ROYAL VALLEY SUBDIVISION
DRAINAGE REVIEW

Prepared for:

Royal Valley Homeowners Association, Inc.
RVHA P.O. Box 33590
North Royalton, Ohio 44133

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Table of Contents

INTRODUCTION

The Royal Valley Subdivision, located in the City of North Royalton, is a residential development with Homeowners Association including over 300 single family homes. The Subdivision completed its primary construction and selling of homes by 1992. Prior to its construction, the land was primarily undeveloped forested hillsides and riparian valleys. As part of the development, approximately 47-acres of undeveloped, mostly forested riparian corridors and three (3) separate stormwater management basins were preserved as common areas. Undeveloped parcels continued to be developed into the early 2000s. Construction activities within the Subdivision are now complete, with the common areas and stormwater management basins still maintained as originally designated.

The Royal Valley Subdivision has experienced an increase in flooding both in frequency and severity over the past several years. The stormwater management basins are also of particular concern to area residents, as they relate to stormwater management as well as based on aesthetics (visual and olfactory). The Royal Valley Subdivision lies at a unique boundary within the Cuyahoga River Watershed, at the headwaters of the Big Creek Sub-Watershed. Thus, the drainage area and any pollutants entering the stormwater basins are likely a result of runoff within the development's footprint, since there are no tributaries further upstream of the subdivision.

The Royal Valley Homeowners Association (RVHA) has taken preliminary steps to identify and address these stormwater management concerns. Detailed Stormwater Basin Inspection was performed in 2019 as part of the Northeast Ohio Regional Sewer District's (NEORSD) Cuyahoga River North Stormwater Master Plan. The RVHA has created and implemented a Watershed Remediation Plan which took effect in the Fall of 2015. Most recently, in June of 2021, the RVHA authorized Chagrin Valley Engineering (CVE) to perform a subdivision-wide drainage review. This document is the result of that directive.

The purpose of this study was to evaluate the existing drainage system, excluding closed conduits, between Wallings Road and the three (3) stormwater management basins (Basin #53, #54, and #55) the RVHA maintains. CVE performed detailed research cataloging pertinent ecological, geological, and engineering technical data paired with extensive on-site inspections and resident input. These efforts were utilized in preparation of Feasible Alternatives to address flooding and stormwater failures throughout the subdivision.

This report will first describe the research performed to characterize and investigate the existing stormwater conveyance system. The field reconnaissance portion of the study will then be discussed, including the employed methods and findings of the field visits. Feasible alternatives will then be divided and discussed in three separate categories: optimum utilization of existing assets, infrastructure improvements, and channel or green space improvement. Lastly CVE will summarize and provide a priority list of these findings and alternatives in the form of a Facilities Plan, to guide the decision-making process of the RVHA.

RECORD EVALUATION OF EXISTING STUDY AREA

Drainage Area Delineation & Characteristics

CVE compiled existing publicly available GIS data to create an AutoCAD base map for use in analyzing the existing study area. A drainage area delineation was performed based on the County topography and all available storm sewer data. Drainage areas to each basin were determined, and are shown in the attached Drainage Area Maps (see Appendix A). The delineated areas vary slightly from the NEORSD Basin Maps dated 03-05-2020 (see Appendix B). Conservative assumptions were made where it could not be definitively determined if storm sewers were or were not included in a certain drainage area.

Additional features of the drainage area were considered and compiled into Figures contained within Appendix C. These Figures contain information regarding land-use, land cover, impervious surface, etc. The list of Watershed Characterization Figures is as-follows:

- Figure 1: USGS Watershed Boundary Map
- Figure 2: Fish and Wildlife Service Wetland Inventory Map
- Figure 3: FEMA Flood Hazard Map
- Figure 4: Open Space Map
- Figure 5: Stream Location Map
- Figure 6: Topographic Map
- Figure 7: Impervious Surface Map
- Figure 8: Tree Canopy Change
- Figure 9: Land Cover Map
- Figure 10: Land Use Map

Public Records

Analysis of the existing drainage area involved review of available public records. CVE requested record plans from NEORSD and the City of North Royalton, and received several documents in response. The pertinent documents include:

- "Basin No. 53 Basin Plan": Improvement Plans for Basin 53, dated December, 1985
- "Royal Valley Basin #54_#55 – Design Report": Original design report with detailed calculation methods, dated September, 1987
- "Drainage Area Map- Royal Valley": Drainage Area Map to Basins 53 and 55, dated October 1985
- "Royal Valley Area Retention Basin Modifications": Improvement Plans for basin modifications within all three stormwater basins, dated April, 2011

These documents were reviewed and used for analysis, particularly for the existing stormwater basins. One of the documents received included the original design report for Basins 54 and 55. A detailed review of the report was performed, and is described in the next section of this report. Unfortunately, subdivision and roadway plans were not received as part of the Public Records Request. The closed conduit system was not a component of this study, which focused instead on the overland flow, open channels, and existing detention basins, so additional follow-up for request of the plans was not necessary.

CVE also reviewed a variety of online resources in preparation for onsite reconnaissance to properly identify potential points of stormwater failure. The utilized background resource material includes the following:

- Natural Resource Conservation Service Web Soil Survey
- National Wetland Inventory Map
- Federal Emergency Management Agency Maps
- United States Geological Survey (USGS) StreamStats v4.5.3
- Multi-Resolution Land Characteristics (MRLC) consortium's National Land Cover Database (NLCD)
- Cuyahoga County Planning Commission's Urban Tree Canopy (UTC)
- GIS Web Mapping Application
- Cuyahoga County Enterprise GIS Web Mapping Application
- Ohio EPA's Water Quality: Assessment Unit Summaries (2020)

These resources were also supplemented by primary source conversations and directions by the RVHA and its members.

Soils Analysis

Soils are the first line of defense against stormwater runoff. Well-drained soils allow for subsurface percolation and limit the amount and severity of runoff. Soils within the sub-development were researched using the National Resource Conservation Service (NRCS) web soil survey online, and were investigated onsite. Soil profiles designated by NRCS matched onsite observations. The soils within the development are typical of the region, characterized by gradual to steep slopes, very limited drainage potential, very slow infiltration rate, average to above-average erodibility, and a perched or apparent water table (see Appendix D for Soils Report with additional technical detail). These features translate into a potentially high volume of surface water runoff with very limited opportunity for water absorption. Any topographical depressions within the subdivision will retain water for extended periods of time, and increase the likelihood of flooding during rain events and wet periods of the year.

The NRCS classifies soils within hydrologic soil group based on infiltration capacity and surface runoff potential. A soil in Group 'A' has the highest infiltration rate and, thus, is the most useful for reducing stormwater runoff. Group 'D', conversely, has the lowest infiltration rate, and is most prone to increased surface runoff. The table below lists the most common soils found within the Subdevelopment and their Hydrologic Soil Group assignment.

Royal Valley Drainage Area Hydrologic Soil Groups

Soil Name	Hydrologic Soil Group
Ct – Condit silty clay loam	Group C/D
ElB/ElC/ElD/ElF – Ellsworth silt loam, 2-70% Slopes	Group D
MgA/MgB – Mahoning Silt Loam, 0-6% Slopes	Group D
Or – Orrville silt loam, frequently flooded	Group D

Group D is described as follows (Hydrologic Soil Group and Surface Runoff—Cuyahoga County, OH):

> *"Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission."*

Detention Basin Design Review

Basin Design Methodology and Parameters

As part of this drainage study, CVE considered the stormwater basin design, to see if additional modification or retrofit of the basins would be beneficial. The original design report for basins 54 and 55 was obtained from the City of North Royalton. The report was completed in September 1987 by Euthenics, Inc. The design report was reviewed to determine how the original design calculations and parameters may be impacting present functionality. No design report was available for basin 53, but it can be reasonably assumed that the design procedure for basin 53 was similar to that utilized for design of basins 54 and 55. The results of this review are described below.

The engineering methodology utilized in design of the basins is consistent with engineering design principles utilized today. The TR-55 method is still utilized today for modeling flows within an urban drainage area. However, the stormwater regulations that dictate the parameters of design have changed significantly since the basin was originally designed. The basins were designed so that the post-development outflows are kept below pre-developed flows for the 10-year storm event. The primary spillway is sized to convey a 10-year, 24-hour storm, and the emergency spillway can handle the 100-year, 24-hour storm. These parameters are less stringent than current regulations. If redesigned to meet current standards, the basin would require a Critical Storm Design. The detention basin would be required to restrict outflows for all storm events up to and including the Critical Storm Event down to below the 1-year, 24-hour pre-developed flow rate. For example, a 10-year Critical Storm Event would require the 1-year, 5-year, and 10-year post-development outflows to be less than the 1-year pre-development outflows. All storm events would be analyzed, up to and including the 100-year storm, and must be less than the pre-developed flow. In the original design, only the 10-year storm event was analyzed for pre versus post flow comparison in the original design.

Rainfall Depth

The published rainfall depths utilized in the design have also changed over the last 30 years along with stormwater management regulations. For the 10-year storm, the increase is minor, from 3.40 inches utilized to 3.46 inches current. For the 100-year storm event, the increase is more significant, increasing from 4.35 inches in the report to 5.35 inches today. The 100-year storm was utilized to design and size the emergency spillways, so these structures may be undersized for handling the more severe storm events that are experienced today.

Water Quality

An additional facet of modern design that is not present within the existing design is the water quality component. Detention basins for subdivisions today typically also provide water quality storage within the basin, which allows a designed volume of water to discharge from the basin over a period of 24-48 hours. The required volume of water leaves the basin via a small orifice (typically less than 6”). This allows the water to sit in the basin and encourages sediment-deposition within the basin, for a cleaner outflow.

Stormwater management basins are also currently designed with constructed depressions within the basin located at any inlet and outlet points of the basin. At the inlet, this depression is referred to as a forebay; at the outlet, a micropool. The forebay and micropool are important design components of stormwater basins. These localized depressions are designed as permanent pools of water, approximately 3’-5’ deep, where water first enters or leaves the basin, and sediment is encouraged to deposit within these depressions. This concentrates deposition of sediment within these smaller footprints. This provides for ease of maintenance, where the forebay and micropool can be dredged and restored to design volume with smaller equipment, requiring less time and less expense than removing a thinner layer of sediment spread throughout the entirety of the basin. These water quality features are a standard requirement for basins built today, but were not developed at the time Basins 53, 54, and 55 were constructed.

FIELD RECONNAISSANCE- METHODS & FINDINGS

Throughout June 2021, CVE personnel performed field investigation of the Royal Valley Drainage Area. This review included visiting the site to evaluate the condition of open channels, green space areas, existing inlets and outfalls, and stormwater features in general to identify areas of concern or potential areas for improvement within the watershed. Each of the three detention basins where inspected. There were also several Areas of Interest (AOIs) identified by the RVHA as potentially contributing to flooding, and these areas were evaluated for determination of drainage patterns and potential problems/solutions. Field personnel visited the site and viewed AOIs during dry weather as well as during and immediately after rain events.

Prior to performing site inspections, CVE compiled necessary data into a base map within the ArcGIS System. This base map contains topography, aerial background, delineated drainage areas, and all available storm sewer and open channel location information. This map was utilized when out in the field through the Arc Collector software. During site visits, investigators used an electronic tablet with the georeferenced mapping to identify and track areas requiring inspection. This was particularly valuable for locating and inspecting portions of open channel, where location in real space would have otherwise been difficult to identify accurately on a map. Field notes and photos were attached to the base map, to quantify stormwater features and note failure points. CVE has made this map publicly viewable to interested parties, with a summary of the methods for viewing the map included in Appendix E.

Observational data was collected both during and between rainfall events at the start of the drainage basins, near Wallings Road, and continuing to the basins themselves. The dates of inspection and amount of precipitation within 24 hours are included in the table below:

Inspection Date and Precipitation Data
(NEORSD Rainfall Dashboard – North Royalton, Ohio)

Date	Approx. Rainfall within 24 Hours (in.)	Basin Catchment
June 14, 2021	0.03	53
June 17, 2021	0.00	53, 55
June 18, 2021	0.17	55, 54
June 21, 2021	0.28	53
June 30, 2021	0.33	53, 55
Aug. 13, 2021	0.49	53

The total drainage area of Royal Valley Subdivision is 244 acres. The critical areas requiring inspection were separated into four categories. Each of the categories are described below, along with the objective and findings of the inspection.

- Common Areas and Environmentally Sensitive Features
- Streams and Open Channels
- Stormwater Basins
- Areas of Interest
    - Corkwood Drive
    - Heasley Soccer Fields
    - St. Paul Greek Orthodox Church

Common Areas

There are six areas of preserved open space within the Royal Valley Subdivision (see Appendix C, Figure 4 for a map of the open areas labeled with Permanent Parcel Number). These areas are designed common areas, and generally serve as drainage paths for open channel portions of stream. Preserved natural open space plays a critical role in urban environments. These areas have aesthetic value for area residents, providing attractive screening between residential homes and rear yards. These areas also perform a multitude of ecological functions. Natural green space provides water quality treatment, filtering out pollutants and sediment from runoff. Green space and woods slow the flow of water, preventing downstream erosion and reducing peak flows. Natural areas provide air quality treatment and reduce the urban heat island impact. The riparian corridors surrounding streams can be a useful indication of the ecological health of a watershed, and can also be an indicator of the functionality of an urban stormwater management system. Therefore, characterization of the open space within the Royal Valley Subdivision is crucial to understanding the current condition of stormwater management.

Open space between Corkwood and Scottsdale.

The classification of these areas was completed using a host of publicly available data. This included an analysis of soil types, topography, current and historic land cover and use, and water resources. The background data was used as a supplement to the field investigations, as land classification within historically urban areas can be difficult based on field-observation alone.

Also noted within common areas were possible indicators of impairment, such as steep or undercut banks, exposed roots, and evidence of bank erosion and slope failure. This impairment can lead to reduced flood-carrying capacity within the area, and reduces the ability of the green space to provide ecological services such as natural filtration of contaminants from stormwater. Specific probable causes for any impairment were identified, is possible, such as dumping of yard waste or structural encroachments. The ability of these riparian and stream corridors to handle stormwater flow was assessed, along with the potential to improve this capacity.

The findings within the six common areas are described below as indicated by Permanent Parcel Number and Basin number that the open space drains to. One of the parcels (PPN 489-21-007) has been separated into two areas, the western half that drains towards Basin 53 and the eastern half draining to Basin 55.

PPN 489-17-024 (Basin #53)

The southwest Common Area contains the headwaters to Basin #53. This area receives hydrology from several residential parcels along Wallings Road as well as Heasley Soccer fields. The southernmost portion of this parcel is a gently sloping vegetated ponding area. Several ephemeral braided streams were found within the southern portions of the valley. Woody vegetation and wetland grasses were found west of the parking lot of St. Paul Greek Orthodox Church.

Riparian valley of Common Area PPN#489-17-024

It is likely that the headwater floodplain within this common area is providing significant water retention in the form of a sinuous, braided channel and completely vegetated floodplain.

The area receives several point source stormwater inputs from Heasley Soccer Field and residential units to the south. St. Paul Greek Orthodox Church to the southeast also drains a large portion of its area to this parcel. This Common Area collects several upstream stormwater inputs. The stormwater basins along Princeton Drive, Scottsdale Drive, and Vale Drive all have a point source outlet into the Common Area. Eventually the entire hydrological regime flows to a point at Royal Valley Drive where it is culverted. As the floodplain narrows, plateau areas give way to steeply sloped upland valleys.

Eagleview (CEGIS) of Common Area PPN#489-17-024 headwaters. April 4, 2019

<u>PPN 489-17-019 (Basin #53)</u>


Erosion protection at Persimmon Lane.

This Common Area lies downstream of the Common Areas at PPN 489-17-024 and 489-21-007. To the west of Persimmon Lane, the corridor becomes significantly sloped and narrow, and evidence of erosion protection was found where open channels run near residential structures. This was apparent at the outlet of the northern Ridgeline Drive stormwater outfall.

As the Common Area expands, so does the floodplain, eventually becoming a wide, vegetated area which terminates at Basin #53. During investigations it was found that this area contained depositions of silt and detritus from yard waste and upstream erosion or transportation of sediment.

East of Persimmon Lane the common area contains a wide floodplain which receives hydrology from the road culvert at Royal Valley Drive and receives overland flow from the southeast where a gently sloping upland woods was noted. In addition, an outlet from Persimmon Ln was observed discharging into the riparian corridor. As was described with the western tributary, the riparian corridor becomes inundated with silt and detritus.

Eagleview (CEGIS) of Common Area PPN#489-17-019 headwaters. April 4, 2019

PPN 489-21-007 West (Basin #53)

As previously mentioned, this parcel is separated into two portions based on drainage area. The western portion drains to Basin #53 and is discussed here. This common area is characterized by upland forested communities buffering two mainstream channels. Water sheet flows down gradual slopes into the two riparian valleys. Two culverted perennial streams were found discharging into the common area leading to Basin #53 north of Corkwood Drive at 4991 and 5031. The 4991 outfall is the daylighting of the hydrology caught at 5030 Corkwood Drive. Similarly, the 5031 outfall is discharging water which was caught south of 5060 Corkwood. The drainage to the south of Corkwood is discussed in detail within the Area of Interest- Corkwood Drive section of the report.


Failed perpendicular gabion feature, 5031 Corkwood Dr.

Near the outfalls (North of Corkwood), perpendicular gabion structures were found in failing or near failing state. The structure appears to have been installed to reduce water flow rate and channelization. This portion of stream channel and surrounding open areas had low quality natural environmental features. Current and past slope failures were present along the riparian corridors.

South of Royal Valley Drive, the two riparian valleys confluence and are culverted. The riparian valleys cut deep channels which do not allow for the formation of a significant buffering wetland. The majority of water is transported in deep perennial channels and little evidence of overtopping or sharing of hydrology with areas outside of the stream channel was observed. There was evidence of meandering stream channel within the valley as well as wetland seeps within hillsides.

PPN 489-21-007 East (Basin #55)

The eastern portion of this Common Area is characterized by typical upland sloped woods dominated by Oak and Hickory tree species. The area allows for sheet flow which becomes concentrated near the rear yard of 9940 Dublin Drive. Several sprawling instances of yard waste piles were noted.

Eventually enough hydrology is gained within this area to provide sediment transportation and the creation of a stream channel. Additionally, an outfall from Dublin Drive daylights between 9890 and 9880. Another failed perpendicular gabion structure was observed where water has bypassed the historic channel, causing significant erosion. Approximately 50' from this outfall, the stream confluences with the natural channel.

Dublin Dr. outfall near 9890-9880.

PPN 489-22-018 (Basin #55)

This common area receives the majority of its hydrology from the outfall north of Royal Valley Drive. This is downstream of the eastern portion of Common Area PPN 489-21-007. This outfall has caused severe erosion and has resulting limited flood plain. The corridor through this area contains concave landforms and slope failure throughout. This contrasts with the eastern area, which is a natural riparian channel beginning at 9791 Royal Valley. The corridor through the eastern portion of the area contains gently rolling convex hillsides. A contrast between the landforms can be seen in the image below (see next page).

Western degraded stream corridor (left), contrasted with well developed, gently sloping hillside (right)

After the confluence of the two valleys, the flat floodplain resembles those described previously, leading directly to Basin #55. Vegetation is roughly split between shrub vegetation and tree canopy. A significant amount of siltation and detritus was observed, matching the amount seen in similarly situated open spaces.

<u>PPN 489-21-035 (Basin #54)</u>

This Common Area is the first of two that drain to Basin #54. The open space within this area is characterized by steep eroding valleys flanked by excessive amount of yard waste. The Common Area contains two stormwater outfalls. The storm sewer system along Sweetleaf Lane and Pinckneya Drive discharges behind 5117 Pinckneya Drive. This outfall produces deleterious environmental outcomes as the outfall itself is perched above the stream channel, creating scouring at the outfall and undercutting downstream. Failed gabion baskets were noted at the outfall, located perpendicular to the outfall's flow direction.

Yard waste/debris within Common Area PPN 489-21-035

A second outfall discharges from Bayleaf Drive, parallel to the existing stream channel. The Common Area terminates between the homes at 9854 and 9844 Royal Valley Drive, where hydrology is culverted.

PPN 489-22-001 (Basin #54)

This open area is fairly uniform as it leads into Basin #54. The open space begins at the culvert under Royal Valley Drive just west of Silverleaf Drive. A narrow and eroded right bank was noted within the open space at the rear of 9804 Silverleaf Drive. A floodplain surrounds a stream channel which is flanked by upland sloped wooded area.

Eagleview (CEGIS) of Common Area PPN#489-21-001. April 4, 2019

Streams/Open Channels

The stormwater conveyance system within Royal Valley Subdivision is a combination of closed conduit and open channel. The open channels throughout the subdivision typically are natural channels characterized by natural substrate and banks comprised of a variety of differently sized coarse material (sand, gravel, cobble, boulder, or bedrock) and some amount of natural detritus (woody debris), silt, or clay deposits. There are no known artificial open channels within the drainage area.

Riparian corridor between Buttonbush and Dublin Drive

The presence of functional open channels within a stormwater conveyance system is crucial to the protection of surrounding areas against flooding and to promote healthy waterways. Degraded or impaired open channels often have the opposite effect, exacerbating stormwater pollution and flooding in the form of heavy sediment loading due to severe bank erosion. Extreme cases of erosion can lead to catastrophic slope failure and damage to nearby structures. Open channels were investigated and quantified for existing and potential functional fluvial geomorphology.

The assessment of open channels, like all other assets, was completed using a blend of comprehensive background data and onsite inspection. The physical identification of a stream channel is based upon criteria commonly applied by governmental agencies like the USACE and OEPA. These include, but are not limited to:

- Physical appearance of a well-defined stream bed and bank on two sides
- Water flow (seasonally or permanent)
- Notation of the stream on the United States Geological Survey Map
- Presence of an Ordinary High-Water Mark

In addition, streams can be categorized in a multitude of empirical dimensions, the most basic being their flow regime. A stream as defined by the United States Environmental Protection Agency (USEPA) under Section 404 of the Clean Water Act (CWA) can fall into one of the three categories:

Ephemeral - flows only in response to rain events or snow melt.
Intermittent (seasonal) – flows during certain times of the year, supplemented by some appreciable amount of ground water.
Perennial (year-round) – typically contains flowing water for the entirety of the year and is some combination of ephemeral, intermittent, and groundwater network.

Perennial channel leading to Stormwater Retention Basin #55.

Open channels were assessed for their qualitative morphological characteristics such as their position in the landscape, functional habitat features, and potential stormwater failure points. The evaluation of these features was performed in accordance with the Ohio EPA, Division of Surface Water standards as described in the Field Methods for Evaluation Primary Headwater Streams in Ohio (Version 4.0, October 2018).

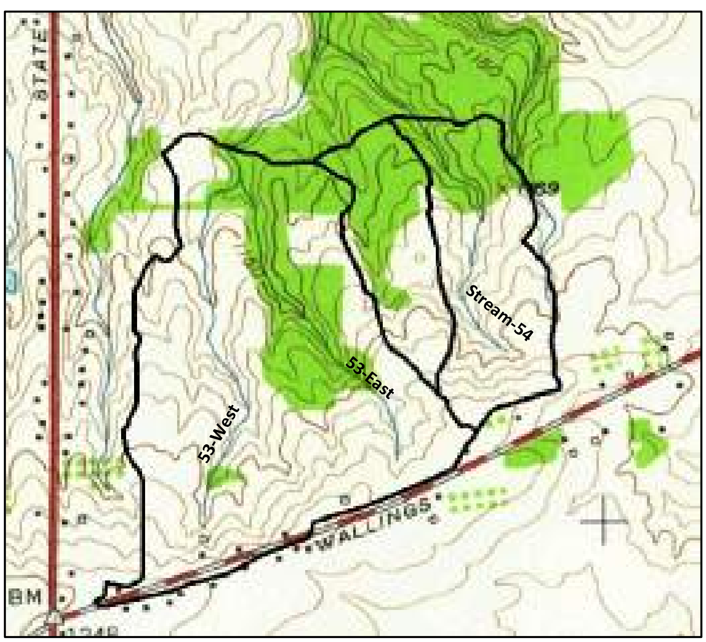
Historic Analysis

Stream 53 West Between Scottsdale Dr. and Corkwood Dr.

As previously noted, the Royal Valley Subdivision contains the headwaters for the Big Creek Watershed. Headwaters are those streams which are located at the top, or beginning, of a watershed. The health of larger streams and rivers are directly dependent on the quality of their headwater tributaries. Properly functioning headwater streams within natural corridors also provide ecosystem services which can increase property value through aesthetics, pest control, recreation, and stormwater management.

Four main channels currently exist within the development. These are classified as 53-West, 53-East, Stream 55, and Stream 54 in order of their location west to east (See Figure 5 in Appendix C). Initially a historic analysis of the open channel system was performed. The age of stream channels, their morphological traits, and recovery state is crucial in understanding their capacity for improvement or restoration. Many streams within the Cuyahoga River watershed were channelized or converted into agricultural ditches to support agricultural land use. This appears to have been the case for several streams within the subdivision throughout the mid 20th century.

Three of the four streams appear as blue lines as early as 1953 in the Broadview Heights 1:24000 Quadrangle USGS Topographical Map (53-West, 53-East, and Stream 54 as seen in the photo below). Also noted is the preservation of non-developed green space surrounding a portion of 53-East, Stream 55, and Stream 54.



USGS Topo Map 1953 - Broadview Heights Quadrangle

Publicly available historic aerials were compared with the USGS Topographical maps. The aerials show the 53-West mainstem was stripped of a riparian corridor and used as an agricultural ditch up until the 1970s. The same is true for a majority of Stream-54. By the late 70s and early 80s, the majority of farming activities ceased and riparian corridors surrounding the current stream channels began to reform. This was confirmed by field observations of tree age, riparian quality, and stream morphology. Cleared recreational areas including Heasley Soccer Field and St. Paul Greek Orthodox Church are visible as far back as 1970.

Streams 53-East and Stream-55 appear to have maintained their riparian corridors, and were not subject to the degradation exhibited by the other channels. These areas may not be subject to as significant recent impacts or were not able to be terraformed as readily. The age of trees and quality of water features noted during field investigation confirmed the mature age and more substantial historic preservation of these areas.

By 1994, the infrastructure and majority of homes within the subdivision were in place. This includes culverting of stream channels, construction of stormwater basins, and all other stormwater features. The photo below shows an aerial (Google Earth Pro) from 1994, the boundary of the drainage areas to each stormwater basin, and the approximate original stream channel footprint prior to construction of the subdevelopment. Red circles indicate current culvert location. At 5030 Corkwood Drive, the stream is captured in several stormwater basin inlets, and then culverted north.

1994 Aerial overlay with Cuyahoga County Stream GIS Layer.

Today, the four stream channels exhibit similar morphology due to their urbanization. Their upstream components are relatively high quality including a wide flood plain, sinuous channel, and substrate free from embeddedness or washed-out hardpan. This contrasts to the downstream portions, with heavily incised channels, higher levels of turbidity and silt, and hardened substrate as the channels are culverted and receive additional stormwater inputs.

Comparison of upstream higher quality channel substrate (left) vs downstream lower quality (right)

<u>Field Classification</u>

The upstream portions of the subdivision open channel system are an asset to the Big Creek watershed. Wide vegetated floodplains with sinuous, braided channels are rare within the highly urbanized Watershed. As channels increase in size, investigators found several instances of high-quality morphological features such as natural pool – glide – riffle – run complexes, stable boulder-cobble-gravel substrate, and naturally occurring overhanging vegetation and downed woody debris. These open channels contain the baseline factors for achieving high quality classification if preserved properly.

The streams within the project area were scored using specific quantitative metrics as established by the OEPA's Primary Headwater Habitat Evaluation Index (see Appendix C, Figure 5 for Stream Locations and Appendix F for classification results). These classifications are approximations and not a professional designation. Channels were categorized as ephemeral, intermittent, or perennial streams based on flow regime, and Class I, II, or III based on quality (Class I being the lowest quality and Class III the highest). A Class III perennial stream is one supporting a wide diversity of groundwater-fed native fauna year-round. All streams found within the study area fall between Class I (ephemeral) and Class II (intermittent and perennial) channels.

<u>Impairments</u>

As previously stated, the quality of these headwater streams is directly tied to the amount and type of stormwater outfalls and artificial stream modifications. These impacts are most apparent within the corridors which have had the least amount of time to regain their natural morphology after the cessation of agricultural use. The main sources of impairment include excessive water volume and velocity from stormwater outfalls, failed flow control devices, and non-point source pollutants/eutrophication.

Excessive water volume and velocity at stormwater outfalls occurs in several locations throughout the subdivision open channels. Water downstream of these point sources removes substrate from stream banks as it moves downstream at a rate much higher than would be natural. Downstream sedimentation can clog stormwater basins and lessen quality of water resources. Additionally, as the substrate is washed away, hardpan or bedrock is exposed, which in turns allows for less restriction of flow and exacerbates the flow rate. Evidence of this was discovered throughout the subdivision, particularly in areas downstream of stormwater outfalls. In some cases, outfalls were discovered at an elevated height above the stream channel creating a scour pool or extreme bank erosion. The locations and photos detailing the amount and types of failure are detailed in the publicly available ArcGIS Collector Map.

Outfall near 5117 Pinckneya Drive with 2-foot-deep scour pool

During investigations, several locations of failed gabion baskets were identified. Most were installed perpendicular to the flow of the channel, often near a stormwater outfall. Water has either bypassed these structures or completely removed their functionality. Once these structures have failed, they create a concentrated flow of water through a new channel, increasing erosion and downstream sedimentation. This was apparent at the outfall behind 5031 Corkwood Drive, where water has carved a new channel through what was previously upland. Additional failed gabion structures are present at 9780 Royal Valley Drive and 5117 Pinckneya.

5031 Corkwood Drive- failed gabion baskets

Lastly, and most frequently, evidence of eutrophication was observed throughout the Royal Valley Subdivision. Eutrophication is the process where nutrients such as nitrogen or phosphorus are added to water resources at elevated levels. In urban areas, these nutrients typically come from the composting of yard waste (grass clippings, branches, vegetation), excessive fertilization, and pet waste. These nutrients create an environment which is deleterious to native aquatic species, depleting oxygen and preventing growth of most native flora and fauna. Evidence of this can be observed in downstream portions of all open channels, where algae dominate the surface and a layer of organic detritus is found covering substrate. The algae growth observed in the stormwater basins, as summarized in the following section, is another indicator of eutrophication within the watershed.

Comparison of upstream yard waste decomposing and downstream evidence of eutrophication.

Stormwater Basins

Drainage within the Royal Valley Subdivision eventually discharges to one of three existing stormwater management basins (see Appendix A for Basin Drainage Area Exhibits). Basin 53 is the Western-most basin, Basin 55 is central, and Basin 54 is the Eastern-most basin. The stormwater management basins were designed and installed in the 1980's, to provide stormwater management for the subdivision. The drainage design report for two of the basins was obtained and analyzed for design methodology and comparison to today's stormwater management guidelines. Results of this analysis are summarized in subsequent sections of the report.

The basins were inspected by the Cuyahoga County Soil and Water Conservation District in 2019. These inspection reports were reviewed, and CVE field personnel performed an updated inspection on all three basins as well. This inspection was performed following the procedure and reporting developed and utilized by CVE staff for routine EPA-mandated inspection on municipal-owned basins. The basins were inspected during a three-day period, including June 14, 15 & 16, 2021. The entire footprint of the basin was visually examined, as well as any structural components of the basins (inlets, outlets, overflows, etc.). The flow paths into the three basins were inspected, to observe any potential flooding issues or inflow problems. Deficiencies and necessary action items to correct any deficiencies were noted. Photo documentation was obtained, and included in the compiled report. The inspection findings are summarized below, and copies of the reports are attached herein (see Appendix G).

Basin # 53 (West)

- Inflow structures appeared to be free of debris and functioning properly. The attached report notes several structural issues. The inlets at the east side of the basin show signs of erosion around and underneath the concrete inflow channel. Holes should be back filled and then covered with construction grade stone to prevent further erosion. See report for photos.
- Invasive phragmites were observed in the permanent pool area. At the time of inspection, they were being treated with an herbicide. Continued maintenance or removal is required to eliminate the invasives and restore basin to original capacity.
- Excessive amounts of sediment were observed in the permanent pool area. Water appeared brown and murky. Basin should be dredged to restore basin to original design elevations.
- Outlet structure and emergency spillway appear to be in good condition and functioning properly. Routine checks for debris should be performed on a regular basis especially after a rain event. Any accumulated debris should be removed to allow proper dewatering.

Basin # 55 (Center)

- Several areas around the entirety of the embankment are eroding and/or have very sparse vegetation. Use a seeded matting to re-establish vegetation to aid in prevention of further erosion. See attached report for photos
- Excessive amounts of sediment were observed in the permanent pool area. Basin should be dredged to restore basin to original design elevations.
- Excessive amounts of algae are present in the permanent pool. Treatment was being administered at time of inspection but may not be sufficient. Consider more aggressive treatment and/or the installation of an aeration mechanism. An aeration system such as a fountain or bubbler will also reduce the number of harmful insects such as mosquitos.
- Outlet structure and emergency spillway appear to be in good condition. Routine maintenance is required, especially after a rain event, to clear any accumulation.

Basin #54 (East)

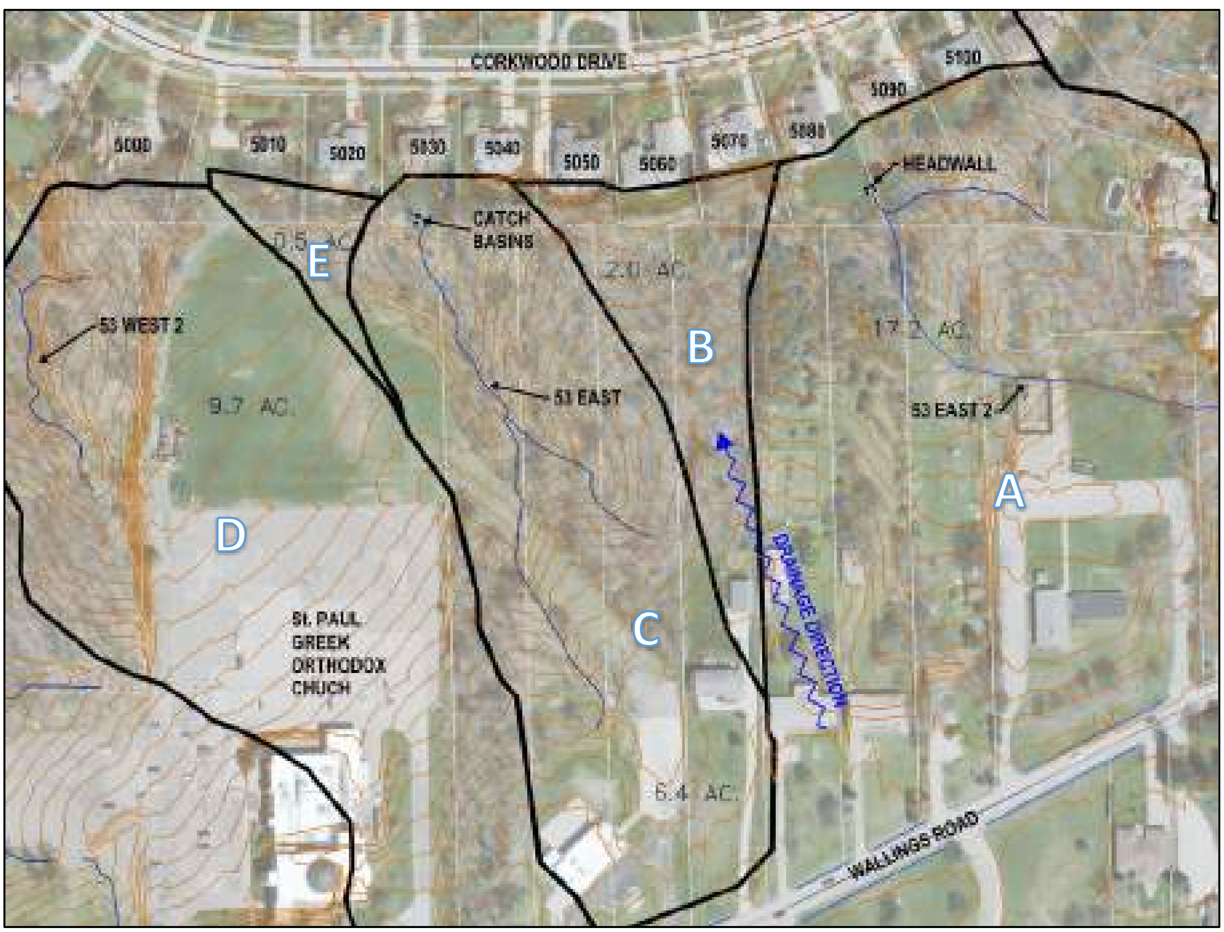
- Inlets appear to be functioning properly but have some structural issues. Concrete inflow channel is being undercut and several sink holes are present. Voids should be back filled and then covered with construction grade stone to prevent further erosion. Inflow path appears to be blocked by vegetation. Clear vegetation from channel to ensure a free-flowing path. See report for photos.
- Embankments are sparsely vegetated and showing signs or erosion. Use a seeding mat to encourage vegetation and reduce the amount of erosion.
- Excessive amounts of sediment were observed in the permanent pool area. Basin should be dredged to restore basin to original design elevations.
- Excessive amounts of algae are present in the permanent pool. Treatment was being administered at time of inspection but may not be sufficient. Consider more aggressive treatment and/or the installation of an aeration mechanism. An aeration system such as a fountain or bubbler will also reduce the number of harmful insects such as mosquitos.
- Outlet structure and emergency spillway appear to be in good condition. Routine maintenance is required, especially after a rain event, to clear any accumulation.

Areas of Interest

Corkwood Drive

One of the areas of particular concern within the subdivision is for homes located south along Corkwood Drive, generally between the area of Pickneya Drive to the east and 4990 Corkwood Drive to the west. Drainage beginning at Wallings Road flows north towards these homes. The drainage area is comprised of single-family residential parcels, greater than 1 acre in size. Ground cover includes the residence, driveway, and the remainder is grass or woods in good condition. Drainage channels direct the flow throughout a portion of the area. Rear yard inlets (basins and a headwall) have been installed to capture the flow coming from the south towards the homes.

There are four drainage divides for this sub-watershed, which include a headwall to storm sewer at 5080/5090 (**A**), rear yard catch basin to storm sewer at 5060 (**B**), rear yard catch basin to storm sewer at 5030 (**C**), and an open channel running behind 4990/5000 that continues northwest towards River Valley Drive (**D**). A minor sub-catchment (0.5-acre) of overland flow is uncaptured by the 5030 basins or the riparian valley south and west of 5000 Corkwood (**E**). This area drains to 5010 and 5020 Corkwood. The headwall at 5080/5090 as well as the open channel behind 4990/5000 (A/D) were identified as areas of least concern with only minor impairments. The inlets for the other two channels (B/C) do exhibit deficiencies that indicate flow is not efficiently entering the storm sewer system and is contributing to drainage concerns.



Existing Corkwood sub-watershed and minor sub-catchment drainage areas between Wallings Road and Corkwood Drive.

The most significant issue identified for this AOI is the drainage divide to 5030 Corkwood Drive. This yard is at the end of an approximately 6.3-acre drainage area. There are two (2) yard basins with trapezoidal raised grates that have insufficient inlet capacity (see Figures 1 and 2, right). A localized depression has developed at the basins. This appears to be a function of the type of structure and casting at the location. There are windows on one side of each structure, so water is ponding on the other three sides before reaching the level of the inlet grate. The capacity of one of these windows is also further restricted by a drainage pipe tied directly into the window. The trapezoidal grate requires water to pond before the full capacity of the grate can be utilized. The depth of the localized depression at the basins is about equal to the top of the grate, indicating that ponding levels do periodically reach the top of the basin, and that the full capacity of the inlet grate is needed at this location.

Figure 1. Rear yard basins at 5030 Corkwood

Figure 2. Drainage channel to basins at 5030 Corkwood

These dual basins drain to a third catch basin located nearer the home (see Figures 3 and 4 below, next page). This basin has a beehive grate and is surrounded by landscape pavers on three sides, which appears to have been installed as a measure against the erosion occurring at the basin. This basin does not appear to have as significant issues as the dual upstream basins.

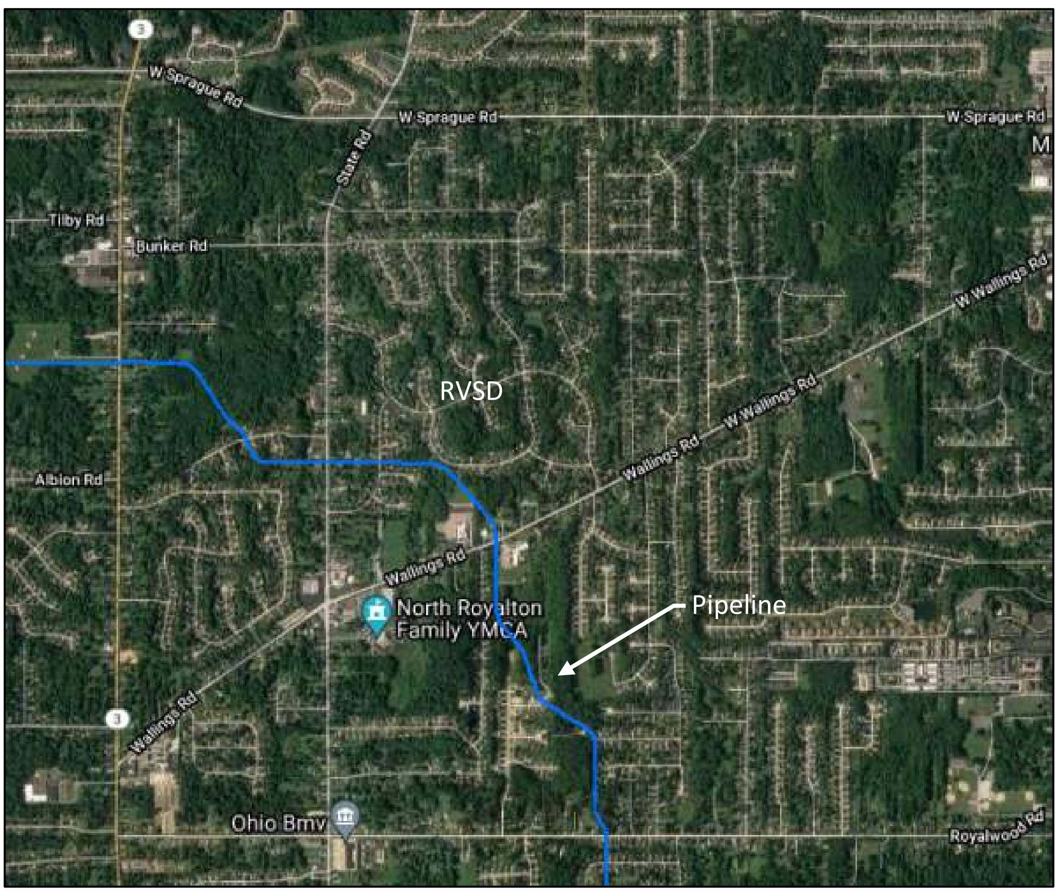
Figure 3. Downstream beehive basin at 5030 Corkwood Drive

Figure 4. Downstream beehive basin at 5030 Corkwood Drive

Overland flow may contribute to only part of the stormwater issues within the Corkwood Area of Interest. Investigators noticed unnatural topographic conditions south of the Corkwood Drive and observed flow that diverted underground prior to the catch basins at 5030 Corkwood. Previously disturbed soils may function dissimilarly to expected or known soil properties. Subsurface flow may cause significant foundational issues to homeowners as has been documented to be the case for homeowners, and discussion with homeowners between 5010 and 5030 Corkwood suggests that this is happening on Corkwood.

During background investigation, one possibly significant alterations to the substrate within the Corkwood Drive 5010-5030 AOI were discovered. A Dominion Energy Ohio natural gas transmission pipeline was found to be traversing the Subdivision and the greenspace north of St. Paul Greek Orthodox Church, originating at 4402 Wallings Road. The exact installation date of the pipeline is unknown. A corresponding clearing appears on aerials dating back to at least 1952 and the pipeline is specifically noted on the 1963 USGS 7.5-minute Broadview Heights Quadrangle Map. Based on this information, the pipeline predates both the Church greenspace and Subdivision.

The pipeline heads due north from Wallings Road then diverts northwest across the Church greenspace (current soccer fields) eventually entering the Subdivision at the backyard of 5010 Corkwood. The pipeline continues through 5000, 4990, and 4980 Corkwood before turning directly west through the common area (PPN 489-17-024) and between the parcels north of Scottsdale and south of Vale Drive. Eventually the pipeline crosses through 10060 Ridgeline Drive and exits the development to the west.



National Pipeline Mapping System – Gas Transmission Pipeline

The drainage channel at 5060 includes a rock-lined channel to a rear yard catch basin that is covered with screening in order to capture debris (see Figures 5 and 6, below). This catch basin catches approximately 2.0 acres of drainage, which is mostly wooded land and can be defined as good condition, based on the presence of adequate litter and brush covering the soil. The drainage area is naturalized and no specific cause for the excessive debris to this catch basin was noted. Flooding specific to this residence was not evident in field investigation. However, the installed debris screening indicates there is excessive debris within the runoff carried to this inlet. The current homeowner is maintaining the system and it appears in good condition; however there is concern that such a high burden of maintenance rests with a homeowner on a private property.

Figure 5. Screening over inlet basin at 5060 Corkwood Drive

Figure 6. Inlet basin at 5060 Corkwood Drive

Heasley Soccer Fields

Existing drainage swale to the north of Heasley Soccer Fields

An additional location selected by the RVHA for close investigation is the Heasley Soccer Fields located along Wallings Road, towards the west of the study area. The area includes a western parking lot and three east-west facing full size soccer fields occupying a total of 9.9-acres. These fields are all within the drainage watershed of Basin 53. The area was thoroughly investigated, during both dry and wet conditions. This investigation included background research as well as onsite visits to confirm existing conditions. The Heasley Soccer Fields facilities predate the Subdivision as they were likely converted from farmland during the early 1980s. By the late 1990s, paved parking areas are visible on historic aerials, as well as the stormwater improvements along the northern border of the fields. These stormwater drainage features were likely installed to intercept overland flow draining to Princeton Drive. There are five catch basins within a drainage swale south of an earthen berm along the northern border of the property as well as two french drains between the southern-middle and middle-northern fields. It was found that the Heasley Soccer field drainage system is completely enclosed, with no direct connection to RVHA, and drains to a headwall at the northeastern corner of the parcel. See figures on the next page for aerial view.

Eagleview (CEGIS) of Heasley Soccer Fields PPN#489-19-010 northern swale and border south of Princeton Drive with basin labels, April 4, 2019.

Circular Basin 1 (CB1) looking west within the drainage swale of Heasly Soccer Fields

Inside of Inlet Basin 2 (IB2) from north showing an east and west pipe orientation.

Inlet Basin 3 (IB3) looking west within drainage swale of Heasley Soccer Fields

Eagleview (CEGIS) of Heasley Soccer Fields PPN#489-19-010, with approximate catch basin locations and general flow direction. April 4, 2019

View looking south at HW-1 (see aerial view (left) for location) which discharges the storm drains along the northern field border.

Northern limit of parking lot, with arrow pointing to single inlet basin (IB1).

The soccer fields are bordered to the west by an asphalt drive and parking lot. This area amounts to approximately 2.0 acres of impervious surface, all of which drains to the north. The slope within the parking lot is as much as 6% in the southern sections of the lot. These characteristics mean that stormwater travels at a rapid velocity down the parking lot, unimpeded and uncaptured. There is a single inlet basin located at the northeast corner of the parking lot. The northern-most portion of the parking lot appears to have been recently paved, and visually appears to drain towards the basin. However, this single inlet is likely insufficient for all of the runoff from the 2.0 acres of pavement. There is evidence of channelizing and erosion within the grass north of the parking lot, suggesting that during heavy rain events the stormwater continues to flow north towards Princeton Drive. Unlike the system of grass drainage swale and series of inlet basins, the drainage within the pavement is sheet flow to a single basin. There is no redundancy or overflow protection for drainage that bypasses the single inlet.

Looking south, view of parking lot draining north towards single inlet basin.

Southern portion of parking lot. No inlet basins.

The soccer field and adjacent pavement area was investigated during dry weather, rain events, and immediately after periods of rainy weather. No flow was directly witnessed bypassing the basins or overtopping the berm. The drainage swale north of the fields is well-defined and appears to be functioning to direct water to the inlet basins. However, the rain events experienced during the field investigation may not have been intense enough to trigger such a flooding event. Storm sewer systems and drainage ditches are typically designed with capacity for 10-year storm events. With rain events of higher intensity occurring more frequently, it is likely high intensity storms were experienced several times in recent years, and caused the residential impacts attributed to drainage from the fields. These events likely result in the bypassing of the inlet basins and overtopping the drainage swale. This would most likely be accentuated within the parking drainage area as the velocity of flow and topography limit the effectiveness of the existing stormwater features.

St. Paul Greek Orthodox Church

The St. Paul Greek Orthodox Church developed property was also identified as an AOI. The Church and adjacent facilities are within the drainage watershed to Basin 53. The property was examined for potential contributions to the drainage issues within the Royal Valley Subdivision.

According to the documents available online via the Cuyahoga County Auditor and corroborated with historic aerials, the church acquired the land and built the structure proper in the early to mid-1970s. The historic aerials shown below demonstrate the existence of the church starting pre-1970, with various expansions and alterations to the property over the years. The original record drainage area maps for Royal Valley Subdivision were reviewed. The original design does include the Church as part of the drainage area, and Basin 53 was designed to capture flow from the Church property.

Historic Aerial 1970 (ODOT Aerial Archive)

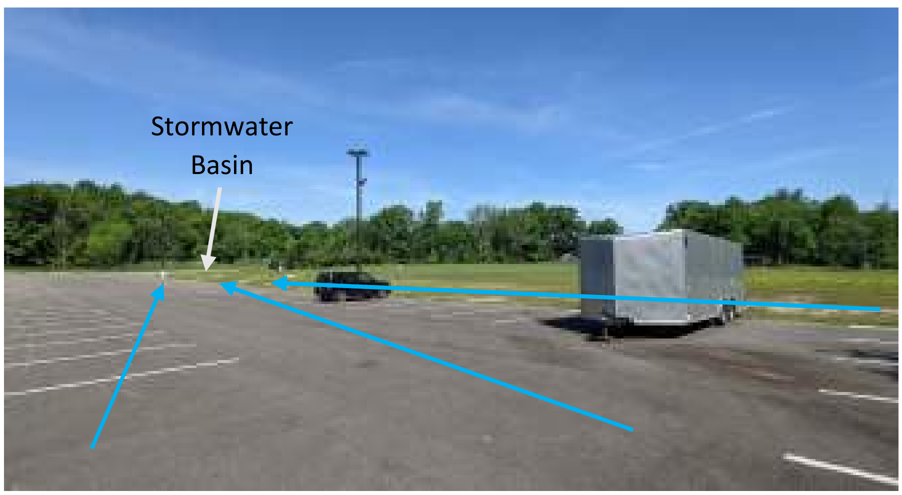
Historic Aerial 1986 (ODOT Aerial Archive)

Historic Aerial 1998 (ODOT Aerial Archive)

April 23, 2022 Aerial (Nearmap)

As can also be seen in the aerials, the Church most recently constructed a newer portion of asphalt parking lot located to the west of the facility. During investigation it was found that the lot drains west towards an existing detention basin with outlet structure. This was corroborated using survey data (Cuyahoga County GIS), onsite observations, and aerial analysis. Drainage patterns were found both onsite and via aerial which correspond with survey data showing westward drainage of the parking area and a majority of the greenspace. There is a well-defined channel and riparian corridor adjacent to the church, continuing northwest of the property, and the flow from the church parking and greenspace drain to this channel.

Stormwater basin west of church parking expansion.



View of Church Parking Lot from the east which drains to PPN 489-17-024.

In addition to the parking and main building area, the Church maintains an approximately 2.5-acre greenspace north of their parking lot. Effluent flow from this green space and the stormwater basin mentioned above both converge within Stream 53 West 2 channel. The 53 West 2 stream is a well-defined channel that transverses the rear yards at or near 4990, 4980, 4970 Corkwood Drive. From field investigation, any impacts to this stream appear to be due to natural processes and are not attributable to redirected or unaccounted-for flow from the church property. The Church property has existed in some capacity since 1970, and is a natural part of the drainage area that travels through the subdivision to the detention basins. The most recent expansion on the property appears to have been installed according to current state and local stormwater regulations, and there is no field evidence that any activity by the Church is exasperating the drainage issues within the subdivision.

FEASIBLE ALTERNATIVES

The evaluation of the existing drainage area as described above was performed to identify potential alternatives to address the drainage concerns throughout the subdivision. These alternatives are discussed in detail within the following sections.

A. OPTIMUM UTILIZATION OF EXISTING SYSTEMS

1. Detention Basin Maintenance and Upgrades

a. Routine Maintenance

Detailed inspection was performed on all three of the existing detention basins. The methods and findings are described above. There are several suggestions made within the CVE inspection reports, as well as in the inspection reports completed by the Cuyahoga Soil and Water Conservation District in 2019. The following routine maintenance items should be performed within the next year, to address concerns with the stormwater basins:

- Dredge all stormwater basins to restore designed storage capacity of the basins
- Install LSM or rock to eliminate voids under inlets in Basin 53 and 54
- Install erosion control matting on eroded banks of Basin 55 and 54
- Treat for phragmites (Basin 53) and algae (all Basins)

One additional item to address concerns with the basins is to develop an Inspection and Maintenance Plan for each basin. The plan would contain period routine inspections that should be performed, such as inspecting and clearing structures after rain event. The plan would also account for facets of maintenance that should be performed periodically, such as treating for algae and invasive plant species, or surveying and dredging the basins as needed to maintain sufficient storage capacity within the basin. Having the Plan formally established and adopted by the RVHA would assist in planning for cost of these various maintenance items, and ensure that repairs are completed when first occurring, in a timely fashion before issues exasperate to more extensive (and costly) projects.

It is important to note that the stormwater basins are at the downstream limits of the watershed. It will not be possible to alleviate the upstream flooding issues by correcting deficiencies within these detention basins. However, the issues within the basins should be addressed simultaneously with the upstream improvements. Correcting deficiencies upstream as suggested herein will in some locations allow water to travel more quickly and efficiently through the watershed and eventually to the stormwater basins. If the storage capacity of the basins is not restored, it is possible the improved flow path to the basins will cause localized flooding and overtopping of the basins that is not currently experienced today. Basin maintenance alongside upstream improvements should both be performed as components of improving overall drainage conditions within the watershed.

b. Basin Redesign

It would be possible to retrofit the detention basins to meet the standards that would today be required for new development. This could potentially be accomplished within the existing footprint of the basins. A topographic survey of the basins would be performed to capture existing storage volumes, and the outlet structure would be replaced and redesigned to restrict the outflows as described above. However, such a project is not recommended as a necessary or beneficial project for the RVHA to undertake at this time. As mentioned previously, the detention basins are located at the southern extents of the watershed. The flooding issues that were investigated as part of this study were upstream, and did not appear to be a result of back-up beginning at the detention basin. There is no indication that the tailwater elevation within the basins is causing flooding issues upstream. The review of the drainage report does not suggest that the design methodology was flawed, or in other way negatively impacting the functioning of the basin. A redesign of the basins would reduce flow downstream and is beneficial for several reasons, but the benefits would not necessarily be experienced by the stakeholders within the project area.

As mentioned previously in the report, published rainfall depths have increased over the last 30 years along with stormwater management regulations, most notably with the severe storm events. The 100-year flow data utilized in the original design is lower than would be calculated today, so the current basin emergency spillways may not be adequately sized to convey today's extreme weather events. As such, it may be beneficial to redesign the emergency spillways to accommodate the overflows calculated using today's rainfall depth for the 100-year event. This would be a low priority project, as structural issues with the current spillways were not seen, and no anecdotal evidence was collected to suggest the spillways are vastly undersized. It may be prudent to conduct bathymetric surveys of the existing conditions of the basins in order to determine their continued effectiveness.

c. Water Quality

Water Quality was not a consideration of stormwater management design when the subdivision basins were built. There would be benefit to the RVHA in retrofitting the stormwater basins to address certain aspects of water quality design. It is not recommended that the basins be retrofit to treat for water quality based on today's standards. Treating a designed water quality volume would not address the flood-mitigation concerns driving this report. This retrofit would require replacement of all outlet structures, and may require expansion of the footprint of the basins. The basin would serve to provide water quality treatment for the outflow of the basin, which is not necessarily one of the project goals. Water quality basins also require more frequent monitoring, as they require small orifice restrictions to ensure the gradual drain time within the basins.

Installing a forebay and micropool would be beneficial to the RVHA, and would allow for a portion of stormwater to be treated for water quality without having to undergo any major reconstruction or expansion of the basins. The present condition of the basins suggests that sediment deposition does occur within the basin, and concentrating this sediment within smaller pools within the basin will make maintenance easier in the future. These smaller pools will need to be dredged, but the procedure will not have the significant expense associated with dredging of the entire basin.

One other consideration regarding the water quality component of the basins is to advertise these basins as assets available for use by a third-party organization. A water quality retrofit of the basins would provide water quality improvement within the Big Creek Watershed as a whole. There may be grants or funding available that could be applied for, in which redesign and retrofit of the basins with water quality storage, micropools, forebays, and updated flow calculations could be accomplished for less cost than construction of new basins. Environmentally conscious entities, such as NEORSD, may be interested in funding the retrofit of these existing basins to provide improved water quality for the entire watershed. The subdivision is located within the headwaters of Big Creek Watershed, so improvements for outflow from the drainage area could have significant impacts downstream. The RVHA would also benefit directly from the project through the installation of the forebays and micropools as discussed, with the cost being covered through grant dollars or funding by a third-party organization. It may also be possible to secure long-term assistance with monitoring and inspection of the basins as part of such a project.

2. Routine Maintenance of Local Storm Sewer System

Extensive closed conduit investigation was not included as part of the project scope, but some investigation of the system was performed as incidental to the remainder of the fieldwork. Catch basins were investigated in areas where evidence of stormwater debris was visible within the pavement gutters. Catch basins throughout these areas were consistently full of standing water and debris. A number of the catch basins appeared to have orifice plates installed over the outlets, and from the cursory investigation, some of these plates appear to be completely covering outlet pipes. Record plans were requested from the City, but were not available in the supplied documents, so the design function of these outlet restrictions is unknown.

Roadway debris within gutter along Pickneya Drive

One of the suggestions is to clean out catch basins within the drainage area. Restricting the outflow to a small orifice, which appears to be the case in certain locations throughout the drainage area, means the catch basins are highly susceptible to clogging. Developing a routine schedule for inspecting and maintaining the catch basins, on an annual basis or periodically by street or section, would be a best practice to adapt to encourage efficient flow to the storm sewer system during rain events. The standing debris within streets suggests that water is ponding within gutters during rain events, and generally suggests that the local storm sewer system is not effectively conveying stormwater.

Catch basin debris- Ridge Line Drive

Catch basin debris- Sweetleaf Lane

An additional step would be to consider authorizing full analysis of the existing closed conduit system, to determine if outlet restrictions can be removed. It may also be beneficial to determine if storm sewer is appropriately sized for the drainage area and current rainfall intensities. Undersized storm sewers result in higher tailwater for open channels to drain to, and this may contribute to flooding within open channels and the small tributaries or outlet pipes that drain to those channels. A review of the subdivision plans and original design for the storm sewers could be performed, to determine the relevancy of the design to today's standards and methodology (similar to the review described herein for the stormwater management basins). It would be valuable to identify any deficiencies within the closed conduit system, and if the local sewer system is magnifying flooding concerns or otherwise contributing negatively to the stormwater management system.

Circular orifice plate restriction- Corkwood Drive

Catch basin debris with orifice restriction- Pickneya Drive

3. Targeted Channel/Outfall Improvements

Open Channels and stormwater outfalls throughout the Royal Valley Subdivision were inspected for general condition and functionality. There were five impaired locations identified for potential project improvements. A map of these locations has been included for reference (see Appendix H). A brief summary of the potential improvement at each location follows, in order of priority:

- 5031 Corkwood Drive: remove failed gabion structure from open channel; install flow dissipation at the outlet; consider natural channel design to expand floodplain downstream of the outfall

5031 Corkwood Drive outfall

Failed gabion and bank erosion downstream of 5031 Corkwood Drive

- 5117 Pinckneya: remove failed gabion structure from outlet channel; repair scouring and install rock channel protection and flow dissipation measures at outfall

5117 Pinckneya Outfall

Failed gabion downstream of 5117 Pinckneya

- 9836 Silverleaf: install flow dissipation and/or realignment of stream at outlet; install erosion control matting/geoweb wall to address existing bank erosion

9836 Silverleaf Outfall

Steep eroded bank at 9836 Silverleaf

- 9769 Royal Valley: install flow dissipation at outlet, combined with natural channel design to address downstream erosion

9769 Royal Valley Outfall

Downstream bank erosion at 9769 Royal Valley

- 9780 Royal Valley: install flow dissipation at outlet, remove failed gabion structure, combined with natural channel design to address downstream erosion

9780 Royal Valley Outfall

Failed Gabion structure within channel between Dublin Drive and Buttonbush Lane

Designing flow dissipation at these various outfalls would serve multiple benefits. These locations are exhibiting bank erosion directly downstream of the outfalls. This bank erosion can be discouraged by slowing the velocity of water as it discharges from the sewer into the channel. One of the most reliable and cost effective forms of flow dissipation is the installation of large boulders, lined with filter fabric. This rock channel protection should be designed based on actual flow to these locations. The size, thickness, length, and width of stone would be selected to specifically protect against future erosion at these locations. The rock channel would replace the concrete collars present at most of these locations, which allows the water to travel at an accelerated rate to the natural channel. The stone slows down the velocity of water as it travels through the section, which will reduce occurrence of erosion, among other benefits. Reduced velocity also means there will be less turbulence within the stream, and less sediment being scoured from the stream bottom and bank, carried through the corridor and deposited into the stormwater basins.

The suggestion for these targeted improvements also includes combining the outfall improvement with downstream stream restoration. The existing occurrences of bank erosion would be corrected, and additional floodplain may also be added up or downstream of the outfall. Slowing down the rate of water within the channel will positively benefit the stream banks, but it is important this is not accomplished to the detriment of the stormwater system elsewhere. The improvement needs to be properly designed, to ensure the water is not slowed to such an extent that it increases tailwater at the outfall and causes back-up within the storm sewer upstream.

4. Stream Channel Restoration

As mentioned throughout this report, open channels are an important component of the watershed. These assets reduce sediment-load throughout the system, improve overall water quality, and provide flood-mitigation. A stable, healthy stream channel has natural sinuosity and variations in depths throughout the channel, with deep, calmer segments known as pools and shallow, more rapid rock-lined portions called riffles. This pattern allows for a balanced deposition of sediment within the stream channel, so that sediment neither accumulates nor deposits within the water as it moves through the channel, but is cycled at an equal rate throughout the channel. Stable streams have stable banks that do not exhibit significant erosion, which would be evidenced by exposed roots, steep banks, sloughing of vegetation into the channel, etc. Instead these banks have gradual slopes with well-established vegetation throughout. Healthy streams have sufficient adjacent floodplain so that water spreads naturally into these adjacent flat areas during heavy rain events, and is temporarily stored before reentering the channel once the peak flows have dissipated. A natural, healthy stream corridor is one of the most valuable assets within a watershed.

There are portions of open channel within Royal Valley which do exhibit characteristics of a natural, healthy stream channel. There is sufficient floodplain, vegetative plantings indicating healthy wetland ecology, and stable banks without evidence of undercutting or erosion. Preserving these streams as protected open areas is an important step the RVHA can take to continue to benefit from these portions of stream. These areas are mostly located within the upstream portions of the drainage area, as described in previous sections.

There are also potential areas that can be candidates for a stream channel restoration project. Such a restoration would employ facets of natural channel design. This design methodology involves restoring the stream to its natural, stable condition through the use of various design tools. One tool involves introducing sinuosity back to the stream. As mentioned, the sinuosity of a stream is an important component in its overall health. If land constraints allow, natural channel design introduces curvature back to the stream channel. Structural components are also installed in order to reduce flow velocities, change grade within the stream, or other objectives as needed. The technical terms are features such as J-hooks, Cross Vanes, and Rock Riffles. The various features include installing aggregate, boulders, logs, etc. in various orientations. Additional components include the installation of vegetation to serve as anchoring of channel banks, and to perform regrading of the channel and adjacent area to provide expanded floodplain and water storage during severe storm events.

One potential area that would be an appropriate location for stream channel restoration utilizing facets of natural channel design is in portions of Stream 55 (see Appendix C, Figure 5 for location). The specific project location is both north and south of Royal Valley Drive, west of Dublin Drive. This area of stream exhibits incised banks subject to erosion. There are also failed gabion structures in the area that could be removed, and a natural stream channel with floodplain could be installed. The priority would be to perform the project for the portion North of Royal Valley Drive first, and then proceed with the portion south of Royal Drive once the downstream improvements are installed.

Incised channel between Dublin Drive and Buttonbush Lane

Another segment that would benefit from this type of project is within the drainage area to 5030 Corkwood, the area to the east of St. Paul Orthodox Church. This is Stream 53 West 2 (see Appendix C, Figure 5). This area is a desirable candidate not necessarily due to poor conditions within the channel, but due to the downstream concerns at 5030 Corkwood. This report contains recommendations for improving the inlet capacity at 5030, but this alone may not be sufficient to correct the drainage issues at this and nearby residences. It may be possible to reduce peak flow rates arriving at the inlet basin by improving conditions within the upstream channel. Installing additional floodplain along the corridor and installing energy dissipating structures may serve to reduce the peak flows that arrive at the inlets. The 6-acre drainage area is a significant amount of flow to capture within a single inlet structure, regardless of the efficiency and design utilized at the structure. If it were possible to slow the outflow upstream within the stream corridor by installing flow dissipating structures and expanding floodplain, combined with optimizing the inlet capacity at 5030, this would be a multi-faceted approach that could correct the issue for the long-term.

B. INFRASTRUCTURE IMPROVEMENTS

1. Corkwood Drive

The rear yard inlets along Corkwood Drive, particularly at 5030 Corkwood, were identified as a particular point of failure within the overall drainage area. A potential improvement for Corkwood Drive would include retrofitting the two trapezoidal-top structures with additional windows on all three sides of the structure, and with flat-top grates. This would increase inlet capacity and reduce localized flooding. The drainage pipe should be tied into the sidewall of the structure, as opposed to the window. The project would include a repair of the area to eliminate the sinkhole and install a more gradual depression to the structures. Erosion control matting can be installed in the vicinity of the catch basin to prevent a similar failure from occurring in the future. The final design would include consideration for debris control, particularly when modifying to the flat grate. It would be beneficial to obtain a permanent stormwater easement over these catch basins and the storm sewer line into the rear yard, so that access to the structure is ensured over time, and the structures can be routinely inspected and maintained.

A more substantial and long-term solution that does not carry the risk of increased clogging would be to redesign flow path to enter into the stormwater system upstream of the existing rear yard inlets. Through review of record improvement plans, it is apparent that the original design was for an open pipe inlet with a headwall as opposed to the inlet basins that were installed. A headwall would have a larger open inlet, and would allow the flow to be captured within the storm sewer system prior to entering the residential backyards. The new headwall would need to be properly sized and designed, and the project would involve field survey, approval from the City, possible easements/property acquisition, and potentially environmental permitting.

The third catch basin on this property has the round beehive grate, which encourages water levels to pond before the full inlet capacity is utilized. There are advantages to installing this style of raised grate, to prevent clogging and debris from covering the catch basin, particularly in a lawn area. However, for this scenario where it is necessary to more quickly and efficiently drain the property, a flat top grate may be more appropriate. The lawn grades surrounding this structure are substantial, and it may be possible to reduce these grades by installing at a flat grate with increased inlet capacity.

One of the concerns with the system of smaller rear yard inlets along Corkwood is in the burden of maintenance remaining on the homeowner. Several of the catch basins have been modified or flow is unintentionally being impeded by retrofits that appear to have been installed by residents. It is possible that grass clippings, leaves, and other yard waste interfere further with these drainage structures during certain times of year. While the current homeowners appear to maintain and ensure the various catch basin remains clear, future owners may not be as vigilant. Ensuring these rear yard basins are placed in a stormwater easement, or otherwise placed on a City or RVHA task list for annual inspection, would be beneficial to protect the structure in perpetuity. The recommendation would be for all such rear yard inlets within the subdivision to be placed under the stewardship of a formal entity, having continuous access to the structure for routine inspection and maintenance.

2. Outreach and Education

One of the identified issues within the watershed is related to actions of homeowners living within the subdivision. As previously discussed within the report, field investigations identified frequent occurrence of residents dumping yard waste, grass clippings, woody debris, trash, and other obstructions within stream channel flow paths. This is problematic for several reasons. The debris is unsightly strictly from an aesthetic standpoint, leads to eutrophication of area streams, and is an issue from a drainage standpoint. These piles of debris prevent water from flowing efficiently throughout the stream corridor, and are causing channels to develop around the blockages, which can lead to localized flooding and back-up within the channel further upstream. This method of disposal also contributes to clogging further downstream within the local storm sewer system, as was witnessed at catch basins throughout the subdivision.

Yard waste/debris- Silverleaf Drive

RVHA regulations specifically restrict this type of dumping and disposal of yard waste. One measure that can be taken to address this behavior is to issue communication to all homeowners within the subdivision. This should be a multi-faceted approach, including potentially a public meeting, mailer, and posted signs indicating specifically the types of behavior that are restricted. The RVHA may want to consider instituting specific policies that allow for formal issuance of warnings, fines, and removal of obstructions at the expense of responsible parties.

Yard waste/debris- Dublin Drive

One additional concern for the subdivision is regarding the existing deer population. The HOA is limited as to actions that can be taken to eliminate or prevent deer within the green spaces of the subdivision. These animals can have a detrimental impact on existing vegetation, and can therefore accelerate natural erosion within the stream channels. However, one action that can reduce the negative impact from the large deer population is to prevent individual residents from feeding or otherwise supporting the deer population, particularly in residential areas. Outreach and education regarding yard waste and debris could be utilized to also remind residents that feeding deer is prohibited. The same policies enacted to encourage proper disposal of yard waste (a formal process for warnings, fines, etc.) could be considered for residents that continue to feed the deer population. There are repellents that individual homeowners can utilize, as well as deer fences. However, as stated, the green spaces within the HOA are natural habitat for these populations, and it is not likely that any actions can entirely eliminate their presence. It is believed, though, that through proper actions of all residents within the HOA, namely not feeding the animals, can help to reduce the population and minimize negative impacts from these animals.

3. Heasley Soccer Fields

The existing storm sewer system along the northern limit of Heasley Soccer Fields does appear to be an effective system for capturing flow from the grass fields if proper modifications are undertaken. One option is to increase inlet capacity further along the existing storm sewer system to capture more flow during severe rain events. There are four inlet or circular basins located at the northern extents of the grass fields. Additional inline basins can be installed along this line, to encourage the capture of additional flow. This improvement would not require replacement of the entire storm sewer line. Drop-in basins can instead be installed along the existing storm.

The main recommendation for the Heasley parcel is to introduce additional inlets throughout the parking areas, the most likely contributor to deleterious stormwater flow. This installation would require additional storm sewer. There is a break in the parking lot, delineating the newer portion of the pavement from the old. A topographic survey would be required, but visually it appears it may be possible to introduce a local depression at or near this break point. Additional catch basins located here and tied into the existing storm sewer system north would reduce the flow concentrating down the parking lot and into backyards along Princeton. It may also be possible to repave portions of the lot to direct drainage of the parking lot into a grass or rock-lined channel outside of the pavement area. Such a diversion could slow the flow of water, and inlet basins could be installed along with perforated pipe within the swale to maximize capture of rainwater.

It may also be beneficial to increase the height of the earthen berm between the fields and the residences. The berm acts as the final barrier for any flow that does bypass the inlets, and increasing the height will provide an additional factor of safety against flooding during severe storm events. This berm should be fortified with erosion control matting, providing additional assurance that failure does not occur during flooding. Along the same lines, installation of a vertical curb along the newly paved portion of the parking lot, or along the northern edge at a minimum, would prevent water from flowing directly into rear yards. The curb would need to be installed as well as the new pavement reinstalled to pitch towards the existing catch basins. Conversely, an additional basin(s) could be installed along the northern curb to allow for less concentrated flow. If a vertical curb is not feasible, a drainage swale should be installed immediately north of the parking lot. The swale could be a rock lined drain with perforated pipe in the bottom of the trench, to act as a final path for any run-off that does bypass the storm sewer system within the parking lot.

C. CHANNEL OR GREEN SPACE IMPROVEMENTS

1. St. Paul Greek Orthodox Church

One suggestion regarding the St. Paul Greek Orthodox Church would be to include the Church administration on any public outreach or education regarding property disposal of leaves, grass clippings, and any other yard waste. In addition, it is not known whether the Church would be receptive to potentially allocating all or a portion of the available green space at the northern extent of the property for use as a stormwater management feature. The area does appear from aerial imagery and onsite observations to be utilized as an existing soccer field. An aboveground stormwater management basin may therefore not be plausible. However, an underground detention system could be a possibility. The Church could potentially maintain the property as a soccer field, with the underground system being located within an easement under the field. If the Church were receptive to the concept, such a system could be a very valuable tool to alleviate issues along Corkwood. Drainage from the 6.4-acre drainage watershed to 5030 Corkwood could be diverted into this basin and would be released over a 24-48 hour period at a reduced flow rate. This would benefit the residents along Corkwood, as well as residents downstream, by reducing peak flows within the open channel that eventually runs beneath Royal Valley Drive. At a minimum, a drainage swale could be constructed to divert uncaptured flow directed at 5010-5020 Corkwood to the west towards Stream 53 West 2 to alleviate direct discharge to residential units.

FACILITIES PLAN

The alternatives posed in the previous section have varying degrees of impact. Each alternative also has consideration of cost, timeframe, duration of implementation, required input from third-parties, etc. As such, CVE compiled the suggestions into an overall Facilities Plan, that assigns a targeted project initiation date to the various projects with approximate duration of implementation and estimated total cost. The Facilities Plan is meant as a guideline, to assist in prioritizing the various suggestions and tracking the time-critical projects versus those that can be part of a long-term plan for the Subdivision. The Facilities Plan should be used as a guideline for discussion and planning, and is meant to be updated as the RVHA moves through the various suggestions. The document is attached (see Appendix I).

CONCLUSION

Chagrin Valley Engineering Ltd. worked on behalf of the Royal Valley Homeowner's Association (RVHA) to investigate the Royal Valley Subdivision Watershed. This evaluation included compilation and review of record information along with field investigation throughout the drainage area. This information was gathered for use in the development of suggestions for how to address existing concerns with drainage and water quality throughout the region.

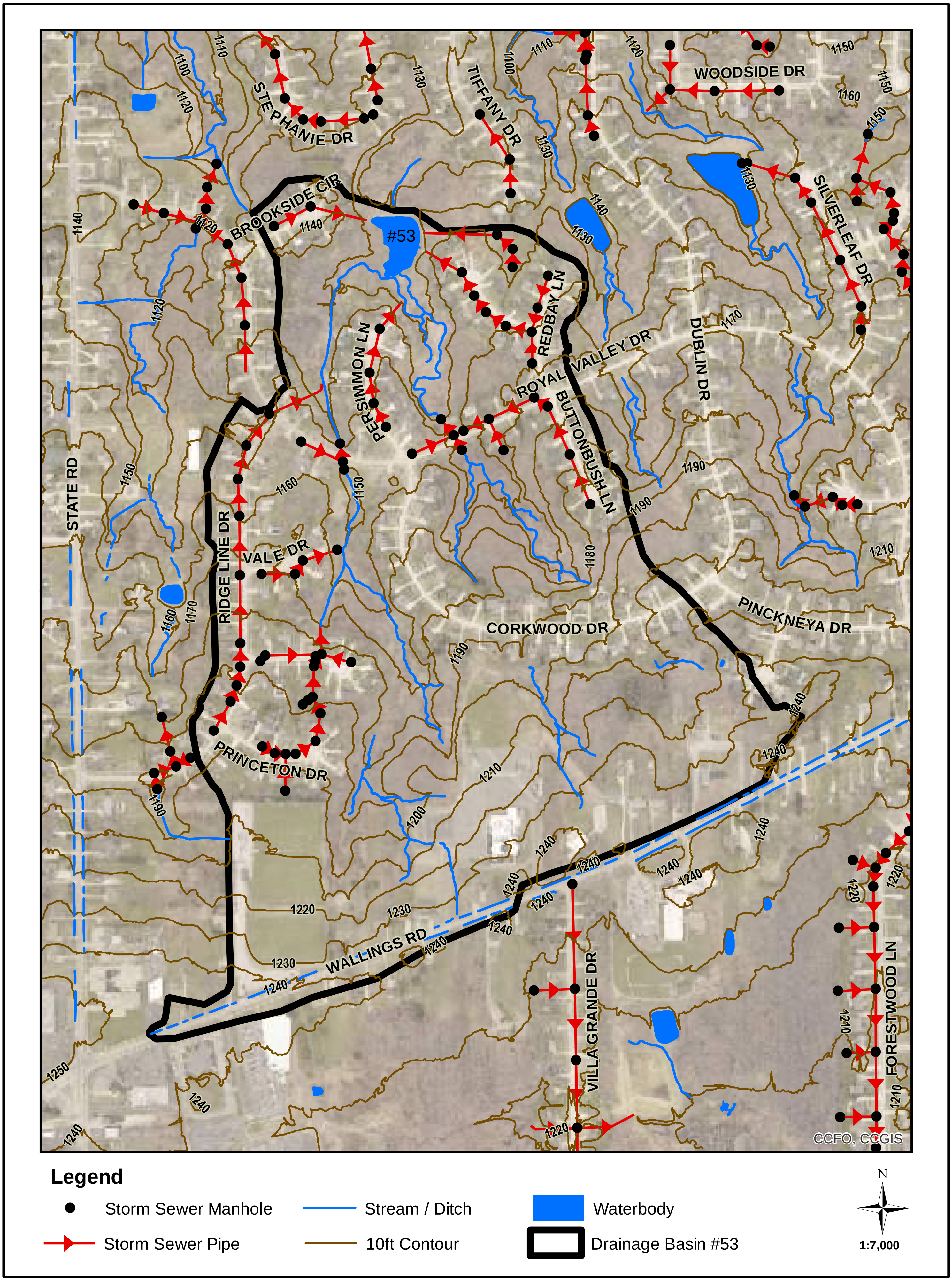
The Royal Valley Subdivision has portions of open channel and greens pace that are in healthy, stable condition and are a valuable asset to the community. There are also portions of channel that are eroding and negatively contributing to the sediment load, localized flooding, and other stormwater management concerns within the area. Fortunately, there are concrete improvements and options that the RVHA can undertake to correct deficiencies within the watershed, as outlined within this report. Electing to perform any number of the improvements outlined within this report will improve deficient areas and preserve the existing assets for the long-term.

APPENDIX

- Drainage Area Exhibits and Record Plans
  - Basin 53
  - Basin 55
  - Basin 54
- NEORSD Detention Basin Maps
  - Basin 53
  - Basin 55
  - Basin 54
- Watershed Characterization Figures 1-10
  - Figure 1: USGS Watershed Boundary Map
  - Figure 2: Fish and Wildlife Service Wetland Inventory Map
  - Figure 3: FEMA Flood Hazard Map
  - Figure 4: Open Space Map
  - Figure 5: Stream Location Map
  - Figure 6: Topographic Map
  - Figure 7: Impervious Surface Map
  - Figure 8: Tree Canopy Change
  - Figure 9: Land Cover Map
  - Figure 10: Land Use Map
- Soils Reports
  - Drainage
  - Water Features
  - Surface Runoff
- Instructions for Accessing the ArcCollector Map?
- Basin Inspection Reports
  - Basin 53
  - Basin 55
  - Basin 54
- Map of Outfall Improvements
- Facilities Plan

APPENDIX A: Drainage Area Exhibits & Record Plans

- Basin 53
- Basin 55
- Basin 54



#53
STATE RD
BROOKSIDE CIR
STEPHANIE DR
TIFFANY DR
WOODSIDE DR
SILVERLEAF DR
REDBAY LN
ROYAL VALLEY DR
DUBLIN DR
PERSIMMON LN
BUTTONBUSH LN
RIDGE LINE DR
VALE DR
CORKWOOD DR
PINCKNEYA DR
PRINCETON DR
WALLINGS RD
VILLA GRANDE DR
FORESTWOOD LN
CCFO, CCGIS
Legend
Storm Sewer Manhole
Stream / Ditch
Waterbody
Storm Sewer Pipe
10ft Contour
Drainage Basin #53
N
1:7,000

PHASE I-A

ROYAL VALLEY P.U.D.

PLAN VIEW

WET DETENTION BASIN

CITY OF NORTH ROYALTON

SLABE & MACKAY – Civil Engineers & Surveyors

CLEVELAND, OHIO 84-E4	DATE JUNE - 1985
SCALE: HOR. 1"=30' VERT.	SHEET 4 OF 6

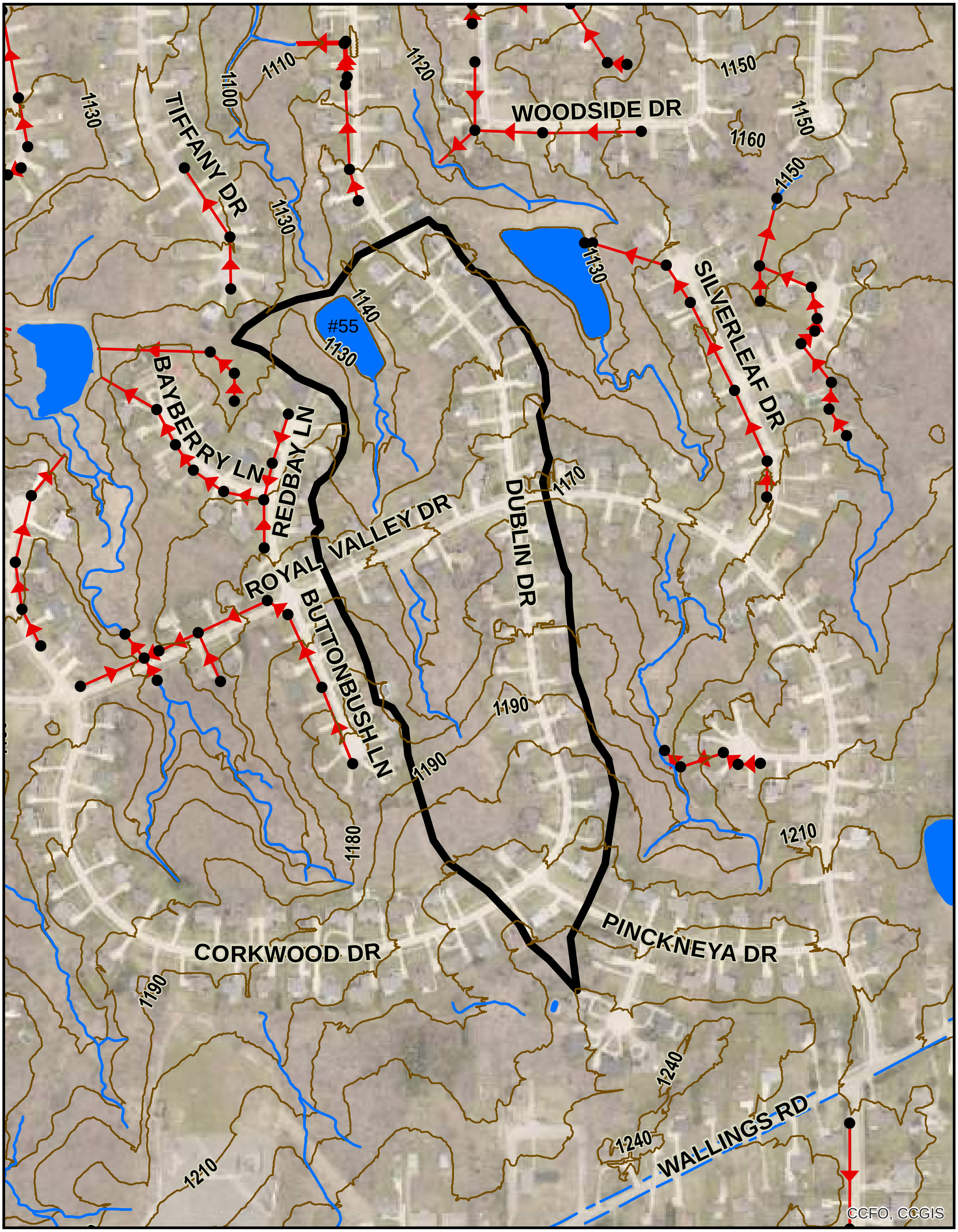
PHASE 1-A

ROYAL VALLEY P.U.D.
PROFILE & DETAILS
WET DETENTION BASIN
CITY OF NORTH ROYALTON

SLABE & MACKAY – Civil Engineers & Surveyors

CLEVELAND, OHIO 84-E4 DATE DECEMBER-1985
SCALE: HOR. AS SHOWN VERT. AS SHOWN SHEET 5 OF 6

E-2

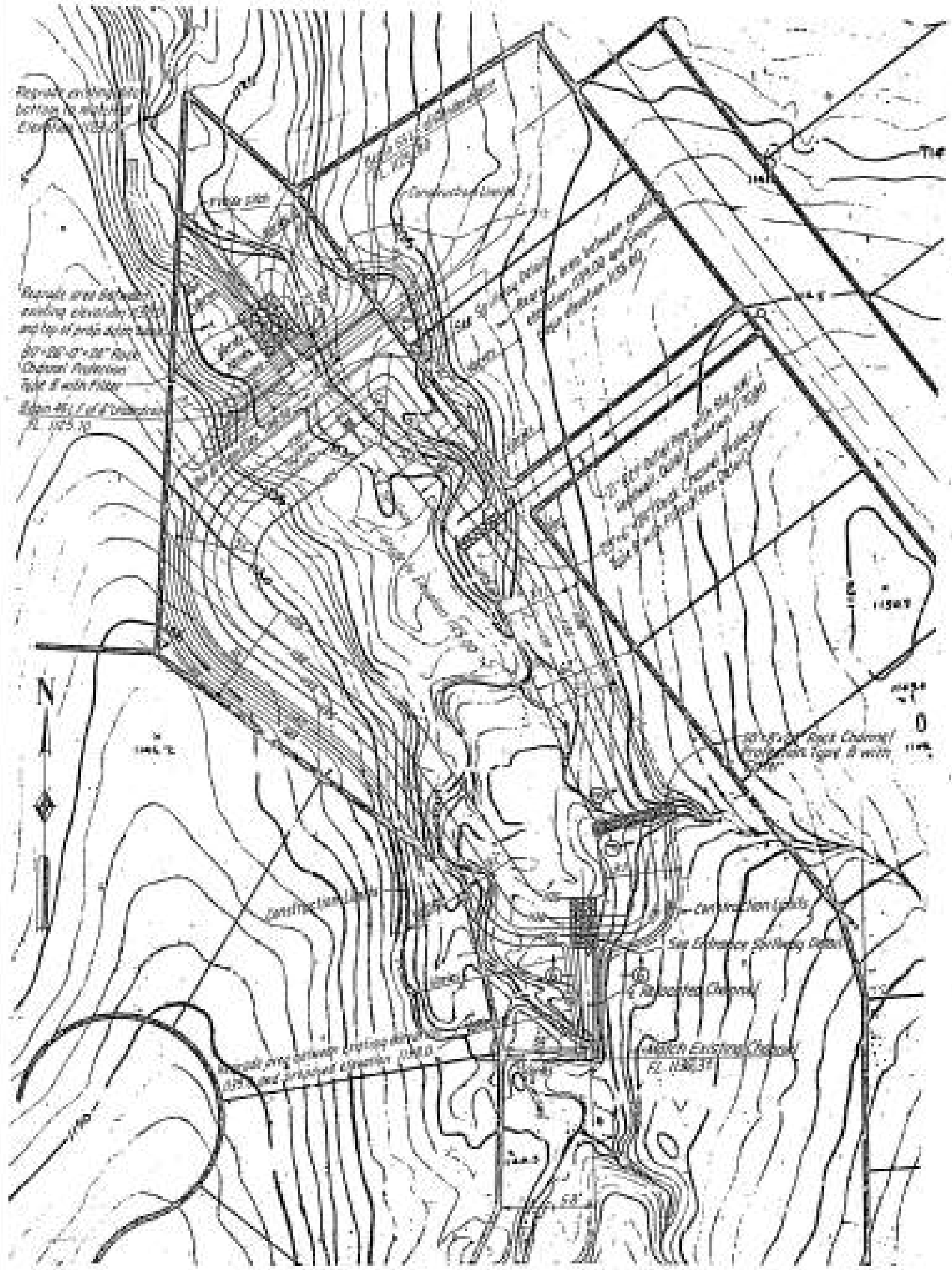


Legend

- Storm Sewer Manhole
- Storm Sewer Pipe
- Stream / Ditch
- 10ft Contour
- Waterbody
- Drainage Basin #55

N

1:5,000



BASIN PLAN
Scale: 1"=50'

HYDRAULIC DATA

Drainage Area	=	30.2 Acres
Q_{10} Peak Runoff	=	49.56 cfs
Q_{10} Peak Basin Discharge	=	5.84 cfs
Q_{10} Maximum Water Surface	=	1132.42
Q_{100} Peak Runoff	=	79.77 cfs
Q_{100} Peak Basin Discharge	=	34.23 cfs
Q_{100} Maximum Water Surface	=	1133.16
Freeboard Spillway Peak Discharge	=	408.48 cfs
Freeboard Spillway Maximum Water Surface	=	1136.72

Revised 4-14-89 - Revised 5-25-89

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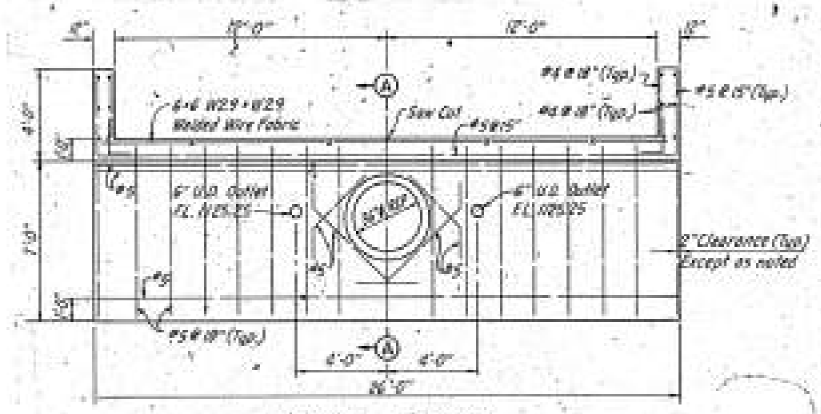
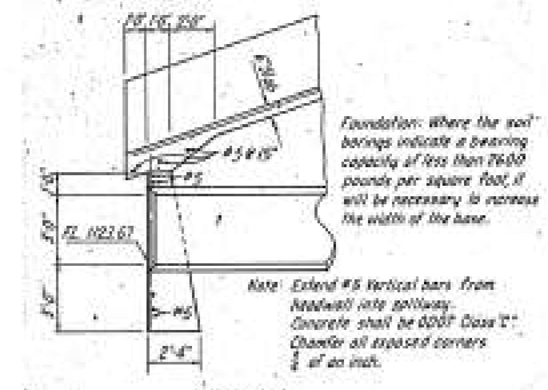
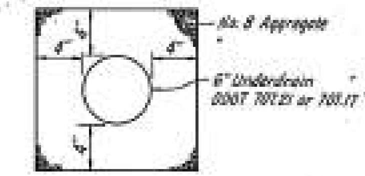
CLEVELAND OHIO



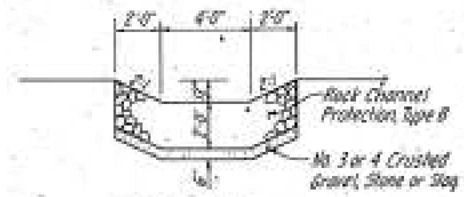
HEADWALL ELEVATION
Scale: ¼"=1'-0"



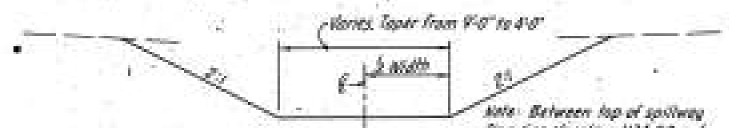
HEADWALL SECTION A-A
Scale: ¼"=1'-0"



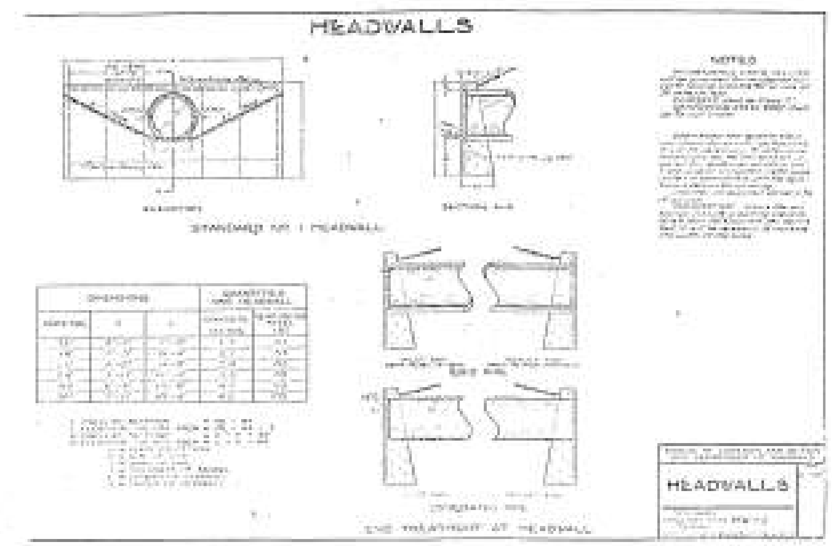
UNDERDRAIN DETAIL
Scale: 1½"=1'-0"

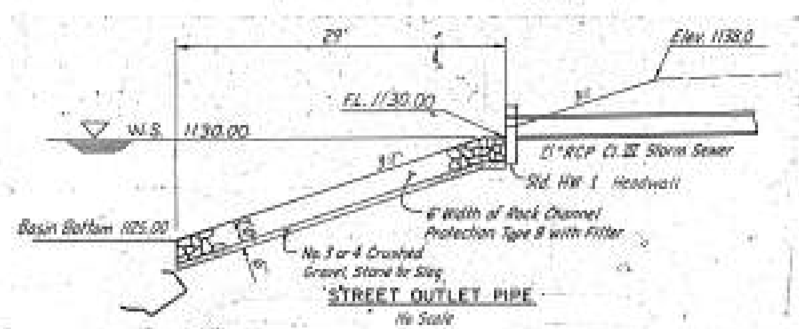


SECTION F-F
Scale: ¼"=1'-0"

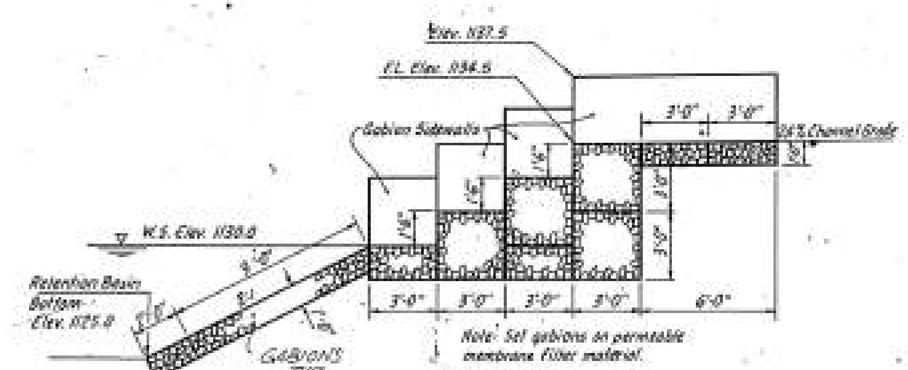


SECTION G-G
Scale: ¼"=1'-0"





STREET OUTLET PIPE
No Scale



SECTION H-H
RETENTION BASIN ENTRANCE SPILLWAY
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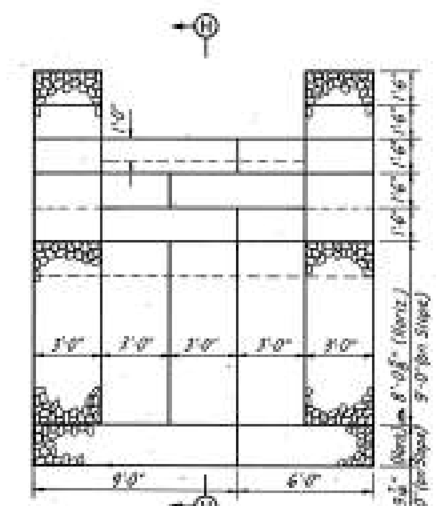
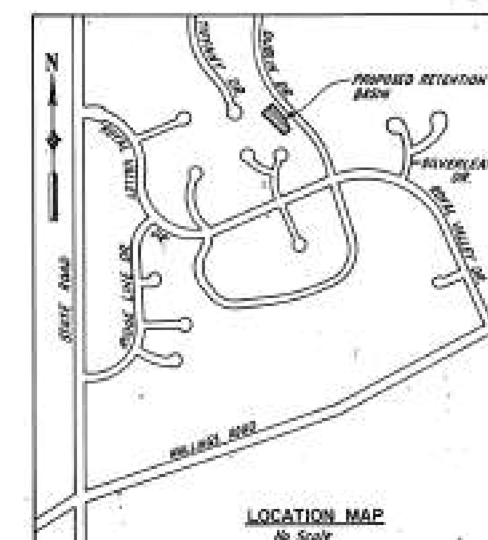
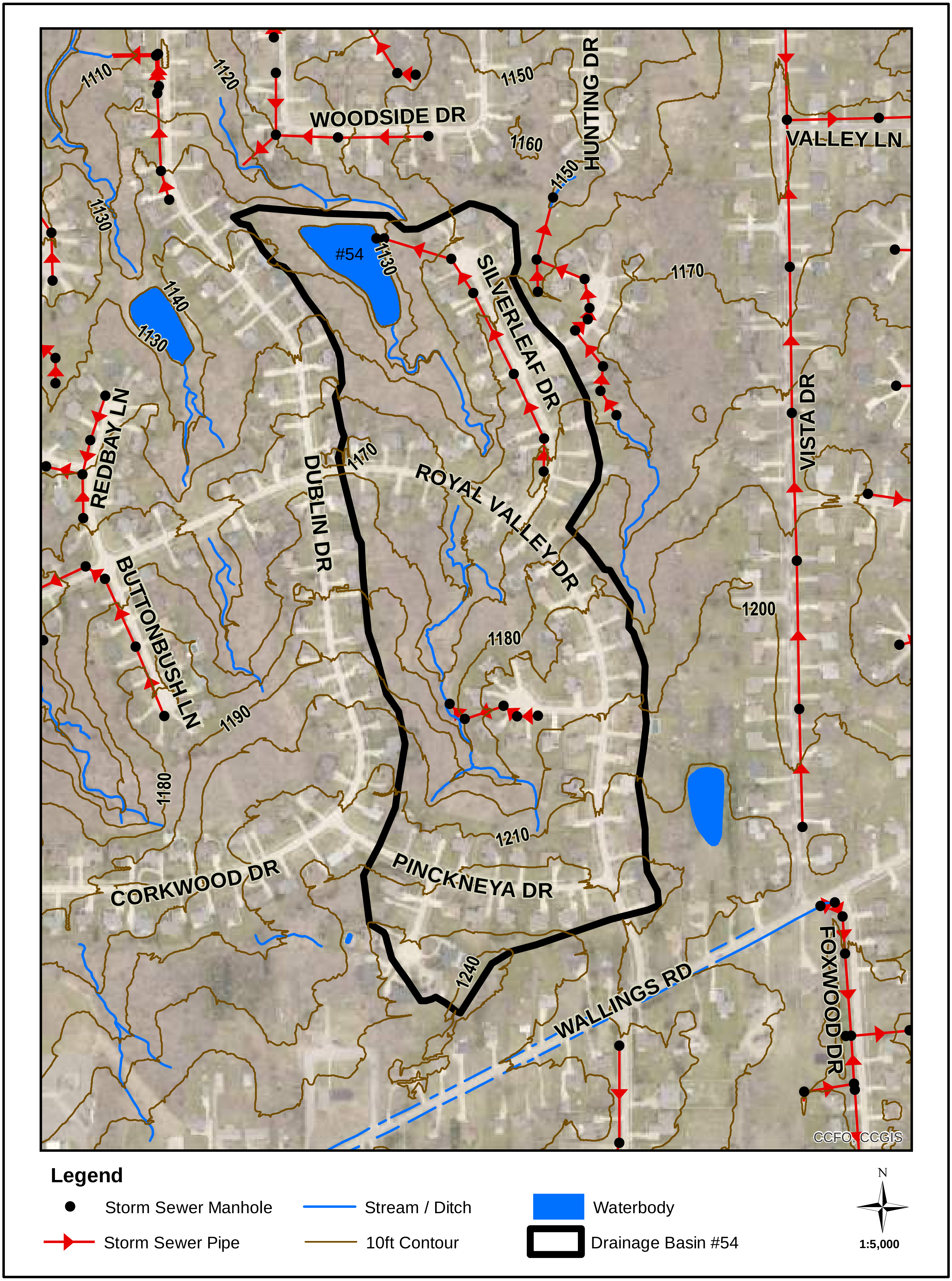


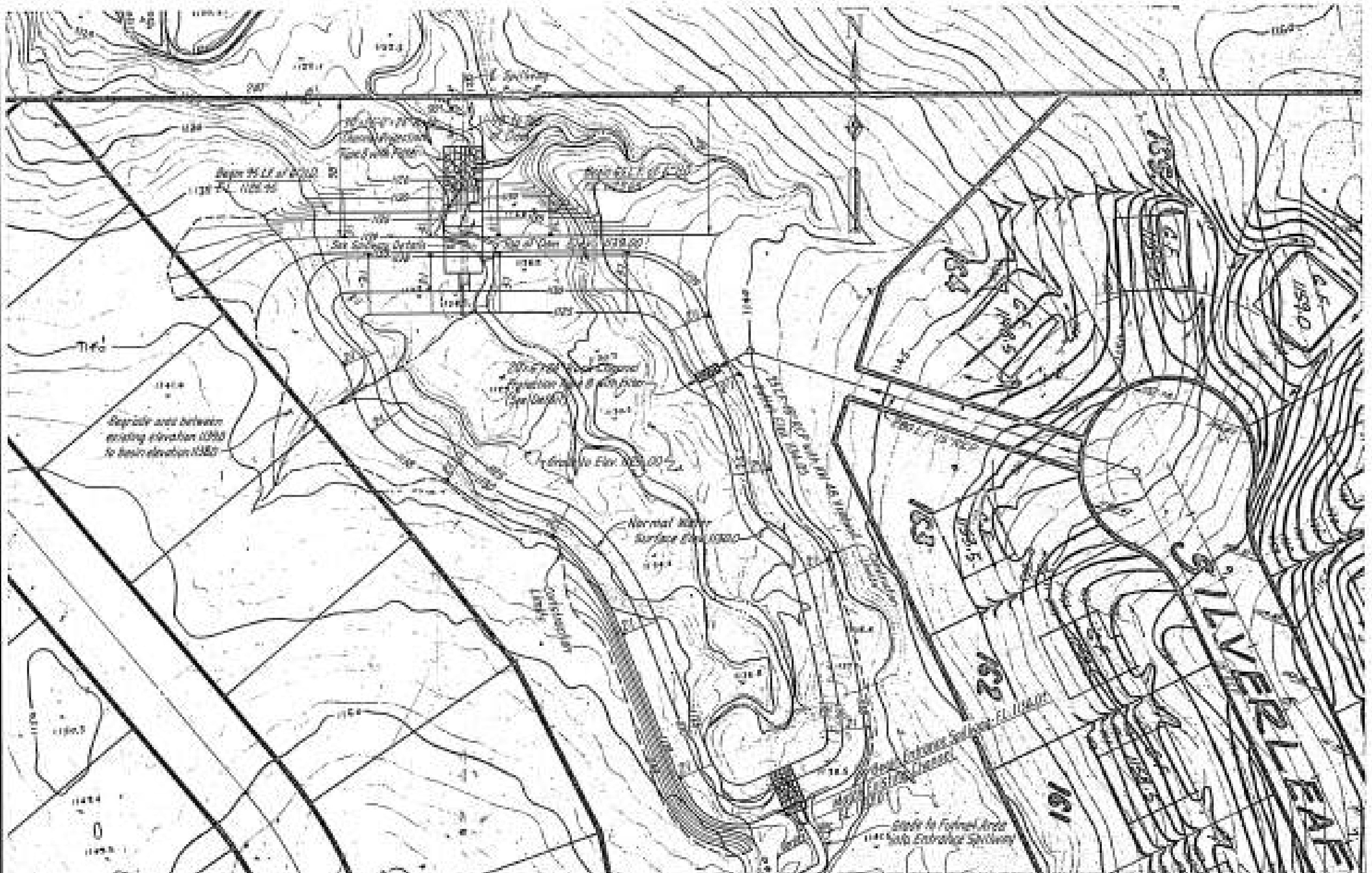
ENTRANCE SPILLWAY DETAIL PLAN ELEVATION
Scale: ¼"=1'-0"



LOCATION MAP
No Scale

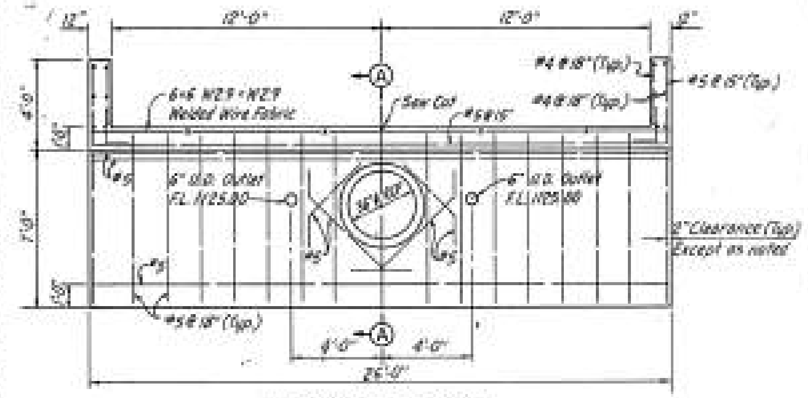
ROYAL VALLEY MIDDLE RETENTION BASIN


WOODSIDE DR
VALLEY LN
HUNTING DR
SILVERLEAF DR
REDBAY LN
DUBLIN DR
ROYAL VALLEY DR
VISTA DR
BUTTONBUSH LN
CORKWOOD DR
PINCKNEYA DR
WALLINGS RD
FOXWOOD DR
#54
1110
1120
1130
1140
1150
1160
1170
1180
1190
1200
1210
1240
CCFO, CCGIS
Legend
Storm Sewer Manhole
Storm Sewer Pipe
Stream / Ditch
10ft Contour
Waterbody
Drainage Basin #54
N
1:5,000



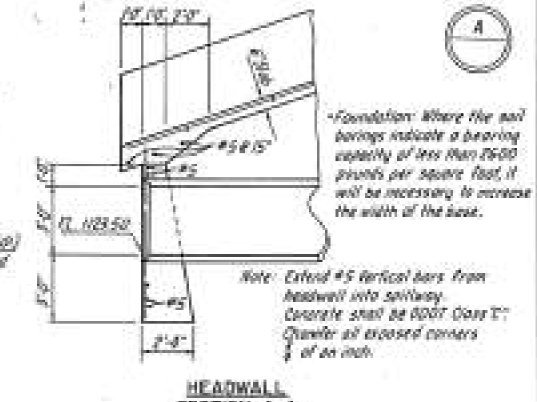
BASIN PLAN

Scale: 1"=50'



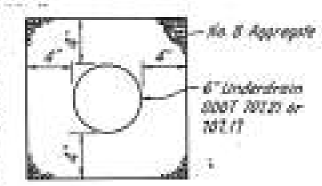
HEADWALL ELEVATION

Scale: 1/4"=1'-0"



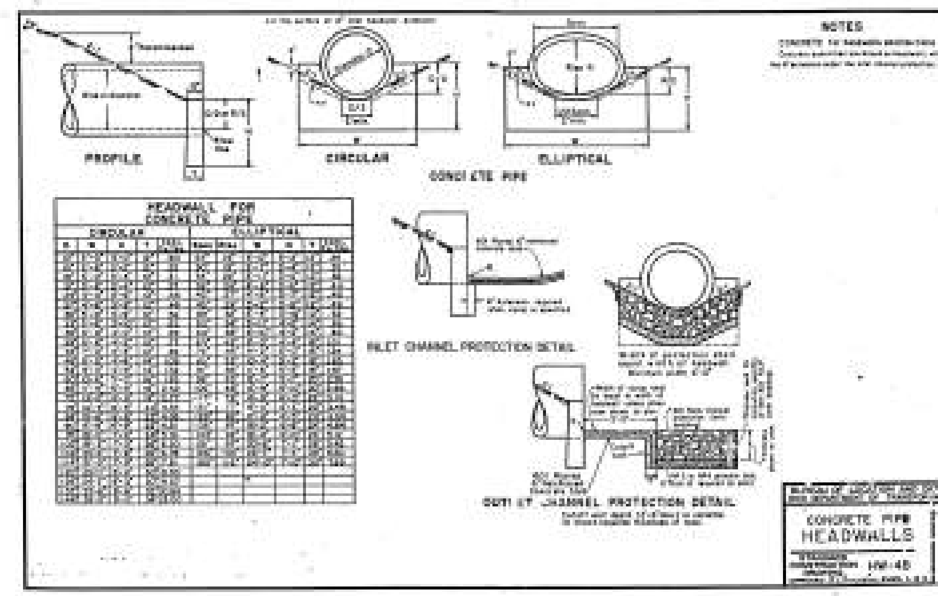
HEADWALL SECTION A-A

Scale: 1/4"=1'-0"



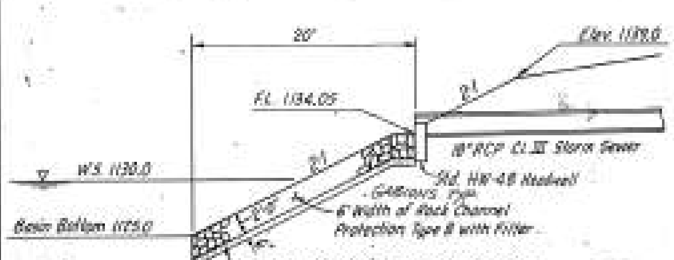
UNDERDRAIN DETAIL

Scale: 1 1/2"=1'-0"



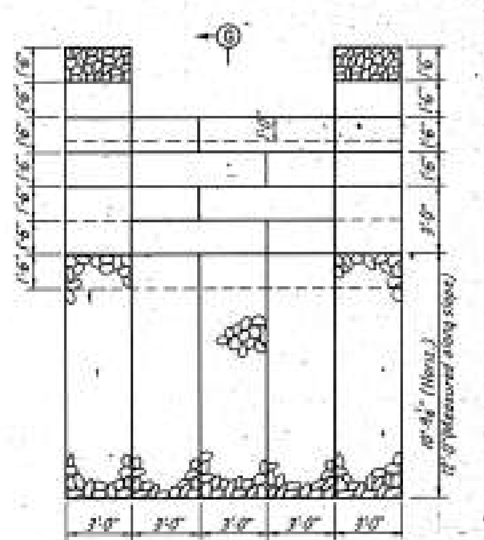
HYDRAULIC DATA

Drainage Area	= 48.5 Acres
Q_{10} Peak Runoff	= 60.39 cfs
Q_{10} Peak Basin Discharge	= 8.05 cfs
Q_{10} Maximum Water Surface	= 1132.68
Q_{100} Peak Runoff	= 97.72 cfs
Q_{100} Peak Basin Discharge	= 22.80 cfs
Q_{100} Maximum Water Surface	= 1133.91
Freeboard Spillway Peak Discharge	= 653.97 cfs
Freeboard Spillway Maximum Water Surface	= 1138.51



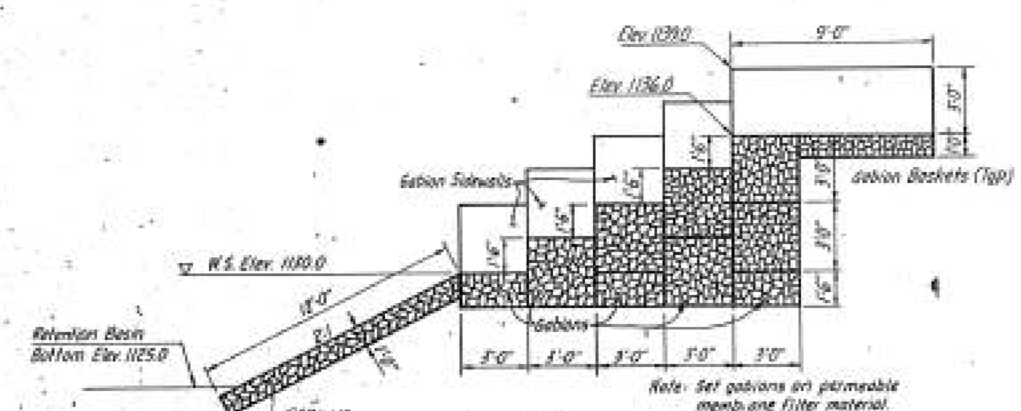
OUTLET PIPE FROM SILVERLEAF DRIVE

Scale: 1/8"=1'-0"



ENTRANCE SPILLWAY FRONT ELEVATION VIEW

Scale: 1/4"=1'-0"



SECTION G-G

RETENTION BASIN ENTRANCE SPILLWAY

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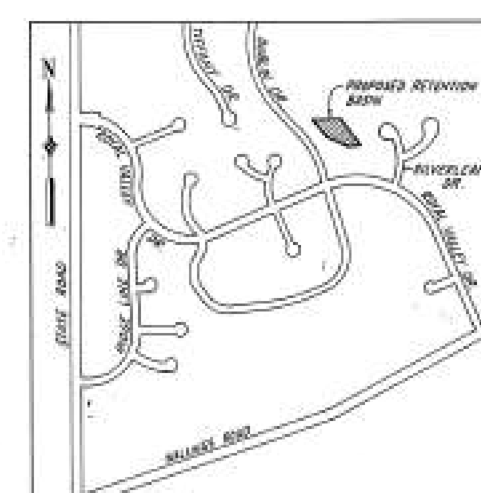

LOCATION MAP

No Scale

Revised 4-14-89

SCALE: As Shown
DRAWN: _____ DATE: _____
CHKD: _____ DATE: _____
CKD: _____ DATE: _____

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CLEVELAND OHIO

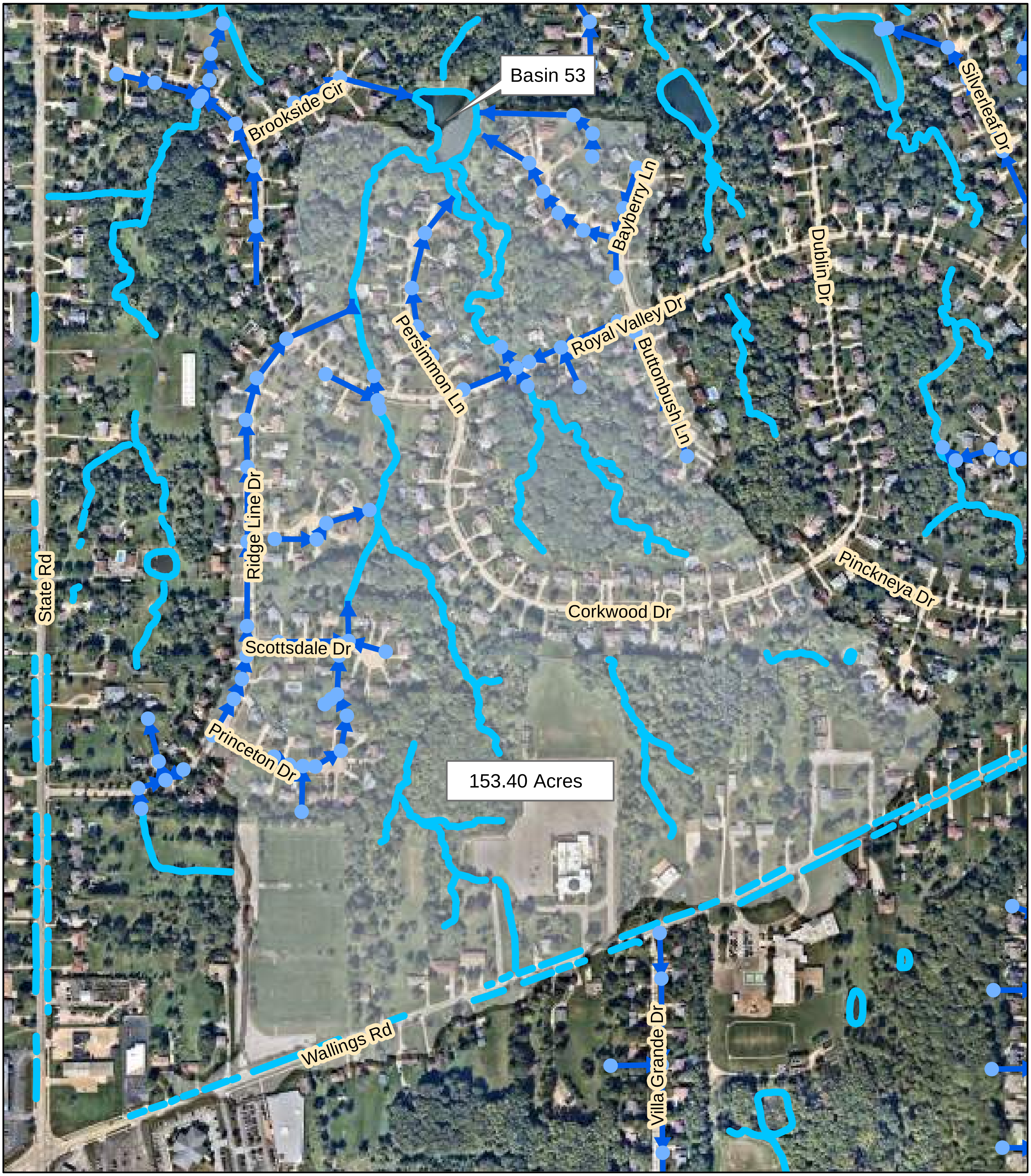
ROYAL VALLEY STAGE 4 EAST RETENTION BASIN

SHEET 22 of 30

APPENDIX B: NEORSD Detention Basin Maps

- Basin 53
- Basin 55
- Basin 54

Northeast Ohio Regional Sewer District



Legend

- Storm Manhole
- Cuyahoga County Hydro
- Storm Sewer Pipe
- Basin 53 Drainage Area

N

0 230 460 920 Feet

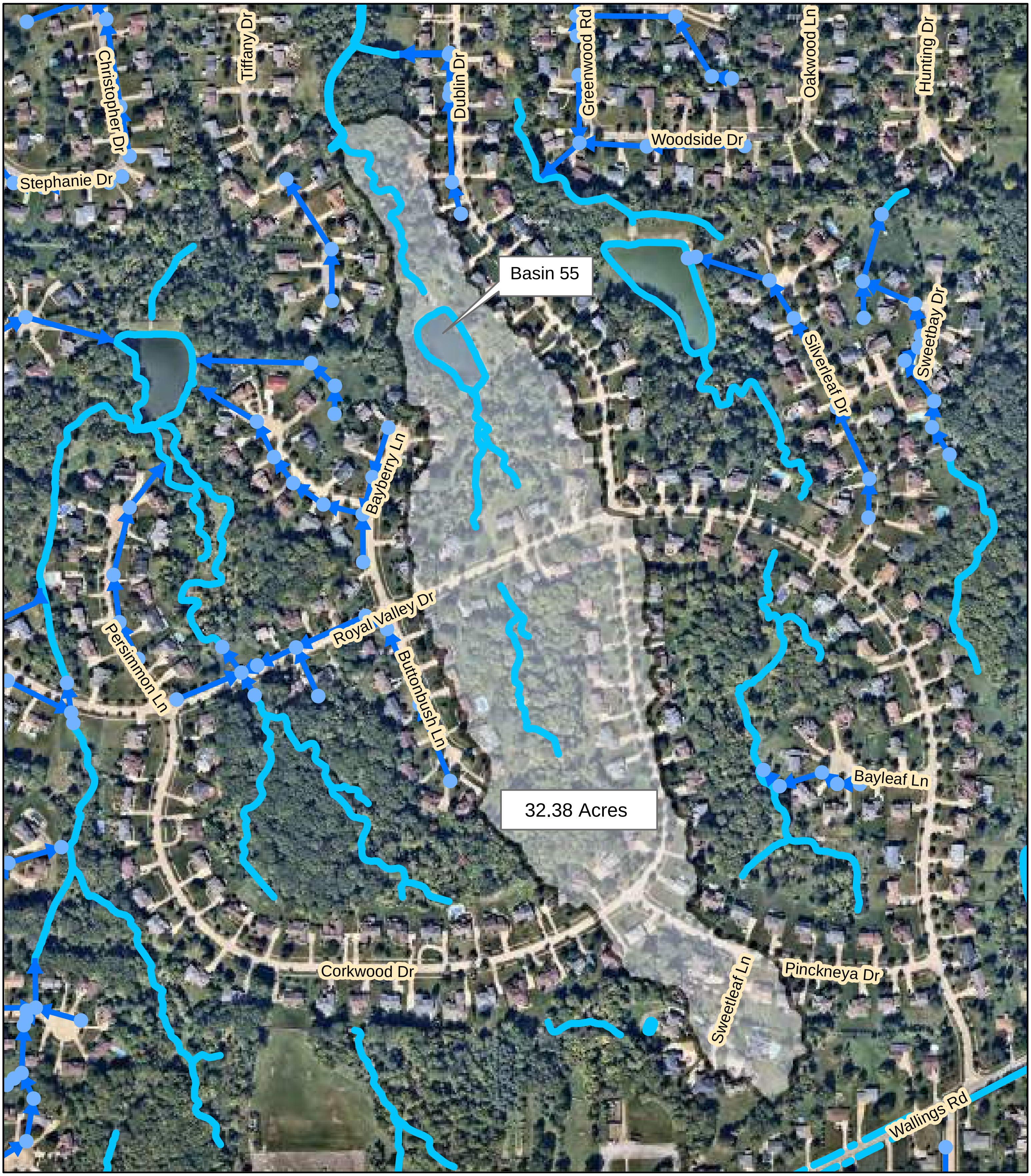
Coordinate System : Ohio State Plan North

Date Created: 03-05-2020

Projection: Lambert Conformal Conic

Sources: NEORSD GIS, Cleveland GIS, Cuyahoga Co. GIS

Northeast Ohio Regional Sewer District



Legend

- Storm Manhole
- Storm Sewer Pipe
- Cuyahoga County Hydro
- Basin 54 Drainage Area

N

0 190 380 760 Feet

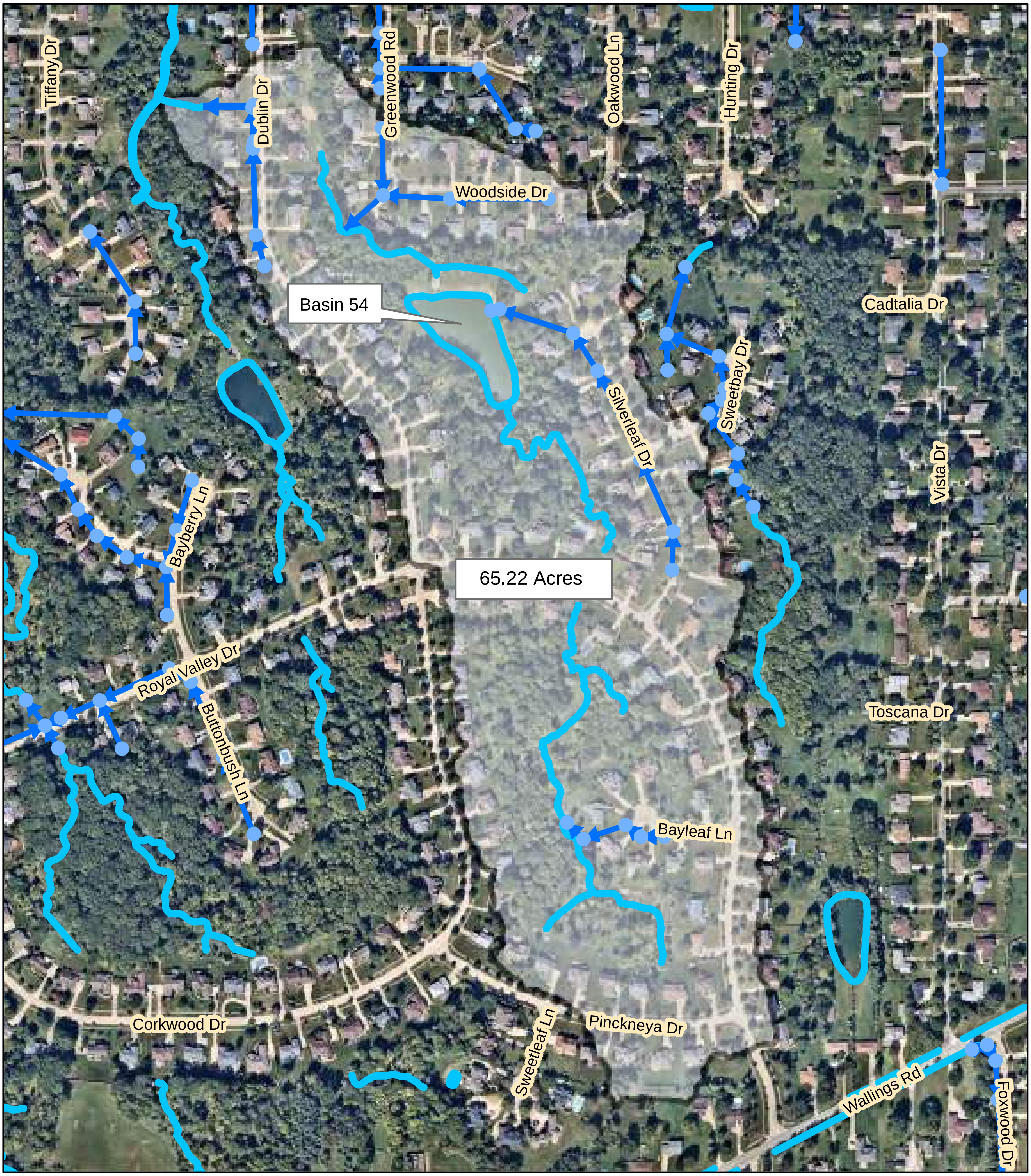
Coordinate System : Ohio State Plan North

Date Created: 03-05-2020

Projection: Lambert Conformal Conic

Sources: NEORSD GIS, Cleveland GIS, Cuyahoga Co. GIS

Northeast Ohio Regional Sewer District



Legend

- Storm Manhole
- Storm Sewer Pipe
- Cuyahoga County Hydro
- Basin 55 Drainage Area

N

0 190 380 760 Feet

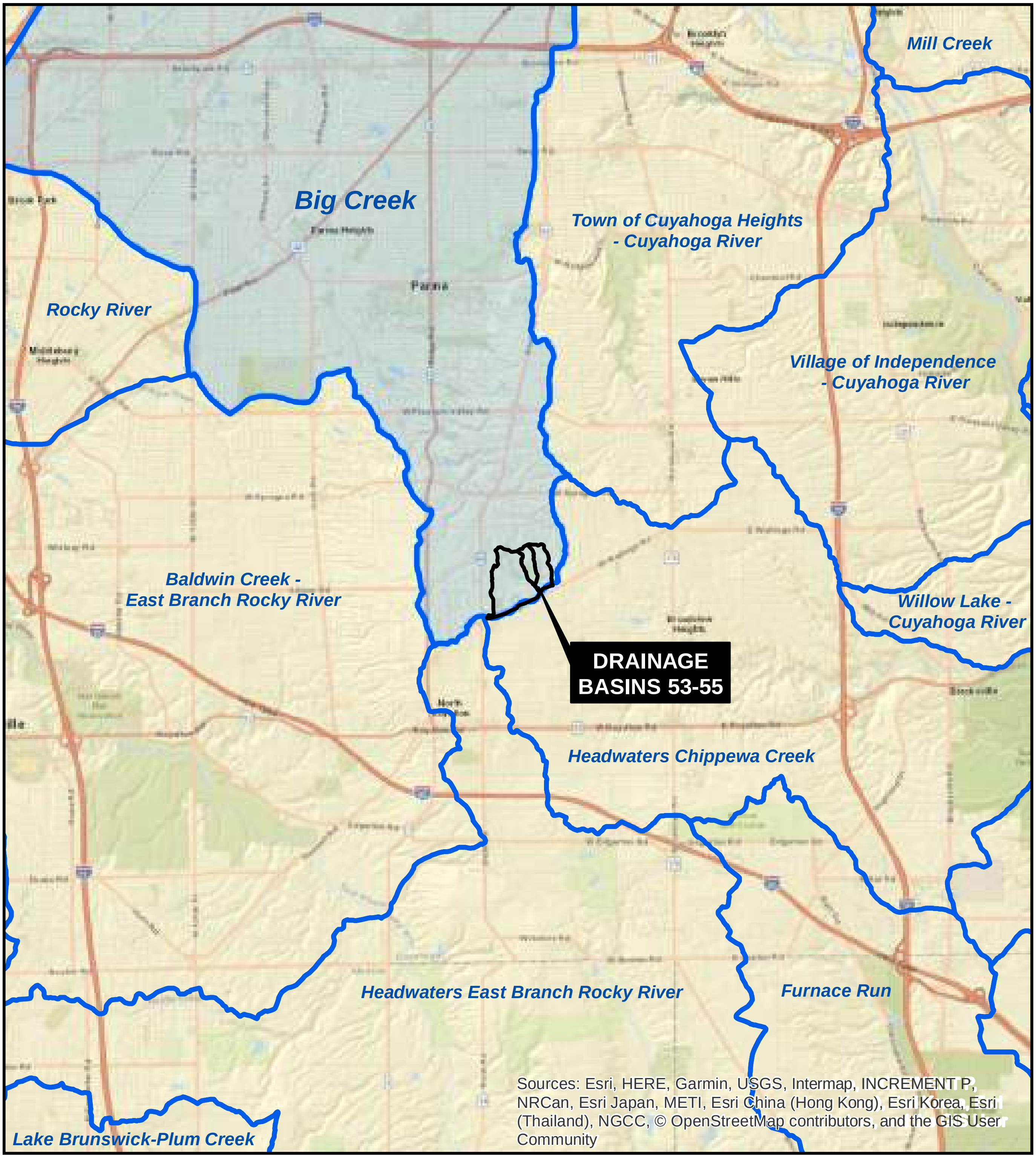
Coordinate System : Ohio State Plan North

Date Created: 03-05-2020

Projection: Lambert Conformal Conic

Sources: NEORSD GIS, Cleveland GIS, Cuyahoga Co. GIS

APPENDIX C: Watershed Characterization Figures



Legend

- Watershed Boundary
- Big Creek Watershed

N

1:100,000

Data Source: National Hydrography Watershed Boundary Dataset, 2013

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

USGS Watershed Boundary Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 1

CVE CHAGRIN VALLEY ENGINEERING LTD

N.W.I. Classification Codes on Drainage Areas

Riverine: R4SBC

Freshwater Emergent Wetland: PEM1C

Freshwater Pond: PUBGx

For full classification code descriptions and detailed information regarding the National Wetlands Inventory, visit https://www.fws.gov/wetlands/data/wetland-codes.html

Legend

- Freshwater Emergent Wetland
- Freshwater Forested & Shrub Wetland
- Freshwater Pond
- Riverine

N

1:10,000

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

FWS National Wetland Inventory Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 2

CVE Chagrin Valley Engineering Ltd

Flood Hazard Areas

500 Year Floodplain

N

1:10,000

Data Source: FEMA, 2017

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

FEMA Flood Hazard Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 3

CHAGRIN VALLEY ENGINEERING LTD

Legend

Open Space (47.1 acres)

Parcel Boundary

N

1:10,000

Data Source: Cuyahoga County GIS, 2021

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

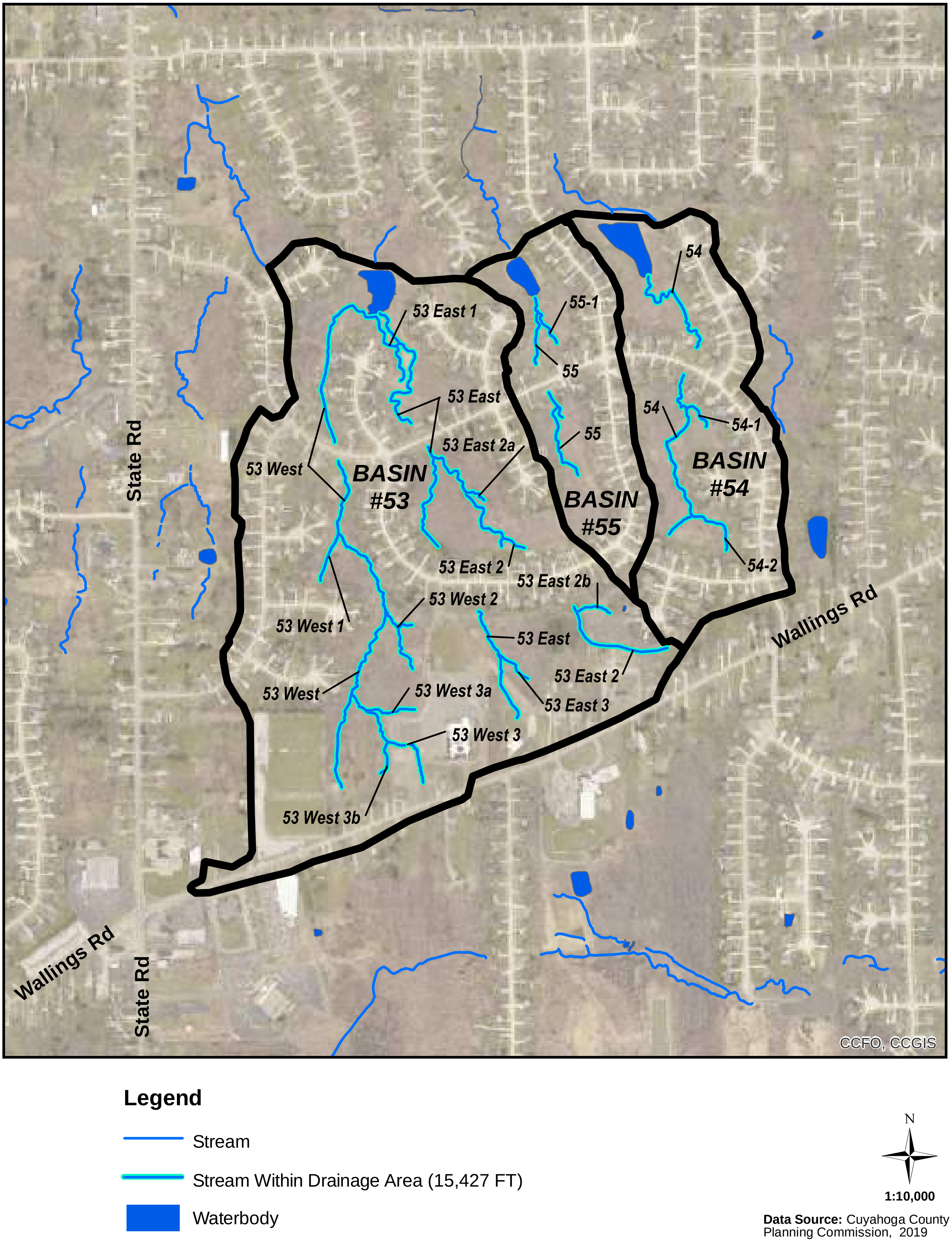
PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Open Space Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 4

CVE CHAGRIN VALLEY ENGINEERING LTD



Data Source: Cuyahoga County Planning Commission, 2019

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Stream Location Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 5

CHAGRIN VALLEY ENGINEERING LTD

Legend

Drainage Basins 53 - 55

Data Source:USGS, 2019

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

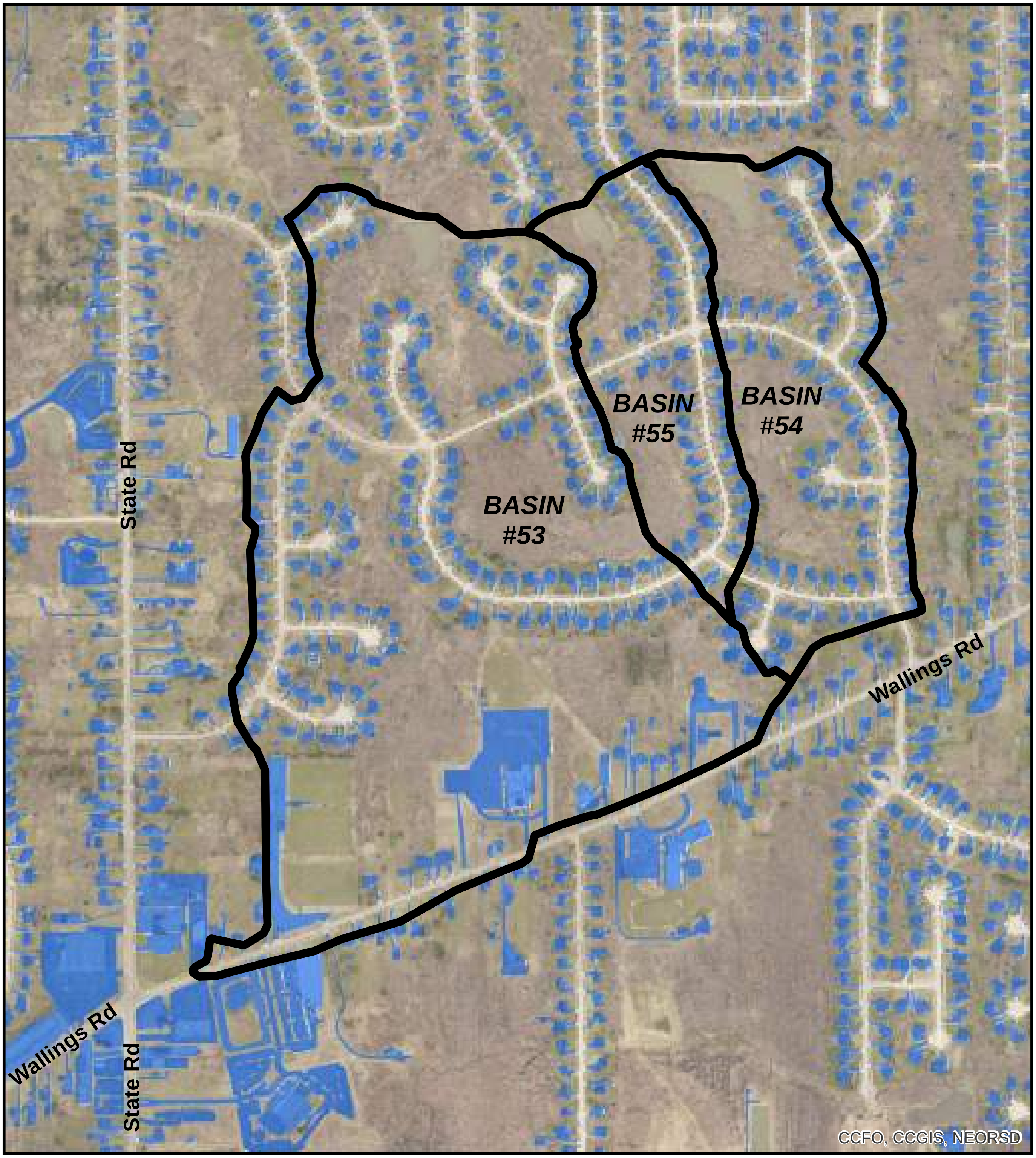
PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Topographic Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 6

CVE CHAGRIN VALLEY ENGINEERING LTD



Legend

Impervious Surface

N

1:9,000

Data Source: Northeast Ohio Regional Sewer District, 2021

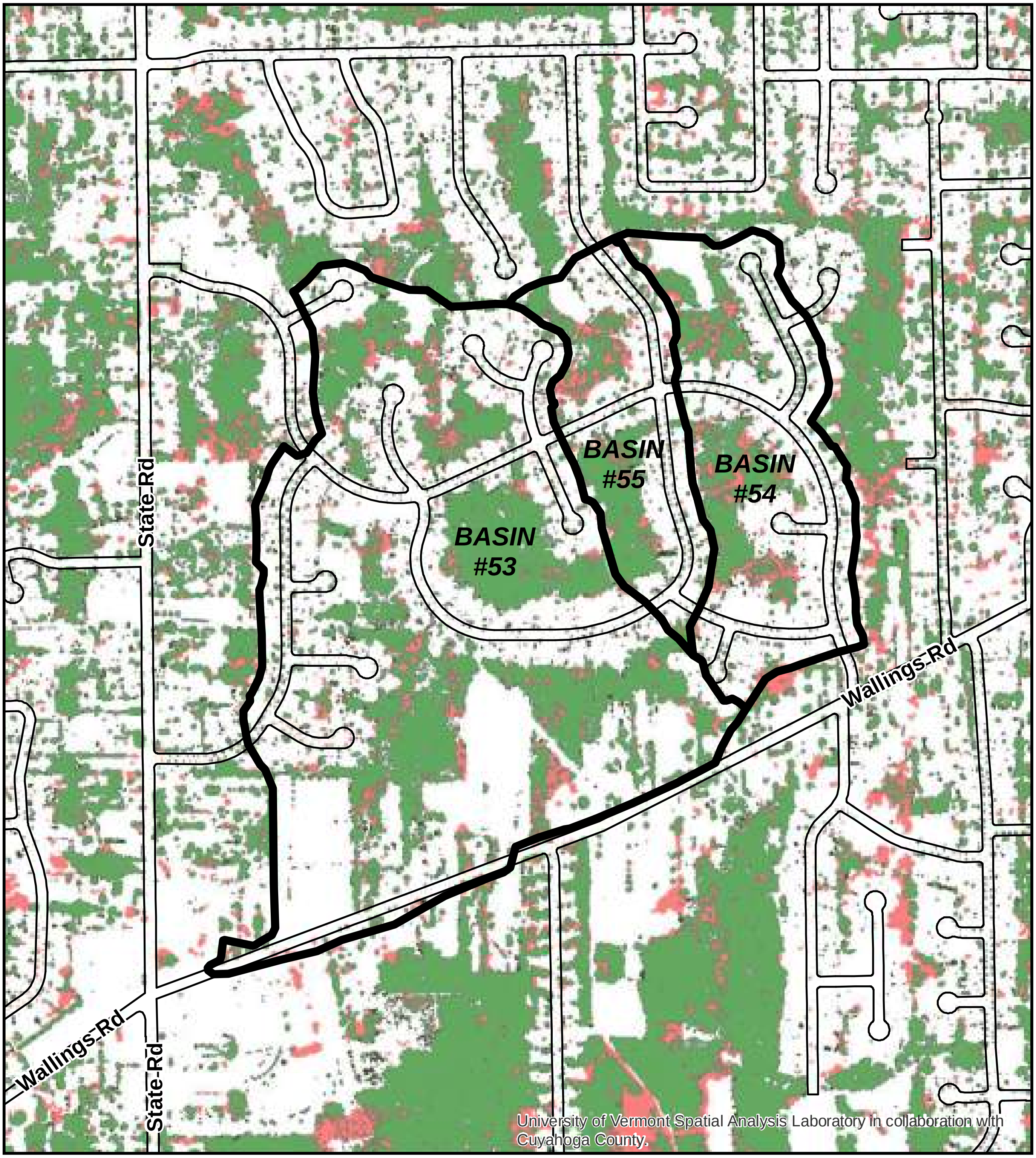
CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Impervious Surface Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 7



Tree Canopy Change (2011 - 2017)

- Gain
- No Change
- Loss

N

1:10,000

Data Source: University of Vermont Spatial Analysis Laboratory in collaboration with Cuyahoga County GIS 2020

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Tree Canopy Change

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 8

Land Cover

Grass/Shrub	Buildings	Tree Canopy over Vegetation/Bare Soil	Tree Canopy over Other Paved
Bare Soil	Roads	Tree Canopy over Building	
Water	Other Paved	Tree Canopy over Road	

N

1:10,000

Data Source: University of Vermont Spatial Analysis Laboratory in collaboration with Cuyahoga County GIS, 2017

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

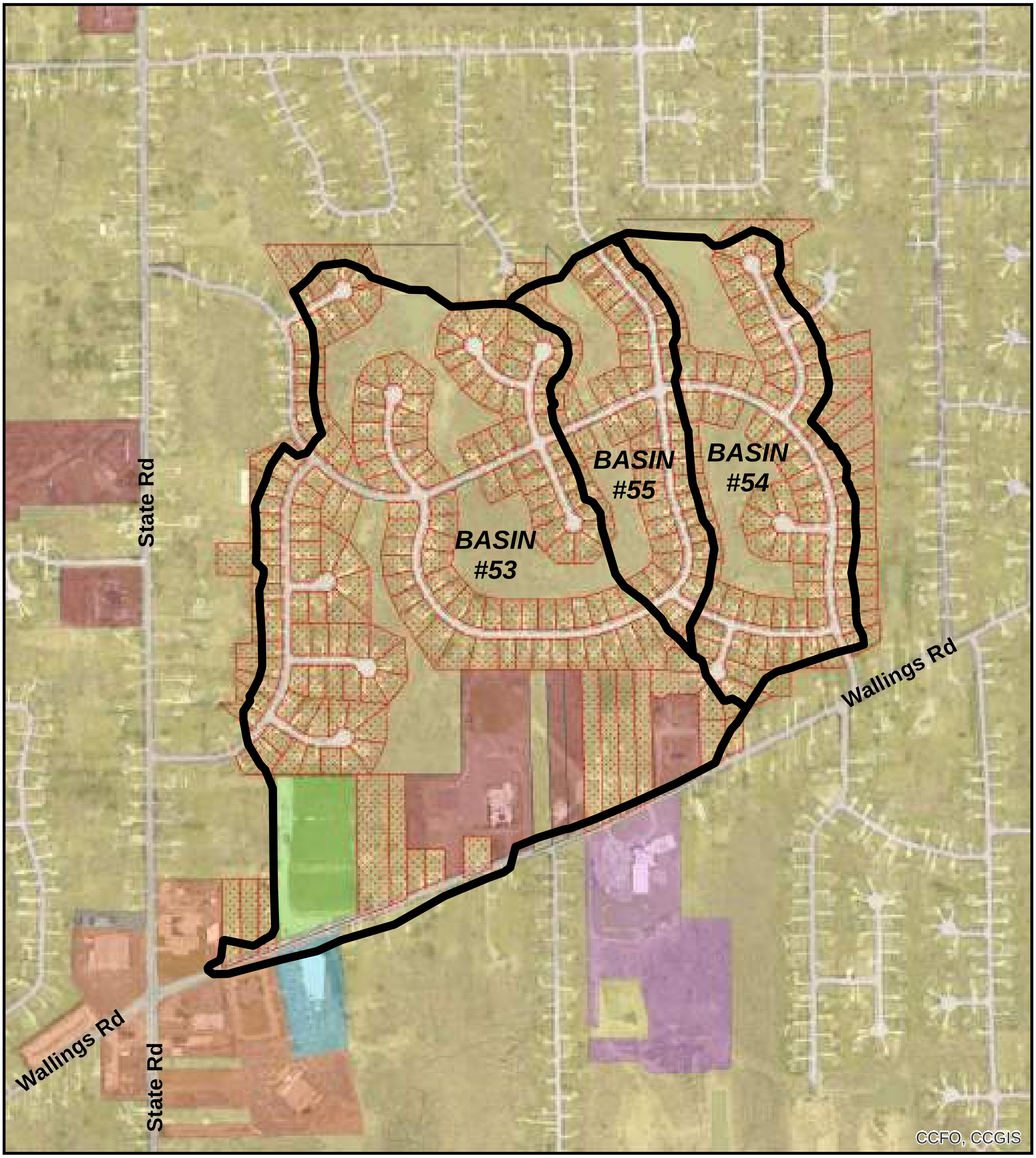
PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Land Cover Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 9

CVE CHAGRIN VALLEY ENGINEERING LTD



Land Use

Commercial	Religious	Utility	Single Family Lot (304 Units)
Green Space	Residential		
Government	School		

N

1:10,000

Data Source: Cuyahoga County GIS 2021

CVE No: 21226
DATE: 8/19/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Land Use Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Figure 10

CVE CHAGRIN VALLEY ENGINEERING LTD

APPENDIX D: Soils Report

- Drainage
- Water Features
- Hydrologic Soil Group and Surface Runoff


81° 43' 41" W
81° 42' 22" W
439100
439400
439700
440000
440300
440600
440900
41° 20' 54" N
41° 19' 35" N
4577500
4577200
4576900
4576600
4576300
4576000
4575700
4575400
Bunker Rd
Vista Dr
State Rd
94
Parking Lot
EIC
EID
Or
EIB
MgB
EIF
MgA
LoB
Ct
N
Map Scale: 1:11,900 if printed on A portrait (8.5" x 11") sheet.
Meters
0
150
300
600
900
Feet
0
500
1000
2000
3000
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 17N WGS84

MAP LEGEND

Area of Interest (AOI)
Area of Interest (AOI)

Soils

Soil Rating Polygons
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Lines
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Soil Rating Points
- Very limited
- Somewhat limited
- Not limited
- Not rated or not available

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Cuyahoga County, Ohio
Survey Area Data: Version 19, Jun 11, 2020

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Aug 16, 2014—Oct 12, 2014

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Drainage (OH)

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
Ct	Condit silty clay loam	Very limited	Condit (85%)	Ponding (1.00)	0.8	0.1%
				Frost action (1.00)		
				Restricted permeability (0.91)		
EIB	Ellsworth silt loam, 2 to 6 percent slopes	Very limited	Ellsworth (85%)	Restricted permeability (1.00)	57.5	9.8%
				Slope (0.04)		
			Mahoning (10%)	Restricted permeability (1.00)		
				Slope (0.04)		
			Trumbull (5%)	Ponding (1.00)		
				Frost action (1.00)		
				Restricted permeability (0.97)		
EIC	Ellsworth silt loam, 6 to 12 percent slopes	Very limited	Ellsworth (90%)	Restricted permeability (1.00)	91.5	15.6%
				Slope (0.96)		
			Mahoning (10%)	Restricted permeability (1.00)		
				Slope (0.04)		
EID	Ellsworth silt loam, 12 to 18 percent slopes	Very limited	Ellsworth (90%)	Slope (1.00)	61.6	10.5%
				Restricted permeability (1.00)		
			Mahoning (5%)	Restricted permeability (1.00)		
				Slope (0.96)		
			Brecksville (5%)	Slope (1.00)		
				Depth to saturated zone (1.00)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
				Restricted permeability (0.91)		
				Depth to bedrock (0.12)		
EIF	Ellsworth silt loam, 25 to 70 percent slopes	Very limited	Ellsworth (85%)	Slope (1.00)	0.1	0.0%
				Restricted permeability (1.00)		
			Brecksville (15%)	Slope (1.00)		
				Depth to saturated zone (1.00)		
				Restricted permeability (0.91)		
				Depth to bedrock (0.12)		
LoB	Loudonville silt loam, 2 to 6 percent slopes	Very limited	Loudonville (85%)	Depth to saturated zone (1.00)	2.1	0.4%
				Depth to bedrock (0.11)		
				Slope (0.04)		
MgA	Mahoning silt loam, 0 to 2 percent slopes	Very limited	Mahoning (85%)	Restricted permeability (1.00)	43.3	7.4%
			Ellsworth (5%)	Restricted permeability (1.00)		
				Slope (0.04)		
			Trumbull (5%)	Ponding (1.00)		
				Frost action (1.00)		
				Restricted permeability (0.97)		
			Miner (5%)	Ponding (1.00)		
				Frost action (1.00)		
				Restricted permeability (0.97)		
MgB	Mahoning silt loam, 2 to 6 percent slopes	Very limited	Mahoning (85%)	Restricted permeability (1.00)	296.3	50.6%
				Slope (0.04)		

Map unit symbol	Map unit name	Rating	Component name (percent)	Rating reasons (numeric values)	Acres in AOI	Percent of AOI
			Ellsworth (10%)	Restricted permeability (1.00)		
				Slope (0.04)		
			Trumbull (5%)	Ponding (1.00)		
				Frost action (1.00)		
				Restricted permeability (0.97)		
Or	Orrville silt loam, frequently flooded	Very limited	Orrville (85%)	Flooding (1.00)	32.2	5.5%
				Frost action (1.00)		
Totals for Area of Interest					**585.4**	**100.0%**

Rating	Acres in AOI	Percent of AOI
Very limited	585.4	100.0%
Totals for Area of Interest	**585.4**	**100.0%**

Description

Drainage is the removal excess surface and subsurface water from the soil. How easily and effectively a soil is drained depends on depth to the water table, ponding, saturated hydraulic conductivity (Ksat), depth to bedrock, flooding, subsidence of organic layers, potential for frost action, and slope. Excavating and grading and the stability of trench sides or ditchbanks are affected by depth to bedrock, large stones, slope gradient and complexity, and the hazard of cutbanks caving. The productivity of the soil after drainage depends on extreme acidity an on the presence of toxic substances in the root zone, such as salts, sodium, and sulfur.

The ratings are both verbal and numerical. Rating class terms indicate the extent to which the soils are limited by all of the soil features that affect a drainage system. "Not limited" indicates that the soil has features that are very favorable for a drainage system. Good performance and very low maintenance can be expected. "Somewhat limited" indicates that the soil has features that are moderately favorable for a drainage system. The limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. "Very limited" indicates that the soil has one or more features that are unfavorable for a drainage system. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected.

Numerical ratings indicate the severity of individual limitations. The ratings are shown as decimal fractions ranging from 0.01 to 1.00. They indicate gradations between the point at which a soil feature has the greatest negative impact on a drainage system (1.00) and the point at which the soil feature is not a limitation (0.00).

The components listed for each map unit in the accompanying Summary by Map Unit table in Web Soil Survey or the Aggregation Report in Soil Data Viewer are determined by the aggregation method chosen. An aggregated rating class is shown for each map unit. The components listed for each map unit are only those that have the same rating class as the one shown for the map unit. The percent composition of each component in a particular map unit is given to help the user better understand the extent to which the rating applies to the map unit.

Other components with different ratings may occur in each map unit. The ratings for all components, regardless the aggregated rating of the map unit, can be viewed by generating the equivalent report from the Soil Reports tab in Web Soil Survey or from the Soil Data Mart site. Onsite investigation may be needed to validate these interpretations and to confirm the identity of the soil on a given site.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

Water Features

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

The *months* in the table indicate the portion of the year in which a water table, ponding, and/or flooding is most likely to be a concern.

Water table refers to a saturated zone in the soil. The water features table indicates, by month, depth to the top (*upper limit*) and base (*lower limit*) of the saturated zone in most years. Estimates of the upper and lower limits are based mainly on observations of the water table at selected sites and on evidence of a saturated zone, namely grayish colors or mottles (redoximorphic features) in the soil. A saturated zone that lasts for less than a month is not considered a water table. The kind of water table, apparent or perched, is given if a seasonal high water table exists in the soil. A water table is perched if free water is restricted from moving downward in the soil by a restrictive feature, in most cases a hardpan; there is a dry layer of soil underneath a wet layer. A water table is apparent if free water is present in all horizons from its upper boundary to below 2 meters or to the depth of observation. The water table kind listed is for the first major component in the map unit.

Ponding is standing water in a closed depression. Unless a drainage system is installed, the water is removed only by percolation, transpiration, or evaporation. The table indicates *surface water depth* and the *duration* and *frequency* of ponding. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, rare, occasional, and frequent. *None* means that ponding is not probable; *rare* that it is unlikely but possible under unusual weather conditions (the chance of ponding is nearly 0 percent to 5 percent in any year); *occasional* that it occurs, on the average, once or less in 2 years (the chance of ponding is 5 to 50 percent in any year); and *frequent* that it occurs, on the average, more than once in 2 years (the chance of ponding is more than 50 percent in any year).

Flooding is the temporary inundation of an area caused by overflowing streams, by runoff from adjacent slopes, or by tides. Water standing for short periods after rainfall or snowmelt is not considered flooding, and water standing in swamps and marshes is considered ponding rather than flooding.

Duration and *frequency* are estimated. Duration is expressed as *extremely brief* if 0.1 hour to 4 hours, *very brief* if 4 hours to 2 days, *brief* if 2 to 7 days, *long* if 7 to 30 days, and *very long* if more than 30 days. Frequency is expressed as none, very rare, rare, occasional, frequent, and very frequent. *None* means that flooding is not probable; *very rare* that it is very unlikely but possible under extremely unusual weather conditions (the chance of flooding is less than 1 percent in any year); *rare* that it is unlikely but possible under unusual weather conditions (the chance of flooding is 1 to 5 percent in any year); *occasional* that it occurs infrequently under normal weather conditions (the chance of flooding is 5 to 50 percent in any year); *frequent* that it is likely to occur often under normal weather conditions (the chance of flooding is more than 50 percent in any year but is less than 50 percent in all months in any year); and *very frequent* that it is likely to occur very often under normal weather conditions (the chance of flooding is more than 50 percent in all months of any year).

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and little or no horizon development.

Also considered are local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

Report—Water Features

Map unit symbol and soil name	Hydrologic group	Surface runoff	Most likely months	Water table			Ponding			Flooding	
				Upper limit	Lower limit	Kind	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*		*Ft*				
Ct—Condit silty clay loam											
Condit	C/D		Jan-Jul	0.0-1.0	3.5-5.0	Perched	0.0-1.0	Long (7 to 30 days)	Frequent	—	None
			Aug-Oct	—	—	—	—	—	—	—	None
			Nov-Dec	0.0-1.0	3.5-5.0	Perched	0.0-1.0	Long (7 to 30 days)	Frequent	—	None
ElB—Ellsworth silt loam, 2 to 6 percent slopes											
Ellsworth	D		Jan-Mar	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
			Apr	0.9-2.0	2.3-3.8	Perched	—	—	None	—	None
			May-Oct	—	—	—	—	—	None	—	None
			Nov	0.9-2.0	2.3-3.8	Perched	—	—	None	—	None
			Dec	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
ElC—Ellsworth silt loam, 6 to 12 percent slopes											
Ellsworth	D		Jan-Mar	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
			Apr	0.9-2.0	2.3-3.8	Perched	—	—	None	—	None
			May-Oct	—	—	—	—	—	None	—	None
			Nov	0.9-2.0	2.3-3.8	Perched	—	—	None	—	None
			Dec	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None

Map unit symbol and soil name	Hydrologic group	Surface runoff	Most likely months	Water table			Ponding			Flooding	
				Upper limit	Lower limit	Kind	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*		*Ft*				
EID—Ellsworth silt loam, 12 to 18 percent slopes											
Ellsworth	D		Jan-Mar	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
			Apr	1.7-3.0	2.3-3.8	Perched	—	—	None	—	None
			May-Oct	—	—	—	—	—	None	—	None
			Nov	0.9-2.0	2.3-3.8	Perched	—	—	None	—	None
			Dec	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
EIF—Ellsworth silt loam, 25 to 70 percent slopes											
Ellsworth	D		Jan-Mar	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
			Apr	1.7-3.0	2.3-3.8	Perched	—	—	None	—	None
			May-Oct	—	—	—	—	—	None	—	None
			Nov	0.9-2.0	2.3-3.8	Perched	—	—	None	—	None
			Dec	0.9-2.0	5.0-6.0	Apparent	—	—	None	—	None
LoB—Loudonville silt loam, 2 to 6 percent slopes											
Loudonville	C		Jan-Dec	—	—	—	—	—	None	—	None
MgA—Mahoning silt loam, 0 to 2 percent slopes											
Mahoning	D		Jan-Mar	0.5-1.0	5.0-6.0	Apparent	—	—	None	—	None
			Apr-May	0.5-1.0	2.3-3.7	Perched	—	—	None	—	None
			Jun	1.2-3.1	2.3-3.7	Perched	—	—	None	—	None
			Jul-Sep	—	—	—	—	—	None	—	None
			Oct	1.2-3.1	2.3-3.7	Perched	—	—	None	—	None
			Nov	0.5-1.0	2.3-3.7	Perched	—	—	None	—	None
			Dec	0.5-1.0	5.0-6.0	Apparent	—	—	None	—	None

Map unit symbol and soil name	Hydrologic group	Surface runoff	Most likely months	Water table			Ponding			Flooding	
				Upper limit	Lower limit	Kind	Surface depth	Duration	Frequency	Duration	Frequency
				Ft	*Ft*		*Ft*				
MgB—Mahoning silt loam, 2 to 6 percent slopes											
Mahoning	D		Jan-Mar	0.5-1.0	5.0-6.0	Apparent	—	—	None	—	None
			Apr-May	0.5-1.0	2.3-3.7	Perched	—	—	None	—	None
			Jun	1.2-3.1	2.3-3.7	Perched	—	—	None	—	None
			Jul-Sep	—	—	—	—	—	None	—	None
			Oct	1.2-3.1	2.3-3.7	Perched	—	—	None	—	None
			Nov	0.5-1.0	2.3-3.7	Perched	—	—	None	—	None
			Dec	0.5-1.0	5.0-6.0	Apparent	—	—	None	—	None
Or—Orrville silt loam, frequently flooded											
Orrville	B/D		Jan-May	1.0-2.5	6.0	Apparent	—	—	None	Brief (2 to 7 days)	Frequent
			Jun	1.0-2.5	6.0	Apparent	—	—	None	—	
			Jul-Oct	—	—	—	—	—	None	—	
			Nov-Dec	1.0-2.5	6.0	Apparent	—	—	None	Brief (2 to 7 days)	Frequent

Data Source Information

Soil Survey Area: Cuyahoga County, Ohio
Survey Area Data: Version 19, Jun 11, 2020

Hydrologic Soil Group and Surface Runoff

This table gives estimates of various soil water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas.

Surface runoff refers to the loss of water from an area by flow over the land surface. Surface runoff classes are based on slope, climate, and vegetative cover. The concept indicates relative runoff for very specific conditions. It is assumed that the surface of the soil is bare and that the retention of surface water resulting from irregularities in the ground surface is minimal. The classes are negligible, very low, low, medium, high, and very high.

Report—Hydrologic Soil Group and Surface Runoff

Absence of an entry indicates that the data were not estimated. The dash indicates no documented presence.

Hydrologic Soil Group and Surface Runoff–Cuyahoga County, Ohio			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
Ct—Condit silty clay loam			
Condit	85	—	C/D

Hydrologic Soil Group and Surface Runoff–Cuyahoga County, Ohio			
Map symbol and soil name	**Pct. of map unit**	**Surface Runoff**	**Hydrologic Soil Group**
ElB—Ellsworth silt loam, 2 to 6 percent slopes			
Ellsworth	85	—	D
ElC—Ellsworth silt loam, 6 to 12 percent slopes			
Ellsworth	90	—	D
ElD—Ellsworth silt loam, 12 to 18 percent slopes			
Ellsworth	90	—	D
ElF—Ellsworth silt loam, 25 to 70 percent slopes			
Ellsworth	85	—	D
LoB—Loudonville silt loam, 2 to 6 percent slopes			
Loudonville	85	—	C
MgA—Mahoning silt loam, 0 to 2 percent slopes			
Mahoning	85	—	D
MgB—Mahoning silt loam, 2 to 6 percent slopes			
Mahoning	85	—	D
Or—Orrville silt loam, frequently flooded			
Orrville	85	—	B/D

Data Source Information

Soil Survey Area: Cuyahoga County, Ohio
Survey Area Data: Version 19, Jun 11, 2020

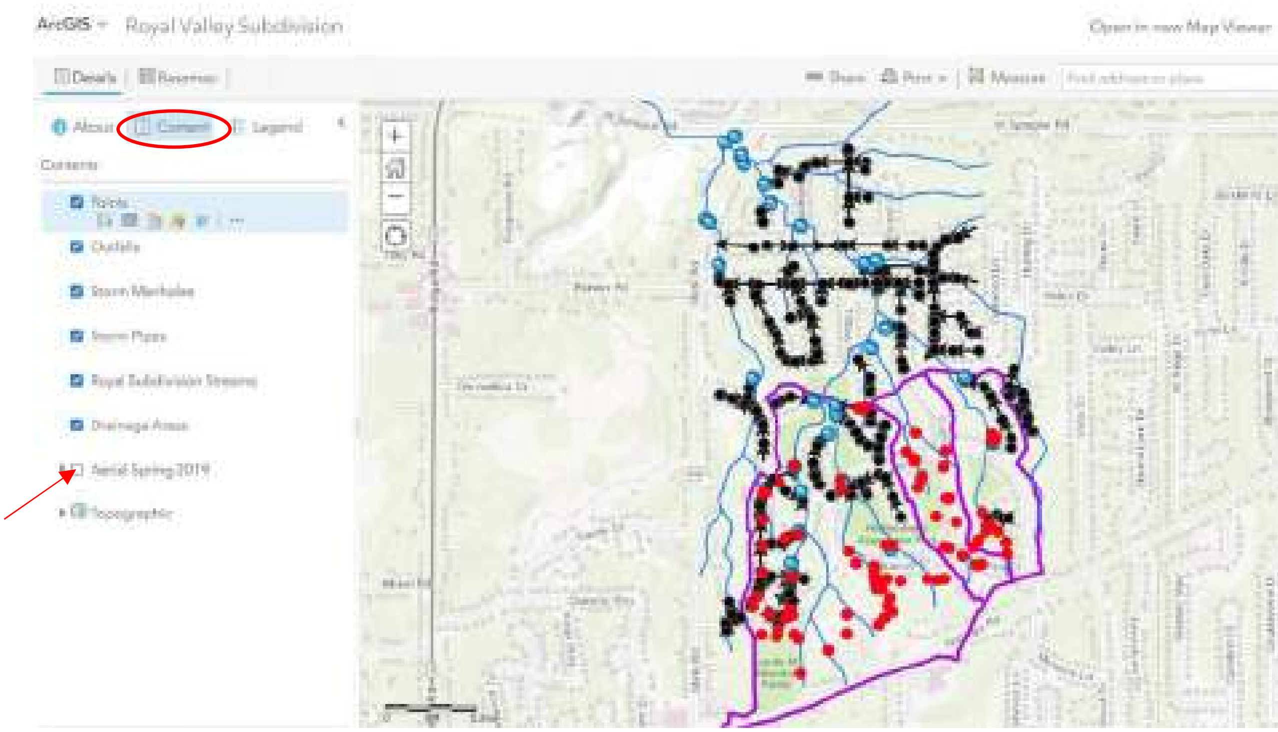
APPENDIX E: Instructions for Accessing the ArcCollector Map

As part of the project deliverable, CVE created an interactive Geographic Information System (GIS) map of the Royal Valley Subdivision Watershed.

The map is available for public viewing at the following website:

https://arcg.is/1K5mWL

Users can click on the various red circles to view pictures taken throughout the Watershed, in the approximate location where the red circle appears. An aerial background can also be turned on, by clicking on Content and checking the box next to "Aerial Spring 2019"



The map contains the delineated drainage areas (purple lines) publicly available stream channel and storm sewer information, and topography. Please note this information is not comprehensive. There are closed conduits that exist beyond what is shown in the map, and streams locations are approximate.

APPENDIX F: Royal Valley Subdivision Open Channel Classification and Length

Stream Name	Classification	Type	Length (feet)
Basin 53 Drainage Area			
53-West	Class II	Perennial	3,515
53-West-1	Class II	Perennial	325
53-West-2	Class II	Perennial	450
53-West-2a	Class I	Ephemeral	99
53-West-3	Class II	Perennial	795
53-West-3a	Class II	Intermittent	324
53-West-3b	Class II	Intermittent	228
53-East	Class II	Perennial	2,573
53-East-1	Class II	Intermittent	545
53-East-2	Class II	Perennial	1728
53-East-2a	Class I	Ephemeral	142
53-East-2b	Class I	Ephemeral	231
53-East-3	Class II	Intermittent	228
		Basin 53 - Total Open Channel	**11,183**
Basin 55 Drainage Area			
Stream-55	Class II	Perennial	1,082
Stream-55-1	Class I	Ephemeral	255
Stream-55-2	Class I	Ephemeral	91
		Basin 55 – Total Open Channel	**1,428**
Basin 54 Drainage Area			
Stream-54	Class II	Perennial	2,131
Stream-54-1	Class II	Intermittent	219
Stream-54-2	Class I	Ephemeral	384
		Basin 54 – Total Open Channel	**2,734**

Overall Stream Length and Type

Open Channel Type	Length (Feet)
Perennial	12,599
Intermittent	1,544
Ephemeral	1,202
Total	**15,427**

APPENDIX G: Basin Inspection Reports

- Basin 53
- Basin 55
- Basin 54

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:10am

Project Name:	Royal Valley # 53 (West)
Inspected:	Entire Project
Owner:	Unknown Unknown Unknown unknownEmail@6852.com
Jurisdiction:	CVE Special
Inspector:	Sarah Stangelo
Inspection Completed:	**07-23-2021**
Report Completed:	**07-23-2021**
Inspection weather:	Temperature: 82 degrees, Clear
Inspection Type:	Citizen Complaint
Current Activity:	Not Applicable;
Current Site Status:	Deficiencies Exist

1) Are required post construction documents available for review? — **Yes**

2) Record general notes or observations. — **See notes**

Notes Recorded:

Basin is in need of dredging to remove accumulated sediment and debris. Several inlets have erosion issues and burrow or sink holes that need to be addressed as well.

3) PRETREATMENT: Is pretreatment area free of excessive trash and debris? — **NA**

4) PRETREATMENT: Is pretreatment area free of excessive accumulation of sediment? — **NA**

5) DEWATERING: Is water draining within 24 hours as intended and is the water quality orifice visible? — **NA**

6) INLETS: Are inlets in satisfactory structural condition? — **Open Work Items Exist**

Maintenance Action Required

Inlet at east side of basin is eroded on either side and under concrete channel. 1.5-2' deep and 2-4' under channel. It's not clear if this was caused by animals or erosion alone. Area should be checked for signs of animals burrowing. If present, pests should be removed from the area. Holes should be back filled and then covered with construction grade stone to prevent further erosion and maintain the integrity of the inlet structure.

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:10am

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

Photo 3 - 07/23/2021

7)	**INLETS: Are inlets free of obstructions that impede flow (sediment, vegetation, trash, debris)?**	**NA**
8)	**INLETS: Is the area around inlets free of evidence of excessive erosion?**	**NA**
9)	**SLOPES & EMBANKMENTS: Are slopes and embankments free of cracks, seeps and evidence of erosion?**	**Yes**
10)	**SLOPES & EMBANKMENTS: Are slopes and embankments free of trees, and woody vegetation and invasive plants?**	**Yes**
11)	**SLOPES & EMBANKMENTS: Are slopes and embankments stable and free of sinkholes and burrows?**	**NA**
12)	**BASIN PERMANENT POOL: Is the area free of excessive trash and debris?**	**Yes**
13)	**BASIN PERMANENT POOL: Is the area free of invasive plants?** **Maintenance Action Required** **Invasive plants were being treated at time of inspection. Continue maintainence.**	**Open Work Items Exist**
14)	**BASIN PERMANENT POOL: Is the basin free of excessive accumulation of sediment and are pool storage volumes adequate?** **Maintenance Action Required** **Main pool needs to be dredged to restore original capacity and ensure functionality. Large amounts of sediment are visible through the waters surface. Water is brown and murky.**	**Open Work Items Exist**

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:10am

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

Photo 3 - 07/23/2021

Photo 4 - 07/23/2021

15) BASIN PERMANENT POOL: Is the shoreline free of evidence of excessive erosion? **NA**

16) BASIN PERMANENT POOL: Is the pool free of excessive growth of algae? **Open Work Items Exist**

Maintenance Action Required
Basin is currently being treated for algae and invasive species. Continue maintenance.

Report Generated: 07-23-21 11:10am

Photo 1 - 07/23/2021

17) OUTLETS & OVERFLOW STRUCTURES: Are outlets and overflow structures in satisfactory structural condition? **NA; See notes**

Notes Recorded:

Outlet structure and emergency spillway appear to be in good condition and functioning properly.

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

Photo 3 - 07/23/2021

18)	**OUTLETS & OVERFLOW STRUCTURES: Are outlets and overflow structures free of obstructions (trash, vegetation, debris, sediment)?** **Maintenance Action Required** **Routine checks of outlet structure should be performed to remove debris. Especially after a rain event.**	**Open Work Items Exist**
19)	**OUTLETS & OVERFLOW STRUCTURES: Is the area around outlets and overflow structures free of evidence of excessive erosion?**	**NA**
20)	**OUTLETS & OVERFLOW STRUCTURES: Are joints water tight and free of evidence of leaks?**	**NA**
21)	**Do items of non-compliance other than those previously noted exist?**	**Yes**

Inspected by: 00005928

Sarah Stangelo, CESSWI
Chagrin Valley Engineering
Stormwater
(440) 439-1999
stangelo@cvelimited.com

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:11am

Project Name:	Royal Valley #55 (Center)	**Jurisdiction:**	CVE Special
Inspected:	Entire Project		
Owner:	Unknown Unknown		
	Unknown	**Inspector:**	Sarah Stangelo
	unknownEmail@6852.com	**Inspection Completed:**	**07-23-2021**
		Report Completed:	**07-23-2021**
		Inspection weather:	Temperature: 82 degrees, Clear
		Inspection Type:	Citizen Complaint
		Current Activity:	Not Applicable;
		Current Site Status:	Deficiencies Exist

1) Are required post construction documents available for review? **Yes**

2) Record general notes or observations. **See notes**

Notes Recorded:
Basin has excessive amount of algal growth and sediment accumulation. Several areas with sparse vegetation and erosion issues are present on the banks.

3) PRETREATMENT: Is pretreatment area free of excessive trash and debris? **NA**

4) PRETREATMENT: Is pretreatment area free of excessive accumulation of sediment? **NA**

5) DEWATERING: Is water draining within 24 hours as intended and is the water quality orifice visible? **NA**

6) INLETS: Are inlets in satisfactory structural condition? **Yes**

7) INLETS: Are inlets free of obstructions that impede flow (sediment, vegetation, trash, debris)? **Yes**

8) INLETS: Is the area around inlets free of evidence of excessive erosion? **Yes**

9) SLOPES & EMBANKMENTS: Are slopes and embankments free of cracks, seeps and evidence of erosion? **Open Work Items Exist**

Maintenance Action Required
Several areas of the embankment are eroding and sparsely covered with vegetation. Consider seed matting to promote vegetation growth that will help prevent further erosion.

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

Photo 3 - 07/23/2021

10)	**SLOPES & EMBANKMENTS: Are slopes and embankments free of trees, and woody vegetation and invasive plants?**	**Yes**
11)	**SLOPES & EMBANKMENTS: Are slopes and embankments stable and free of sinkholes and burrows?**	**Yes**
12)	**BASIN PERMANENT POOL: Is the area free of excessive trash and debris?**	**Yes**
13)	**BASIN PERMANENT POOL: Is the area free of invasive plants?**	**NA**
14)	**BASIN PERMANENT POOL: Is the basin free of excessive accumulation of sediment and are pool storage volumes adequate?**	**Open Work Items Exist**

Maintenance Action Required
Sediment accumulation is visible through water surface. Basin should be dredged and restored to original capacity.

Photo 1 - 07/23/2021

15) BASIN PERMANENT POOL: Is the shoreline free of evidence of excessive erosion? **NA**

16) BASIN PERMANENT POOL: Is the pool free of excessive growth of algae? **Open Work Items Exist**

Maintenance Action Required
Excessive amounts of algae are present in main pool. Treatment was being ad in is termed during inspection but it doesn't seem to be working efficiently. Consider other methods or more aggressive treatments.

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

17)	**OUTLETS & OVERFLOW STRUCTURES: Are outlets and overflow structures in satisfactory structural condition?**	**Yes**	**See notes**

Notes Recorded:
Outlet structure appears to be in good condition and functioning properly.

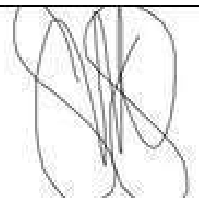
Photo 1 - 07/23/2021

18)	**OUTLETS & OVERFLOW STRUCTURES: Are outlets and overflow structures free of obstructions (trash, vegetation, debris, sediment)?**	**Yes**
19)	**OUTLETS & OVERFLOW STRUCTURES: Is the area around outlets and overflow structures free of evidence of excessive erosion?**	**Yes**
20)	**OUTLETS & OVERFLOW STRUCTURES: Are joints water tight and free of evidence of leaks?**	**Yes**

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:11am

21) Do items of non-compliance other than those previously noted exist? **Yes**



Inspected by: 00005928

Sarah Stangelo, CESSWI
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CHAGRIN VALLEY ENGINEERING, LTD.
Creative Engineers. Intelligent Solutions.

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:06am

Project Name:	Royal Valley #54 (East)	**Jurisdiction:**	CVE Special
Inspected:	Entire Project		
Owner:	Unknown Unknown Unknown unknownEmail@6852.com		
		Inspector:	Sarah Stangelo
		Inspection Completed:	**07-23-2021**
		Report Completed:	**07-23-2021**
		Inspection weather:	Temperature: 82 degrees, Clear
		Inspection Type:	Citizen Complaint
		Current Activity:	Not Applicable;
		Current Site Status:	Deficiencies Exist

1) Are required post construction documents available for review? — **Yes**

2) Record general notes or observations. — **See notes**

Notes Recorded:
Basin is in need of dredging to restore capacity. Slopes are sparsely vegetated and eroding. Concrete channel at inlet is being undercut.

3) PRETREATMENT: Is pretreatment area free of excessive trash and debris? — **NA**

4) PRETREATMENT: Is pretreatment area free of excessive accumulation of sediment? — **NA**

5) DEWATERING: Is water draining within 24 hours as intended and is the water quality orifice visible? — **NA**

6) INLETS: Are inlets in satisfactory structural condition? — **Open Work Items Exist**

Maintenance Action Required
Concrete channel is being undercut. Use backfill and construction grade stone to prevent further erosion.

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

7) INLETS: Are inlets free of obstructions that impede flow (sediment, vegetation, trash, debris)? **Open Work Items Exist**

Maintenance Action Required

Remove vegetation form inlet flow path to insure free flow.

Photo 1 - 07/23/2021

8) INLETS: Is the area around inlets free of evidence of excessive erosion? **NA**

9) SLOPES & EMBANKMENTS: Are slopes and embankments free of cracks, seeps and evidence of erosion? **Open Work Items Exist**

Maintenance Action Required

Multiple areas or sparse vegetation and erosion along embankment. Consider using seeded mating to encourage growth and prevent erosion.

Photo 1 - 07/23/2021

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:06am

Photo 2 - 07/23/2021

10)	**SLOPES & EMBANKMENTS: Are slopes and embankments free of trees, and woody vegetation and invasive plants?**	**NA**
11)	**SLOPES & EMBANKMENTS: Are slopes and embankments stable and free of sinkholes and burrows?**	**Yes**
12)	**BASIN PERMANENT POOL: Is the area free of excessive trash and debris?**	**Yes**
13)	**BASIN PERMANENT POOL: Is the area free of invasive plants?**	**Yes**
14)	**BASIN PERMANENT POOL: Is the basin free of excessive accumulation of sediment and are pool storage volumes adequate?**	**Open Work Items Exist**

Maintenance Action Required

Excessive accumulation of sediment is present in pool. Sediment is visible through the sweater surface. Dredging is required to restore basin capacity.

Stormwater Control Measures Inspection Report
Site Inspection Report

Photo 1 - 07/23/2021

15) BASIN PERMANENT POOL: Is the shoreline free of evidence of excessive erosion? **NA**

16) BASIN PERMANENT POOL: Is the pool free of excessive growth of algae? **Open Work Items Exist**

Maintenance Action Required
Excessive algal growth is present in main pool. Treatment was being administered at time of inspection but does not seem to be efficient. Consider more aggressive treatment and/or alternative methods.

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

17) OUTLETS & OVERFLOW STRUCTURES: Are outlets and overflow structures in satisfactory structural condition? **NA; See notes**

Notes Recorded:

Outlet structure and emergency spill way appear to be in good condition and functioning properly.

Photo 1 - 07/23/2021

Photo 2 - 07/23/2021

18)	**OUTLETS & OVERFLOW STRUCTURES: Are outlets and overflow structures free of obstructions (trash, vegetation, debris, sediment)?** **Maintenance Action Required** **Routine maintenance is suggested, especially after a rain event, to clear debris rack and make sure outlet is functioning properly.**	**Open Work Items Exist**
19)	**OUTLETS & OVERFLOW STRUCTURES: Is the area around outlets and overflow structures free of evidence of excessive erosion?**	**NA**
20)	**OUTLETS & OVERFLOW STRUCTURES: Are joints water tight and free of evidence of leaks?**	**NA**
21)	**Do items of non-compliance other than those previously noted exist?**	**Yes**

Stormwater Control Measures Inspection Report
Site Inspection Report

Report Generated: 07-23-21 11:06am

Inspected by: 00005928

Sarah Stangelo, CESSWI
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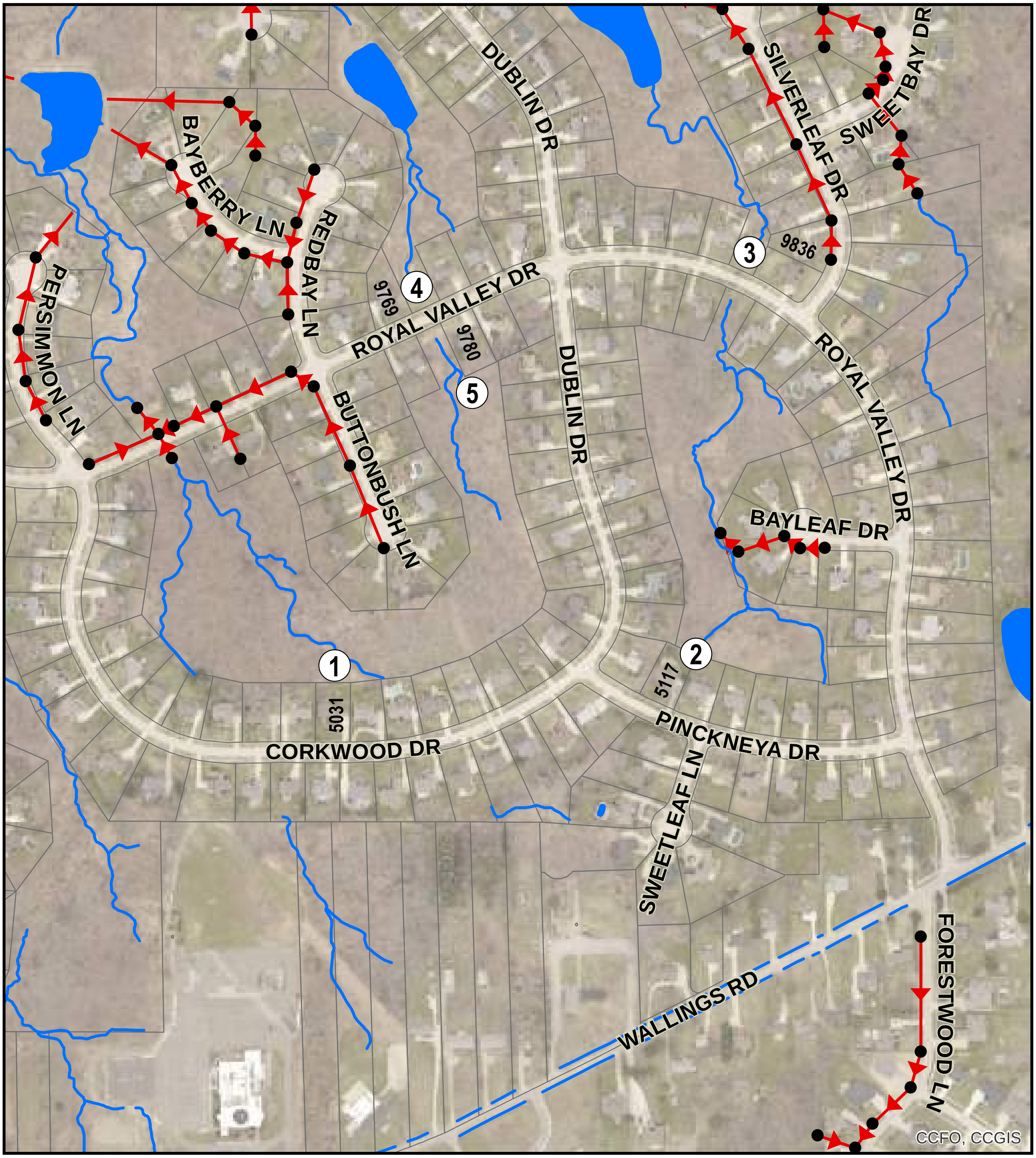
APPENDIX H: Map of Targeted Channel Outfall/improvements



Project Areas

1	5031 Corkwood Dr
2	5117 Pinckneya Dr
3	9836 SIlverleaf Dr
4	9769 Royal Valley Dr
5	9780 Royal Valley Dr

Legend

- Storm Sewer Manhole
- Storm Sewer Pipe
- Stream / Ditch
- Waterbody

N

1:5,000

CVE No: 21226
DATE: 8/26/2021
MAP BY: ALH

PROJECT: ROYAL VALLEY SUBDIVISION STORMWATER INSPECTION

Targeted Channel / Outfall Improvements Map

LOCATION: City of North Royalton, Cuyahoga County, Ohio

Appendix H

CVE CHAGRIN VALLEY ENGINEERING LTD

APPENDIX I: Facilities Plan

Facilities Plan
Royal Valley Homeowners Association, 2022-2030

Category	Feasible Alternative	Basic Project Description	Suggested Timeframe/Year for Project Initiation[1]	Estimated Duration of Implementation (Design to Construction)	Estimated Cost[2]
Maintenance	Outreach and Education	Public forum, mailer, posted signs, development and communication of rules for failure to comply	Within 3 months	Ongoing; periodic mailers (bi-annually in the spring and fall)	$1,500.00
	Local Storm Sewer System	Develop routine inspection and cleaning schedule for basins within	Within 6 months	Ongoing- suggested to perform semi-annual inspection of all basins	$0-$2,500.00[3]
		Clear out existing inlet basins	Within 1 year	1 month	$5,000.00
	Detention Basins	Dredge all stormwater basins	Within 1 year	1 month	$10,000.00 per Basin
		Install LSM or rock to eliminate voids under inlets, Basin 53 (West) and 54 (East)	Within 1 year	1 month	$2,000.00 per inlet
		Install erosion control matting on eroded banks of Basin 55 (Center) and Basin 54 (East)	Within 1 year	1 month	$5,000 per Basin
		Treat for phragmites (Basin 53) and algae (all Basins)	Treatment was witnessed in June; repeat periodically	Ongoing	$10,000.00
		Develop Inspection and Maintenance Plan- address inspection & clearing of structures after rain event, periodic treatments for algae and phragmites, dredging, etc.	Within 1 year	1 month	$0-$2,500.00[3]
Construction	Corkwood Drive basin updates	Increase inlet capacity by replacing basin grates; erosion control matting thorughout area; consideration for debris control	2023	6 months	$15,000.00
	Corkwood Drive basin updates	If topography permits, install headwall with pipe inlet to capture flow within storm sewer system prior to residential rear yard inlets	2024	1 year	$100,000.00
	Targeted Channel/Outfall Improvements	5031 Corkwood- install flow dissipation at outlet, remove failed gabion structure, natural channel design to expand floodplain	2024	6 months	$25,000.00-$75,000.00[4]
		5117 Pinckneya- repair scouring and install rock channel protection at outfall, remove gabions within channel downstream	2024	6 months	$20,000.00
		9836 Silverleaf- install flow dissipation and/or realignment of stream at outlet, install erosion control matting/geoweb wall to address existing bank erosion	2025	1 year	$50,000.00-$100,000.00[4]
		9769 Royal Valley- install flow dissipation at outlet (combine with Dublin/Redbay stream restoration)	2026	1 year	$10,000.00
		9780 Royal Valley- install flow dissipation at outlet, remove failed gabions (combine with Dublin/Buttonbush stream restoration)	2027	1 year	$10,000.00
	Stream Channel Restoration: Stream 55 North (between Dublin/ Redbay)	Natural Channel Design	2026	18 months	$100,000-$250,000.00[4]

Facilities Plan Royal Valley Homeowners Association, 2022-2030					
Construction (cont.)	Stream Channel Restoration: Stream 55 South (between Dublin /Buttonbush)	Natural Channel Design	2027	18 months	\$100,000-\$250,000.00[4]
	Stream Channel Restoration: Stream 53 West 2 (between Corkwood/Ridgeline)	Natural Channel Design	2029	18 months	\$100,000-\$250,000.00[4]
	Stormwater Basin Spillway Redesign	Redesign emergency spillways for current published rainfall data, and reconstruct as needed	2031	6 months	\$10,000 per Basin
	Basin retrofit internally funded	Install forebay and micropool within stormwater management basins	Within 2 years, if at that point the option to have the project performed or funded by a third party is fully investigated	6 months	\$20,000 per Basin
Property Acquisition	St. Paul Greek Orthodox Church Property Inquiry	Investigate purchase of a northern portion of church green space for installation of future stormwater management improvement	2023	Variable, pending receptivity of property owner to selling	TBD[5]
	Corkwood Drive Easements	Place rear yard inlets in permanent easement or secure access agreement for ongoing inspection/maintenance purposes	2023	1 year	\$2,500.00 per Easement[6]
Investigation	Basin Retrofit with third party involvement	Investigate potential grant opportunities for retrofit of basins to provide detention and/or water quality for downstream watershed	2023	Ongoing; grant applications may be submitted annually	\$0-\$5,000.00[3]
	Heasley Soccer Fields	Initiate conversation with City to require all runoff from paved surface to be captured within storm sewer[7]	2023	1 month	\$0-\$5,000.00[3]
	Closed Conduit Analysis	Authorize detailed review of storm sewer system	2026	3 months	\$20,000.00

1. This is a target year in which the RVHA should consider initiation of the project, and has been assigned based roughly on priority and cost consideration. The target year would be for the first step, such as eliciting bids for maintenance activities or engineering services, as opposed to the year in which the project should be completed.

2. Estimated cost, including design (where applicable) and construction. Provided cost is a estimate ONLY. Due to volatility in material and labor costs, as well as the unknown timeframe for project completion, the actual cost at the time of construction may vary significantly from the estimate.

3. Cost depending on preference of RVHA to internally complete these tasks, or consider eliciting bids for third party to complete the tasks on behalf of the RVHA

4. Projects listed with a price range are dependant on the scope of work. Natural channel design projects can be tailored to a certain budget, to only include a certain linear footage of stream, address only one facet of design (for example, limited to increasing floodplain or addressing active bank erosion). Targeted stream channel improvements may include the minimum scope (removing impairments only), or may be expanded to include also addressing erosion and channel improvements.
5. There would be no cost involved in initial conversations, property acquistion cost would be negotiated. Potentially the basin could be placed within an easement, with stormwater management handled underground, so green space could still be utilized by the church.
6. This cost is for boundary survey and preparation of easement documentation only. Cost for purchase of the easement pends negotation, and is not included in this cost.
7. See the report for detailed description of the various methods for capturing the additional runoff from the Heasley Soccer Fields property.