the site for full or partial conveyance of the flow in an open channel. Calculated top widths were compared to a nearby segment of open channel, if one exists.

If the channel will fully replace the pipe, it was designed to have a trapezoidal shape with a low stage channel able to convey the 2-year flow rate and high stage channel to convey the 100-year flow rate. The width of the channel bottom was based on the span of the enclosure, and the minimum depth was set assuming 1:3 or 1:4 bank side slopes and a roughness coefficient of 0.100. Steeper bank slopes were considered if necessary. Where there are space constraints, and the channel was not designed to fully replace the pipe, the design may omit the separate low and high flow channels. In this case, the pipe will remain in place to convey high flows.

Storage sites were identified based on the available open space and topography.

After these preliminary assessments had been completed, a site visit was done on December 1, 2014 to identify other site-specific constraints that may exist, such as the locations of overhead and underground utilities, buildings, topography, and general use of the site (playgrounds, athletic fields, etc.). Some of the photographs from this site visit are included in this document.

Opinions of cost were prepared for each opportunity and considered. The opinions of cost considered the following general items:

- Design and construction engineering
- Legal, administration, and financing costs
- Traffic control
- Soil erosion control
- Clearing and tree removal
- Excavation and construction of the open channel
- Abandonment, removal, and relocation of utilities, including storm sewer, sanitary sewer, water main, and electric poles
- Construction of new sewers, culverts, and headwalls
- Paving
- Turf restoration

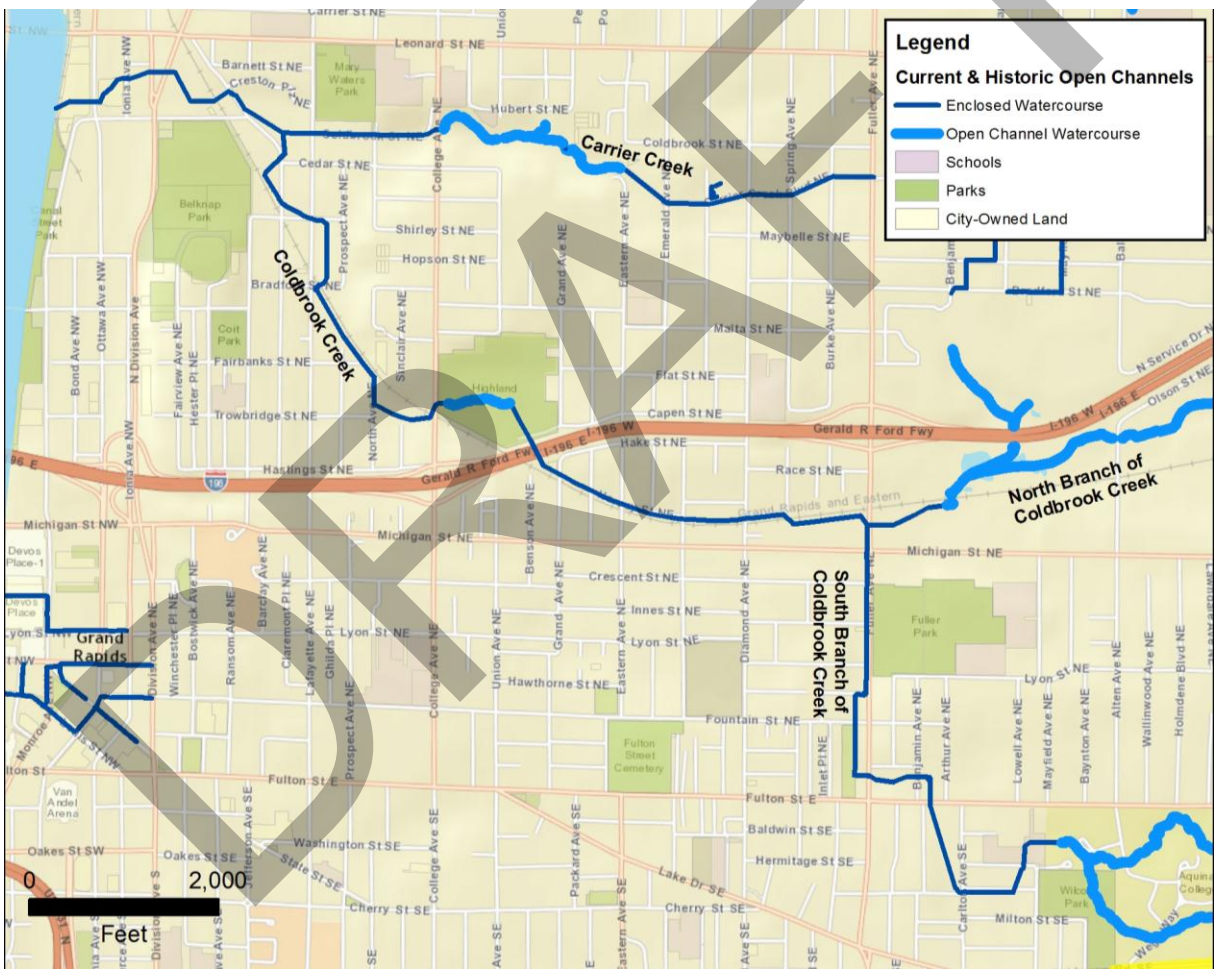
3.0 OPPORTUNITIES

Each of the opportunities is described in this section and a qualitative ranking of all opportunities is provided in Section 3.11. Conceptual drawings, including a summary of the opinions of cost are provided in Appendix A.

3.1 COLDBROOK CREEK

Coldbrook Creek, shown in Figure 2, is located north of downtown, and discharges to the Grand River on its east side at Coldbrook Street. The main branch of the creek, 12,500 feet in length from Fuller Avenue to the Grand River, is fully enclosed except for a 680-foot segment within Highland Park. The downstream end of the enclosure, downstream of Taylor Avenue, is within FEMA Flood Zone B of the Grand River. There are no FEMA-defined flood zones along Coldbrook Creek or its tributaries.

Figure 2: Coldbrook Creek Vicinity Map



The enclosure on the main branch of Coldbrook Creek was constructed between 1893 and 1930, except for the portion of the enclosure in Highland Park, which was constructed in 1963. At the downstream end, it is box-shaped with dimensions of 10- by 9-feet. At the upstream end, at Fuller Avenue, it is an 11- by 7-foot horseshoe-shaped pipe. Surcharging of the pipe is known to occur along portions of the enclosure.

Coldbrook Creek at Highland Park

- Tributary Area = 9.4 square miles
- Enclosure Size = 10 by 8 feet
- Peak Flow Rates
  - 2-year = 300 cfs
  - 10-year = 550 cfs
  - 25-year = 800 cfs
  - 50-year = 1,100 cfs
  - 100-year = 1,300 cfs
- Length of Daylighting = 200 feet
- Estimated Top Width and Depth of Daylighted Section = 100 by 10 feet
- Cost to Daylight = $730,000 (costs do not include storage)
- Benefits
  - Extends open channel within park
  - Space available for storage for locally generated flows
- Constraints
  - 12-inch sanitary sewer would likely have to be relocated
  - Proximity to playground and other structures limits length of daylighting

Downstream of Lafayette Street, Coldbrook Creek passes under buildings and parking lots. Upstream of Lafayette Street, most of the enclosure outside of Highland Park parallels a railroad grade with a few deviations along roads and alleys. This railroad is currently in use, but if it were ever vacated the railroad grade would provide a possible opportunity to daylight an extensive length of the creek.

Daylighting opportunities were reviewed along a section of the creek near Clancy Avenue, which the City is considering abandoning between Creston and Leonard Streets. However, the section of the street that is to be abandoned is north of where Coldbrook Creek turns east away from Clancy Avenue and is higher in elevation making it an unsuitable site for daylighting the creek.

One opportunity to daylight a portion of Coldbrook Creek is to extend the open portion of the creek within Highland Park. The open channel portion of the creek is 15 to 20 feet wide once away from the outfall. The enclosure in the park conveys the creek under Lloyd Peterson Road, a playground, and between two existing buildings. From the site visit, it looks likely that there would only be adequate space to daylight the creek downstream of the playground. Photograph 1 shows the area where Coldbrook Creek is enclosed within the park.

In addition to daylighting Coldbrook Creek, the concept includes removing a 200-foot segment of 36-inch storm sewer adjacent to the existing headwall on Coldbrook Creek. A portion of the pipe would likely be exposed when the headwall was removed and by the necessary grading to accommodate the open channel. The sewer would be removed downstream of the first bend in the pipe and a new outfall and headwall would be constructed.

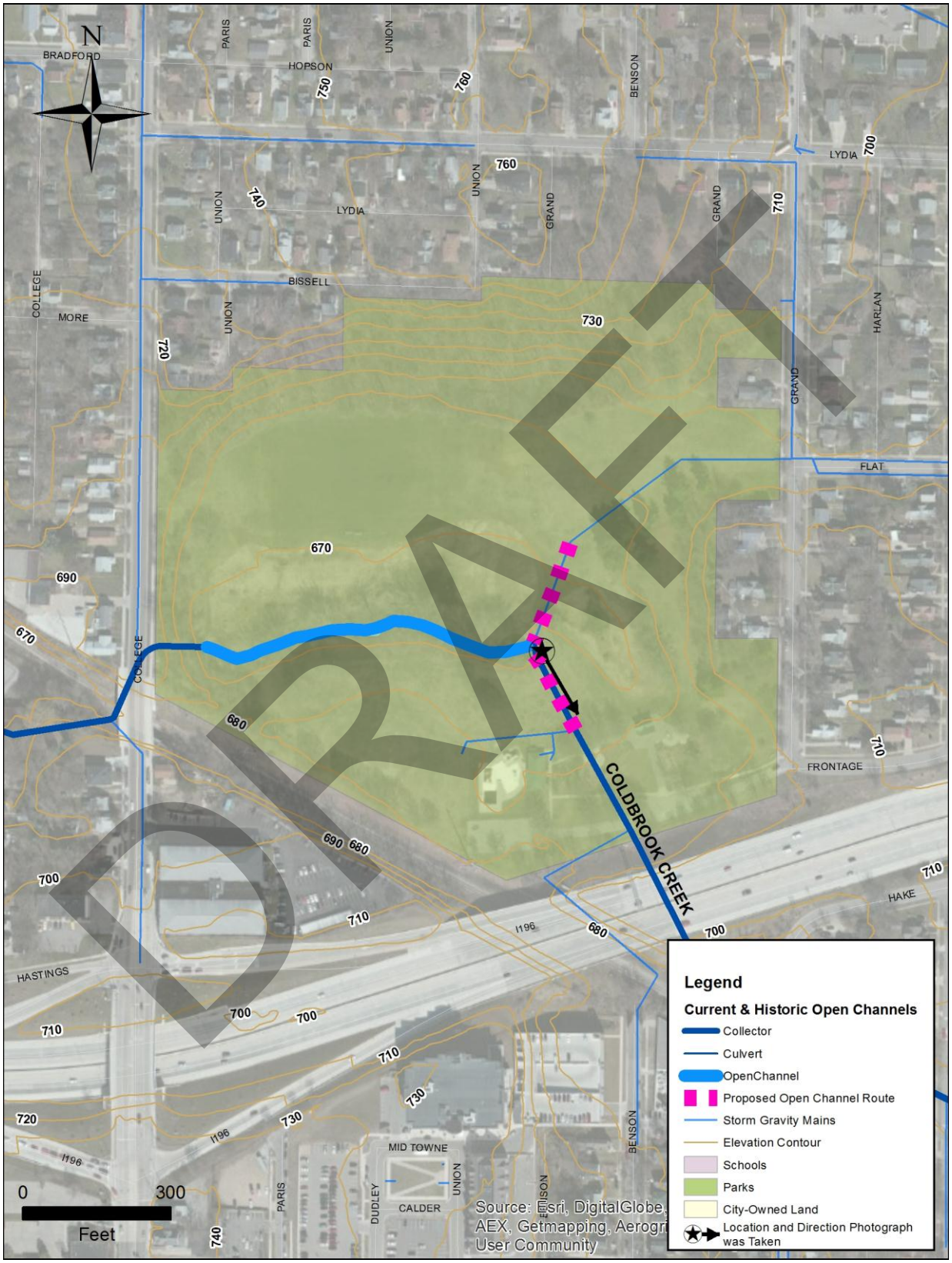
Photograph 1: General Location of Coldbrook Creek Enclosed under Highland Park

The park already appears to contain some storage volume in a low area to the north and east of the creek. There is a potential to expand the storage area. Any additional volume would have little impact on the peak flow rates in the creek, but could be used to retain and / or detain flows from the 36-inch storm sewer that discharges near the downstream end of the current enclosure.

There is a 12-inch, 8 to 16-foot deep, sanitary sewer that crosses the creek in the area that could be daylighted and would likely have to be re-located and remain on the north side of Coldbrook Creek through Highland Park until College Avenue where it could cross Coldbrook Creek and re-connect to the interceptor.

A map of the opportunity with the proposed daylighted channel is shown in Figure 3.

Figure 3: Coldbrook Creek at Highland Park Opportunity Map



3.1.1 North Branch of Coldbrook Creek

The main branch of Coldbrook Creek ends at the confluence of the north and south branches of the creek at Fuller Avenue. The North Branch is enclosed in a 48-inch diameter pipe for the first 900 feet upstream of Fuller Avenue and is an open channel elsewhere upstream, except a few, scattered short lengths that cross under roads or parking lots as culverts. The enclosed part of the North Branch is under parking lots and adjacent to the railroad, so there are no reasonable opportunities to daylight the creek.

3.1.2 South Branch of Coldbrook Creek

The South Branch of Coldbrook Creek roughly parallels Fuller Avenue until Fulton Avenue where it is conveyed along several other streets. This branch is enclosed from Wilcox Park to the main branch of Coldbrook Creek, approximately 6,300 feet in length. The enclosure was constructed between 1919 and 1927, except for the segment nearest Wilcox Park, which was constructed between 1958 and 1965. At the downstream end it is a 114- by 75-inch elliptical pipe and decreases to a 78-inch circular pipe at the upstream end.

Most of the enclosure is under roadways or buildings and present no opportunities for daylighting the creek. A section of the creek does pass by Fuller Park, but daylighting opportunities do not appear viable due to the location of athletic fields, parking areas, and the fact that the ground in the park is several feet higher in elevation than at the location of the enclosure.

Upstream of Wilcox Park, the creek is almost entirely open channel within the City. Even so, Wilcox Park and some of the adjacent larger privately owned parcels (some owned by Aquinas College) could be potential locations to include some storage along the creek to attenuate peaks entering the downstream enclosure. The only enclosed portion upstream of Wilcox Park is 1,200 feet of 54-inch sewer roughly along Mayfair Drive that was constructed between 1949 and 1966. This area is a residential neighborhood, and there is inadequate space to daylight the creek in its present location. Depending on the elevations of the stream channels, it may be possible to relocate the entire creek around its current enclosure through the Aquinas College campus. Most of this route would be outside the city limits and was not pursued as an opportunity for the City.

3.1.3 Carrier Creek

Carrier Creek discharges to Coldbrook Creek near Coldbrook Street and Lafayette Avenue and has two enclosed sections, largely constructed in the late 1920s, surrounding a segment of open channel. The downstream enclosure, located under Coldbrook Street from Coldbrook Creek to College Avenue, is 1,700 feet long and 54 inches in diameter. From College to Eastern Avenues, there is 2,300 feet of open channel through several larger parcels owned by the Kent County Drain Commissioner. The remainder of Carrier Creek, 2,900 feet from Eastern to Fuller Avenues, is enclosed in 36- to 54-inch pipe that follows Carrier Creek Boulevard. Both sections of the enclosure are located in residential neighborhoods with small lots and do not provide any opportunities for daylighting.

3.2 COMSTOCK AND SLIGH BOULEVARD DRAINS

The Comstock and Sligh Boulevard Drains are a system of storm sewers located north of downtown on the east side of Grand River. Most of the storm sewers drain runoff from streets, but near the downstream end there are larger storm sewers that may have once been an intermittent, surficial watercourse. One daylighting opportunity was found within Riverside Park at Guild Street where the Comstock and Sligh Boulevard Drainage Districts discharge to the Grand River.

Comstock and Sligh Drains at Riverside Park

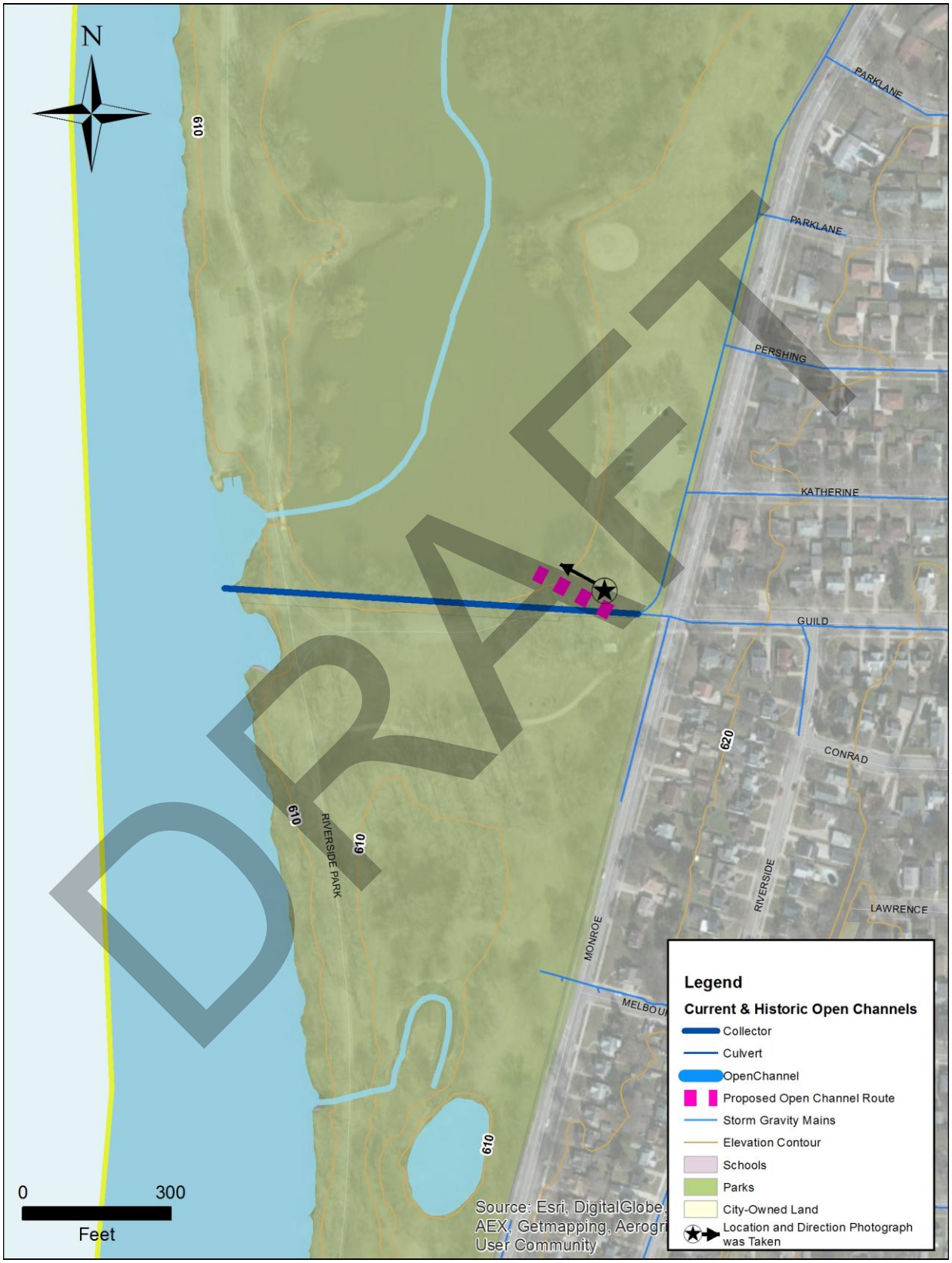
- Tributary Area = 770 acres
- Enclosure Diameter = 6 feet
- Peak Flow Rates
  - 2-year = 80 cfs
  - 10-year = 250 cfs
  - 25-year = 370 cfs
  - 50-year = 490 cfs
  - 100-year = 610 cfs
- Length of Daylighting = 100 feet (740 feet of storm sewer would be abandoned)
- Estimated Top Width and Depth of Daylighted Section = 70 by 8 feet
- Cost to Daylight = $320,000
- No other open channel segments on drain
- Constraints
  - Short length of daylighting
  - Potential change in pond level and sedimentation in pond at discharge

The storm sewer is a 72-inch, circular concrete pipe constructed in 1927 and the portion in Riverside Park is located within the 100-year floodplain of the Grand River (FEMA Flood Zone A). The conceptual design includes discharging the storm sewer to the north side of the park drive at Guild Street (downstream of the recent road and trail work) and conveying the water in an open channel to the pond within the park rather than to the Grand River. The storm sewer would be abandoned downstream of the channel. The potential discharge location is shown in Photograph 2. A map of the area is shown in Figure 4.

Several large trees would likely have to be cut to construct an open channel. The two existing channels connecting the pond to the Grand River would likely convey additional water from the pond to the Grand River without impacting the water level in the pond, but this should be verified to determine if there would be any potential harm to recreational use in the park and to the hydraulic grade line of a 27-inch storm sewer that currently discharges to the pond. Sedimentation in the pond from debris in the storm sewer would also have to be considered. There is only one other smaller, 27-inch storm sewer that discharges to the ponds currently.

Photograph 2: Potential Discharge Point of Comstock-Sligh Drain into Riverside Park Pond at Guild Street

Figure 4: Comstock and Sligh Boulevard Drainage Districts Opportunity Map



3.3 HEYBOER DRAIN

Heyboer Drain is located at the southern edge of the City, south of 40th Street. It is completely enclosed within the City, and runs under several buildings and parking lots. There are no opportunities to daylight the drain.

3.4 HOGADONE CREEK

Hogadone Creek is located on the west side of Grand Rapids, mostly west of Bona Vista Drive and south of 7th Street. It flows south of the City before eventually discharging to the Grand River. It is an open channel for its entire length within the City.

3.5 INDIAN MILL CREEK

Indian Mill Creek is located in northwest Grand Rapids and discharges to the Grand River south of Ann Street. It is an open channel within the city limits, but there are enclosed watercourses on several of its tributaries. None of the enclosed parts of the tributaries are located within FEMA-defined flood zones.

In Richmond Hills Park, there is a diversion from Indian Mill Creek used to feed a pond. This was never an open channel as far as has been determined, but the City has considered daylighting the storm sewer to try to reduce erosion at the outlet of the pipe. It is a 12-inch diameter pipe and is largely conveyed under open space within the park, except for the most downstream 500 feet, which are conveyed under a building, pool and splash park, and parking lot.

Diversion Drain at Richmond Hills Park

- Tributary Area = diversion channel – no unique drainage
- Enclosure Diameter = 1 foot
- Peak Flow Rates (based on pipe capacity)
  - 2-year = 2 cfs
  - 10-year = 2 cfs
  - 25-year = 3 cfs
  - 50-year = 4 cfs
  - 100-year = 4 cfs
- Length of Daylighting = 1,700 feet
- Estimated Top Width and Depth of Daylighted Section = 50 by 3 feet
- Cost to Daylight = $600,000
- No other open channel segments on drain
- Constraints
  - Not a natural stream
  - Power lines along north boundary
  - Proximity to athletic fields
  - Potential to increase flows to pond and cause flooding
  - Sanitary sewer would cross channel

The concept includes daylighting the upstream portion of the pipe and constructing the channel largely along the same alignment as the pipe, west of the ball field fence and tennis courts and east of the hill. It is likely that the last 500 feet would not be able to be daylighted because this would require a new route around structures and there are not adequate options (structures to the east and a hill to the west). A map of the area is shown in Figure 5.

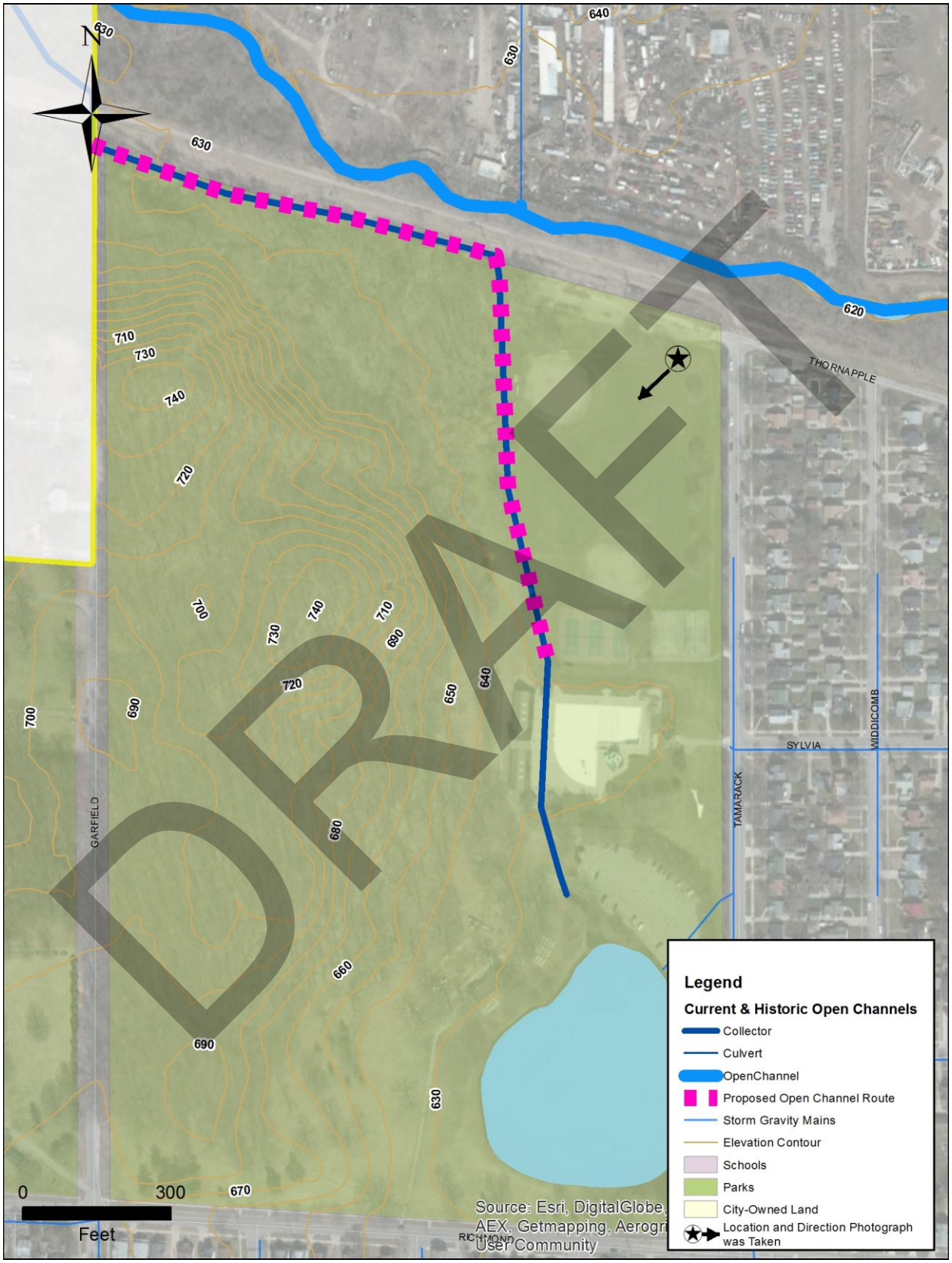
There is no definitive tributary area, so peak flow rates were estimated assuming that the pipe capacity is the same as the 10-year flow rate.

The portion of Richmond Hills Park where the enclosure is located is shown in Photograph 3. In the photograph, the ball field and tennis courts are in the foreground and the potential route of the open channel along the tree line is in the background. The pipe would have to remain under the buildings on the left (south) side of the photograph.

The design would also have to consider power lines and a 24-inch sanitary sewer along the north boundary of the park. The sanitary sewer would have to cross the open channel, but it appears to be deep enough (6 to 8 feet) to cross under it. There is also the possibility that opening the channel will increase flows to the pond, which may cause the level of the pond to rise if the outlet is not adequately sized.

Photograph 3: General Area of 12-inch Storm Sewer under Richmond Hills Park

Figure 5: Richmond Hills Park Opportunity Map



3.5.1 Brandywine Creek

Brandywine Creek is a tributary of Indian Mill Creek west of Walker Avenue in the northwest corner of the city. Within the city, it is entirely an open channel. There is some open space for possible storage within the Blanford Nature Center, but was not considered an opportunity in this document because there are no enclosures nearby that would be impacted by storage along Brandywine Creek.

3.5.2 Reeds-Barlow Drain

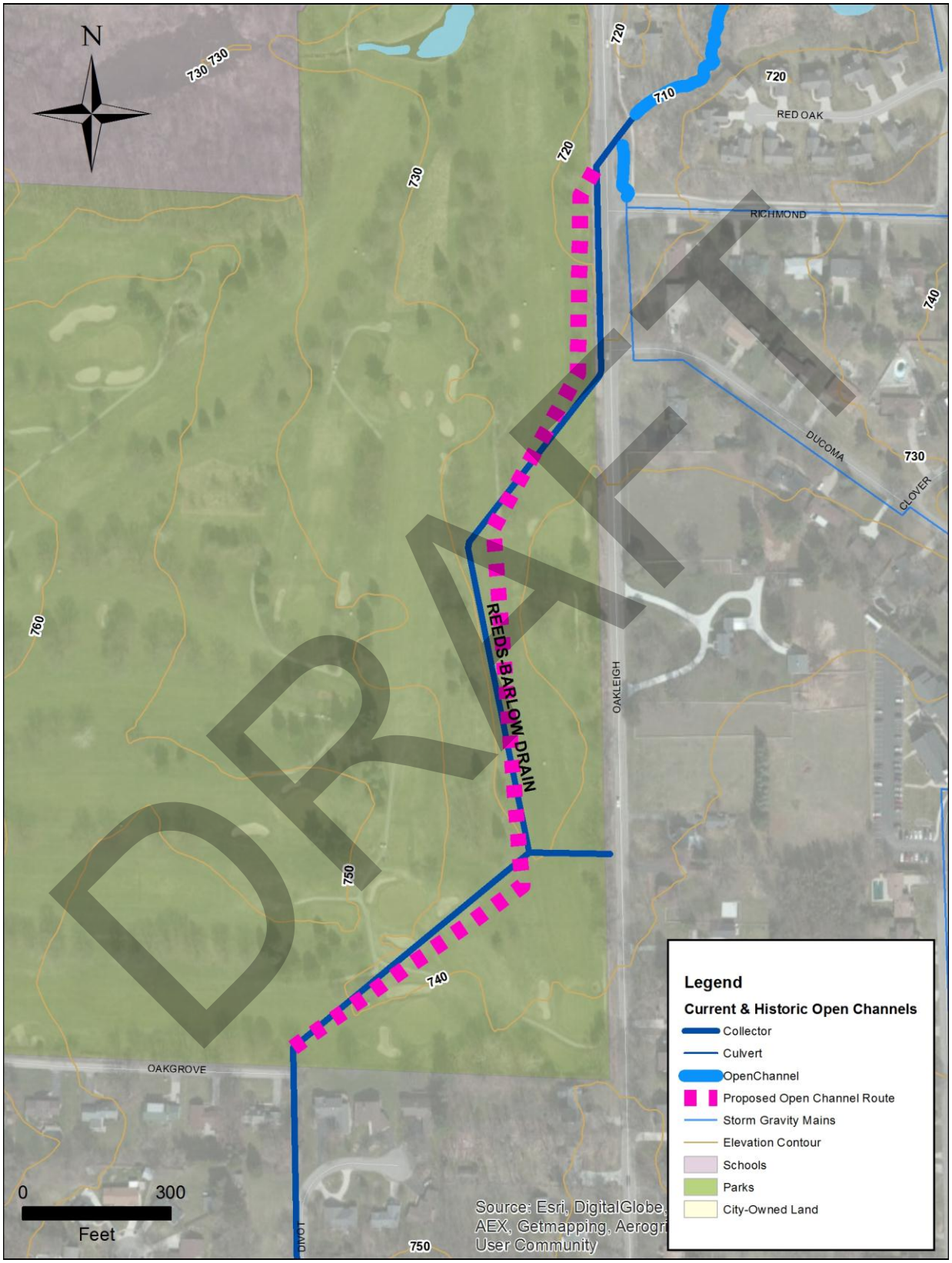
Reeds-Barlow Drain is a tributary of Brandywine Creek. Its downstream reach, north of Richmond Street, is an open channel. The upstream portion of the drain, south of Richmond Street, is enclosed for 4,200 feet in a 27 to 54-inch diameter pipe constructed in 1975.

About half of the enclosure is located in the Highland Golf Course along Oakleigh Road, so any discussion of daylighting the drain would have to include the property owner. Daylighting the drain will likely require crossing the property in its current route, which would impact the current operation of the golf course. There are no structures in this part of the golf course, but about 400 feet of 12-inch sanitary sewer at the upstream end of the proposed daylighted section would likely have to be relocated to accommodate a channel. The sanitary sewer is 6 to 10 feet deep in this area. A culvert would remain under Oakleigh Road. A map of the area is shown in Figure 6.

Reeds-Barlow Drain at Highland Golf Course

- Tributary Area = 200 acres
- Enclosure Diameter = 3.5 – 4 feet
- Peak Flow Rates
  - 2-year = 70 cfs
  - 10-year = 170 cfs
  - 25-year = 230 cfs
  - 50-year = 290 cfs
  - 100-year = 350 cfs
- Length of Daylighting = 2,000 feet
- Estimated Top Width and Depth of Daylighted Section = 60 by 6 feet
- Cost to Daylight = $1,360,000
- Extends downstream open channel
- Constraints
  - Located on private property and would likely impact current operations of the golf course
  - 400 feet of sanitary sewer would likely have to be relocated

Figure 6: Reeds-Barlow Drain Opportunity Map



3.5.3 West Leonard Drain

The West Leonard Drain is a tributary of Indian Mill Creek, which it discharges to at Walker Avenue. It is completely enclosed. The downstream-most 2,300 feet of the drain is parallel to Walker Avenue and adjacent to Holy Cross Cemetery. Much of the cemetery adjacent to the road is occupied by buildings or gravestones or is higher in elevation and would be difficult to daylight the drain even if space was available. However, north of Blue Bell Way, daylighting the drain may be possible because of a wider area of open space between the road and the cemetery fence.

West Leonard Drain at Indian Mill Creek

- Tributary Area = 330 acres
- Enclosure Diameter = 2.5 feet
- Peak Flow Rates
  - 2-year = 55 cfs
  - 10-year = 150 cfs
  - 25-year = 210 cfs
  - 50-year = 270 cfs
  - 100-year = 330 cfs
- Length of Daylighting = 700 feet
- Estimated Top Width and Depth of Daylighted Section = 50 by 6 feet
- Cost to Daylight = $460,000
- Provides open channel discharge to Indian Mill Creek
- Constraints
  - Grading would likely encroach on private property and easement will likely be required
  - Sanitary sewer and gas line may need to be relocated
  - Guard rail may be necessary along Walker Avenue
  - Relatively steep channel may require additional erosion protection

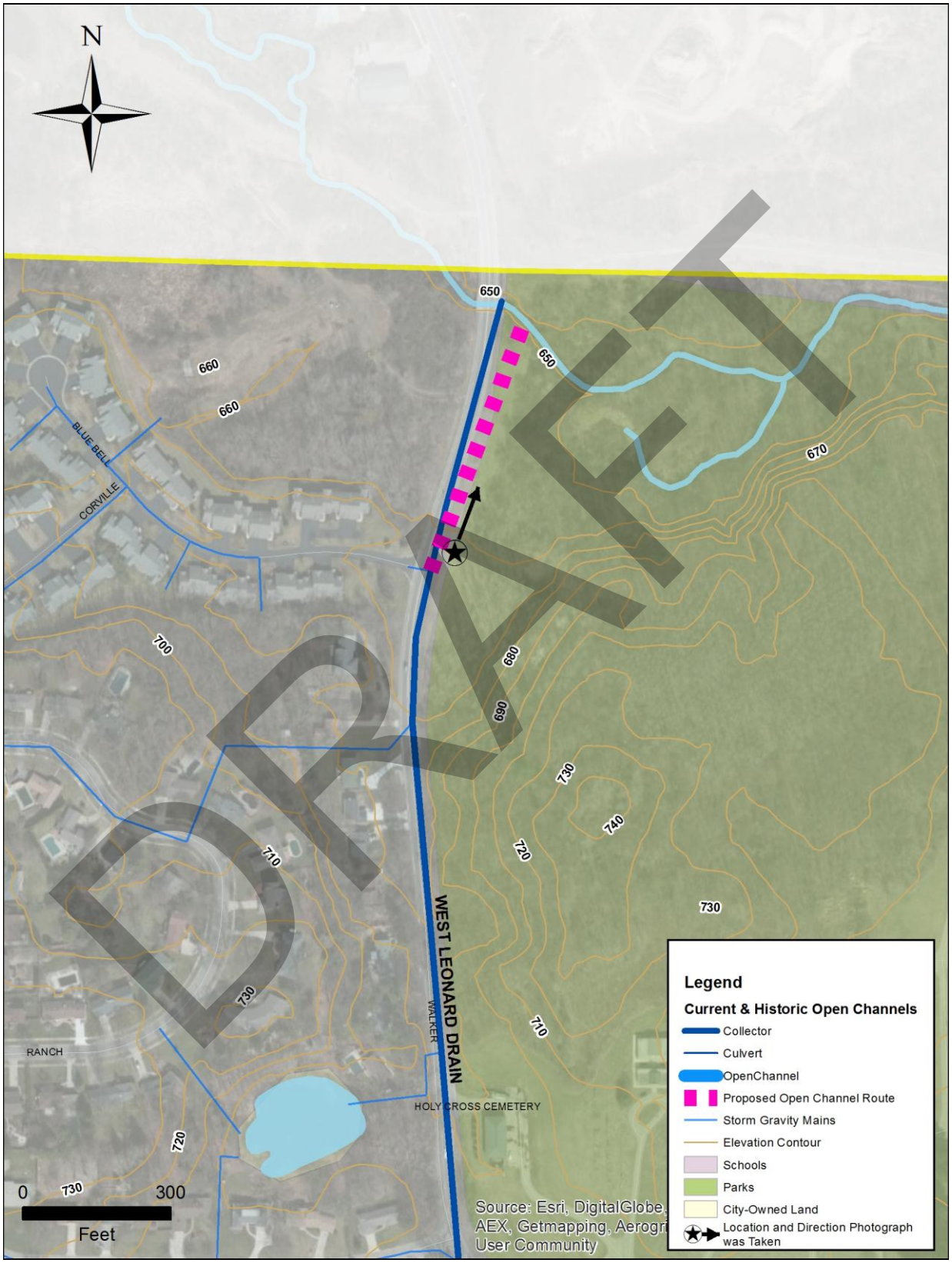
The concept would include discharging the storm sewer to the right-of-way on the east side of Walker Avenue where adequate space first becomes available and abandoning the storm sewer. The design would have to consider a gas line and 15-inch sanitary sewer along Walker Avenue and may require cooperation with the owner of the cemetery property as any grading of the banks would likely encroach upon the fence line. A guard rail may be necessary for safety along portions of Walker Avenue, especially near where the pipe would outfall to the channel because it is likely to be deeper channel with steeper banks at that location. A map of the area is shown in Figure 7.

In this area, the cemetery appears to be wooded and undeveloped. Although the concept maintains the channel within the right-of-way, the most natural slope for a channel would be through the cemetery property, so an alternative route could be considered if the cemetery property owner was willing to assist. The site is shown in Photograph 4 with Walker Avenue on the left (west) and Indian Mill Creek in the background (north).

The open channel would discharge to Indian Mill Creek near the current storm sewer outfall. The bank around the outfall is eroded and the end section is in poor condition. The terrain is relatively steep in this area (more than one percent slope) and would likely require some consideration of erosion before implementation.

Photograph 4: Potential Location for Daylighting West Leonard Drain along Walker Avenue

Figure 7: West Leonard Drain Opportunity Map



3.5.4 Worden Drain

Worden Drain is a tributary of Brandywine Creek on the west side of the City. It discharges to Brandywine Creek near Milo Street west of Laughlin Drive. The entirety of the main branch of the Worden Drain is an open channel. Some of the branches are enclosed, but run through developed areas and provide no opportunities for daylighting.

3.6 LAMBERTON CREEK

Lamberton Creek is located in northeast Grand Rapids and discharges to the Grand River south of I-96. The creek is an open channel system throughout its entire length within the City (29,000 feet). However, two tributary drains are enclosed that have potential daylighting opportunities.

3.6.1 Richards Fairplains Drain

Richards Fairplains Drain is an open channel where it discharges into Lamberton Creek inside of Huff Park, but is enclosed further upstream in the park and is a potential daylighting opportunity. The enclosed portion of the drain begins about 1,000 feet upstream of the confluence. Upstream of Huff Park the drain runs through developed neighborhoods. There appear to be no additional opportunities upstream of Huff Park.

Richards Fairplains Drain at Huff Park

- Tributary Area = 21 acres
- Enclosure Diameter = 1.5 feet
- Peak Flow Rates
  - 2-year = 6 cfs
  - 10-year = 15 cfs
  - 25-year = 22 cfs
  - 50-year = 27 cfs
  - 100-year = 34 cfs
- Length of Daylighting = 400 feet
- Estimated Top Width and Depth of Daylighted Section = 25 by 3 feet
- Cost to Daylight = $100,000 (does not include storage)
- Benefits
  - Would extend downstream open channel within park
  - Space available for storage that would reduce peak flow rates discharged to Lamberton Creek
- Constraints
  - Significant clearing required for open channel and storage
  - Relatively steep channel may require additional erosion protection

The enclosed portion of the drain appears to be completely outside the Zone A (100-year) floodplain defined by FEMA for Lamberton Creek.

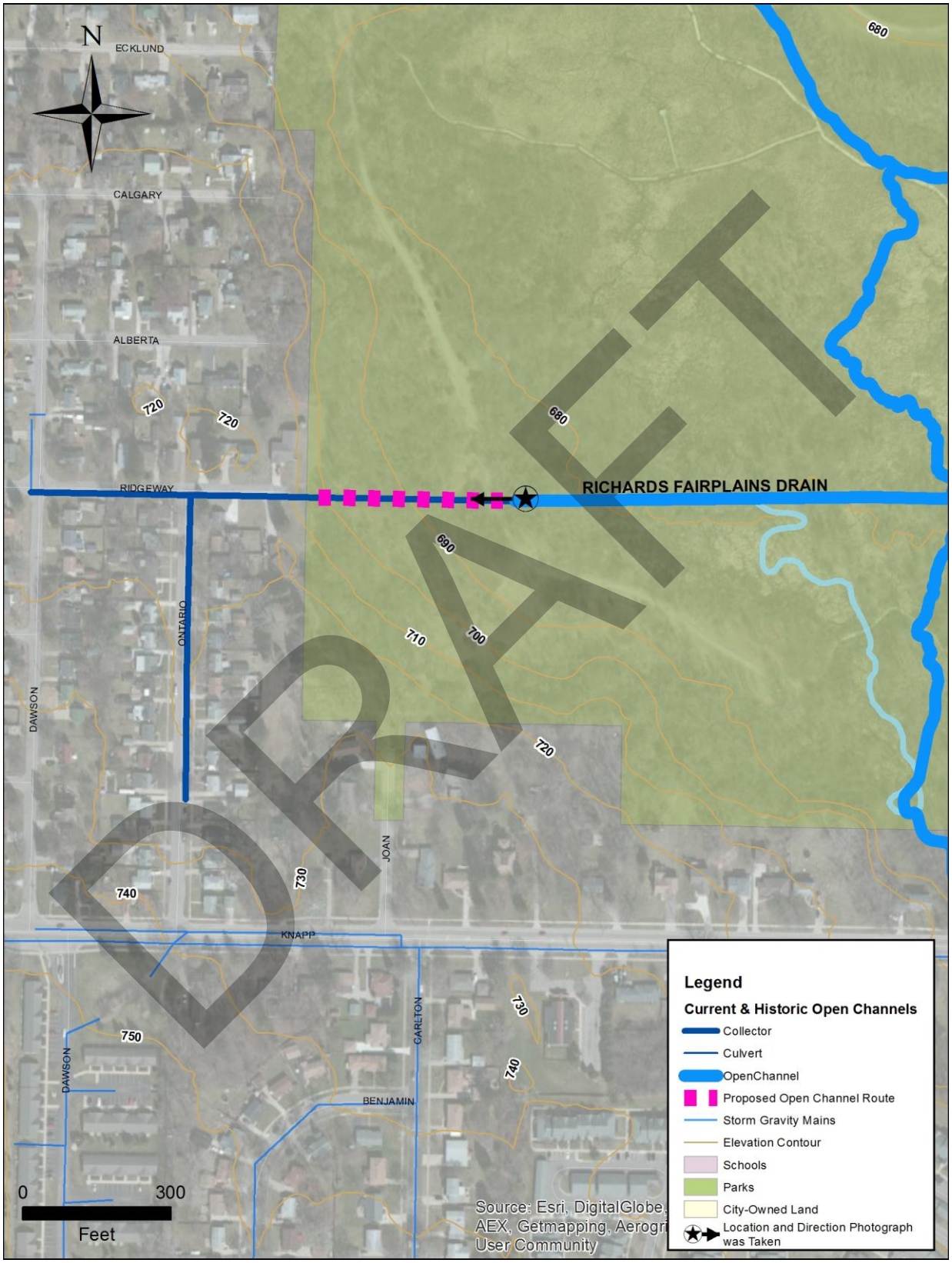
The concept includes constructing an open channel along the same alignment as the storm sewer and abandoning the storm sewer. The enclosed portion of the drain within Huff Park is an intermittent watercourse and is relatively steep, with an average slope of 3.65 percent (steeper nearer Ridgeway Street), which may require additional considerations for erosion protection. This section of the drain is steeper than the current open channel portion within Huff Park, which is about 2 feet wide and 1 foot deep with a wide, shallow overbank area. The downstream end of the pipe has settled with some erosion around the outfall structure. It is shown in Photograph 5 with the footpath in the background.

Storage in Huff Park along Lamberton Creek or Richards Fairplains Drain could be added in the undeveloped space near the current discharge point of the enclosure. It would be most effective to retain or detain water from Richards Fairplains Drain and reduce flow rates discharged to Lamberton Creek. It would likely not be large enough to impact flows, if directly connected to Lamberton Creek.

Both the conceptual open channel alignment and potential storage site are largely wooded and would require clearing to construct. A culvert would be required under the footpath about 50 feet upstream of the current outfall. A map of the area is shown in Figure 8.

Photograph 5: Richards Fairplains Drain Outfall in Huff Park

Figure 8: Richards Fairplains Drain Opportunity Map



3.6.2 Wells Drain

Wells Drain is fully enclosed within the City. It discharges into the Lamberton Creek culvert under Coit Avenue from a 24-inch diameter pipe. It crosses under I-96 about 400 feet upstream of Lamberton Creek, and is largely conveyed through residential areas. The downstream end of the Wells Drain enclosure is within FEMA's 100-year floodplain (Zone A) for Lamberton Creek. No other parts of Wells Drain are within a FEMA-defined flood zone. Most of the drain is not suitable for daylighting because it runs under streets and developed neighborhoods.

3.7 LOUIS AND LYON DRAINS

The Louis and Lyon Drains are located downtown and discharge to the Grand River at Louis Street and north of Lyon Street, respectively. These drains are located in high density development, and there are no opportunities to daylight any portion of these watercourses.

3.8 PALMER / LEONARD HEIGHTS DRAIN

The Palmer / Leonard Heights Drain is fully enclosed, except for a 270-foot segment at Ball Street at the very upstream end of the drain. It discharges to the Grand River at the end of Elmwood Street. A map of the drain is shown in Figure 9. The drain primarily crosses residential areas, but does cross larger parcels that have daylighting opportunities. The downstream end of the enclosure, downstream of Monroe Street, is located in FEMA Flood Zone B. None of the opportunities are in this area.

Palmer / Leonard Heights Drain at the Kent Country Club

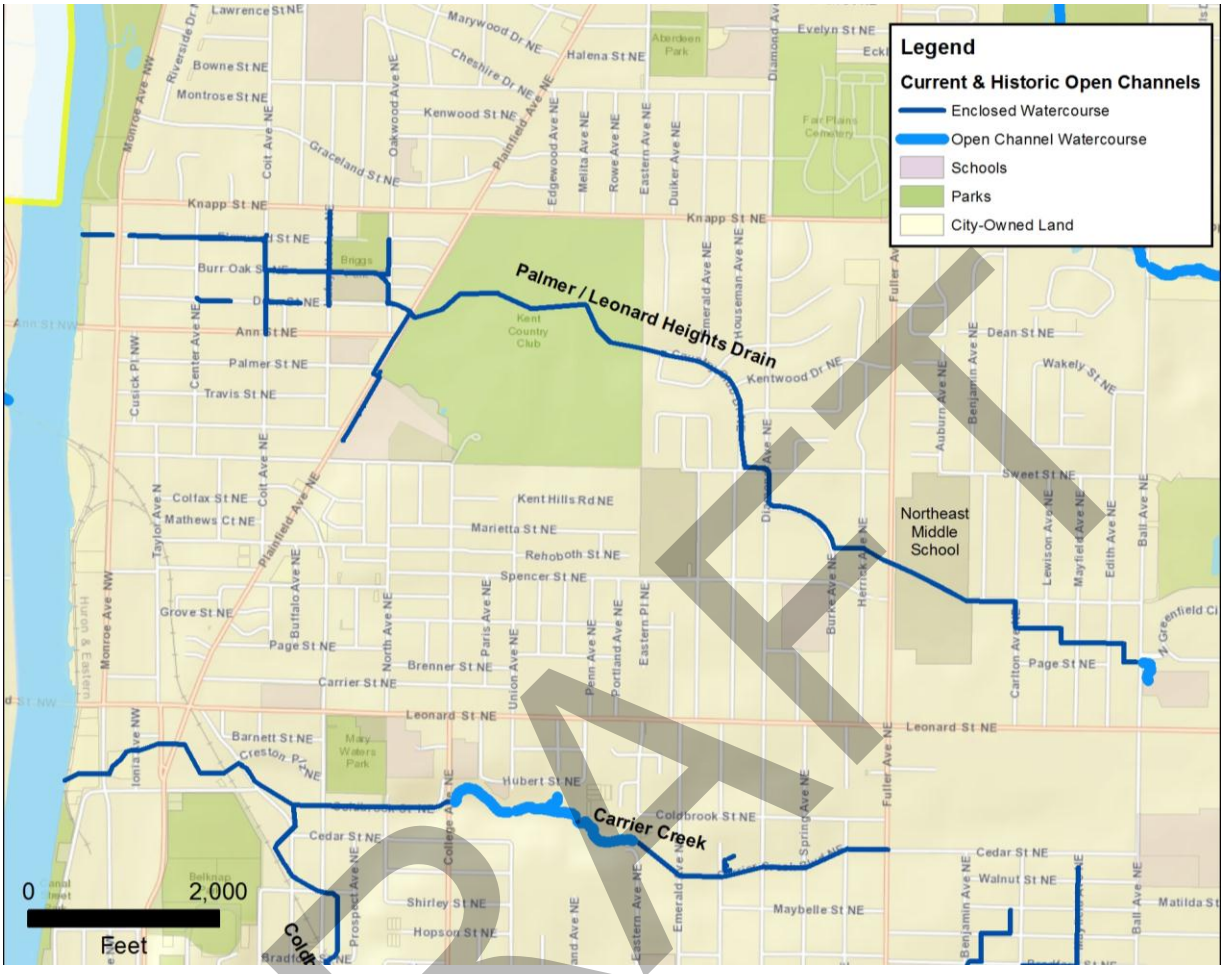
- Tributary Area = 710 acres
- Enclosure Diameter = 5.0 feet
- Peak Flow Rates
  - 2-year = 130 cfs
  - 10-year = 330 cfs
  - 25-year = 460 cfs
  - 50-year = 580 cfs
  - 100-year = 710 cfs
- Length of Daylighting = 2,700 feet
- Estimated Top Width and Depth of Daylighted Section = 60 by 8 feet
- Cost to Daylight = $1,960,000
- No other sections of open channel on the watercourse
- Constraints
  - Located on private property and would likely impact current operations of the golf course
  - Sanitary sewer may need to be relocated along portions of the daylighted section

From the Grand River upstream 3,500 feet to Lafayette Street, the drain runs under the city streets and there are no opportunities for daylighting. At Lafayette Street, the drain runs along the south edge of Briggs Park for 650 feet. Briggs Park is elevated above the adjacent track and significant earthwork would be required to daylight the stream. Therefore, based on the existing higher elevations in the park and lower elevations around the track there does not appear to be adequate space to daylight the drain cost-effectively.

Five hundred (500) feet upstream of Briggs Park, the drain crosses through the Kent Country Club. The 2,700 feet of 60-inch diameter drain through the center of the golf course was enclosed in 1996. This section of the drain could be re-opened. The concept includes constructing the open channel along the sewer alignment because this is the most natural route based on topography. The enclosure would be abandoned. A map of the area is shown in Figure 10.

Although there are not any buildings along the drain, the operations of the golf course would be impacted by daylighting the drain and there is an 18-inch sanitary sewer, 10 to 15 feet deep, that roughly parallels the drain and may need to be relocated if the drain is daylighted. Other routes were considered that would avoid the center of golf course, but topography does not allow alternative routes.

Figure 9: Palmer / Leonard Heights Drain Vicinity Map



Palmer / Leonard Heights Drain near Northeast Middle School

- Tributary Area = 410 acres
- Enclosure Diameter = 4.5 to 5.0 feet
- Peak Flow Rates
  - 2-year = 120 cfs
  - 10-year = 310 cfs
  - 25-year = 430 cfs
  - 50-year = 540 cfs
  - 100-year = 660 cfs
- Length of Daylighting = 850 feet
- Estimated Top Width and Depth of Daylighted Section = 60 by 8 feet
- Cost to Daylight = $1,060,000
- No other sections of open channel on the watercourse
- Constraints
  - Sanitary sewer may need to be relocated along the daylighted section
  - Proximity to athletic fields

The drain is under streets for the next 3,700 feet until it reaches Herrick Avenue. Between Herrick Avenue and Fuller Avenue, there is an open 60-foot right-of-way that includes the drain. However, based on the depth and available width, there is not adequate space to daylight all or part of the drain between these two streets.

Across Fuller Avenue, the drain crosses through an open area south of Northeast Middle School. Within the school property, the drain bisects athletic fields, so the concept includes an open channel route around the south side of the fields and north of the tennis courts. Some of the athletic fields may need to be shifted away from the drain. The enclosure would be abandoned. A 12-inch sanitary sewer that is 10 to 12 feet deep also follows the alignment of the proposed open channel and may have to be relocated. This area is shown in Figure 11.

Upstream of Northeast Middle School, the drain crosses between homes and along streets and there are no suitable sites.

Figure 10: Palmer / Leonard Heights Drain Opportunity Map at the Kent Country Club

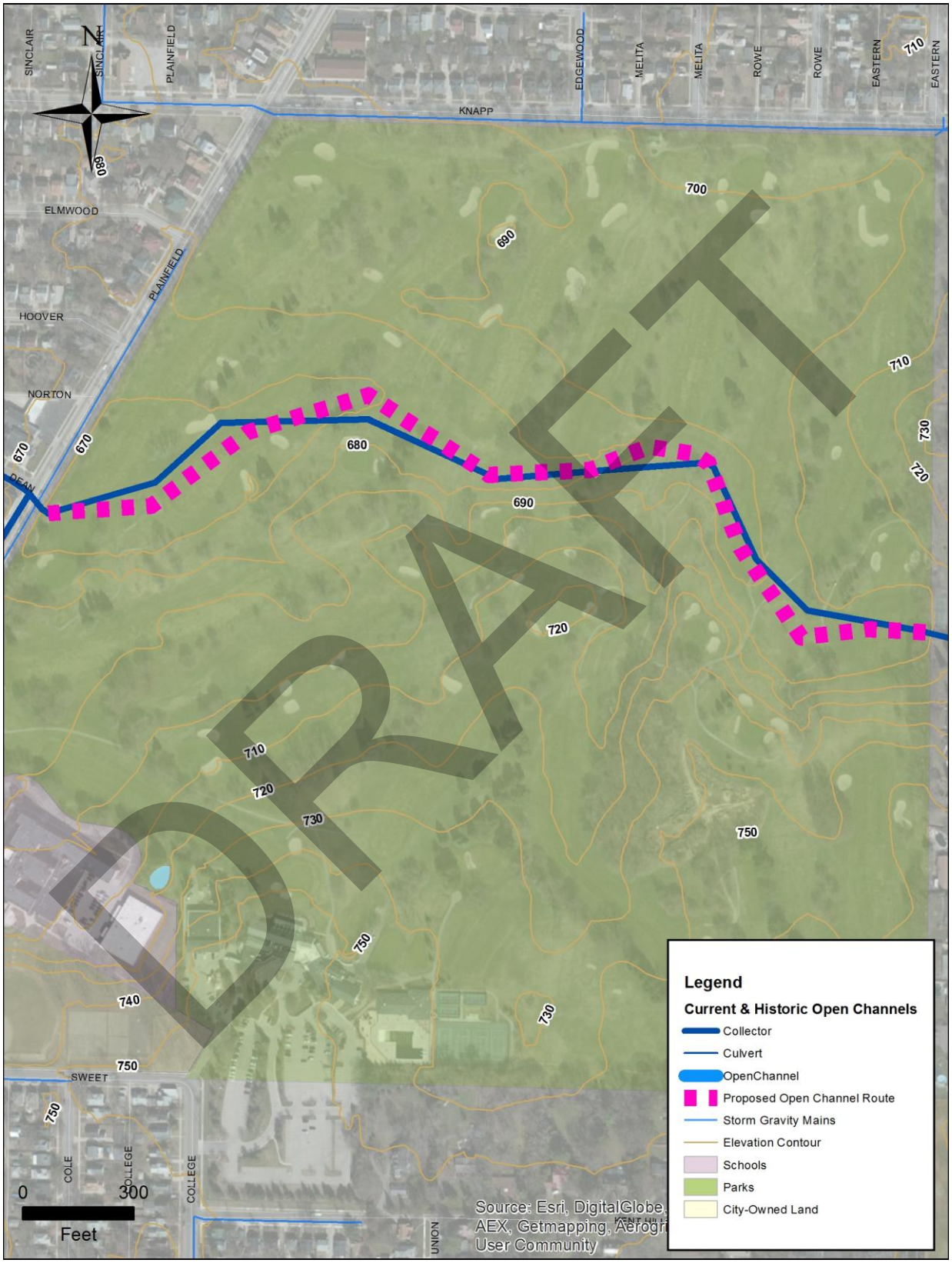
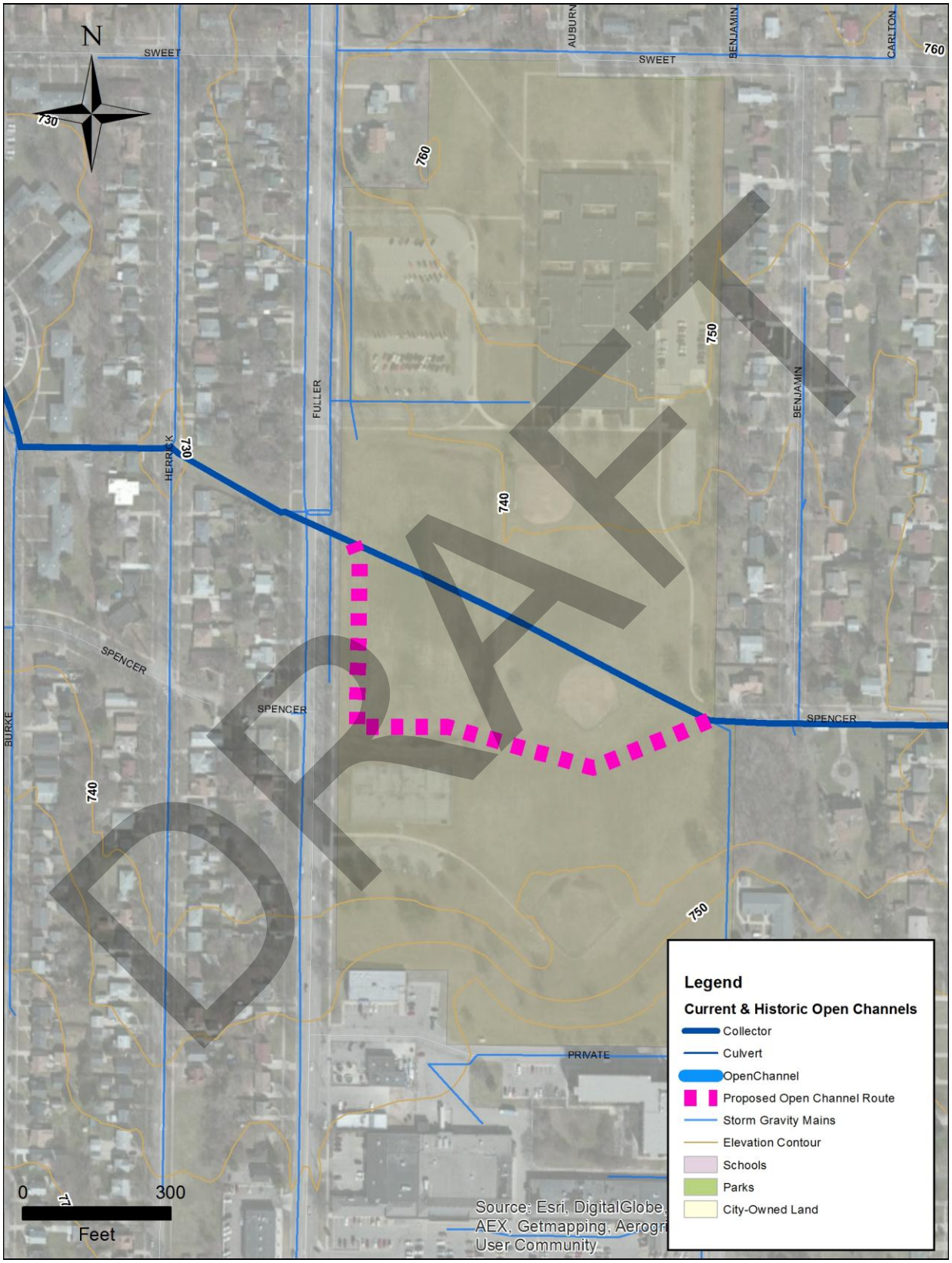


Figure 11: Palmer / Leonard Heights Drain Opportunity Map at Northeast Middle School



3.9 PLASTER CREEK

Plaster Creek is located on the south side of Grand Rapids and discharges to the Grand River near Market Avenue west of Freeman Avenue. Plaster Creek is an open channel throughout its entire length within the City, but there are two tributary drains that have potential daylighting opportunities.

3.9.1 Burton-Breton Drain

The Burton-Breton Drain discharges into Plaster Creek near Kalamazoo Avenue and 32nd Street. The Burton-Breton Drain and its tributaries are all open channels, except for two isolated sections where the drain is located between homes. These enclosures are listed below, but are not considered feasible opportunities to daylight because of their proximity to buildings and their relatively short lengths.

The drain enclosures on the Burton-Breton Drain include:

- 370 feet of 27-inch enclosure behind 2360 and 2410 Glen Echo Drive SE and 2601 Greentree Drive SE.
- 310 feet of 66-inch enclosure behind 2249, 2255, and 2261 Shawnee Drive SE and 2109 and 2111 Onekama Drive SE.

3.9.2 Laraway-Brooklyn Drain

The Laraway-Brooklyn Drain discharges to Plaster Creek near 28th Street and Brooklyn Avenue. Most of the Laraway-Brooklyn Drain is open channel, but there are two enclosed sections, including one segment near MacKay-Jaycees Park that was shown as a possible daylighting opportunity in the March 2012 *Green Grand Rapids* master plan document (page 68).

The first enclosure, constructed in 1966, is 72 inches in diameter and 900 feet in length. It conveys the drain under parking lots and between buildings on the south side of 28th Street until Plaster Creek. All the land is privately-owned and the current location of buildings and parking would make an open channel route difficult to find.

The second enclosure, the one proposed for daylighting, is located between Woodlawn Cemetery and MacKay-Jaycees Park near Kalamazoo Avenue. It was constructed in 1935.

The cemetery and the park appear to be within the same parcel and the location of an open channel does not appear to within the cemetery's current limits. Future land use would have to be considered.

An open channel would be located in an undeveloped portion of the property between the developed portions of the park and cemetery, along the route of enclosure. There also appears to be adequate space to provide some storage. It is possible that a portion of the southernmost drive in the cemetery could be encroached upon by an open channel. There are also parallel 15- and 24-inch

Laraway-Brooklyn Drain at MacKay Jaycees Park

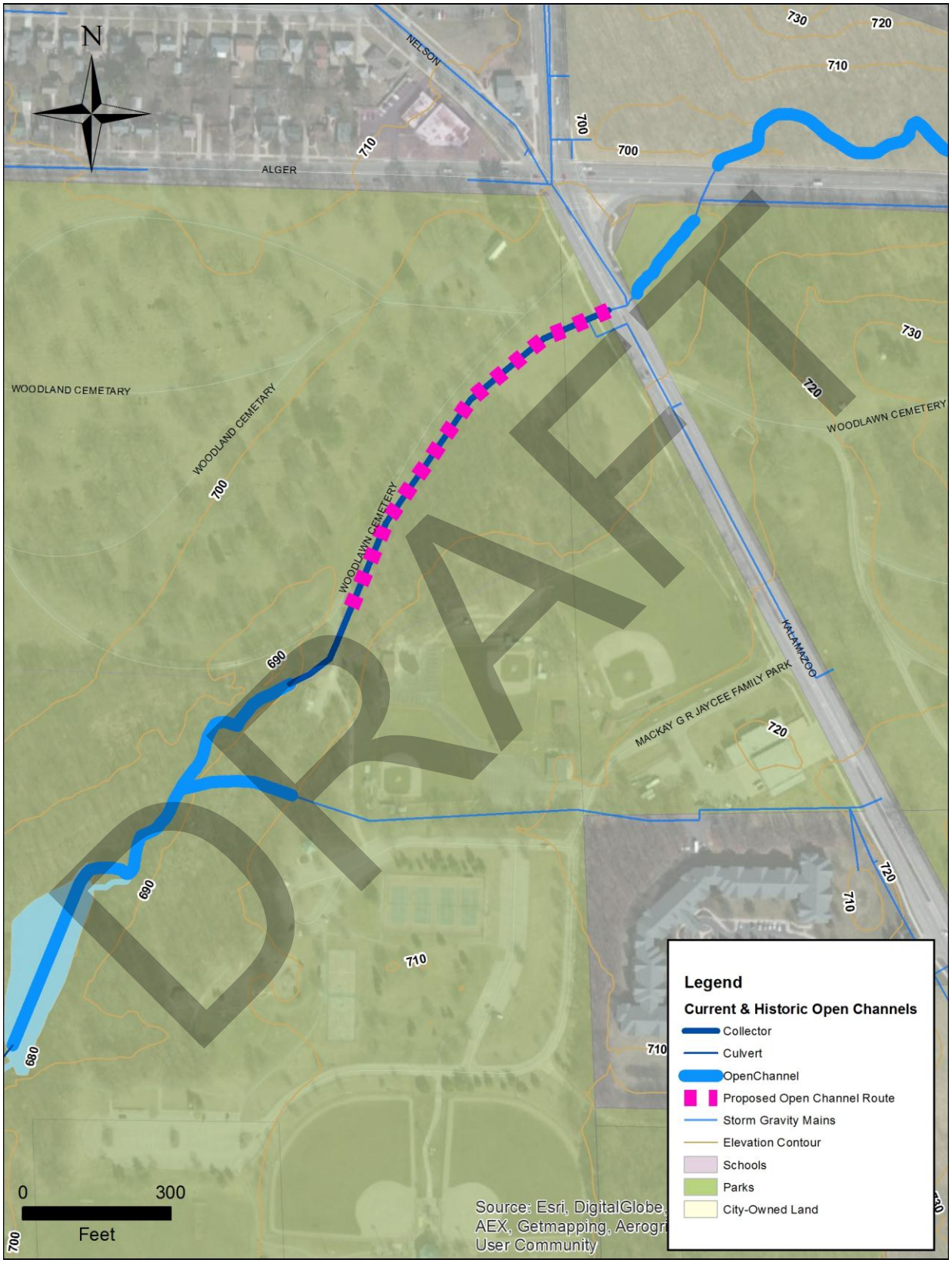
- Tributary Area = 320 acres
- Enclosure Diameter = 3.5 feet
- Peak Flow Rates
  - 2-year = 80 cfs
  - 10-year = 210 cfs
  - 25-year = 310 cfs
  - 50-year = 400 cfs
  - 100-year = 490 cfs
- Length of Daylighting = 850 feet
- Estimated Top Width and Depth of Daylighted Section = 60 by 7 feet
- Cost to Daylight = $610,000 (excludes storage)
- Benefits
  - Would connect to open channel sections of the watercourse
  - Space is available for storage
- Constraints
  - May encroach upon cemetery property and future land use
  - Sanitary sewer may need to be relocated

sanitary sewers, 8 to 10 feet deep, which may also have to be relocated to accommodate the channel. The enclosure would be abandoned.

There appears to be about 1 acre available for storage along the south side of the drain near Kalamazoo Avenue to detain locally generated runoff. A basin of this size would have little impact on the peak flow rates in the drain, but could be used to store (or offset) flows from the local storm sewers that discharge to the drain along Kalamazoo Avenue.

The channel upstream and downstream of the enclosure is about 5 feet wide and 2 feet deep with a 50 to 75-foot floodplain. Most of the conceptual route is wooded and would require clearing to accommodate the channel. The area near the current outfall would have to remain enclosed to be conveyed under a service drive and past a maintenance building. A map of the area is shown in Figure 12.

Figure 12: Laraway-Brooklyn Drain Opportunity Map



3.9.3 Silver Creek

Silver Creek discharges to Plaster Creek west of the intersection of Crofton Street and Clyde Park Avenue. Within the City, its entire 22,000-foot watercourse is enclosed, except for a 300-foot segment around Calvin and Ramona Streets. At its downstream end, the enclosure is a 132-inch by 102-inch elliptical pipe. Most of the enclosure was constructed between 1920 and 1933. The very upstream reaches of the enclosure were constructed in 1980. No part of Silver Creek within the City of Grand Rapids is located within a FEMA-defined flood zone.

From Plaster Creek to Jefferson Avenue, roughly 7,800 feet, Silver Creek is enclosed under local streets, US-131, a railroad yard, and several privately owned building and paved lots. The 13,000 feet of Silver Creek upstream of Madison Street is also located under streets and under or near privately-owned buildings. Neither of these two reaches have opportunities to daylight the creek.

The 1,200 feet between Jefferson and Madison Streets, through South Field was considered as an opportunity to daylight Silver Creek. This area currently appears to be used as a detention or flood control basin for the enclosure with two outfall structures connecting the enclosure and the storage. The concept was ultimately discarded because a new outfall and inlet would be difficult to construct without impacting existing buildings and moving utilities, including sanitary sewer, storm sewer, and water main in Madison and Crofton Streets. Furthermore, the existing sewer would not be able to be abandoned because of storm sewer inputs and potentially discharges from the building on top of the sewer.

3.10 WEST SIDE DITCH

The West Side Ditch discharges to the Grand River south of Wealthy Street. During high river stage it is pumped to the Grand River by the Wealthy Street Storm Water Pump Station. The area south of Mt. Mercy Drive is within a FEMA-defined flood zone of the Grand River.

The main branch of the drain is fully enclosed, except right at the Grand River. The size of the pipe ranges from a 16- by 7-foot box near the Grand River to an 11- by 5-foot box at Lincoln Park. It was re-constructed between 1992 and 1994. It follows Marion Avenue to Lincoln Park, where it crosses I-196 at Valley Avenue. The area is completely developed with the only available open space at Lincoln Park where it still crosses a playground and athletic courts.

The only opportunity to daylight the main branch of the drain is in the open area along the south side of Wealthy Street, which was enclosed in 1996 and 1997. Daylighting this section of the drain could also potentially require changes to the Wealthy Street Storm Water Pump Station. No opportunities were assessed on this watercourse.

Another branch of the drain, a 108- by 72-inch enclosure constructed around 1960, runs primarily along Garfield and Valley Avenues. A portion of it crosses John Ball Park near areas that appear to be used as overflow parking for the park and zoo. Beyond the park limits, there are no opportunities because of the density of the development.

3.11 SUMMARY OF OPPORTUNITIES

Each of the watercourses that were reviewed for opportunities are summarized in Table 1 and ranked according to the potential for the watercourse to be daylighted. Figure 13 shows an overall map of the locations of the daylighting opportunities within the city.

Two qualitative rankings are provided in the table. The route ranking considers the engineering feasibility of the route and the quality ranking considers the potential benefits of daylighting the stream.

A description of the route rankings are summarized below:

- High: Adequate open space for entire channel width on public property. Minimum potential to impact buildings, roads, utilities, and other structures.
- Medium: Adequate open space for channel width on public property, but may encroach on private property. Impacts to buildings, roads, utilities, and other structures must be considered.
- Low: There appear to be space constraints or the channel would be required to cross private property. There may be impacts to property uses (particular current uses on private property) and buildings, roads, utilities, and other structures. There may be safety concerns due to the proximity to playgrounds, schools, roads, and sports facilities.

A description of the quality rankings include:

- High: More than 1,000 feet can be daylighted or storage can be provided. Daylighting will link significant portions of current open channel sections.
- Medium: More than 500 feet can be daylighted or storage can be provided. Daylighting may or may not link other sections of open channel.
- Low: Less than 500 feet of can be daylighted and daylighting would not link other sections of open channel.

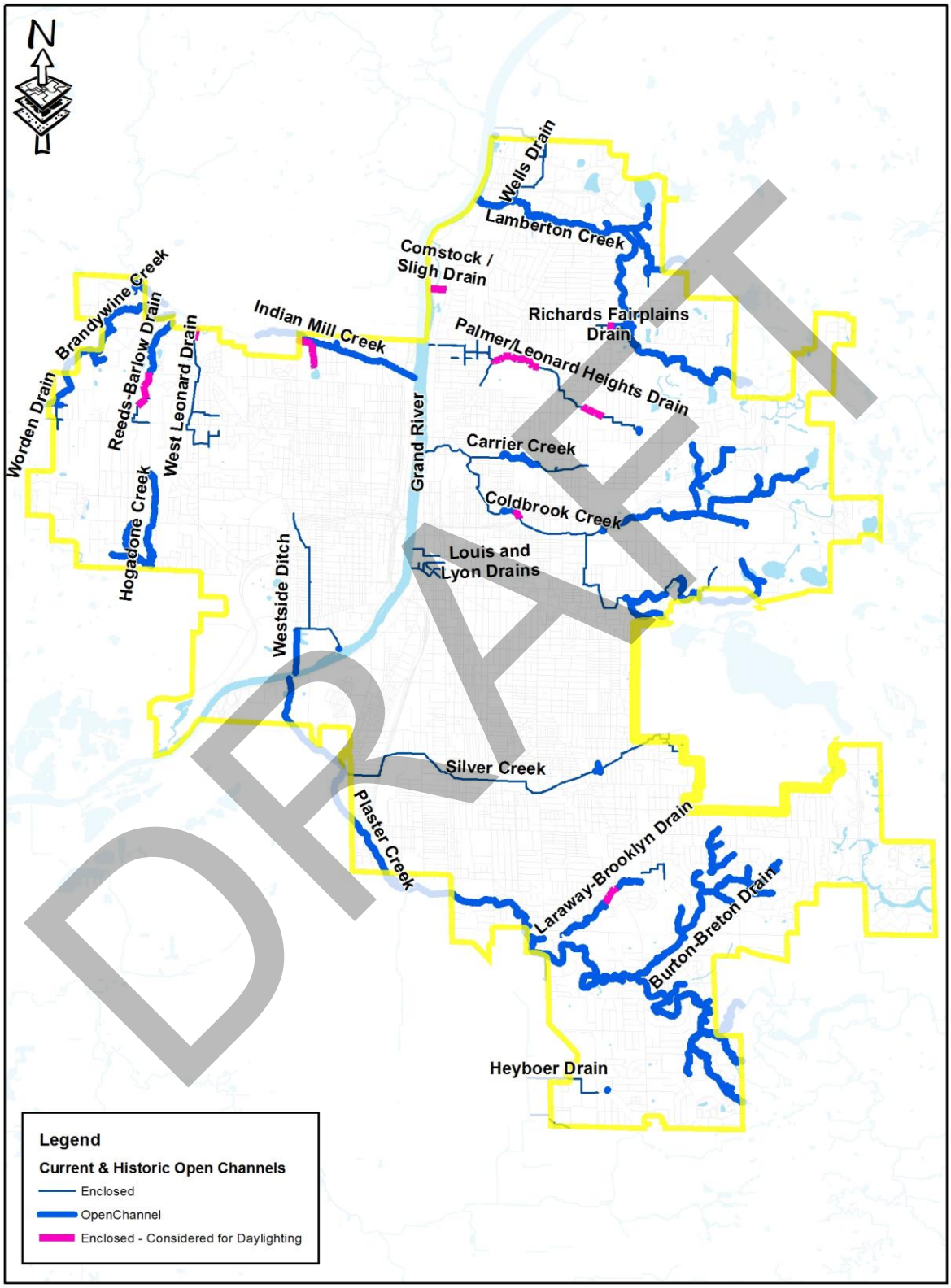
Table 1: Opportunity Assessment Summary

Watercourse	Location	Route Ranking	Quality Ranking	Type of Opportunity	Comments
Coldbrook Creek	Highland Park	Medium	Medium	Daylighting up to 200 feet and storage	Daylighting could be extended if a playground can be relocated.
North Branch of Coldbrook Creek	-	-	-	None	Mostly open channel, except for a portion at the downstream end through developed land.
South Branch of Coldbrook Creek	-	-	-	None	Enclosed sections are located under roadways through neighborhoods with little available space.
Coldbrook Creek: Carrier Creek	-	-	-	None	Enclosure is located under roadways through neighborhoods with little available space.
Comstock and Sligh Boulevard Drains	Riverside Park	High	Low	Daylighting up to 100 feet	Enclosure is within the 100-year floodplain of the Grand River. 740 feet of storm sewer would be abandoned.
Heyboer Drain	-	-	-	None	Enclosure is located under developed land.
Hogadone Creek	-	-	-	None	Entirely open channel.
Indian Mill Creek: Richmond Hills Park Pond Diversion	Richmond Hills Park	Medium	Low	Daylighting up to 1.700 feet	Storm sewer in park is a diversion channel and has no definite tributary area.
Indian Mill Creek: Brandywine Creek	-	-	-	None	Entirely open channel.
Indian Mill Creek: Reeds-Barlow Drain	Highland Golf Course	Low	High	Daylighting up to 2,000 feet	Requires crossing golf course property and may impact use of property.
Indian Mill Creek: West Leonard Drain	Walker Avenue right-of-way	Medium	Medium	Daylighting up to 700 feet	Impacts to cemetery must be considered. Steep slopes may require erosion protection.
Indian Mill Creek: Worden Drain	-	-	-	None	Mostly open channel.
Lamberton Creek	-	-	-	None	Entirely open channel.

Table 1: Opportunity Assessment Summary (continued)

Watercourse	Location	Route Ranking	Quality Ranking	Type of Opportunity	Comments
Lamberton Creek: Richards Fairplains Drain	Huff Park	High	Low	Daylighting up to 400 feet and storage	Steep slopes may require erosion protection.
Lamberton Creek: Wells Drain	-	-	-	None	Enclosure is located under developed land
Louis and Lyon Drains	-	-	-	None	Located downtown. No open space.
Palmer/Leonard Heights Drain	Kent Country Club	Low	Medium	Daylighting up to 2,700 feet	Enclosed in the mid-1990s. Requires crossing golf course property and may impact use of property.
Palmer/Leonard Heights Drain	Northeast Middle School	Low	Medium	Daylighting up to 850 feet	An open channel would need to be located between existing athletic fields.
Plaster Creek	-	-	-	None	Entirely open channel.
Plaster Creek: Burton-Breton Drain	-	-	-	None	Mostly open channel. Enclosed portions are within developed areas.
Plaster Creek: Laraway-Brooklyn Drain	MacKay-Jaycees Park	Medium	High	Daylighting up to 850 feet and storage	Daylighting would remove all enclosures upstream of 28th Street. Located between park and cemetery.
Plaster Creek: Silver Creek	-	-	-	-	Enclosure is located under developed land.
Westside Ditch	-	-	-	None	Area is heavily developed. Enclosure was recently reconstructed.

Figure 13: Summary Map of Opportunities

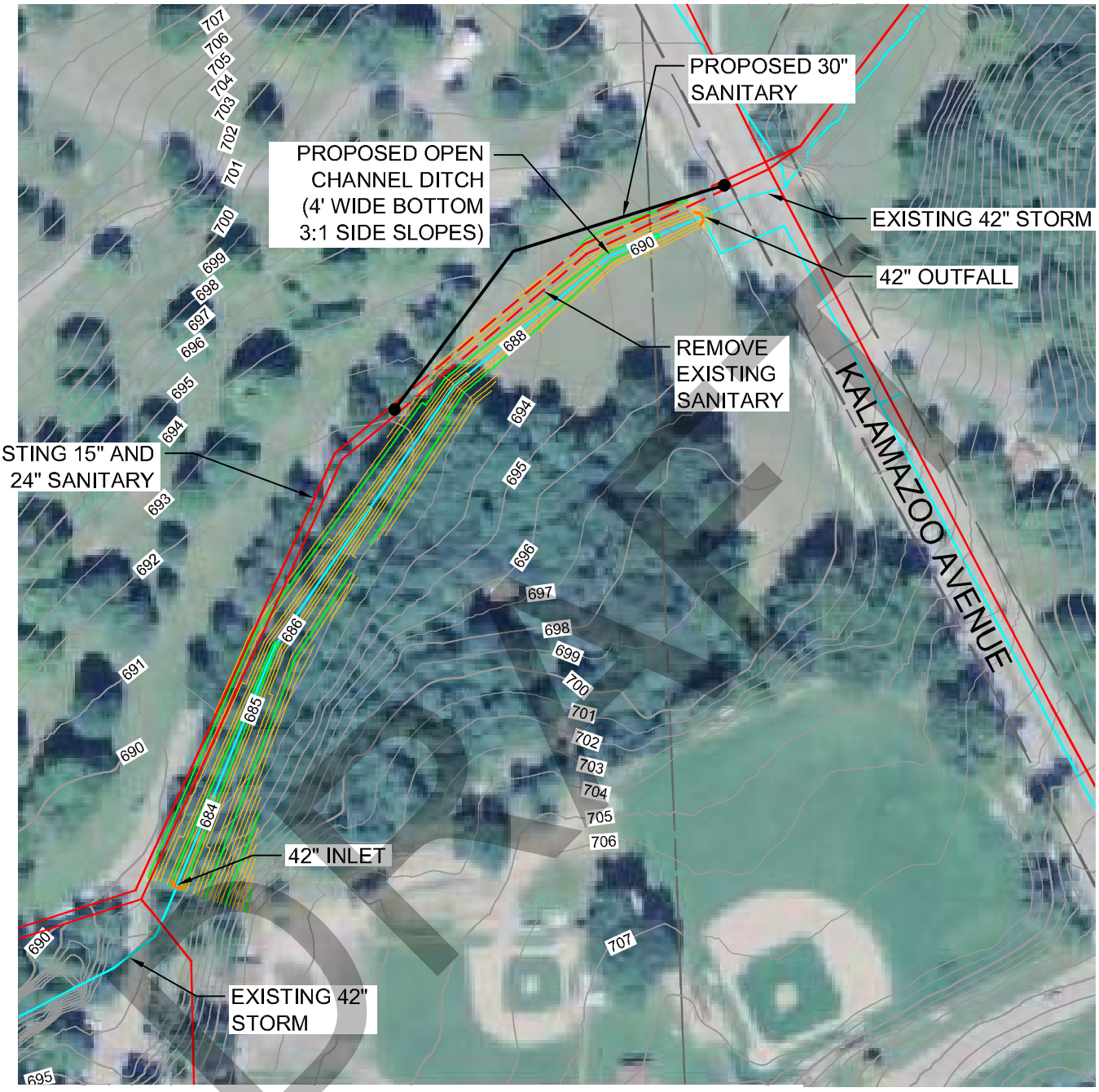


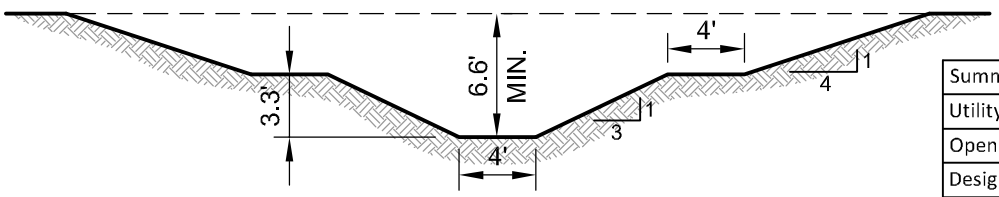
Opinions of cost associated with the conceptual design are shown in Table 2.

Table 2: Summary of Opinions of Cost

Opportunity	Cost	Cost per Foot of Daylighting
Coldbrook Creek at Highland Park	$730,000	$3,650
Comstock and Sligh Boulevard Drain at Riverside Park	$320,000	$3,200
Richmond Hills Park Pond Diversion	$600,000	$350
Reeds-Barlow Drain at Highland Golf Course	$1,360,000	$680
West Leonard Drain at Walker Avenue	$460,000	$660
Richards Fairplains Drain at Huff Park	$100,000	$250
Palmer / Leonard Heights Drain at the Kent Country Club	$1,960,000	$730
Palmer / Leonard Heights Drain at Northeast Middle School	$1,060,000	$1,250
Laraway-Brooklyn Drain at MacKay-Jaycees Park	$610,000	$720

APPENDIX A – CONCEPTUAL SITE DRAWINGS



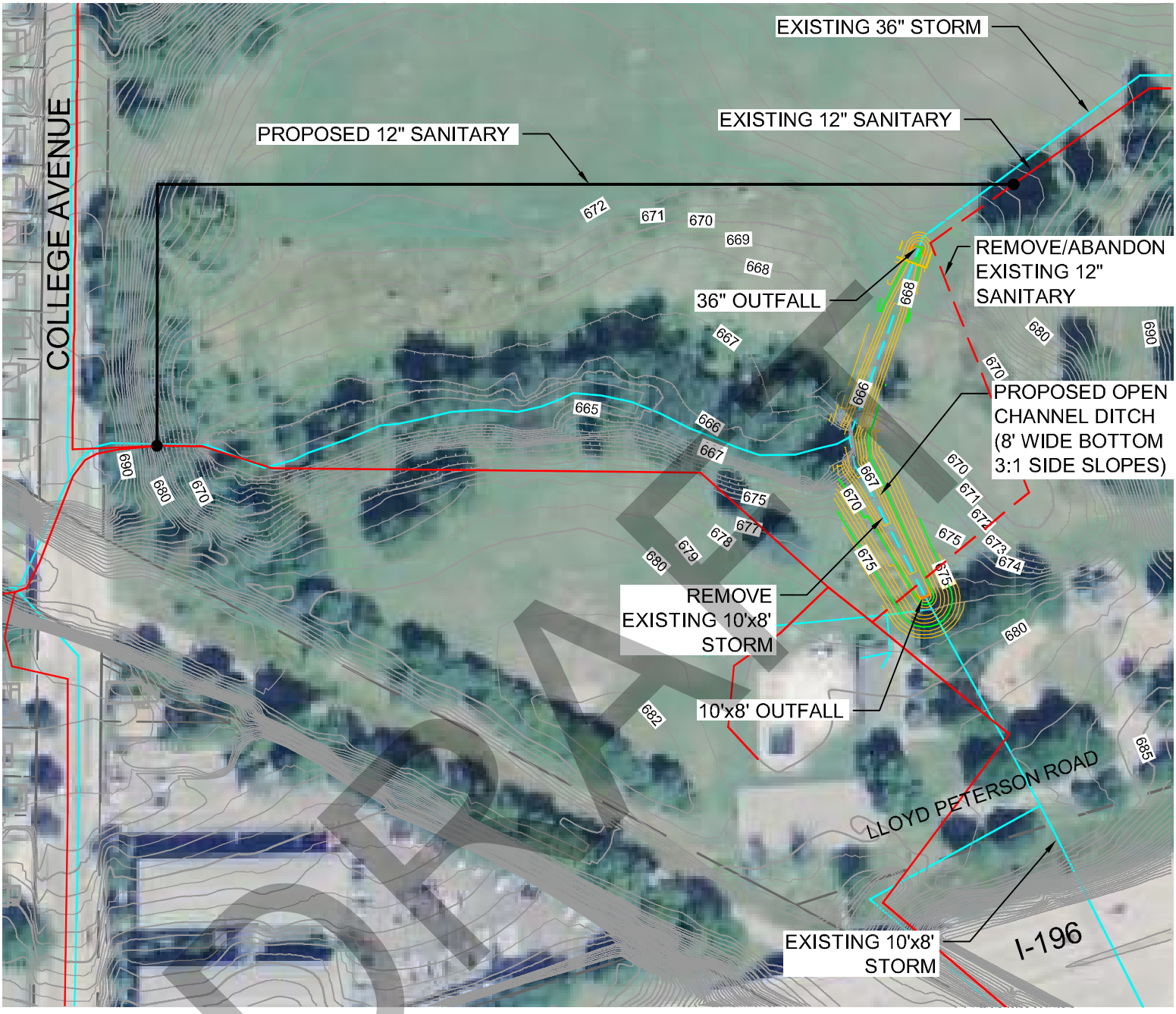


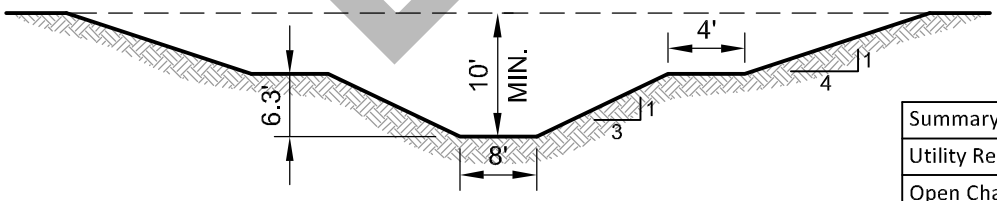
TYPICAL CHANNEL SECTION

Summary Table	
Utility Removal and Relocation	$240,000
Open Channel Construction and Installation	$250,000
Design and Construction Engineering & Legal	$120,000
Total	$610,000

LARAWAY - BROOKLYN DRAIN AT MACKAY - JAYCEES PARK

SCALE: 1" = 150'



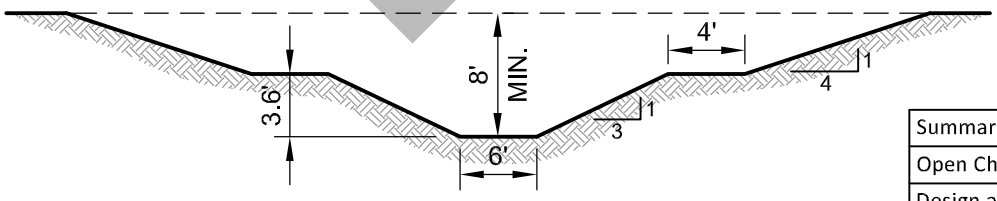


TYPICAL CHANNEL SECTION

Summary Table	
Utility Removal and Relocation	$430,000
Open Channel Construction and Installation	$160,000
Design and Construction Engineering & Legal	$140,000
Total	$730,000

COLDBROOK CREEK AT HIGHLAND PARK

SCALE: 1" = 150'

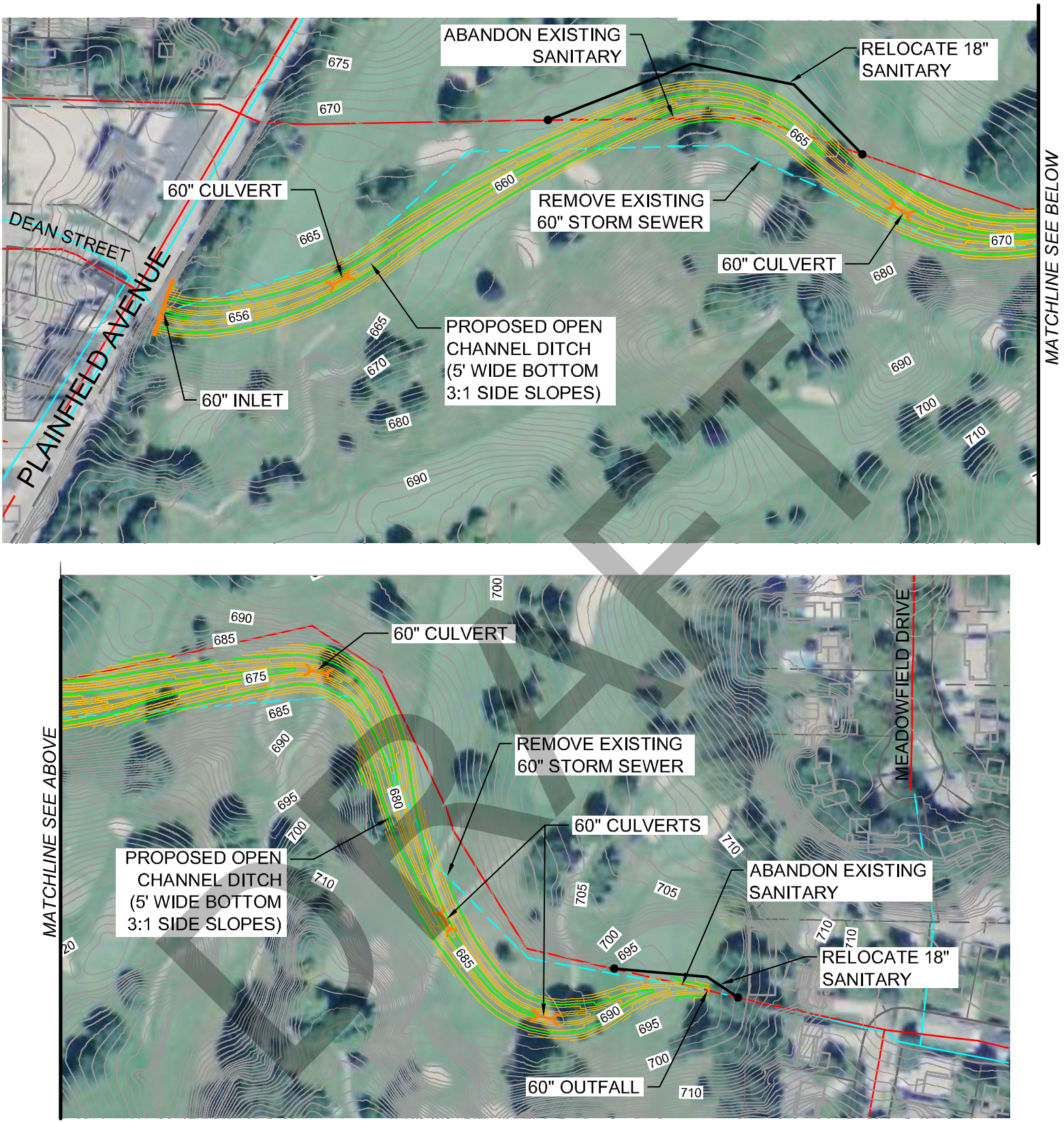


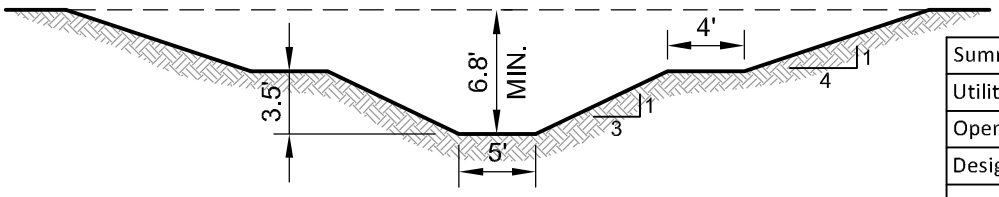
TYPICAL CHANNEL SECTION

Summary Table	
Open Channel Construction and Installation	$260,000
Design and Construction Engineering & Legal	$60,000
Total	$320,000

COMSTOCK AND SLIGH BLVD DRAINS AT RIVERSIDE PARK

SCALE: 1" = 150'



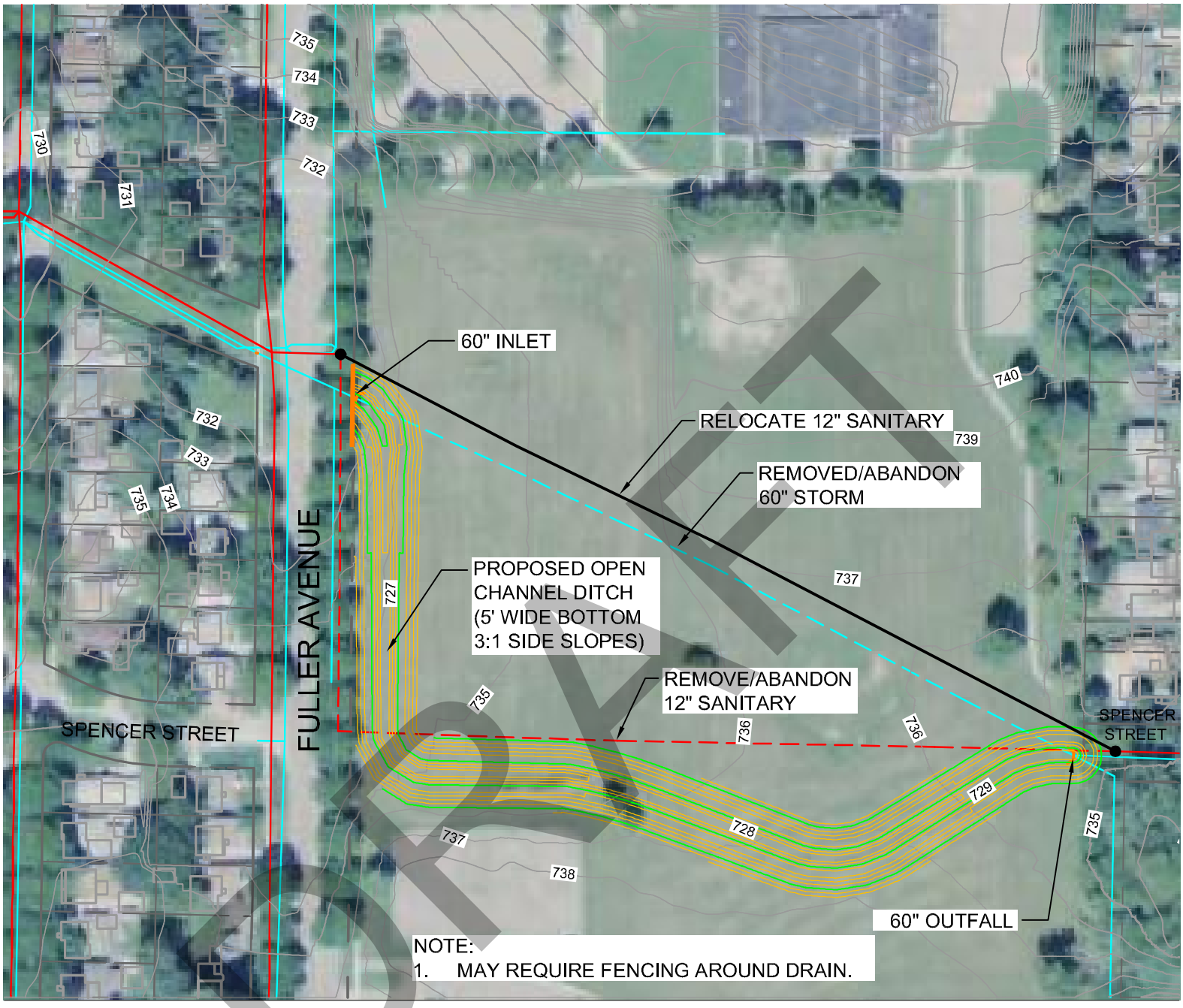


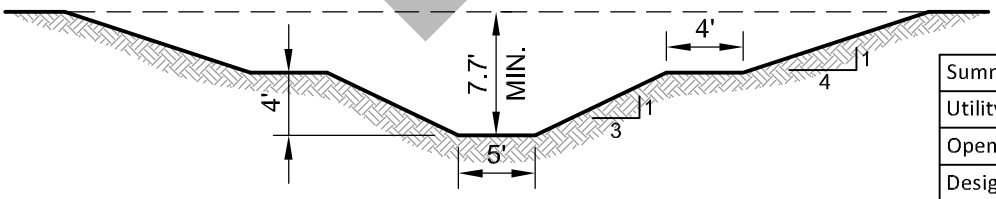
TYPICAL CHANNEL SECTION

Summary Table	
Utility Removal and Relocation	$350,000
Open Channel Construction and Installation	$1,240,000
Design and Construction Engineering & Legal	$370,000
Total	$1,960,000

PALMER DRAIN AT KENT COUNTRY CLUB

SCALE: 1" = 200'



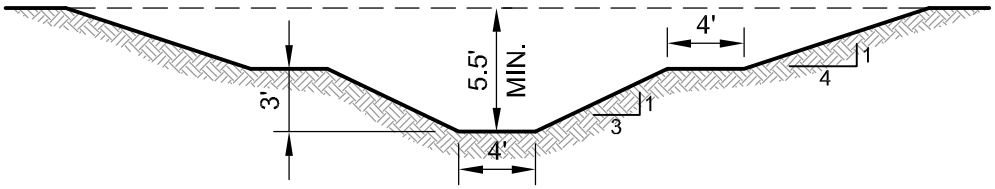


TYPICAL CHANNEL SECTION

Summary Table	
Utility Removal and Relocation	$370,000
Open Channel Construction and Installation	$490,000
Design and Construction Engineering & Legal	$200,000
Total	$1,060,000

PALMER DRAIN AT NE MIDDLE SCHOOL

SCALE: 1" = 150'



TYPICAL CHANNEL SECTION

Summary Table	
Utility Removal and Relocation	$160,000
Open Channel Construction and Installation	$940,000
Design and Construction Engineering & Legal	$260,000
Total	$1,360,000

RICHMOND STREET

54" INLET

54" CULVERT

REMOVE/ABANDON EXISTING 42-48" STORM

OAKLEIGH ROAD

PROPOSED OPEN CHANNEL DITCH (4' WIDE BOTTOM 3:1 SIDE SLOPES)

ABANDON 12" SANITARY

24" OUTFALL

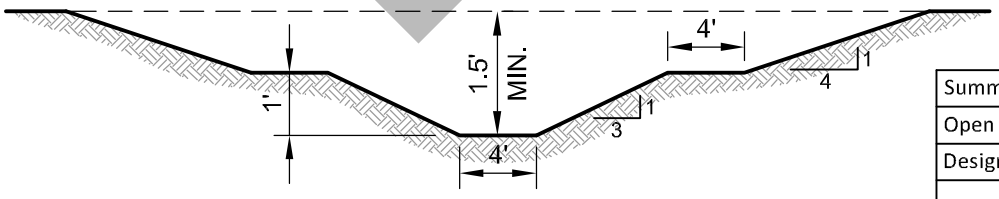
54" CULVERT

42" OUTFALL

RELOCATE 12" SANITARY

REEDS - BARLOW DRAIN

SCALE: 1" = 200'

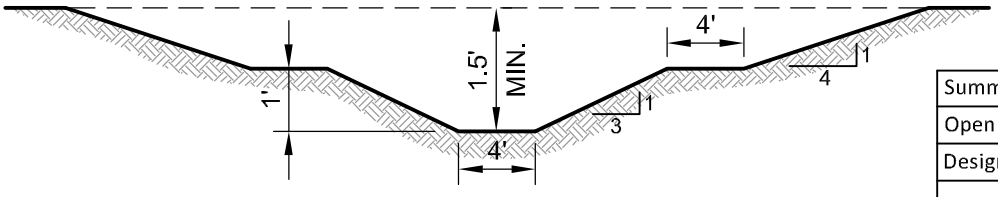


TYPICAL CHANNEL SECTION

Summary Table	
Open Channel Construction and Installation	$80,000
Design and Construction Engineering & Legal	$20,000
Total	$100,000

RICHARDS FAIRBANKS DRAIN

SCALE: 1" = 150'

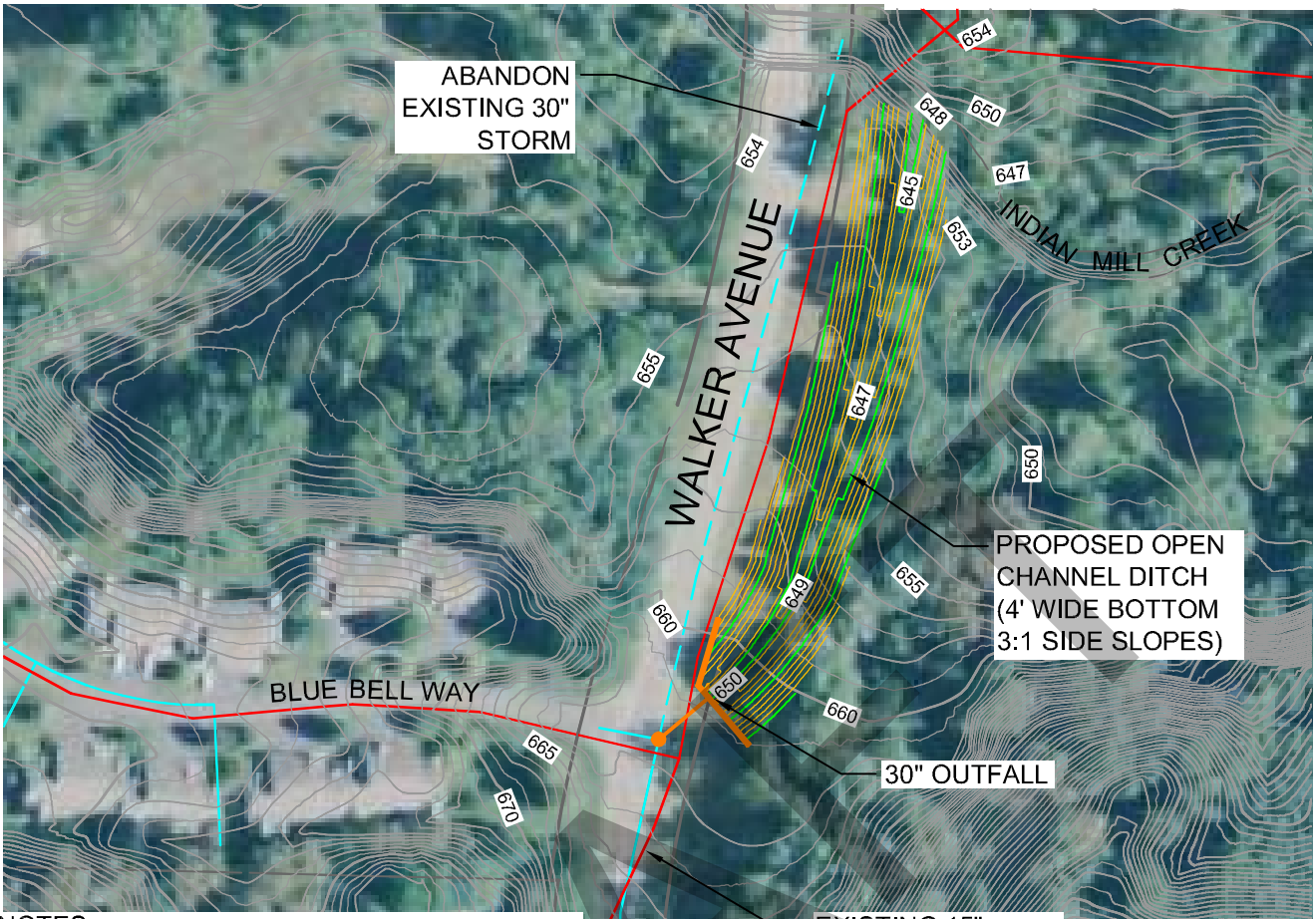


TYPICAL CHANNEL SECTION

Summary Table	
Open Channel Construction and Installation	$480,000
Design and Construction Engineering & Legal	$120,000
Total	$600,000

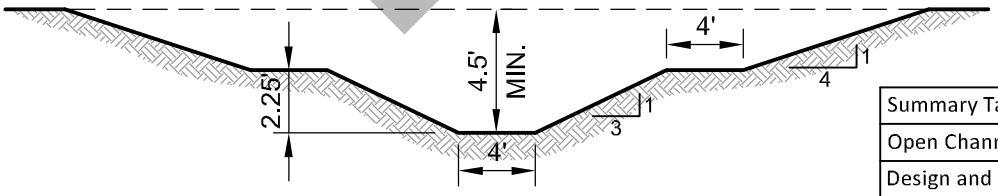
RICHMOND HILLS PARK

SCALE: 1" = 150'



NOTES:

1. SANITARY SEWER AND GAS LINE LOCATED ON EAST SIDE OF WALKER.
2. GUARDRAIL MAY BE NECESSARY ALONG WALKER.
3. FENCE ALONG CEMETERY PROPERTY MUST BE PROTECTED OR REMOVED AND REPLACED WITH EQUAL MATERIAL AND CONSTRUCTION.
4. EASEMENT WILL LIKELY BE NECESSARY.



TYPICAL CHANNEL SECTION

Summary Table		
Open Channel Construction and Installation	$	370,000
Design and Construction Engineering & Legal	$	90,000
Total	$	460,000

W. LEONARD DRAIN

SCALE: 1" = 150'