WEST SIDE WOODS SUBDIVISION PRELIMINARY ENGINEERING REPORT

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1.0 SUBDIVISION OVERVIEW

1.1 PROJECT DESCRIPTION AND LOCATION

The West Side Woods Subdivision is located on the westside of Helena south of US Highway 12. More specifically, the subdivision is located in the South ½ of Section 23 and the North ½ of Section 26, Township 10 North, Range 4 West, P.M.M., Lewis and Clark County, Montana. The West Side Woods Subdivision is proposed to be developed in four phases for full buildout, as shown in Table 1 and on the preliminary plat that is included as part of this Preliminary Plat Application. This Preliminary Engineering Report summarizes the essential infrastructure required to support the development of the subdivision. A separate Final Design Report and Engineering Plans will be submitted for review and approval for each phase of the development.

Table 1. West Side Woods Subdivision Phase Plan

Phase Number	Zoning	Number of Lots/Units	Proposed Year to be Developed
1	Single-family Residential (R-3)	28	2023
	Multi-family Fourplex (RO)	28	
	Open Space	2	
2	Single-family Residential (R-3)	10	2025
	Multi-family Duplex (RO)	20	
	Open Space	1	
3	Single-family Residential (R-3)	43	2027
	Open Space	1	
4	Single-family Residential (R-3)	11	2029
	Multi-family Duplex (RO)	32	

2.0 WATER DISTRIBUTION SYSTEM

The water system for the West Side Woods Subdivision has been designed around existing and approved connections to the City of Helena (COH) distribution system as described below.

2.1 WATER SYSTEM DESIGN SUMMARY

The water distribution system has been designed to meet COH Standards, as well as Department of Environmental Quality (DEQ) requirements. Water main piping 12 inches in diameter or smaller will be DR-14 Class 200 PVC. All joints exceeding 11.25° shall be mechanically restrained joints and must meet thrust blocking requirements outlined in the Montana Public Works Standard Specifications, Seventh Edition (MPWSS). All other connections shall consist of push-on joints with rubber gaskets. Long radius curves within the system have

been designed according to MPWSS standards, which states that these curves can be accomplished by standard pipe deflection at the joints.

The water system has been designed as a looped network with minimal dead-end lines. The only dead ends are at the end of the proposed cul-de-sacs. Valve and hydrant locations have been designed to meet City design standards. Spacing between water valves does not exceed 600 feet. Hydrant locations were placed at strategic locations approximately 400 feet apart. Installation of valves and hydrants shall be in accordance with the City of Helena detailed drawings and MPWSS.

2.2 City of Helena Water Main Connection

Four existing tie-in points connect the water distribution system for the West Side Woods Subdivision to the existing City of Helena water mains outside of the project boundaries. The four tie-in locations are designated as:

- Connections 1 and 2 – Hauser Street: Two connections to the existing 10-inch water main that runs along Hauser Street.
- Connection 3 – Overlook Boulevard: A connection to an existing 8-inch water main dead end at the southern end of Overlook Boulevard.
- Connection 4 – Woodward Avenue: A connection to an existing 8-inch water main dead end at the western end of Woodward Avenue.

An existing 24-inch transmission main runs from west to east across the property. A proposed road will be constructed over the existing transmission main to facilitate future access and maintenance. The transmission main will remain in place and will not need to be relocated for this project. The proposed water mains will not connect to the 24-inch transmission main. The interior water network for the West Side Woods Subdivision will consist of 8-inch diameter pipe. Preliminary design plans showing the plan view layout of the water mains as well as the other proposed infrastructure for the subdivision has been submitted to the City of Helena concurrently with this report.

2.3 Water System Modeling

The City of Helena's water system is modeled using InfoWater software from Innovyze, that operates within ESRI's ArcGIS platform. WWC contracted with AE2S to analyze the water demands, system pressures, fire flow capacity and impacts to the city's storage tanks for the proposed subdivision. AE2S was selected to perform these analyses due to their company owning the software required for the city's model and their experience modeling the city's water system as a result of their recent completion of the city's 2020 water masterplan update. AE2S provided a technical memorandum detailing their analyses and results, which is provided in Appendix A and summarized in the following sections. The AE2S technical memorandum shows that all applicable design requirements are satisfied for the West Side Woods Major Subdivision.

2.3.1 Modeling Proposed Subdivision

WWC provided AE2S with a PDF of the proposed subdivision, per their request. The PDF included the proposed plat showing the roadways, single-family and multi-family lots, water main extensions and tie-in locations, elevation contours, and the existing and proposed ground elevations. The PDF provided also shows the proposed water model nodes, node area boundaries, the numbers of lots, duplexes and fourplexes within each node, and the location of proposed fire hydrants. This PDF is provided with AE2S's technical memorandum in Appendix A. All the proposed water mains are 8-inch diameter PVC that AE2S modeled with an assumed Hazen-Williams roughness coefficient of 140. The subdivision will connect to the city's existing water system at four proposed locations within the Malben High pressure zone. The subdivision will not connect to the 24-inch cross town connector transmission main which runs through the development.

2.3.2 Water Demand Requirements

The COH 2020 water masterplan update, developed by AE2S, determined that the Equivalent Residential Unit (ERU) uses 743 gallons (0.52 gpm) during a maximum day of water usage. AE2S used this same ERU for the proposed lots within the West Side Woods Major Subdivision. The model also uses a minimum operating pressure of 50 psi that was recommended in the 2020 masterplan, which exceeds DEQ's minimum recommendation of 35 psi. Multi-family units (duplex and fourplexes) were assigned multiple ERU's in the model.

2.3.3 Peak Demand Analysis

The AE2S evaluation shows the junction locations, elevations, and water demands for their peak demand analysis, which includes model evaluations for the maximum day and peak hour. Their analysis shows that the maximum day demand results in operating pressures within the subdivision ranging from 60 to 145 psi, as shown graphically in their report figures. The locations with lower elevations have higher pressures while the area with higher elevations have lower pressures. It should be noted that the locations with lower elevations and higher pressures will require pressure reducing valves for each residence, as typically occurs for lots in each of the pressure zones established by the city.

2.3.4 Fire Flow Analysis

AE2S used the InfoWater model to evaluate the fire flow capacity at each of the proposed fire hydrants for the subdivision. The hydrant available fire flows were calculated by limiting the minimum pressure at each hydrant to 20 psi. AE2S determined that all hydrant fire flows exceed the required 1,750 gpm within the subdivision.

2.3.5 Storage Analysis

AE2S used the InfoWater model to evaluate the city's storage capacity and the impacts from the addition of the proposed subdivision, which will be connecting into the Malben High pressure zone. A 72-hour max day demand analysis was performed and shows no major impact to storage with the addition of the West Side Woods Major Subdivision. The current storage (Malben, Nob Hill, and Woolston Tanks) supplying the Malben High pressure zone should be sufficient to meet the additional demands from the West Side Woods Major Subdivision. All three of the tanks remain above 70% full for the entire duration of the 72-hour analysis.

2.3.6 Water System Modeling Conclusion

From the analysis performed by AE2S in the city's hydraulic model, the proposed water distribution improvements in the West Side Woods Major subdivision provide adequate pressure and fire flow. The existing storage tanks supplying the Malben High pressure zone have sufficient storage capacity for the proposed subdivision. The technical memorandum from AE2S detailing their evaluations and analysis is provided in Appendix A.

3.0 WASTEWATER SYSTEM

Projected wastewater flows for the West Side Woods Subdivision were determined using the design average flows as well as peak hourly flows for various hydraulic conditions. The area's current and projected populations were obtained through a count of existing and proposed residences, or equivalent dwelling units (EDUs). The COH Engineering and Design Standards, Section 3.2 states that each EDU shall be assumed to contain 2.39 residents. The existing and proposed EDU counts were obtained as follows:

Existing EDU: Existing EDUs were obtained from a review of current COH GIS data. Aerial imagery was used to determine whether these individual GIS-identified connections were servicing multi-family housing units, and if so, the multi-family housing connections were accounted for in the EDU count.

Proposed EDU: Proposed EDU counts were determined from proposed services associated with connections to single-family and multi-family units within the boundary of the West Side Woods Subdivision.

3.1.1 Hydraulic Capacity

The project design involved determining the design average flows as well as peak hourly flows for various hydraulic analysis. A description of how the design average flows were obtained is provided below. The peak hourly flow was conservatively assumed to equal 4 times the design average flow rather than using Equation 10-1 in DEQ-2 for flow analysis within the subdivision. This is due to the smaller population located internally within the subdivision boundary. For downstream flow analysis, Equation 10-1 in DEQ-2 was used to calculate the peak hour factor. The population used to calculate the peak hour factor combined the West Side Woods Subdivision, Phase 2 from the COH water and sewer project, existing Granite Street hookups, and Overlook Estates hookups. The total projected population for this area was estimated to be 729 people which results in a peak hour factor of 3.884.

The design maximum daily flow and design maximum monthly flow were not determined as these values would usually be used in determining the adequacy of treatment facilities, and the current COH treatment plant has significant excess capacity to handle the relatively small increase in wastewater flows that would be generated from the proposed subdivision. Detailed hydraulic calculations used in the wastewater analysis are provided in Appendix B.

3.1.2 Water Demand Inputs

Residential Flows

The COH Engineering Standards, Section 3.2 states that wastewater flow generation should be estimated assuming an average of 112 gallons per day (gpd) per capita for single-family

residence and an average of 2.39 people per residence. Thus, each equivalent dwelling unit (EDU) connection was assumed to produce wastewater flows of 268 gpd for design average daily demand calculations. The guidance was utilized to determine existing and proposed wastewater flows from residential connections.

Infiltration and Inflow

The COH Engineering Standards, Section 3.4.1 requires that the sanitary sewer main infiltration and inflow (I&I) rate shall be assumed as 150 gallons per acre of coverage per day.

Wastewater Design Flows

The average daily flow and peak hourly flows were developed for the project area described in the previous sections. A summary of each phase of the West Side Woods Subdivision is presented in Table 2.

3.1.3 General Sanitary Sewer Flow Patterns

The collection system for the proposed West Side Woods Subdivision was designed to convey wastewater from the project area and connect to existing City of Helena sanitary sewer mains. The topography of the project area will force all gravity sewer flows generally to the north and connections to the existing sanitary sewer mains on Overlook Boulevard and Hauser Boulevard. A portion of flows from the proposed Phase 1 of the subdivision would be conveyed to the Hauser Boulevard sewer main while the remaining Phase 1 flows and all flows from Phases 2, 3, and 4 would be conveyed to the Overlook Boulevard sanitary sewer main. A layout of the proposed sanitary sewer main with arrows indicating flow directions is included in Appendix B. Sewer flows from both Hauser Boulevard and Overlook Boulevard flow through the Overlook Estates gravity network before converging at the Granite Street sewer main. From Granite Street, the flows are conveyed north across Euclid Avenue, travel northwest along Broadway Avenue, then turn northeast toward Country Club Lane before converging with flows at the intersection of Joslyn Street and Brady Street. From this location, the flows will continue in a northeast direction until connecting to the large cross-town sewer collectors flowing west to east and generally following Custer Avenue before entering the Helena Wastewater Treatment Plant located at the intersection of Washington Street and East Custer Avenue. The general flow pattern is presented in the wastewater flow schematic on Exhibit 2.

Table 2. West Side Woods Subdivision Wastewater Flow Estimates

Source	Unit	Flow (gpd/unit)	# of Units	Flow (gpd)	Flow (gpm)
Phase 1 EDUs	EDU	268	56	15,008	10.42
Phase 1 Infiltration & Inflow (I&I)	Acre	150	12.10	1,815	1.26
Phase 1 Design Average Flow (Including I&I)				**16,823**	**11.68**
Phase 1 Design Peak Hourly Flow (4 times average daily + I&I)				**61,847**	**42.95**
Phase 2 EDUs	EDU	268	30	8,040	5.58
Phase 2 Infiltration & Inflow (I&I)	Acre	150	11.30	1,695	1.18
Phase 2 Design Average Flow (Including I&I)				**9,735**	**6.76**

Source	Unit	Flow (gpd/unit)	# of Units	Flow (gpd)	Flow (gpm)
Phase 2 Design Peak Hourly Flow (4 times average daily + I&I)				**33,855**	**23.51**
Phase 3 EDUs	EDU	268	43	11,524	8.00
Phase 3 Infiltration & Inflow (I&I)	Acre	150	18.60	2,790	1.94
Phase 3 Design Average Flow (Including I&I)				**14,314**	**9.94**
Phase 3 Design Peak Hourly Flow (4 times average daily + I&I)				**48,886**	**33.95**
Phase 4 EDUs	EDU	268	43	11,524	8.00
Phase 4 Infiltration & Inflow (I&I)	Acre	150	16.90	2,535	1.76
Phase 4 Design Average Flow (Including I&I)				**14,059**	**9.76**
Phase 4 Design Peak Hourly Flow (4 times average daily + I&I)				**48,631**	**33.77**
Total Design Average Flow (Including I&I) =				**54,931**	**38.15**
Total Design Peak Hourly Flow (4 times average daily + I&I) =				**193,219**	**134.18**

3.1.4 Hydraulic Analysis

In order to calculate the hydraulic capacities of the COH existing downstream sewer collection system and the proposed sewer collection system within the West Side Woods Subdivision, two analyses were performed. Each analysis is described in the following sections of this report. All hydraulic calculations were performed using Bentley's Flowmaster® software using the Manning's Equation for Uniform Pipe Flow. For the downstream pipe analysis, Manning's "n" values for PVC pipe, clay pipe, and RCP pipe were assumed to be 0.013, 0.014, and 0.013, respectively.

Analysis 1 (Proposed Main Hydraulics)

All new gravity sewer mains proposed within the West Side Woods Subdivision area are 8-inch diameter PVC and are capable of conveying wastewater flows much larger than what is expected from the flows generated by the proposed subdivision. The minimum and maximum slopes for the proposed sewer mains are 0.550% and 19.581%, respectively. Detailed calculations from Flowmaster are provided in Appendix B. To align with COH Engineering Standards, Section 3.4.1 Slope, a Manning's "n" value of 0.013 was used to determine the minimum pipe slope for when the flow depth is at 0.3 of the sewer main's inside diameter. The flow depth and resulting velocities of each pipe are as follows:

- 8" PVC Pipe (Manning "n" = 0.013) at 0.550% (min) slope
    - 25% Depth: 55.10 gpm, velocity = 1.80 ft/sec
    - 50% Depth: 201.11 gpm, velocity = 2.57 ft/sec
    - 75% Depth: 366.77 gpm, velocity = 2.91 ft/sec
    - 100% Depth: 402.21 gpm, velocity = 2.57 ft/sec
- 8" PVC Pipe (Manning "n" = 0.013) at 0.550% (min) slope

    - 0.3 Full: 78.77 gpm, velocity = 1.99 ft/sec
- 8" PVC Pipe (Manning "n" = 0.013) at 19.581% (max) slope
    - 25% Depth: 328.74 gpm, velocity = 10.73 ft/sec
    - 50% Depth: 1,199.95 gpm, velocity = 15.32 ft/sec
    - 75% Depth: 2,188.41 gpm, velocity = 17.36 ft/sec
    - 100% Depth: 2,399.89 gpm, velocity = 15.32 ft/sec

DEQ-2 Section 33.45 regarding high velocity protection, states that where velocities greater than 15 feet per sec are attained, special provisions must be made to protect against displacement by erosion and impact. For the section of sewer pipe in the proposed subdivision with a slope of 19.581%, at 25% capacity the velocity is 10.73 feet per second. The peak hourly flow from full build out of the subdivision is 132.69 gpm. The resulting velocity from this peak hourly flow through the section of pipe with the maximum grade is 8.22 ft/sec and would not require special provisions to protect against displacement by erosion and impact.

Analysis 2 (Downstream Sewer Main Capacity)

The second analysis involved determining the flow capacity of the existing COH sewer collection system downstream of the proposed subdivision. For this report, the downstream flows were analyzed using a combination of existing EDU counts, flow meter data from the COH, designated as Area 1, and a 2008 report developed by Morrison Maierle, Inc., and Burns & McDonnell titled Helena Wastewater Collection System Master Plan (WW Master Plan), designated as Area 2. As shown on Exhibit 3, all of Area 1 consists of only the hatched West Side Woods Subdivision, existing residential lots, Kessler School, commercial lots, and the entire upstream sewer collection system that is conveyed through Joslyn Street (not hatched). Area 2 consists of all sanitary sewer collection mains downstream of city manhole number 531-6 on Brady Street.

Area 1

Flow meter data provided by the city was used to evaluate existing peak flows at strategic locations downstream of the proposed subdivision. Flow meters were installed in city manhole numbers 99-14-6, 73-20-4, and 531-6. These flow meter locations are shown on Exhibit 3. The flow meters were programmed to collect flow data every 15 minutes for a three-month period from approximately September 2020 to November 2020. Detailed flow meter readings are available upon request or can be provided by the City as there are over 6,000 readings for each flow meter. Summarized flow meter readings for the maximum flow that occurred during the period of observation are shown in Table 3.

Table 3. Flow Meter Maximum Flow Rate

Manhole Flow Meter Located in	Start Date	End Date	Maximum Flow Observed (GPM)
99-14-6	9/9/2020	11/12/2020	66.72
73-20-4	8/27/2020	11/12/2020	90.63
531-6	8/27/2020	11/12/2020	492.45

These flow meter readings were taken in the late summer/early fall period where additional flows from infiltration and inflow (I&I) may not be fully experienced. Therefore, I&I for each area tributary was conservatively added to the flow meter data. Tributary areas were separated into existing residential and commercial development areas. A summary of I&I flows for Area 1 is shown in Table 4.

Table 4. Area 1 I&I Flow Estimates

Source	Unit	Flow (gpd/unit)	# of Units	Flow (gpd)	Flow (gpm)	MH # to Add I&I
Overlook Estates						
Infiltration & Inflow (I&I)	Acre	150	18.00	2,700	1.88	MH 99-14-6
Existing Granite Street						
Infiltration & Inflow (I&I)	Acre	150	10.40	1,560	1.08	MH 99-14-6
Green Meadow Country Club						
Infiltration & Inflow (I&I)	Acre	150	6.30	945	0.66	MH 73-20-4
Country Club Ave. Resident						
Infiltration & Inflow (I&I)	Acre	150	7.70	1,155	0.80	MH 73-20-4
Spring Meadow Lake State Park						
Infiltration & Inflow (I&I)	Acre	150	1.70	255	0.18	MH 73-20-4
MFWP Montana WILD Center						
Infiltration & Inflow (I&I)	Acre	150	3.00	450	0.31	MH 73-20-4
Broadwater Avenue Commercial Businesses (Trihydro, George's Distributing, Farcountry Press, Sweetgrass Books)						
Infiltration & Inflow (I&I)	Acre	150	9.10	1,365	0.95	MH 99-14-6
Joslyn Street (Upstream)						
Infiltration & Inflow (I&I)	Acre	150	255.00	38,250	26.56	MH 531-6

- Green Meadow County Club
    - The Green Meadow County Club adds I&I flow to the sanitary sewer main between manholes 73-20-13 and 73-20-12. These flows are conveyed to manhole 73-20-10 where existing and proposed West Side Woods Subdivision flows would merge.
- Spring Meadow Lake State Park

- The Spring Meadow Lake State Park adds I&I flow to the sanitary sewer main between manholes 73-20-15 and 73-20-14. These flows are conveyed to manhole 73-20-10 where existing and proposed West Side Woods Subdivision flows would merge.

- Montana Fish Wildlife and Parks – Montana WILD Visitor Center
  - The MFWP Montana Wild Center adds I&I flows to the sanitary sewer main between manholes 99-14-8 and 99-14-9, a section of downstream sewer main that would be conveying flows from the West Side Woods Subdivision. Based on a conversation with an employee of the center on August 25, 2020, the center employs 10 personnel. A spreadsheet showing the daily visitors for the past several years was provided by MFWP. The highest daily visitor total was 211 visitors on June 27, 2017. Using Table 3.1-2 from DEQ-4, the estimated visitor center wastewater flow is 5 gpd/visitor and 10 gpd/employee.

- West Side Woods Phase 1 and 2 Flows

  Currently, there is a project underway to connect a recently annexed area near the proposed subdivision to City water and sanitary sewer infrastructure as part of the City of Helena's West Side Water and Sewer Project, currently under construction. For the purpose of predicting flows downstream of the private West Side Woods Subdivision Project, flows from the City's West Side Water and Sewer Project will be added to the flow meter data that was recently obtained in September – November 2020. The city's public infrastructure project was separated into two phases, Phase 1 and 2, and each are independent from the phases for the private, proposed West Side Woods Subdivision for which this report is associated with. EDU counts from the public Phase 1 and 2 projects were analyzed as part of previous design reports submitted to DEQ and the City for review and approval. During the design of the city's public project, anticipated flows from Phases 1 and 2 were calculated. As shown in these design reports, Phase 1 flows are collected and conveyed through the Joslyn Street trunk line and would merge with flows from the proposed subdivision at manhole 527-1. Peak flows from Phase 1 are calculated to be 111.59 gpm. The remaining flows from Phase 2 would merge with flows from the proposed subdivision at manhole 94-14-3. Peak flows from the Original Phase 2 flows shown in the approved design reports show a peak flow rate of 106.84 gpm based on total EDU counts. While it would be ideal to have flow meter readings at every manhole where additional collection mains are connected to the downstream conveyance system, some conservative assumptions can be made to utilize the data that was collected:

  For the flow meter located in manhole 99-14-6, the maximum measured flow rate of 66.72 gpm plus the I&I flow of 3.91 gpm for a total of 70.63 gpm was assumed to occur for all upstream sections of sanitary sewer to the proposed subdivision connection.

  For the flow meter located in manhole 73-20-4, the maximum measured flow rate of 90.63 gpm plus the I&I flow of 1.95 gpm for a total of 92.52 gpm was assumed to occur

for upstream pipe to manhole 73-20-10. This is where the Green Meadow Country, Spring Meadow Lake State Park, and the Country Club Avenue flows are introduced.

For the flow meter located in manhole 531-6, the maximum measured flow rate of 492.45 gpm plus the I&I flow of 26.56 gpm for a total of 519.01 gpm was assumed to occur for upstream pipe to manhole 527-1. This is where all upstream waste flows collected from Joslyn Street are introduced.

Area 2

Data from the WW Master Plan was utilized for the downstream analysis from the Brady Street/Joslynn Street intersection to the wastewater treatment facility. The most stringent flow analysis provided in the WW Master Plan involved the "Wet Weather (Maximum Day) Loading Condition with 10-year 60-Minute Storm Event" capacity analysis presented in Chapter 5. The analysis results were presented in the WW Master Plan Figure 5-9, and this figure is provided in Appendix C of this report for reference. This WW Master Plan analysis showed that during the most stringent modeling condition, all sewer mains downstream of the proposed project area had utilized 0% to 50% of the gravity main capacity available. Therefore, all existing sewer mains for this area were conservatively assumed to have an existing peak flow rate at 50% of their capacity.

The sewer main full-flow capacities downstream of the proposed project were analyzed using the Manning's Equation for Uniform Pipe Flow, and the results of these calculations are provided in Appendix B. The increased flows resulting from the proposed West Side Woods Subdivision for Areas 1 and 2 were determined and compared to the calculated full-flow capacities of each downstream section of sewer main. For Area 1, these calculated flows from the subdivision were then added to the calculated peak flow meter measurement and I&I flows. For Area 2, these calculated flows from the subdivision were then added to the conservatively assumed maximum 50% capacity as presented in the WW Master Plan to determine the maximum theoretical flows experienced in each stretch of sewer main.

The results of this analysis show that the existing collection system downstream of the West Side Woods Subdivision has sufficient capacity to accommodate the anticipated peak flows from the subdivision with no sewer main capacity upgrades being necessary for the subdivision being built out. No downstream upgrades would be required as results of the additional flows from the proposed subdivision as the capacity for the existing downstream infrastructure will not exceed 75% capacity based on existing and projected flows.

3.1.5 City Helena Wastewater Treatment Plant Capacity

The proposed West Side Woods Subdivision will produce an average daily wastewater flow of 54,398 gpd (0.054 MGD) and a peak flow of 225,054 gpd (0.225 MGD). Helena's wastewater treatment plant is a modified biological nutrient removal facility and has a maximum capacity of approximately 5.4 MGD, with current average daily flows to the plant of approximately 3.0 MGD. Based on these flows, the existing wastewater treatment plant has the capacity to accept the projected wastewater flows from the West Side Woods Subdivision. The wastewater treatment plant has the ability to divert peak flows beyond the capacity of the wastewater treatment plant into an empty primary clarifier for short periods of time. In addition, peak flows from the subdivision are anticipated to attenuate over time and the distance traveled

prior to reaching the wastewater treatment plant. Therefore, it is anticipated that the current wastewater treatment plant can handle the proposed additional flows from the full build out of the West Side Woods Subdivision.

4.0 STORM DRAINAGE

A hydrologic analysis was conducted for the West Side Woods Subdivision to account for on-site and off-site stormwater for pre- and post-development conditions. A pre-development model was created to assess the existing hydrologic conditions. Although the subdivision will be constructed in phases, the stormwater ponds and routing structures required for all four phases will be constructed as part of Phase 1. Therefore, a proposed conditions model has been developed to analyze the full buildout post-development conditions.

4.1 WATERSHED DESCRIPTION

The proposed development is located within a portion of the West Side Woods Drainage Basin. The West Side Drainage Basin is the western most drainage to the City of Helena and is described in the Helena Storm Water Master Plan Update March 2018 (HWSMP). There are several small ephemeral tributaries that flow within the upstream portion of the watershed between its origin along the Mt. Helena ridge and the outlet at the downstream portion of the project. There are two drainage outlets from this project, downstream of the Overlook Estates Subdivision to Spring Meadow Lake (Overlook Outfall) and the west drainage to Euclid Avenue (West Outfall). The contributing tributaries in the West Side Woods Drainage Basin are ephemeral drainages that flow in response to precipitation and snowmelt. In ephemeral drainages, runoff volumes and peaks are dependent on precipitation frequency-duration relationships and on the characteristics of the contributing drainage area. Basin characteristics that control precipitation-runoff characteristics are area, relief, soil type, vegetative cover, and flow length.

For the purpose of identifying the conveyance and hydrologic routes, three pre-development sub-basins of the West Side Drainage have been identified for this report and have been given designations of West (20.6-acres), Central Drainage (278-acres), and East Drainage (234-acres). The proposed subdivision is located in the West and Central Drainages. The West Drainage outfalls to the West Outfall while the Central and East Drainages outfall to the existing Overlook Estates detention pond (Overlook Outfall). Although no development is proposed in the East Drainage sub-basin, it has been included in the analysis as a portion of the sub-basin will be routed through the project area and it contributes to the Overlook Outfall. Depictions of each drainage basin are shown on the Hydrology Map (Existing Conditions) Exhibit Sheet 4. The West Drainage origin begins within the proposed subdivision disturbance area and discharges to an existing 24" diameter CMP culvert at the Overlook Estates property boundary, flows into a small retention pond and then overland flows onto Euclid Avenue where it is collected in existing stormwater inlets. The Central Drainage encompasses the off-site drainage area originating at the Mt. Helena ridge, is generally channelized though the project area, and discharges as overland flow at the Overlook Estates property boundary. The Central Drainage routing through Overlook Estates has existing flood concerns for the residential lots that will be addressed and improved with the outfall location and design for this project.

4.2 HYDROLOGIC WATERSHED ANALYSIS

Runoff and routing calculations for the project area and upstream contributing watershed was performed using the HydroCAD program. HydroCAD is a Computer Aided Design system for modeling the hydrology and hydraulics of stormwater runoff. It is based largely on the hydrology techniques developed by the Soil Conservation Service (SCS/NRCS), combined with other hydrology and hydraulics calculations. For a given rainfall event, these techniques are used to generate hydrographs and evaluate peak flow rates throughout a watershed. This program was selected due to the size of the drainage area, the ability to break the watershed up into smaller sub-watersheds (SWS), routing capabilities, and the universal acceptance of HydroCAD within the hydrologic sciences community. The SCS Unit Hydrograph Method, commonly known as the SCS TR-20 Runoff Method was used in the HydroCAD analysis that is a parametric method of estimating flood peaks and volumes from site-specific data, in addition to providing watershed routing parameters. This method was utilized for the evaluation of individual watershed hydrology while the Muskingum-Cunge Method was used for routing procedures. The major input parameters for the HydroCAD model are summarized as follows:

Precipitation Distribution - The SCS Type I rainfall distribution with 24-hour duration, as described in the City of Helena Engineering Standards, was utilized for the HydroCAD meteorologic model, which implements a synthetic rainfall distribution developed by the NRCS from observed precipitation events. The distribution contains rainfall intensities arranged to maximize the peak runoff for a given total storm depth.

Precipitation Amounts (P) - Precipitation amounts for given storm intervals, as shown in Table 5, were determined from Chapter 7, Appendix B of the Montana Department of Transportation Drainage Manual, 2017, as approved by the COH.

Table 5. Precipitation Amounts

Frequency, Duration	Precipitation (inches)*
Water Quality	0.50
5-year, 24-hour	1.57
100-year, 24-hour	2.44

*Taken from 2019 Draft City of Helena Engineering Standards

Curve Number (CN): The curve number is a numeric, dimensionless index developed to represent the combined hydrologic effect of soil, land use, agricultural land treatment class, hydrologic condition, and antecedent soil moisture. The soils within a typical drainage are given a hydrologic classification, ranging from A (most permeable) to D (least permeable), and are further divided into land use and vegetative cover. The hydrologic soil groups within the drainage area were determined from information provided by the NRCS Web Soil Survey, and curve numbers were selected within HydroCAD based on the land use. For this analysis, the area soils were determined to be hydrologic soils group B based on the HWSMP and confirmed with the NRCS Web Soil Survey. Curve numbers were set based on Table 3-6 of the FHWA HEC-22 Manual (Table 3-6) and NRCS TR-55 Manual (Table 2-2c). The following curve numbers were used to determine composite curve numbers for each watershed:

- Pasture (Fair) = 69

- Woods (Fair) = 60
- Residential (1/4 acre lots) = 75
- Residential (1/3 acre lots) = 72
- Residential (1/2 acre lots) = 70

Drainage Area (A): The contributing drainage area was delineated for each watershed, using the City of Helena LiDAR data. The drainage areas for each sub-watershed are provided with the HydroCAD results in Appendix D.

Watercourse Length (L): This is the length of the longest watercourse from the watershed divide to the point of interest. This value was determined from topographic contours derived from the City of Helena LiDAR Data. The watercourse length for each sub-watershed is provided with the HydroCAD results in Appendix D.

Average Slope of Watercourse, %: This refers to the average slope of the land and was determined from topographic contours derived from the City of Helena LiDAR Data. The slopes for each sub-watershed are provided with the HydroCAD results in Appendix D.

The routing technique used for this analysis was the Muskingum-Cunge standard section method, based on the continuity equation and the diffusion form of the momentum equation. Routing coefficients are automatically computed by the program from specified input parameters. Prismatic standard cross-sections were used based on the topographic condition of the channel within each routing section. Required input includes channel length, elevation difference, slope, bottom width, side slopes and Manning's "n" roughness coefficient.

4.3 Pre-development Analysis

A pre-development stormwater analysis has been conducted to determine the existing hydrologic conditions, establishing pre-development discharge locations, volumes, and flowrates. See Exhibit 4 for pre-development watershed identification.

4.3.1 West Drainage

The West Drainage watershed has a total area of 20.6 acres. The current land use is undeveloped and land cover has been delineated entirely as Pastureland, resulting in a curve number of 69. The time to concentration was determined to be 4.9 minutes based on shallow concentrated flow over grassed waterway. The minimum allowable time to concentration of 5 minutes was used. A summary of the resulting runoff is provided below.

4.3.2 Central Drainage

The Central Drainage watershed has a total area of 278 acres. The current land use includes 236.4 acres of Woods, 19-acres of Pastureland, and 13 acres of upstream ¼ acre Residential lots, 7.3 acres of ¼ acre Residential lots (Overlook Estates), and 1.8 acres of Pastureland (Overlook Estates), resulting in a weighted curve number of 62. The time to concentration was determined to be 24.4 minutes based on 250 feet of sheet flow (Woods Light Underbrush) at

the upper portion of the watershed and channelized flow (Earth Dense Weeds) along the lower flow path.

4.3.3 East Drainage

The East Drainage watershed has a total area of 234-acres. The current land use includes 86.8 acres of Woods, 131.4 acres of ½ acre Residential lots, 3.4 acres of Pastureland, and 12.3 acres of ¼ acre Residential lots (Overlook Estates), resulting in a weighted curve number of 67. The time to concentration was determined to be 52.5 minutes based on 200 feet of sheet flow (Woods Light Underbrush) at the upper portion of the watershed, channelized flow (Shallow Woodland) along the upper flow path, shallow grassed waterways through the neighborhood flow path, and storm drainpipe flow to the Overlook Estates detention pond.

A summary of the resulting pre-development runoff is provided below in Tables 6 and 7 for each drainage for the 5-year and 100-year, 24-hour events.

Table 6. Pre-Development Runoff Summary (West Outfall)

SWS - Name	Area (ac)	Weighted CN	5-yr, 24-hr		100-yr, 24hr	
			Runoff (ac-ft)	Peak Flow (cfs)	Runoff (ac-ft)	Peak Flow (cfs)
West Drainage	20.6	69	0.2	0.2	0.7	3.3

Table 7. Pre-Development Runoff Summary (Overlook Outfall)

SWS - Name	Area (ac)	Weighted CN	5-yr, 24-hr		100-yr, 24hr	
			Runoff (ac-ft)	Peak Flow (cfs)	Runoff (ac-ft)	Peak Flow (cfs)
Central Drainage	278	62	0.4	0.7	4.6	4.8
East Drainage	234	67	1.2	1.4	6.5	9.2
		Total	**1.3**	**2.0**	**10.8**	**12.5**

Note that totals do not equal the sum of runoff due to varying time for the peak discharge flow rate and the existing Overlook Pond dead-storage volumes below the lowest outlet elevation.

4.4 Post-Development Analysis

Construction of curb and gutter along the proposed development's roadways will change the historic flow paths of on-site stormwater. Stormwater inlets along the roadways will collect surface water and route it though pipes to stormwater treatment ponds. Two ponds will be constructed within the development, one along the West Drainage (Pond A) and one along the Central Drainage (Pond B). The ponds will outlet to a proposed storm main that will convey both the West and Central drainages to the existing Overlook Estates storm mains. Stormwater within the proposed development West Drainage will no longer outfall to Euclid Avenue but will now be routed through the Overlook Estates detention pond. Refer to the Hydrology Map (Proposed Conditions) Exhibit 5 for watershed identification. Pond locations and surface water routing are shown on Exhibits 6 and 7.

4.4.1 SWS A – To Pond A

Sub-watershed A (SWS A), located in the pre-development West and Central Drainage, has a total area of 26.5 acres and generally consists of the northern portion of the development.

The area for this sub-watershed increases for the post-development model due to the construction of a ditch to convey the stormwater flows from the northern portion of the development to Pond A. The post-development land cover will consist of Residential Lots. Areas used as open space have been assigned a land use as Pastureland, representing the existing grassed land cover. The resulting weighted curve number has been determined to be 74. The time to concentration was determined to be 10 minutes based on sheet flow over lots and shallow concentrated flow over paved roadways. A summary of the resulting runoff is provided in Table 7.

4.4.2 SWS B1 & B2 - To Pond B

Sub-watershed B (SWS B1, SWS B2) located in the pre-development Central Drainage has a total area of 267.7 acres and generally consists of the southern portion of the development (on-site) and the contributing watershed upstream of the development (off-site). The post-development land cover in the project area will consist of Residential Lots and areas used as open space, which have been assigned a land use as Pastureland. The resulting on-site weighted curve number for SWS B1 has been determined to be 70. The time to concentration was determined to be 10 minutes based on sheet flow over lots and shallow concentrated flow over paved roadways. The post-development off-site (SWS B2) land cover will not change as part of the project and therefore the curve number and runoff parameters will be consistent with the pre-development conditions. A summary of the resulting runoff is provided in Table 7.

4.4.3 SWS C1 & C2 - To Overlook Detention Pond

Sub-watershed C (SWS C1, SWS C2) post-development off-site land cover will not change as part of the project and therefore the curve number and runoff parameters will be similar to the pre-development conditions. SWS C2 (Overlook Estates) is located in the pre-development Central Drainage and SWS C1 is located in the pre-development East Drainage. Although, a small area that contributed to the East Drainage has been removed from SWS C1 as it will be routed through new inlets along Hauser Boulevard and is accounted for in SWS A. A summary of the resulting runoff is provided in Table 8 below.

Table 8. Post-Development Runoff Summary

SWS - Name	Area (ac)	Weighted CN	5-yr, 24-hr		100-yr, 24hr	
			Runoff (ac-ft)	Peak Flow (cfs)	Runoff (ac-ft)	Peak Flow (cfs)
A	26.5	74	0.4	0.4	1.1	5.2
B1	42.6	70	0.3	0.3	1.5	5.0
B2	225.1	60	0.2	0.3	3.0	2.9
C1	230.5	67	1.2	1.3	6.4	9.1
C2	10.2	73	0.1	0.1	0.5	1.5
		Total	**2.2**		**12.5**	

Note that total volumes in Table 7 do not match volumes at the Outfall as described in Table 9 as the existing ponds contain dead-storage volume.

4.4.4 Water Quality

The water quality event is defined as the first 0.5-inch of precipitation to fall on disturbed impermeable areas. The resultant volume must be captured to reduce sediment transport.

Based on the TR-55 Urban Hydrology for Small Watersheds manual and an average lot size of 0.32-acres, the project area is expected to create low permeability areas equal to 30% of the development area. A summary of the water quality event parameters is provided in Table 9 below.

Table 9. Water Quality Summary

SWS - Name	Development Area (ac)	Disturbance Area (ac)	Water Quality Volume (ac-ft)
SWS A	20.12	6.04	0.25
SWS B	22.88	6.86	0.29

Pond A and B provide volumes greater than the water quality volumes to meet detention requirements.

4.5 Detention Pond Design

The detention ponds have been designed to retain a volume equal to or greater than the water quality event, or the difference between the post- minus the pre-development runoff volume resulting from the 100-year, 24-hour storm event, whichever is greater. Due to inadequate percolation rates measured at the site, the retained volume will be discharged within 48-hours after inflow of the 24-hour event ceases. Further, the ponds will attenuate peak flows resulting from the post-development conditions to rates below pre-development conditions for both the 5-year, 24-hour storm and the 100-year, 24-hour storm event.

Both the east (Pond B) and west (Pond A) proposed ponds will be constructed with similar outfall and impoundment configurations. An earthen embankment will be constructed within the existing channels and will be furnished with a primary spillway structure and an emergency spillway weir. The primary spillway will be provided by a 48-inch diameter manhole with a dome 'beehive inlet' grate. The inlet grate will be set at an elevation above the pond bottom elevation such that the required water quality treatment volume is met. The emergency spillway invert will be set 6 inches above the primary spillway inlet with weir dimensions of 1-foot tall by 5-foot wide. The manhole will have an outlet pipe to discharge the primary spillway flows downstream of the pond. To dissipate the retained volume within 48 hours, a 12-inch diameter pipe with a cap and small orifice will be connected to the manhole. See Exhibit 6 for the proposed stormwater pond designs.

Given the existing flooding concern from overland flows on the north boundary of Overlook Estates, both proposed ponds will route stormwater into the Overlook Estates storm main via new subsurface storm sewer piping. As a result, project discharges will be analyzed at the outfall of Overlook Estates. Downstream stormwater routing will be discussed further in the Downstream Hydraulic Connections section below. To meet water quality standards, Pond A and B are required to treat a minimum of 0.25 and 0.29 acre-foot, respectively, or a combined volume greater than the post- minus pre-development runoff for the entire basin area equal to 1.3 acre-feet (see Table 10a for a summary of site discharge volumes). This has been achieved by providing 0.6 and 0.7 acre-feet of storage below the primary spillway in Ponds A and B, respectively, totaling 1.3 acre-feet. Additionally, Pond A and B reduce peak flow rates for each storm event to be less than the pre-development peak flow rates. A summary of each of the proposed pond's outflow rate is provided in Table 10b below.

Table 10a. Site Discharge Volumes Summary

Outfall Location	5-yr, 24-hr Storm			100-yr, 24-hr Storm		
	Pre-Devel (ac-ft)	Post-Devel. (ac-ft)	Net (ac-ft)	Pre-Devel. (ac-ft)	Post-Devel. (ac-ft)	Net (ac-ft)
West	0.2	0.0	-0.2	0.7	0.0	-0.7
Overlook	1.3	1.8	0.5	10.8	12.1	**1.3**

Table 10b. Proposed Pond Discharge Flows Summary

Location	5-yr, 24-hr Storm		100-yr, 24-hr Storm	
	Peak Inflow (cfs)	Peak Outflow (cfs)	Peak Inflow (cfs)	Peak Outflow (cfs)
Pond A	0.4	0.2	5.2	0.9
Pond B	0.6	0.4	5.0	4.1

4.6 Overlook Detention Pond

An as-built survey was conducted for the Overlook Estates detention pond to determine existing stage-storage volumes and inflow/outflow piping. Pond inflow from SWS-C1 is conveyed into the pond by a 36-inch RCP from the east. Pond inflow from SWS-C2 is conveyed into the pond by a 24-inch RCP from the west. The Overlook detention pond treats stormwater entering from the east with a series of five cascading detention ponds and treats stormwater entering from the west with a single larger pond. Each of these individual ponds have been modeled in the Pre- and Post- Development HydroCAD models but have been described as the singular Overlook Pond for the purposes of this report. The Overlook Detention Pond As-Built drawings have been provided in Appendix D. Runoff from SWS's A, B, and C2 will all route through the 24-inch RCP that inflows from the west. Pond outflow is provided by two 24-inch diameter RCP that discharge under Euclid Avenue to a trapezoidal roadside ditch. Peak flow rates for the Overlook detention pond are evaluated at the downstream roadside ditch with the combined flow from both 24-inch RCP pipes. Post-development pond water peak surface elevations with respect to the outlet pipe invert elevations are provided in Table 11, which shows that the existing Overlook Pond has negligible changes with the proposed stormwater facilities for the development.

Table 11. Overlook Pond Capacity Post-Development Impacts

Location	100-yr, 24-hr Storm			
	Invert Elev.	Pre-Dev. Elev.	Post-Dev. Elev.	W.S.E. Change (ft)
24" RCP (West)	3,944.96	3947.00	3947.01	0.01
24" RCP (East)	3,947.40	3948.65	3948.63	-0.02

The Hydraulic Model shows that the Overlook detention pond storage volume is at the peak dead storage elevation due to runoff produced in Overlook Estates (SWS-C2) before the upstream water produced in (SWS-A & B1) or upstream (SWS-B2) of the proposed development reaches the Overlook Pond. This is due to the relatively longer time of concentration of the upstream watersheds and the stormwater storage within Pond A and B.

4.7 Downstream Hydraulic Connections

Current flow patterns discharge the West Drainage onto Euclid Avenue and the Central Drainage overland flows through Overlook Estates to the Overlook stormwater inlets and then

the detention pond. Post-development conditions will capture runoff from the West, Central, and a small portion of the East Drainages in a proposed 18-inch diameter stormwater main and will route them to and then through the existing Overlook detention pond. The flow path from the proposed development to Spring Meadow Lake is shown on the Downstream Hydraulic Connections Exhibit (Sheet 8).

The proposed development and upstream area (SWS A, B1, & B2) is expected to have a peak flow rate of **4.9 cfs** during the 100-year, 24-hour storm. At minimum grade (0.5%) the proposed 18-inch diameter PVC storm main connecting to the Overlook storm main has a sufficient capacity of 6.33 cfs when 80% full.

At the project's connection point to the Overlook storm main, contributing runoff produced from SWS A, B1, B2, and C2 is expected to be **5.2 cfs** during the 100-year, 24-hour storm. The existing pipe is 24-inch diameter RCP with a sufficient capacity of 13.4 cfs when 80% full. The hydraulic capacity calculations are provided in Appendix D.

As shown in Table 12, the project will have essentially no impacts to the Overlook detention pond storage as a result of the construction of the proposed Ponds A and B for the development. The Overlook and West Outfalls have been analyzed to verify post-development peak flows do not exceed pre-development peak flows.

Table 12. Project Downstream Outfall Peak Flows

Location	5-yr, 24-hr Storm		100-yr, 24-hr Storm	
	Pre-Devel. (cfs)	Post-Devel. (cfs)	Pre-Devel. (cfs)	Post-Devel. (cfs)
West	0.2	0.0	3.3	0.0
Overlook	2.0	1.9	12.5	11.4

Although downstream peak flows will be reduced with the implementation of the West Side Woods Subdivision, downstream structures to Spring Meadow Lake have also been analyzed as shown on Exhibit 8. The following describes and analyzes these hydraulic structures from upstream to downstream. The Overlook Outfall discharges 11.4 cfs during the 100-year, 24-hour storm to a 2-foot-deep trapezoidal ditch with a 2-foot bottom width and 0.7% longitudinal slope. The ditch has been determined to be sufficiently sized with a capacity of 46 cfs.

A 24-inch diameter HDPE approach culvert is located in the trapezoidal ditch. The pipe has a slope of 0.6% and an 80% full capacity of 20 cfs.

The trapezoidal ditch discharges to a detention pond located just south of Spring Meadow Lake. Given the pond's relatively small watershed and short time to concentration, the reduction in the Overlook outfall peak flow rates, it is conservatively assumed this pond will be filled to the spillway elevation and upstream flows will pass through this pond. The outlet structure has been analyzed to verify sufficient capacity to accommodate upstream peak flows. The outlet structure consists of a 12-inch diameter PVC culvert, a 6-inch diameter orifice, and a 24-inch diameter beehive grate spillway. To provide a conservative estimate of the pond outlet capacity, the capacity of the low flow outlets has been neglected. The primary spillway can convey 15 cfs at 1-foot of head.

The detention pond outlets to a 30-inch RCP that crosses Broadwater Avenue. The pipe has a slope of 0.5% and an 80% full capacity of 28 cfs.

The 30-inch RCP discharges to a trapezoidal channel that at its most restrictive, has similar characteristics and capacity as described above.

All of the existing downstream stormwater structures have a flow capacity greater than the peak flow rate of 11.4 cfs coming from the Overlook outfall. Additionally, the stormwater Ponds A and B for the proposed development will attenuate the post-development peak flow rate to be below the pre-development peak flow rate. Therefore, the proposed development will not have an impact on the existing infrastructure that conveys stormwater to Spring Meadow.

4.8 Stormwater Design Summary

The project area is located in a portion of the City of Helena's West Side Drainage Basin and currently discharges to the Overlook Estates Subdivision. The proposed development plan will modify the existing flow patterns within the subdivision and downstream of the subdivision to reduce surface water impacts to Overlook Estates by piping upstream flows to the Overlook detention pond. Two ponds will be constructed, one in each drainage, to treat the water quality event and provide a capacity large enough to detain the post- minus the pre-development runoff volume resulting from the 100-year, 24-hour storm for 48 hours. Additionally, the ponds will attenuate flows such that the post-development runoff rate is less than the pre-development runoff rate at both the West and Overlook Outfalls. Low level outlets will discharge additional runoff volumes within 48 hours of the 24-hour storm. All existing and proposed storm mains show adequate capacity to convey the 100-year, 24-hour storm event. Downstream ponds north of Euclid Avenue are conservatively anticipated to be at the spillway elevation for the 100-year event and will have already seen the peak flow from its respective drainage area when the additional volume from the West Side Woods Development reaches them. The outlet structures for each pond have the capacity to allow the peak flow rate from the Overlook Pond to pass through with no ill effects.

5.0 TRANSPORTATION

Streets within the West Side Woods Subdivision will be designed to meet City of Helena Design Standards. There are seven roads that will provide access to and provide connectivity within the subdivision. All roads within the subdivision boundary and the adjacent roads, Hauser Boulevard and Park Drive, that provide access to the subdivision are all classified as local or private roads except for a portion of Hauser Boulevard between Granite Avenue and Park Drive that will be classified as a minor collector. The interior local roads are designated as Crowley Court, Livezey Avenue/Court, Flowerree Court, Brakeman Avenue/Court, and Lee Drive/Court. Per the Traffic Impact Study (TIS) that is included as part of the preliminary plat application, there is a portion of Hauser Boulevard, not directly adjacent to the subdivision boundary, that would be one of the primary access routes to the subdivision and would be classified as a minor collector. This portion of Hauser Boulevard is between the intersection of Hauser Boulevard with Park Drive and the intersection of Hauser Boulevard with Granite Avenue. Road names have been checked and approved through the City/County Address Coordinator, Jason Danielson.

5.1 Drainage Crossings

All drainage crossings for the proposed transportation network will be made via PVC stormwater pipes and are shown on Exhibit 6. The pipes will have adequate bury depths and wall thicknesses to meet the required vehicle load rating for a residential subdivision. Stormwater pipes will be sized and classified during the design engineering for each individual phase.

A stormwater ditch will be constructed to convey runoff from Lot 16, Block 2 to the west to the proposed Pond A to treat the water quality event. Along the northern portion of the subdivision, the ditch with be installed directly adjacent to a proposed pedestrian path. The grading for the stormwater ditch will encroach onto the adjacent lots and a stormwater easement will be required for access and maintenance of the stormwater ditch. The ditch design with occur during the Phase 1 engineering and the easement would be shown on the final plat for Phase 1.

5.2 Typical Section and Right-of-Way Widths

There are four typical sections that will be used for this development. Graphical depictions of the typical sections are in Appendix E. The first (Typical Section 1) will be a local road typical section that will consist of a 34-foot-wide back of curb to back of curb width and a 60-foot right-of-way width. This width includes two 9-foot travel lanes and two 6-foot wide on street parking lanes with a 3% crown at the centerline. Outside of the street section on each side is a 7-foot-wide boulevard and a 5-foot-wide sidewalk. The boulevard and sidewalk are sloped at a 2% grade toward the curb and gutter. This typical section applies to Livezey Avenue, Livezey Court, Floweree Court, Lee Court, Lee Drive, Brakeman Blvd, Brakeman Court, Crowley Court, and a portion of Hauser Boulevard directly adjacent to the subdivision boundary and to the north to the Overlook Estates subdivision.

The second (Typical Section 2) will be a local road typical section that will consist of a 30-foot-wide paved width and a varying existing right-of-way width. This width includes two 9-foot travel lanes and two 6-foot wide on street parking lanes with a 3% crown at the centerline. This section does not include curb and gutter, sidewalks, or boulevards. This typical section applies to portions of Hauser Boulevard and Park Drive that are currently gravel roads and would be improved to paved roads as part of the development. Curb and gutter and sidewalks are not included as the existing roads in the area are either graveled or paved without curb and gutter and include roadside ditches. The paving of these streets without curb and gutter will facilitate the existing stormwater routes for these offsite road improvements.

The third (Typical Section 3) will be a minor collector road typical section that will consist of a 32-foot-wide paved width and a varying existing right-of-way width. This width includes two 10-foot travel lanes and two 6-foot wide on street parking lanes with a 3% crown at the centerline. This section does not include curb and gutter, sidewalks, or boulevards. This typical section applies to a portion of Hauser Boulevard between Park Drive and Granite Avenue that is currently a gravel road and would be improved to paved roads as part of the development. Curb and gutter and sidewalks are not included as the existing roads in the area are either graveled or paved without curb and gutter and includes roadside ditches. The paving

of this street without curb and gutter will facilitate the existing stormwater routes for these offsite road improvements.

The fourth (Typical Section 4) will be for an emergency access road that will be constructed as part of Phase 1 to provide secondary access. This road will be temporary until Phase 3 is implemented but will be constructed where future planned roads will go to avoid unnecessary disturbances. The horizontal and vertical alignments of the emergency access road will follow the future road alignments and will therefore meet City standards for horizontal and vertical design standards. The typical section will consist of a 20-foot-wide graveled width with a 30-foot-wide access easement. The surfacing will consist of 9 inches of 1 ½ inch minus crushed aggregate. The emergency access road will be constructed and maintained by the developer and/or the Homeowners Association until the road is upgraded to a paved street that meets City standards, at which time the city would take ownership and assume maintenance. It is anticipated that the emergency access road will be upgraded to full City standards during Phase 3 of the overall development.

Nonroad typical sections for stormwater access roads and pedestrian trails have also been included in Appendix E. The stormwater access road will have a 12-foot-wide graveled section and a 20-foot-wide right-of-way. The pedestrian trails that traverse along lot lines will have a 10-foot-wide graveled section and a 15-foot-wide access easement.

Based on a soil and traffic analysis of the proposed subdivision, typical sections 1 through 4 will consist of 3 inches of Type-B plant mix surfacing overlying 6 inches of 1 ½ inch crushed aggregate base. A complete geotechnical report will be included as part of the engineering design submittal for each phase of the subdivision. Existing soils and soil suitability reports have been included in Appendix F.

5.3 Horizontal Alignment

The horizontal alignments for all streets will be designed to City of Helena and AASHTO design standards. All internal local roads will have a design speed of 25 mph. Based on City of Helena design standards, the minimum horizontal curve radius is 150 feet, and no super elevation will be used. The 150 feet minimum horizontal curve radius is proposed for all road alignments. Hauser Boulevard is adjacent to the subdivision and runs along the eastern boundary of the project. Where Hauser Boulevard connects to the southern end of the existing Overlook Estates subdivision, the proposed local road typical section with pavement, curb and gutter, boulevard, and sidewalks will tie into the existing road section. The existing angle of the paved road and the graveled road would require a horizontal curve to be designed. Implementing a horizontal curve with a 150-foot radius would encroach significantly into the improved road section and require portions of the existing curb and gutter and sidewalk to be removed and replaced. The horizontal road alignment in this area will be evaluated with the City of Helena Engineering department during the final design. See Exhibit 9 showing the impacts that a 150-foot radius curve would create.

At all intersections, the streets will intersect at 90-degree angles except for the following locations:

- Intersection of Livezey Avenue and Hauser Boulevard = 80 degrees

- Intersection of Flowerree Court and Park Drive = 75 degrees.
- Intersection of Brakeman Avenue and Park Drive = 84 degrees. This intersection occurs at an existing horizontal curve on Park Drive and Brakeman Avenue is designed to follow the existing ground contours to reduce excess cut and fill slopes.

The minimum tangent length used at intersections where a local road meets a local road or collector is 100 feet. The minimum tangent length is achieved at all intersections.

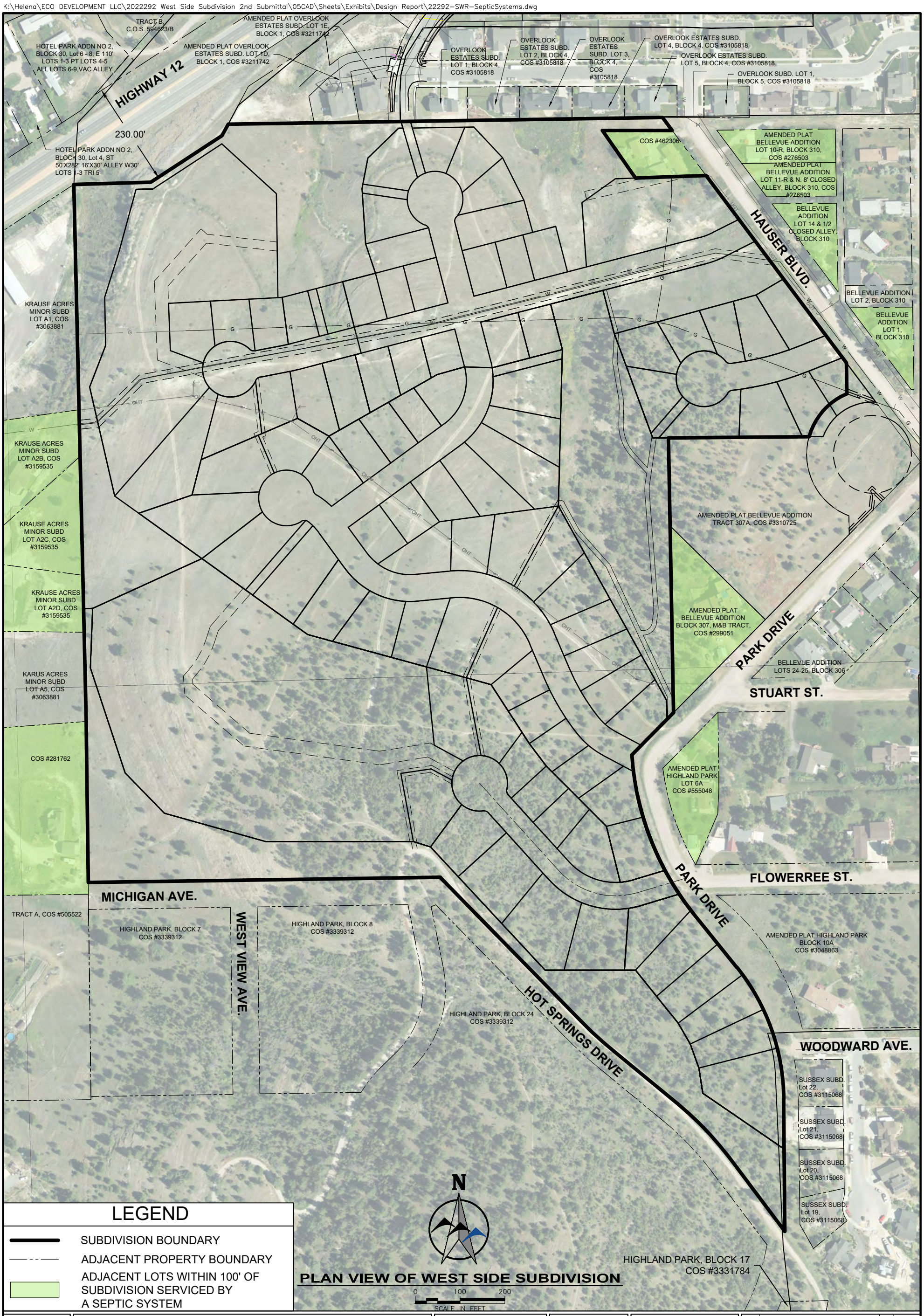
At intersections where local roads meet local roads or collectors, the back of curb radius is 15 feet.

5.4 VERTICAL ALIGNMENTS

The vertical alignments for all streets, including both public and private roads, will be designed to City of Helena design standards. The minimum street grade is 0.5% and the maximum street grade is 10.0%. Vertical curves will be designed at all locations where there is a grade change, except where the road intersects a through street. For local roads, all sag and crest vertical curves will be designed with a minimum K-factor of 37 and 19, respectively and a minimum length of 50 feet for both. The maximum grade within 75 feet of an intersection is 4%.

EXHIBITS

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\Design Report\22292-SWR-SepticSystems.dwg



LEGEND

- SUBDIVISION BOUNDARY
- ADJACENT PROPERTY BOUNDARY
- ADJACENT LOTS WITHIN 100' OF SUBDIVISION SERVICED BY A SEPTIC SYSTEM

SHEET NO. 1

ECO DEVELOPMENT, LLC

WEST SIDE WOODS MAJOR SUBDIVISION

ADJACENT SEPTIC SYSTEM MAP

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

PROJECT: 2022-292
DESIGNED: DDP
DRAWN: DDP
CHECKED: KJG
APPROVED: STH
DATE: SEPTEMBER 15, 2022

NO.	REVISION DESCRIPTION	BY	DATE
1			
2			
3			
4			
5			

LEGEND

PROJECT PHASE BOUNDARY

EXISTING SEWER MAIN

PROPOSED SEWER MAIN

SEWER FLOW ARROW

NORTH

CITY OF HELENA WASTEWATER TREATMENT PLANT (WWTP)

WEST SIDE SUBDIVISION BOUNDARY

FAIRGROUNDS

SPRING MEADOW LAKE STATE PARK

BILL ROBERTS GOLF COURSE

CARROLL COLLEGE

MOUNT HELENA PARK

CUSTER AVE.

BRADY ST.

EUCLID AVE.

JOSLYN ST.

BENTON AVE.

N. MONTANA AVE.

N. WASHINGTON ST.

BNSF RAILROAD

INTERSTATE 15

LYNDALE AVE.

PROSPECT AVE.

PLAN VIEW

0 750 1500

SCALE IN FEET

NO.	REVISION DESCRIPTION	BY	DATE
1			
2			
3			
4			
5			
6			

PROJECT: 2022-292

DESIGNED: DDP

DRAWN: DDP

CHECKED: KJG

APPROVED: STH

DATE: SEPTEMBER 15, 2022

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

ECO DEVELOPMENT, LLC

WEST SIDE WOODS MAJOR SUBDIVISION

DOWNSTREAM WASTEWATER FLOW SCHEMATIC

SHEET NO.

2

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\Design Report\22292-SWR-Overall Exhibit.dwg

LEGEND

- KESSLER SCHOOL
- COMMERCIAL – EXISTING
- RESIDENTIAL – EXISTING
- RESIDENTIAL – WEST SIDE SUBDIVISION
- WESTSIDE PROJECT PHASE 2 BOUNDARY
- S — EXISTING SEWER MAIN

NORTH

FLOW METER MANHOLE 99–14–6

FLOW METER MANHOLE 73–20–4

FLOW METER MANHOLE 531–6

BROADWATER AVE.
COUNTRY CLUB AVE.
WILDER AVE.
EUCLID AVE.
BRADY ST.
JOSEPHINE ST.
CANNON ST.
HAWATHA ST.
WINSTON ST.
CHOTEAU ST.
SILVERETTE ST.
GRANITE AVE.
OVERLOOK BLVD.
KNIGHT ST.
HAUSER BLVD.
PARK DR.
ELIZABETH ST.
STUART ST.

WESTSIDE PROJECT PHASE 2 BOUNDARY

PLAN VIEW

0 300 600

SCALE IN FEET

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NO.	REVISION DESCRIPTION	BY	DATE

PROJECT: 2020-216
DESIGNED: DDP
DRAWN: DDP
CHECKED: JMF
APPROVED: STH
DATE: AUGUST 28, 2020

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

CITY OF HELENA

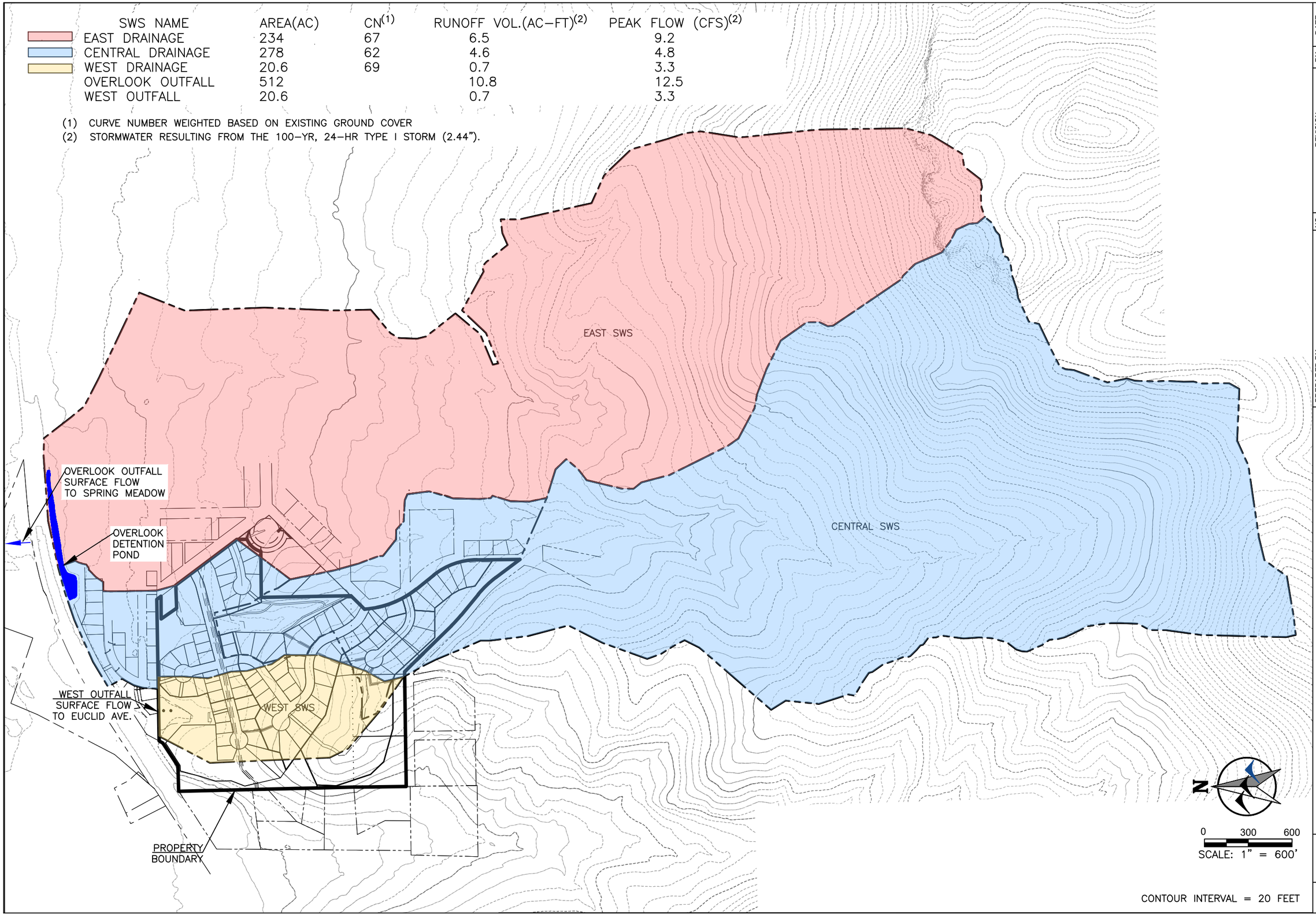
WEST SIDE WOODS SEWER

SEWER MAINS / FLOW METER LOCATION PLAN OVERVIEW

SHEET NO.
3

SWS NAME	AREA(AC)	CN(1)	RUNOFF VOL.(AC-FT)(2)	PEAK FLOW (CFS)(2)
EAST DRAINAGE	234	67	6.5	9.2
CENTRAL DRAINAGE	278	62	4.6	4.8
WEST DRAINAGE	20.6	69	0.7	3.3
OVERLOOK OUTFALL	512		10.8	12.5
WEST OUTFALL	20.6		0.7	3.3

(1) CURVE NUMBER WEIGHTED BASED ON EXISTING GROUND COVER
(2) STORMWATER RESULTING FROM THE 100-YR, 24-HR TYPE I STORM (2.44").



CONTOUR INTERVAL = 20 FEET

NO.	REVISION	BY	DATE

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ECO DEVELOPMENT, LLC.

WEST SIDE WOODS MAJOR SUBDIVISION

HYDROLOGY MAP (EXISTING CONDITIONS)

LEWIS & CLARK COUNTY, MONTANA

DESIGNED BY: DSD
DRAWN BY: DSD
CHECKED BY: STH
DATE: 8/2022

SHEET
4

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\PrePlatApp\2v(1a) - EXHB-HYRO.dwg Hydrology Map (Existing Conditions) 9/9/2022 10:35:54 AM

SWS NAME	AREA(AC)	CN(1)	RUNOFF VOL.(AC-FT)(2)	DIST. AREA (AC)(3)	WATER QUALITY (AC-FT)(4)
SWS – A (POND A)	26.5	74	1.1	6.0	0.25
SWS – B1 (POND B)	42.6	70	1.5	6.9	0.29
SWS – B2 (POND B)	225.1	60	3.0	N/A	N/A
SWS – C1 (O.L. EST.)	230.5	67	6.4	N/A	N/A
SWS – C2 (O.L. EST.)	10.2	73	0.5	N/A	N/A

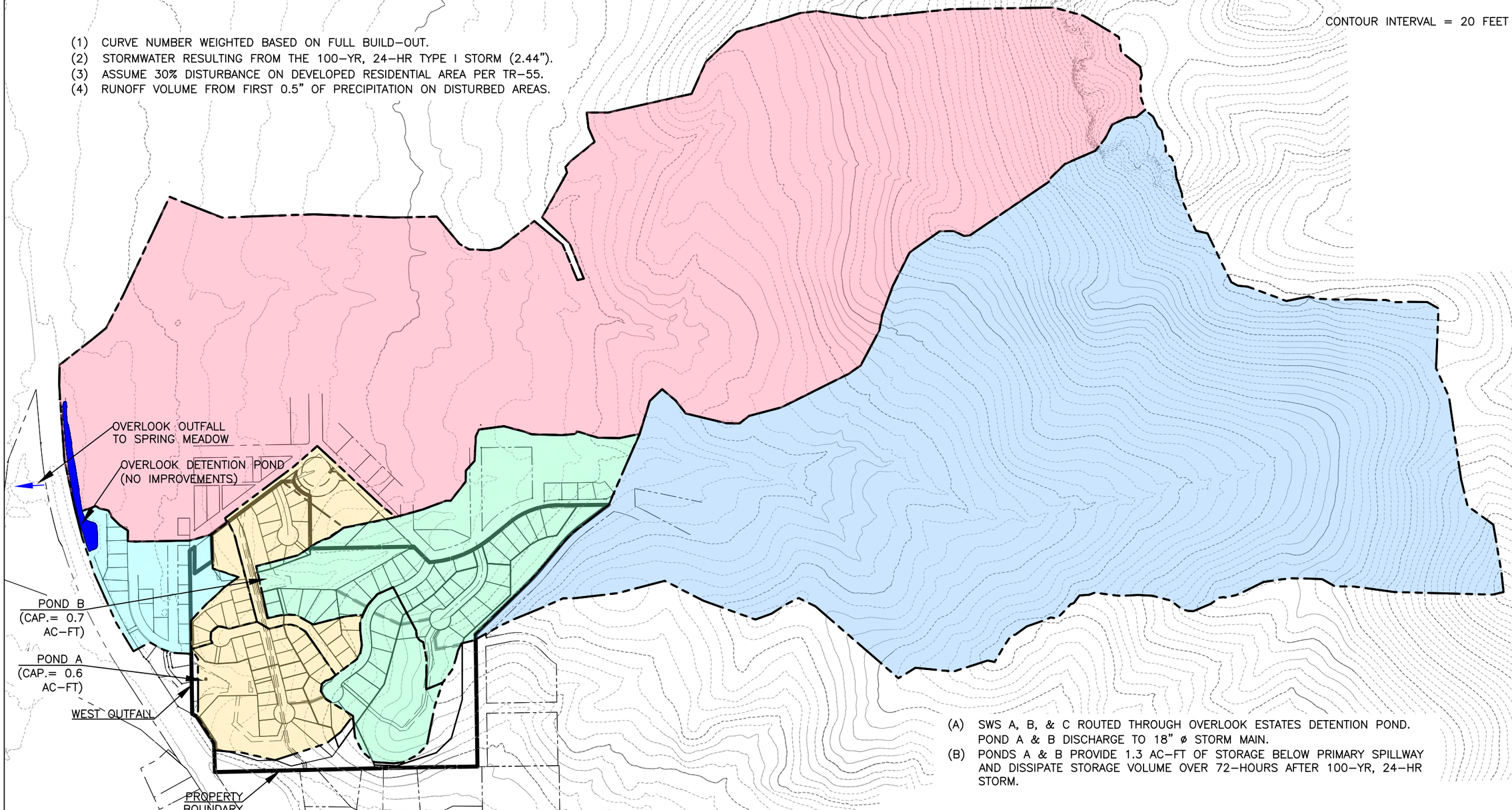
(1) CURVE NUMBER WEIGHTED BASED ON FULL BUILD-OUT.
(2) STORMWATER RESULTING FROM THE 100-YR, 24-HR TYPE I STORM (2.44").
(3) ASSUME 30% DISTURBANCE ON DEVELOPED RESIDENTIAL AREA PER TR-55.
(4) RUNOFF VOLUME FROM FIRST 0.5" OF PRECIPITATION ON DISTURBED AREAS.

N

0 300 600

SCALE: 1" = 600'

CONTOUR INTERVAL = 20 FEET



(A) SWS A, B, & C ROUTED THROUGH OVERLOOK ESTATES DETENTION POND. POND A & B DISCHARGE TO 18" ø STORM MAIN.
(B) PONDS A & B PROVIDE 1.3 AC-FT OF STORAGE BELOW PRIMARY SPILLWAY AND DISSIPATE STORAGE VOLUME OVER 72-HOURS AFTER 100-YR, 24-HR STORM.

PEAK FLOW RATES

	PRE-DEVELOPMENT		POST-DEVELOPMENT(A)	
OUTFALL	5-YR (CFS)	100-YR (CFS)	5-YR (CFS)	100-YR (CFS)
WEST	0.2	3.3	0.0	0.0
OVERLOOK	2.0	12.5	1.9	11.4

RUNOFF VOLUMES

	PRE-DEVELOPMENT		POST-DEVELOPMENT(A)	
OUTFALL	5-YR (AC-FT)	100-YR (AC-FT)	5-YR (AC-FT)	100-YR (AC-FT)(B)
WEST	0.2	0.7	0.0	0.0
OVERLOOK	1.3	10.8	1.8	12.1

NO.	REVISION	BY	DATE

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ECO DEVELOPMENT, LLC.

WEST SIDE WOODS MAJOR SUBDIVISION

HYDROLOGY MAP (PROPOSED CONDITIONS)

LEWIS & CLARK COUNTY, MONTANA

DESIGNED BY: DSD
DRAWN BY: DSD
CHECKED BY: STH
DATE: 8/2022

SHEET
5

EUCLID AVE.

TIE INTO EXISTING
CATCH BASIN

18" PVC
TO OVERLOOK ESTATES
DETENTION POND
LENGTH =700'

OVERLOOK ESTATES
RETENTION POND

EXISTING
24" CMP
(TO BE ABANDONED)

60" ø MH W/
24" BEEHIVE GRATE

18" RCP
INV. OUT EL. 3983.5'

EMERGENCY SPILLWAY WEIR
INV. OUT EL. 3994.5'

48"ø MH
24"ø BEEHIVE GRATE
INV. EL. 3994.0'

12" PVC
W/ 2"ø ORIFICE
INV. EL. 3987.0'

DITCH
(TO POND A)

POND A
TOP OF BERM EL. 3995.5'
INTERIOR TOE EL. 3986.0'

ACCESS ROAD
SLOPE = 17%

18" RCP
INV. OUT EL. 4023.15'

EMERGENCY SPILLWAY WEIR
INV. OUT EL. 4041.0'

MAINTAIN 5' SETBACK
FROM HIGH WATER EL. 4041.0'
TO LOT LINE

POND B
TOP OF BERM EL. 4042.0'
INTERIOR TOE EL. 4034.0'

48"ø MH
12"ø BEEHIVE GRATE INV. EL. 4040.5'
6"ø ORIFICE INV. EL. 4038.25'

12" PVC
W/ 3"ø ORIFICE
INV. EL. 4035.0'

ACCESS ROAD
SLOPE = 6%

N

0 50 100
SCALE: 1" = 100'

POND SUMMARY

NAME	ACTIVE STORAGE VOLUME (AC-FT)	IMPOUNDMENT AREA (AC)	INTERIOR BERM HEIGHT (FT)	FREEBOARD (FT)	STORAGE TYPE	PRIMARY OUTLET	PRIMARY SPILLWAY
POND-A	0.6	0.2	9.5	1	DETENTION	18" PVC	48" MH
POND-B	0.7	0.3	8	1	DETENTION	18" PVC	60" MH

NO.	REVISION	BY	DATE

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ECO DEVELOPMENT, LLC.

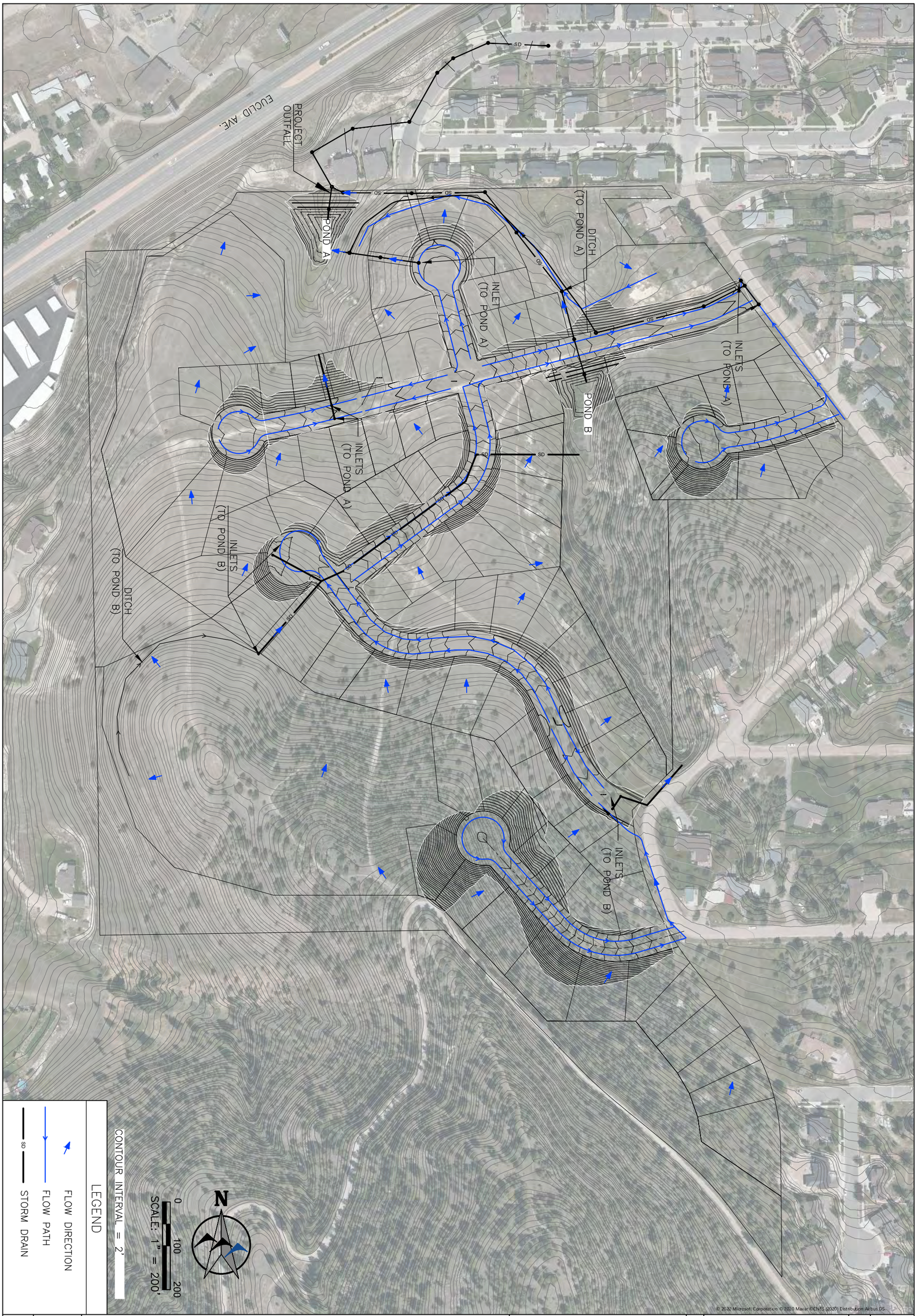
WEST SIDE WOODS MAJOR SUBDIVISION

POND LOCATION MAP

LEWIS & CLARK COUNTY, MONTANA

DESIGNED BY: DSD
DRAWN BY: DSD
CHECKED BY: STH
DATE: 4/2021

SHEET
6



ECO DEVELOPMENT, LLC.

WEST SIDE WOODS MAJOR SUBDIVISION

DRAINAGE PLAN

LEWIS & CLARK COUNTY, MONTANA

PREPARED BY

WWC ENGINEERING

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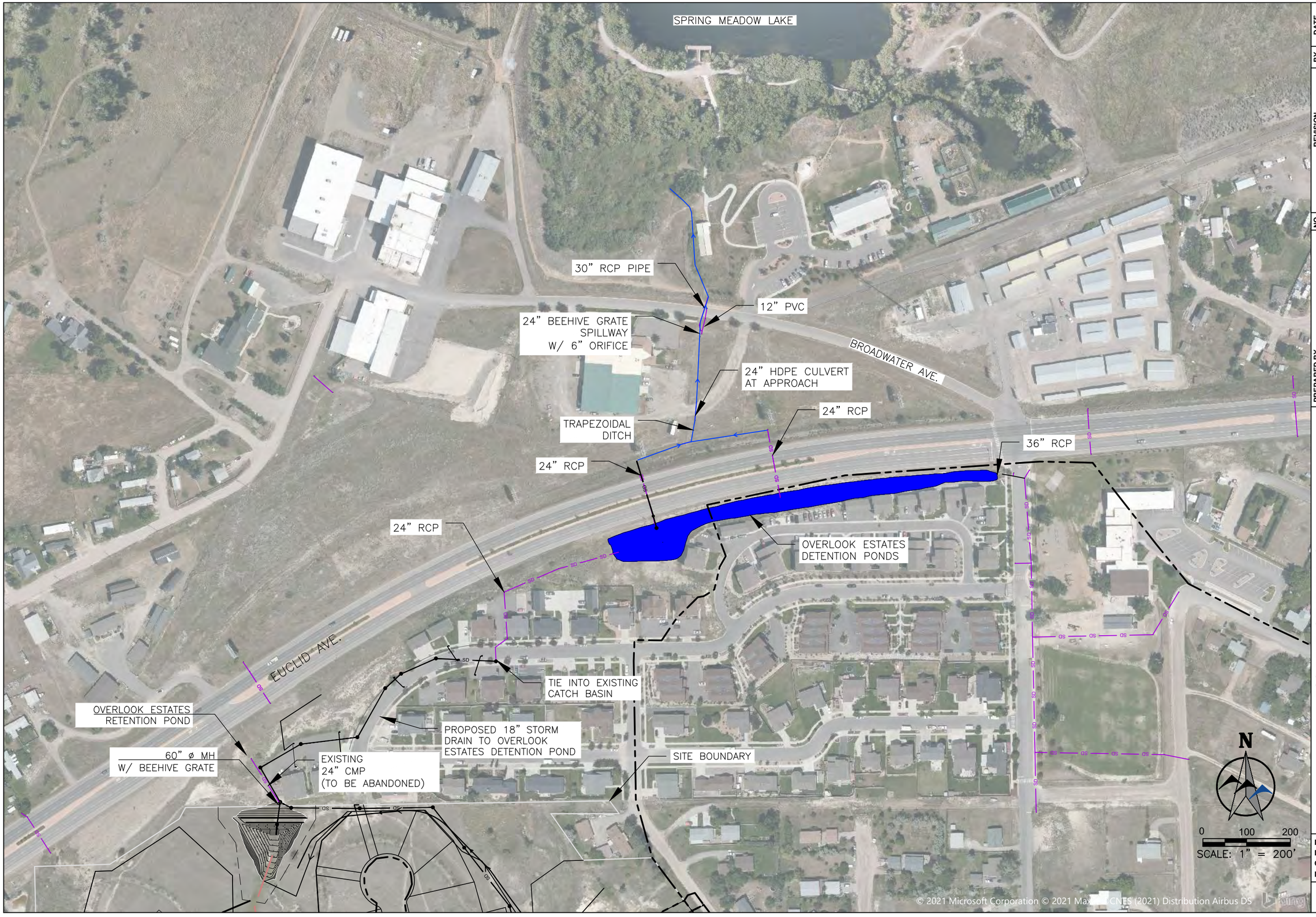
NO.	REVISION	BY	DATE

DESIGNED BY: DSD
DRAWN BY: DSD
CHECKED BY: STH
DATE: 8/2022

SHEET 7

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\PrePlatApp\2x(4) - EXHB-STRM EXIT.dwg Downstream Storm 8/16/2022 1:04:43 PM



NO.	REVISION	BY	DATE

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(406) 443-3962
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ECO DEVELOPMENT, LLC.

WEST SIDE WOODS MAJOR SUBDIVISION

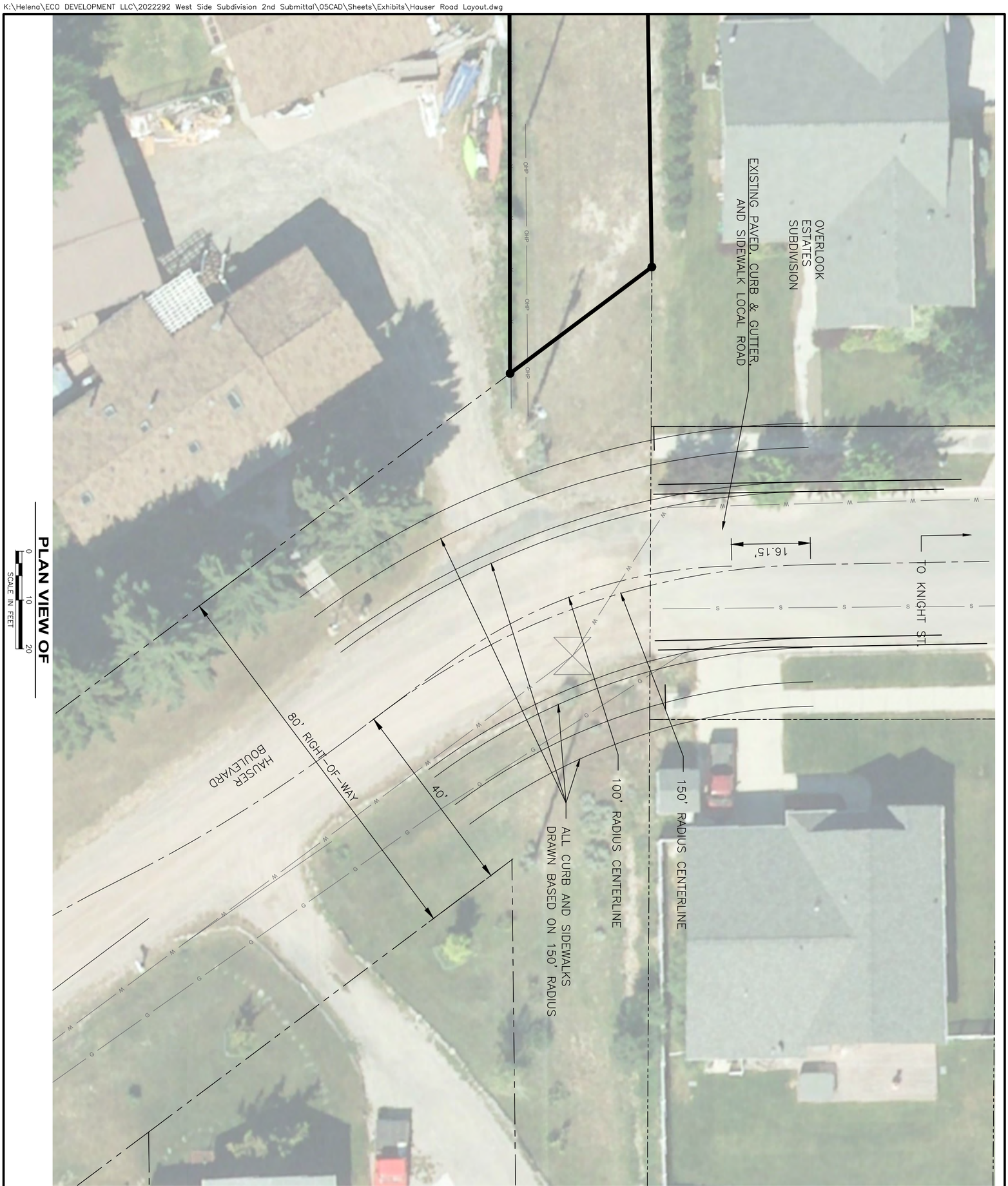
DOWNSTREAM HYDRAULIC CONNECTIONS

LEWIS & CLARK COUNTY, MONTANA

DESIGNED BY: DSD
DRAWN BY: DSD
CHECKED BY: STH
DATE: 8/2022

SHEET
8

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\Hauser Road Layout.dwg



9 SHEET NO.	**ECO DEVELOPMENT, LLC** **WEST SIDE WOODS MAJOR SUBDIVISION** HAUSER BLVD. TIE INTO OVERLOOK ESTATES (ALL IMPROVEMENTS SHOWN AT 150' RADIUS)	WWC ENGINEERING 1275 MAPLE STREET, SUITE F HELENA, MT 59601 (406) 443-3962	

PROJECT: 2020-216	
DESIGNED: DDP	
DRAWN: DDP	
CHECKED: JMF	
APPROVED: STH	
DATE: 08/17/2022	

NO.	REVISION DESCRIPTION	BY	DATE
1			
2			
3			
4			
5			

APPENDIX A
AE2S TECHNICAL MEMO

TECHNICAL MEMORANDUM

To: Drew Pearson, P.E.

From: Trevor Datwyler, P.E.

Re: **Eco Development, LLC – West Side Major Subdivision**
West Side Major Subdivision

Date: April 1, 2021

The West Side Major Subdivision is a proposed development on the west side of Helena, MT along Park Drive and Hauser Boulevard (Figure 1). The subdivision is located in the Malben High pressure zone, which is supplied by the Malben, Nob Hill, and Woolston Tanks as shown in Exhibit 2. The purpose of this memorandum is to document the design of the water distribution system in the West Side Major Subdivision and show that the applicable design requirements are satisfied.

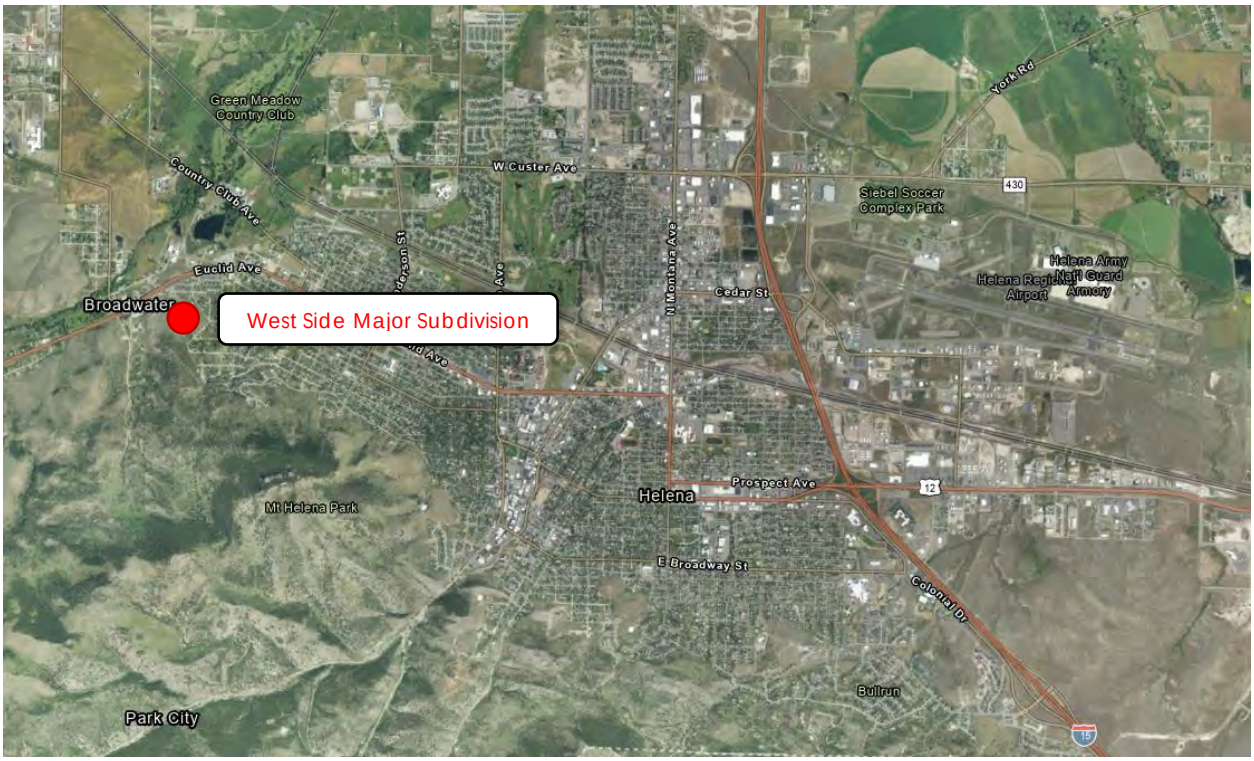


Figure 1 **Eco Development, LLC West Side Major Subdivision – Project Location**

SERVICE AREA

The subdivision is proposed to have 94 single family lots and 76 units for multifamily condos for a total of 170 units. Access roads to the subdivision will be on Hauser Boulevard and Park Drive. The subdivision will not connect to the 24-inch cross town connector transmission main which runs through the development. There are four proposed locations where the subdivision will connect to the existing water distribution network. These locations are shown in the attached water system layout (Exhibit 1).

WATER USAGE

Based on the Equivalent Residential Unit (ERU) analysis completed in the 2020 water masterplan update, an ERU uses 743 gallons per day during a maximum day of water usage. It is estimated that the West Side Major Subdivision will serve a maximum day demand of 743 gallons per day per residence. Multifamily units (duplex and fourplexes) were assigned multiple ERU's in the model.

PERFORMANCE REQUIREMENTS

The performance requirements necessary for the assessment of the water system needs are summarized below:

- Minimum operating pressure: 50 psi (recommended in 2020 masterplan)
- Fire flow requirements: 1,750 gpm (2-hour duration) while maintaining a minimum of 20 psi residual pressure.

WATER SYSTEM ANALYSIS

A water system analysis was performed on the West Side Major Subdivision by Drew Stock on April 1st, 2021. The subdivision was added to the Helena city InfoWater model previously updated by AE2S. Distribution lines in the development were assigned a diameter of 8-in. with an assumed Hazen-Williams roughness coefficient of 140. Pipe lengths were calculated within InfoWater, while node elevations were estimated from the preliminary grading plan for the subdivision.

Maximum Day Demand

Maximum day demands of 0.52 gpm (743 gpd) for each lot or residency, in the case of multiple residencies per lot, were assigned to the node connected to the pipe nearest each lot. Average operating pressures within the subdivision range from 58 to 143 psi (Figure 2).

Figure 2 Maximum Day Demand Average Operating Pressures

Peak Hour Demand

Minimum operating pressures throughout the entire subdivision exceed 50 psi as shown in Figure 3.

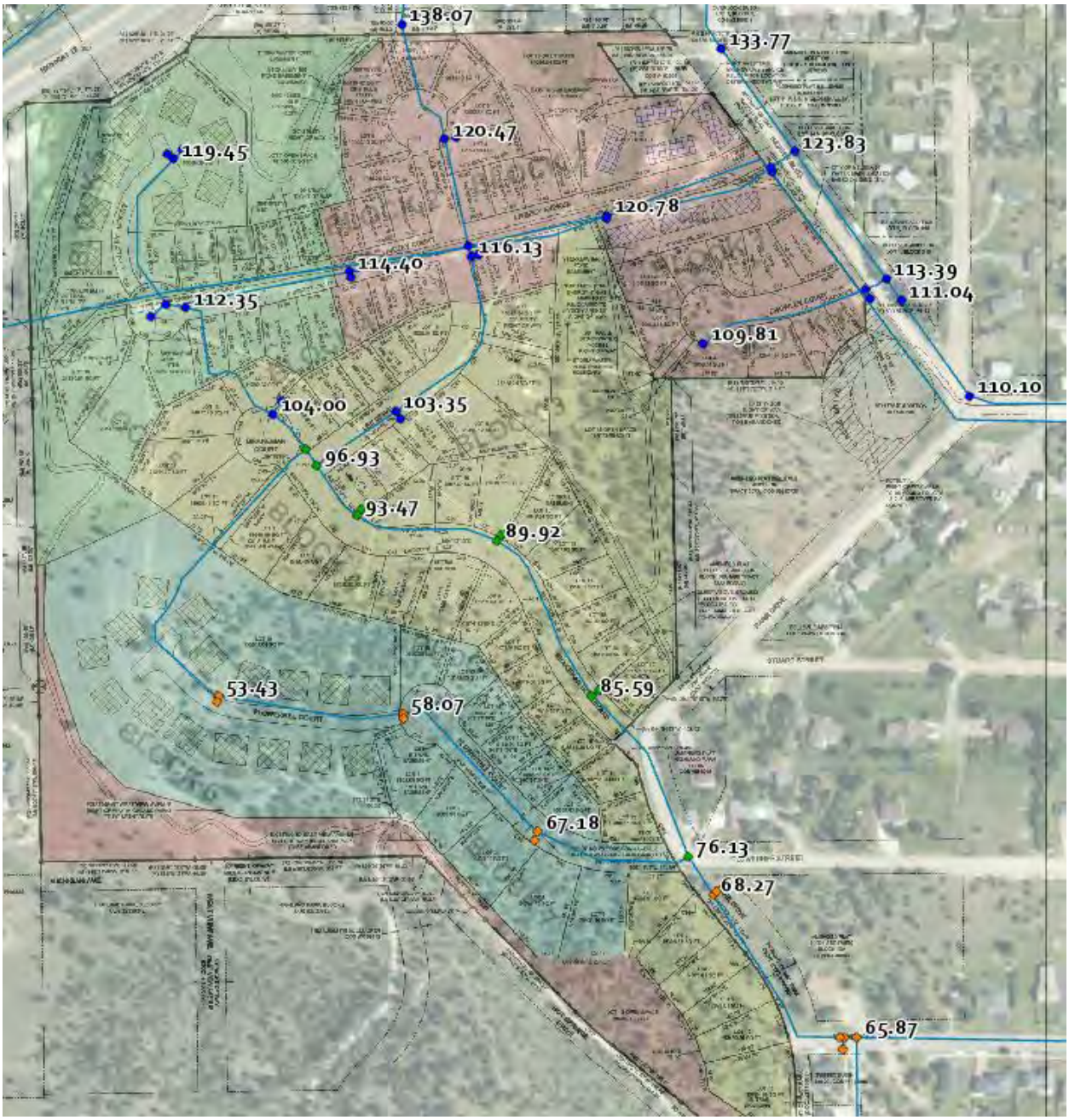


Figure 3 Maximum Day Demand Minimum Operating Pressures

Fire flow

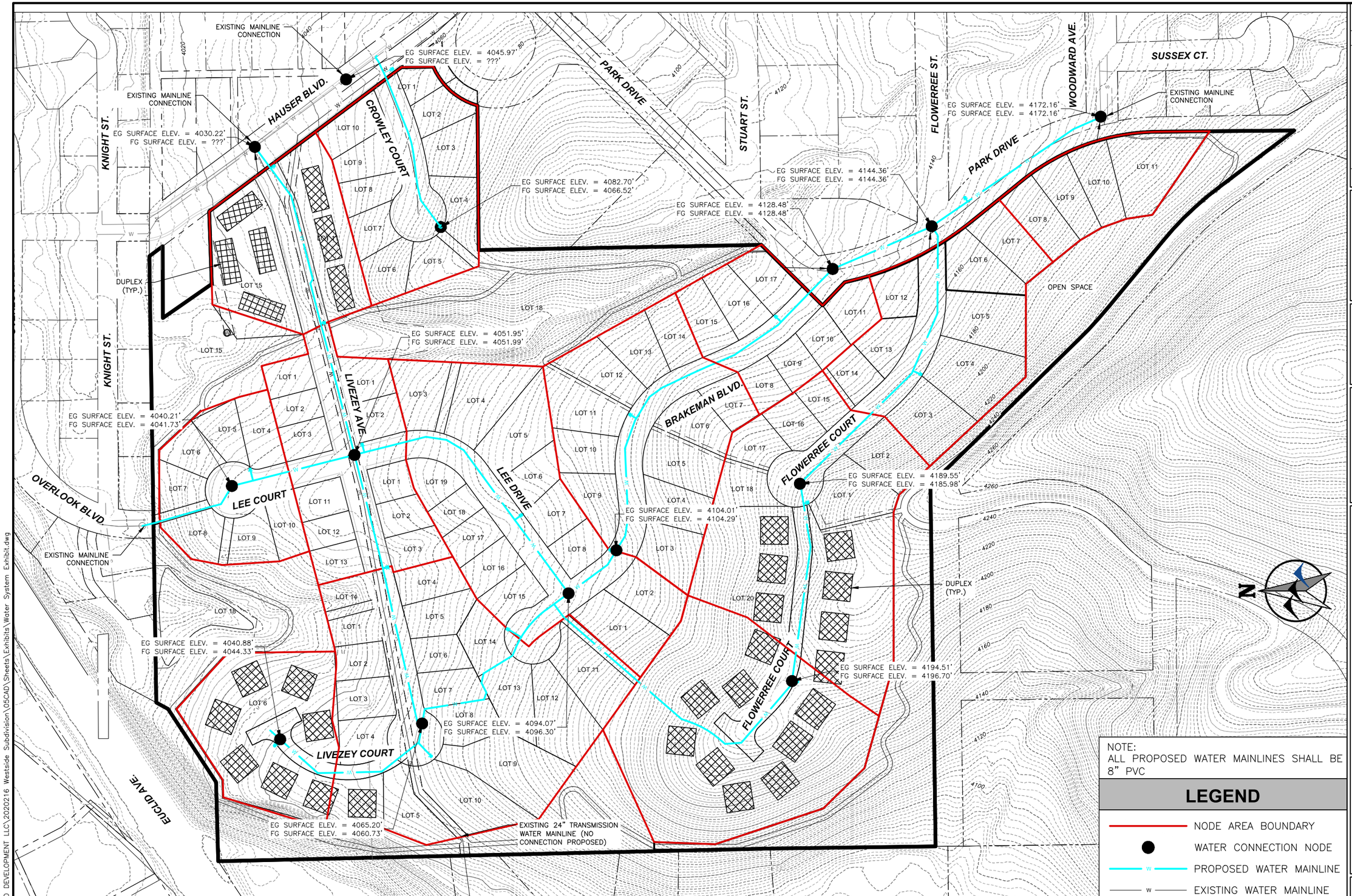
Hydrant available fire flows were calculated by limiting the minimum pressure at each hydrant to 20 psi (Figure 4). All hydrant available fire flows exceed 1,750 gpm within the West Side Major Subdivision.

Figure 4 Hydrant Available Flowrates for Fire flow Analysis

RECOMMENDATIONS AND SUMMARY

From the analysis performed in the City's hydraulic model, the proposed water distribution improvements in the West Side Major subdivision provide adequate pressure and fire flow.

If there are any questions regarding information within this Technical Memorandum, please do not hesitate to contact me at (435) 760-6306.



PLAN VIEW

0 100 200

SCALE IN FEET

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT: 2020-216
DESIGNED: JMF
DRAWN: MRS
CHECKED: DDP
APPROVED: JMF
DATE: AUGUST 20, 2020

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

ECO DEVELOPMENT, LLC

WEST SIDE MAJOR SUBDIVISION

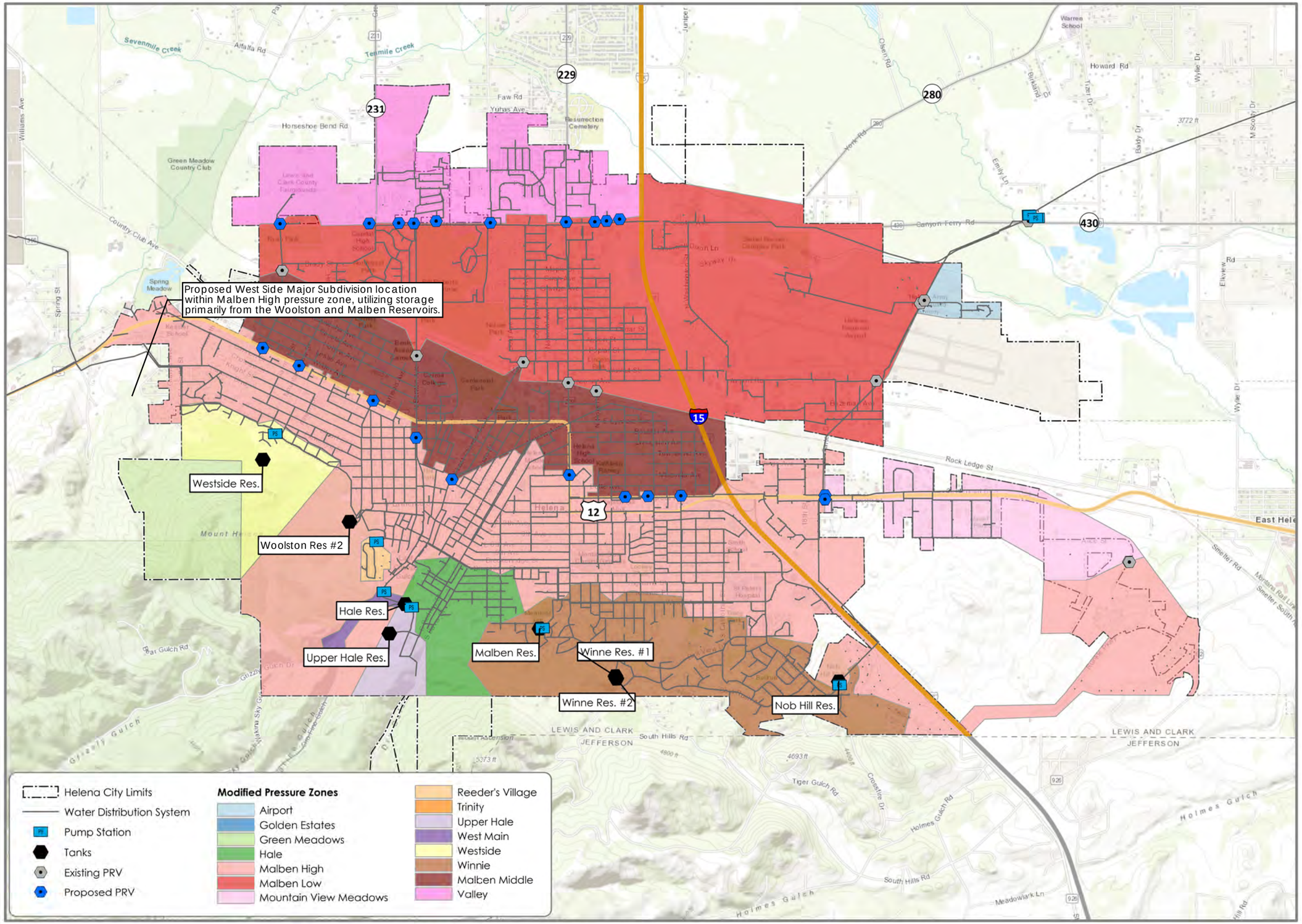
WATER SYSTEM LAYOUT

SHEET NO.

1

K:\Helena\ECO DEVELOPMENT LLC\20202016 Westside Subdivision\05CAD\Sheets\Exhibits\Water System Exhibit.dwg

www.ae2s.com | Advanced Engineering and Environmental Services, Inc.



N

0 0.3 0.6 Miles

Locator Map Not to Scale

Helena
Lewis & Clark County, MT

EXHIBIT 2

MODIFIED PRESSURE ZONES

CITY OF HELENA

Date: 7/31/2020

City of Helena

AE2S

Information depicted may include data unverified by AE2S. Any reliance upon such data is at the user's own risk. AE2S does not warrant this map or its features are either spatially or temporally accurate.

Coordinate System: NAD 1983 StatePlane Montana FIPS 2500 | Edited by: dlissick | C:\Data\Projects\WAFS\H\Helena\05253-2019-001\GIS\Helena - GIS Staff Map Production\Helena - GIS Staff Map Production.aprx | Fig 1- Modified Pressure Zones

LEGEND

"TANK NAME" #.# MG — TANK CAPACITY

#,###' — OVERFLOW ELEVATION

"ZONE NAME" — PRESSURE ZONE

FIRE HYDRANT

PRESSURE REDUCING VALVE

PUMP STATION

PRODUCTION SOURCES

ELEV 4600

ELEV 4500

ELEV 4400

ELEV 4300

ELEV 4200

ELEV 4100

ELEV 4000

ELEV 3900

ELEV 3800

ELEV 3700

TENMILE WTP

WESTSIDE RESERVOIR 0.489 MG 4,480'

WESTSIDE 4,360' 52 psi 4,161' 138 psi

WESTSIDE "FORREST ESTATES" PUMP STATION

WOOLSTON RESERVOIR 3.09 MG 4,321'

REEDER'S VILLAGE PUMP STATION

REEDER'S VILLAGE 4,301' 4,203'

EUREKA WELL / PUMP STATION

WEST MAIN 4,233' 4,147'

UPPER HALE RESERVOIR 0.2 MG 4,542'

UPPER HALE 4,462' 35 psi 4,328' 93 psi

HALE RESERVOIR 2.29 MG 4,370'

HALE 4,334' 15 psi 4,107' 114 psi

HALE PUMP STATION

MANUAL CONNECTION

MALBEN RESERVOIR 4.0 MG 4,321'

DALHAUSEN PUMP STATION

MALBEN HIGH 4,235' 37 psi

WINNE RESERVOIR NO. 1 0.5 MG 4,506'

WINNE RESERVOIR NO. 2 0.6 MG 4,506'

WINNE 4,419' 36 psi 4,137' 158 psi

EAST SIDE "NOB HILL" PUMP STATION

NOB HILL RESERVOIR 4.0 MG 4,321'

PR1 PR2 PR3 PR4 PR5 PR9 PR10 PR13 PR15 PR16 PR17 PR18 PR19 PR21 PR22

3,914' 176 psi

3,963'

MALBEN LOW 3,797'

3,993' 3,934'

MOUNTAIN VIEW MEADOWS

GREEN MEADOW

GOLDEN ESTATES

TRINITY

AIRPORT

MRTP - HIGH

MRTP - LOW

APPENDIX B
WASTEWATER CALCULATIONS

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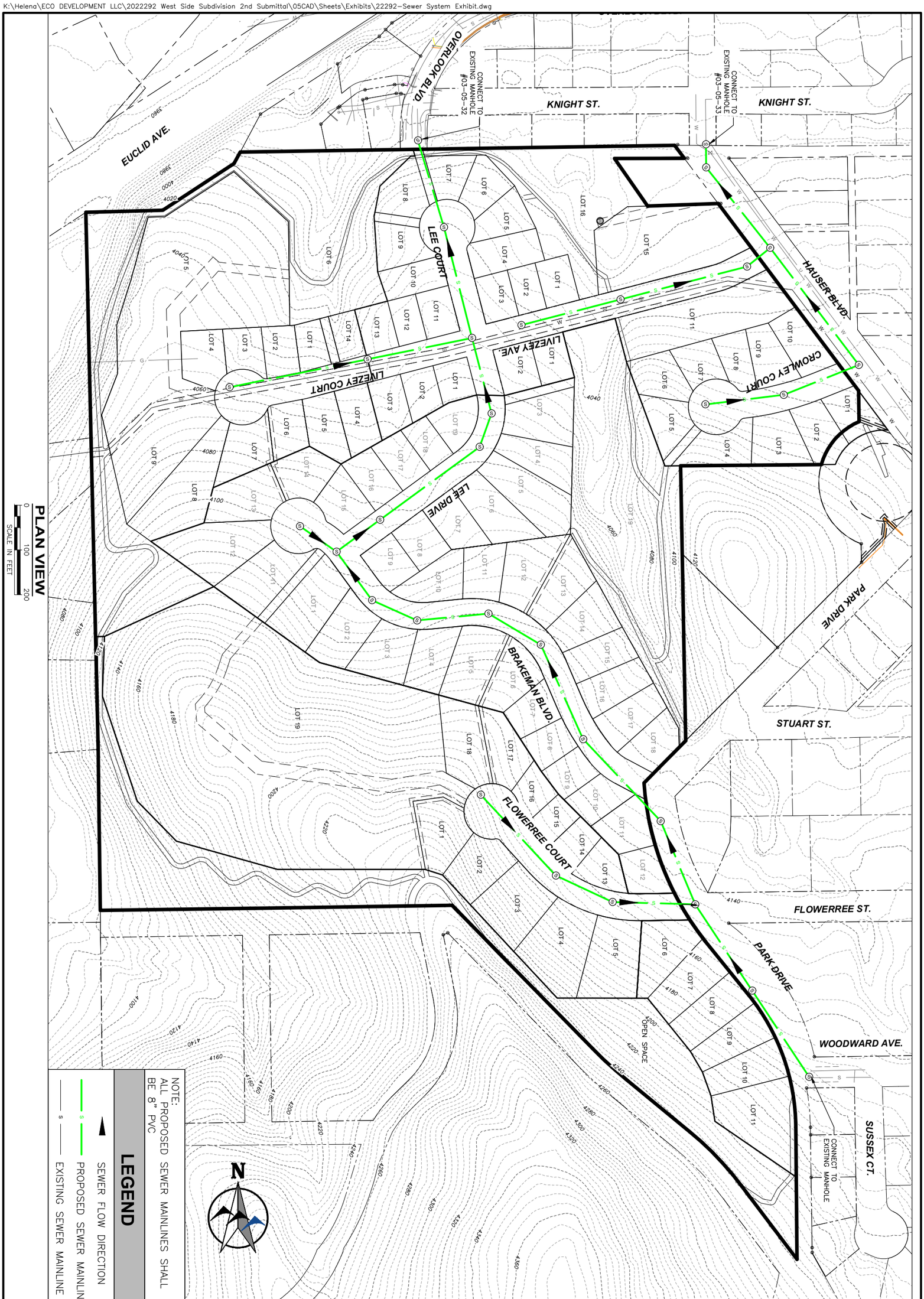


SHEET NO.

ECO DEVELOPMENT, LLC

WEST SIDE WOODS MAJOR SUBDIVISION

SANITARY SEWER SYSTEM LAYOUT

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

PROJECT:	2022-292
DESIGNED:	JMF
DRAWN:	MRS
CHECKED:	DDP
APPROVED:	JMF
DATE:	SEPTEMBER 15, 2022

NO.	REVISION DESCRIPTION	BY	DATE

Wastewater Collection System Demand Calculations

Project: West Side Woods Subdivision
Project #: 2022-292
Calculations By: DDP
Checked By: KJG

Notes:
Cells highligthed in green are used for inputs in the downstream pipe hydraulics calculations.

Inputs:

EDU	267.68	gpd	(COH ENG Standards, Section 3.2, 112 gpd per capita w/ average 2.39 people per
Infiltration/Inflow	150	gpd/acre	(COH ENG Standards, Section 3.4.1)
Total Population (Including all future potential)	734	People	
Peak Hour Factor	3.88269		(Equation 10-1, DEQ Circ. 2)
Peak Hour Factor	4		(where population is not counted)
1cfs	646272	gpd	

West Side Subdivision

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm	
Hauser Blvd. Connection				**Peak Factor = 3.88**	**Peak Factor = 4**	**Peak Factor = 3.88**	**Peak Factor = 4**
Phase 1 (Hauser Blvd. Connection)	EDU	268	41		10,988.00		7.63
Phase 1 Infiltration & Inflow (I&I)	acre	150	5.96		894.00		0.62
Design Average Flow (Including I&I)					**11,882**		8.25
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**43,557**	**44,846**	**30.25**	**31.14**
Phase 1 (Overlook Blvd. Connection)	EDU	268	15		4,020.00		2.79
Phase 1 Infiltration & Inflow (I&I)	acre	150	6.16		924.00		0.64
Design Average Flow (Including I&I)					**4,944**		3.43
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**16,532**	**17,004**	**11.48**	**11.81**
Phase 2 (Overlook Blvd. Connection)	EDU	268	30		8,040		5.58
Phase 2 Infiltration & Inflow (I&I)	acre	150	11.3		1,695		1.18
Design Average Flow (Including I&I)					**9,735**		**6.76**
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**32,912**	**33,855**	**22.86**	**23.51**
Phase 3 (Overlook Blvd. Connection)	EDU	268	43		11,524		8.00
Phase 3 Infiltration & Inflow (I&I)	acre	150	18.6		2,790		1.94
Design Average Flow (Including I&I)					**14,314**		**9.94**
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**47,534**	**48,886**	**33.01**	**33.95**
Phase 4 (Overlook Blvd. Connection)	EDU	268	43		11,524		8.00
Phase 4 Infiltration & Inflow (I&I)	acre	150	16.9		2,535		1.76
Design Average Flow (Including I&I)					**14,059**		**9.76**
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**47,279**	**48,631**	**32.83**	**33.77**
Design Average Flow All Phases (Including I&I)					**54,934**		**38.15**
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**187,814**	**193,222**	**130.43**	**134.18**

Overlook Estates

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
All Houses and Lots	EDU	268	113	30,284		21.03
Infiltration & Inflow (I&I)	acre	150	18.0	2,700		1.88
Design Average Flow (Including I&I)				**32,984**		**22.91**
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**120,283**		**83.53**

Existing Granite Hookups

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Existing Houses	EDU	268	22	5,896		4.09
Infiltration & Inflow (I&I)	acre	150	10.4	1,560		1.08
Design Average Flow (Including I&I)				**7,456**		**5.18**
Design Peak Hourly Flow (Peak Factor times average daily flow + I&I)				**24,452**		**16.98**

Green Meadow Country Club

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Members	EA	80	290	23,200		16.11
Employees	EA	13	10	130		0.09
Infiltration & Inflow (I&I)	acre	150	6.3	945		0.66
Design Average Flow (Including I&I)				**24,275**		**16.86**
Design Peak Hourly Flow (4 times average daily flow + I&I)				**94,265**		**65.46**

Spring Meadow Lake State Park

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Visitor	EA	5	667	3,335		2.32
Infiltration & Inflow (I&I)	acre	150	1.7	255		0.18
Design Average Flow (Including I&I)				**3,590**		**2.49**
Design Peak Hourly Flow (4 times average daily flow + I&I)				**13,595**		**9.44**

Trihydro

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Employees	EA	13	20	260		0.18
Infiltration & Inflow (I&I)	acre	150	2.1	315		0.22
Design Average Flow (Including I&I)				**575**		**0.40**
Design Peak Hourly Flow (4 times average daily flow + I&I)				**1,355**		**0.94**

George's Distributing, Farcountry Press, Sweetgrass Books

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Employees	EA	13	30	390		0.27
Infiltration & Inflow (I&I)	acre	150	7.0	1,050		0.73
Design Average Flow (Including I&I)				**1,440**		**1.00**
Design Peak Hourly Flow (4 times average daily flow + I&I)				**2,610**		**1.81**

MFWP WILD

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Employees	EA	10	10	100		0.07
Visitors	EA	5	211	1,055		0.73
Infiltration & Inflow (I&I)	acre	150	3.0	450		0.31
Design Average Flow (Including I&I)				**1,605**		**1.11**
Design Peak Hourly Flow (4 times average daily flow + I&I)				**5,070**		**3.52**

Country Club Avenue Residential

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Existing Houses	EDU	268	8	2,144		1.49
Infiltration & Inflow (I&I)	acre	150	7.7	1,155		0.80
Design Average Flow (Including I&I)				**3,299**		**2.29**
Design Peak Hourly Flow (4 times average daily flow + I&I)				**9,731**		**6.76**

Joslyn Upstream of Brady Street

Source	Unit	Flow, gpd/unit	# of Units	Flow, gpd		Flow, gpm
Existing Houses	EDU	268	NA			-
Infiltration & Inflow (I&I)	acre	150	255.0	38,250		26.56
Design Average Flow (Including I&I)				**38,250**		**26.56**

Circular Pipe (Subdivision Slopes.fm8)

Label	Solve For	Friction Method	Roughness Coefficient	Channel Slope (ft/ft)	Normal Depth (in)
Min Slope - 25% Full	Discharge	Manning Formula	0.013	0.0055	2.0
Min Slope - 50% Full	Discharge	Manning Formula	0.013	0.0055	4.0
Min Slope - 75% Full	Discharge	Manning Formula	0.013	0.0055	6.0
Min Slope - 100% Full	Discharge	Manning Formula	0.013	0.0055	8.0
Max Slope - 25% Full	Discharge	Manning Formula	0.013	0.1958	2.0
Max Slope - 50% Full	Discharge	Manning Formula	0.013	0.1958	4.0
Max Slope - 75% Full	Discharge	Manning Formula	0.013	0.1958	6.0
Max Slope - 100% Full	Discharge	Manning Formula	0.013	0.1958	8.0
Min Slope - 0.3 Full	Discharge	Manning Formula	0.013	0.0055	2.4
Max Slope - Peak Hour	Normal Depth	Manning Formula	0.013	0.1958	1.3

Diameter (in)	Discharge (gal/min)	Flow Area (ft^2)	Wetted Perimeter (ft)	Hydraulic Radius (in)	Top Width (ft)
8.0	55.10	0.1	0.7	1.2	0.58
8.0	201.11	0.2	1.0	2.0	0.67
8.0	366.77	0.3	1.4	2.4	0.58
8.0	402.21	0.3	2.1	2.0	0.00
8.0	328.74	0.1	0.7	1.2	0.58
8.0	1,199.95	0.2	1.0	2.0	0.67
8.0	2,188.41	0.3	1.4	2.4	0.58
8.0	2,399.89	0.3	2.1	2.0	0.00
8.0	78.77	0.1	0.8	1.4	0.61
8.0	132.69	0.0	0.5	0.8	0.49

Critical Depth (in)	Percent Full (%)	Critical Slope (ft/ft)	Velocity (ft/s)	Velocity Head (ft)	Specific Energy (ft)
1.9	25.0	0.0065	1.80	0.05	0.22
3.8	50.0	0.0068	2.57	0.10	0.44
5.1	75.0	0.0083	2.91	0.13	0.63
5.4	100.0	0.0087	2.57	0.10	0.77
4.9	25.0	0.0079	10.73	1.79	1.96
7.8	50.0	0.0438	15.32	3.65	3.98
8.0	75.0	0.1571	17.36	4.68	5.18
8.0	100.0	0.1900	15.32	3.65	4.31
2.3	30.0	0.0064	1.99	0.06	0.26
3.0	16.0	0.0065	8.22	1.05	1.16

Froude Number	Maximum Discharge (gal/min)	Discharge Full (gal/min)	Slope Full (ft/ft)	Flow Type	Notes
0.922	432.66	402.21	0.0001	Subcritical	
0.885	432.66	402.21	0.0014	Subcritical	
0.736	432.66	402.21	0.0046	Subcritical	

Circular Pipe (Subdivision Slopes.fm8)

Froude Number	Maximum Discharge (gal/min)	Discharge Full (gal/min)	Slope Full (ft/ft)	Flow Type	Notes
(N/A)	432.66	402.21	0.0055	Subcritical	
5.504	2,581.58	2,399.89	0.0037	Supercritical	
5.278	2,581.58	2,399.89	0.0490	Supercritical	
4.389	2,581.58	2,399.89	0.1628	Supercritical	
(N/A)	2,581.58	2,399.89	0.1958	Undefined	
0.925	432.66	402.21	0.0002	Subcritical	
5.344	2,581.58	2,399.89	0.0006	Supercritical	

Messages

WWC

Wastewater Collection System Downstream Pipe Hydraulics

Project: West Side Woods Subdivision — West Side Woods Subdivision
Project #: 2022-292
Calculations By: DDP — DDP
Checked By: KJG — KJG

Data taken from City of Helena GIS database based on survey records and as constructed drawings.
Pipe Capacity done using the Manning Formula for Uniform Pipe Flow

42.95	23.51	33.95	33.77

	Upstream Manhole #	Upstream Manhole Depth, ft.	US Ground Surface Elevation, ft.	Upstream Invert Out Elevation, ft.	Downstream Manhole #	Downstream Manhole Depth, ft.	DS Ground Surface Elevation, ft.	Downstream Invert In Elevation, ft.	Length of Pipe Run, ft.	Pipe Dia,, in.	Pipe Slope, ft./ft.	Pipe Material	Pipe Material Roughness Coefficient, n	Full Pipe Capacity GPM	Half Pipe Capacity GPM
Hauser Blvd	3-05-33	5	4009.7	4004.27	3-05-20	9.8	4006.51	3995.54	100.2	8	0.08713	PVC	0.013	1,600.93	800.46
	3-05-20	10	4006.1	3992.2	3-05-19	10	4002.3	3981.5	395.33	8	0.02707	PVC	0.013	892.30	446.15
	3-05-19	10	4002.3	3981.4	3-05-18	10	3991.5	3980.7	100.59	8	0.00696	PVC	0.013	452.45	226.22
	3-05-18	10	3991.5	3980.6	3-05-17	10	3978.6	3978.7	208.06	8	0.00913	PVC	0.013	518.30	259.15
	3-05-17	10	3978.6	3978.6	3-05-3	10.2	3990.75	3875.7	204.52	8	0.50313	PVC	0.013	3,847.14	1,923.57
	3-05-3	10.2	3990.75	3979.22	3-05-2	10.7	3969.45	3958.25	299.22	8	0.07008	PVC	0.013	1,435.83	717.91
Overlook Blvd	3-05-32	5	3998.09	3995.69	3-05-13	15.3	3998.09	3982.39	82.38	8	0.16145	PVC	0.013	2,179.28	1,089.64
	3-05-13	15.3	3998.09	3978.7	3-05-12	10	3986.5	3976.5	184.81	8	0.0119	PVC	0.013	591.76	295.88
	3-05-12	10.1	3986.5	3976.4	3-05-11	10	3980.1	3970.1	167.38	8	0.03764	PVC	0.013	1,052.24	526.12
	3-05-11	10	3980.1	3970	3-05-10	10	3982.6	3969.1	221.2	8	0.00407	PVC	0.013	345.96	172.98
	3-05-10	13.6	3982.6	3969	3-05-9	15.9	3978.3	3967.4	309.02	8	0.00518	PVC	0.013	390.27	195.13
	3-05-9	15.9	3978.3	3967.7	3-05-8	10.9	3978.3	3967.4	76.31	8	0.00393	PVC	0.013	340.07	170.03
	3-05-8	10.9	3978.3	3967.3	3-05-7	10	3961.8	3961.9	124.84	8	0.04326	PVC	0.013	1,128.02	564.01
	3-05-7	10	3961.8	3961.8	3-05-6	10	3969.3	3959.3	186.35	8	0.01342	PVC	0.013	628.21	314.10
	3-05-6	10	3969.3	3959.2	3-05-5	10	3966.7	3956.7	258.74	8	0.00966	PVC	0.013	533.13	266.57
	3-05-5	10	3966.7	3956.6	3-05-2	10.8	3969.45	3954.3	139.65	8	0.01647	PVC	0.013	696.05	348.03
Overlook Blvd and Hauser Blvd Connect	0-30-52	10.8	3969.45	3958.23	0-30-51	10.9	3962.85	3952.84	138.57	8	0.0389	PVC	0.013	1,069.69	534.85
	3-05-1	10.9	3962.85	3952.81	3-05-1A	6.9	3957.72	3952.4	137.11	8	0.00299	PVC	0.013	296.59	148.29
	3-05-1A	6.9	3957.72	3952.35	99-14-3	6.2	3954	3952.22	19.65	8	0.00662	PVC	0.013	441.15	220.58
Add in Flows from City of Helena Westside Phase 2	99-14-3	6.2	3954	3952.22	99-14-4	7.7	3957.25	3946.46	130.85	8	0.04402	PVC	0.013	1,137.95	568.97
	99-14-4	7.7	3957.25	3946.36	99-14-5	8.2	3941.9	3926	366.29	8	0.05558	PVC	0.013	1,278.72	639.36
	99-14-5	8.2	3941.9	3925.9	99-14-6	11.6	3939.5	3923.6	279.94	8	0.00822	PVC	0.013	491.62	245.81
	99-14-6	11.6	3939.5	3923.5	99-14-7	8.4	3937	3922.78	98.14	8	0.00734	PVC	0.013	464.56	232.28
	99-14-7	8.4	3937	3922.6	99-14-8	9.01	3933.55	3920.07	325.87	8	0.00776	PVC	0.013	477.90	238.95
	99-14-8	9.01	3933.55	3919.97	99-14-9	7.9	3928.75	3916	397.9	8	0.00998	PVC	0.013	541.76	270.88
	99-14-9	7.9	3928.75	3915.9	99-14-10	7.3	3922.5	3911.8	332.19	8	0.01234	PVC	0.013	602.56	301.28
	99-14-10	7.3	3922.5	3911.7	99-14-11	6.8	3917	3906.7	376.47	8	0.01328	PVC	0.013	625.05	312.53
	99-14-11	6.8	3917	3906.6	99-14-12	6.3	3918	3905	196.22	8	0.00815	PVC	0.013	489.76	244.88
	99-14-12	6.3	3918	3904.9	73-20-10	7.7	N/A	3901.4	432.12	8	0.0081	PVC	0.013	488.12	244.06
	73-20-10	7.5	N/A	101.76	73-20-9	4.3	N/A	100.91	314.21	10	0.00271	PVC	0.013	511.48	255.74
	73-20-9	4.3	N/A	100.71	73-20-8	4.4	N/A	99.88	269.49	10	0.00308	PVC	0.013	545.75	272.87
	73-20-8	4.4	N/A	99.83	73-20-7	4.4	N/A	99.15	250.62	10	0.00271	PVC	0.013	512.24	256.12
	73-20-7	4.4	N/A	99.1	73-20-6	3.8	N/A	97.98	354.42	10	0.00316	PVC	0.013	552.81	276.40
	73-20-6	3.8	N/A	97.98	73-20-5	5	N/A	96.86	421.78	10	0.00266	PVC	0.013	506.75	253.37
	73-20-5	5	N/A	96.86	73-20-4	8.6	N/A	95.74	418.4	10	0.00268	PVC	0.013	508.79	254.39
	73-20-4	8.6	N/A	95.74	73-20-3	9.6	N/A	94.62	332.34	10	0.00337	PVC	0.013	570.88	285.44
	73-20-3	9.6	N/A	94.42	73-20-2	10.8	N/A	93.95	153.36	10	0.00306	PVC	0.013	544.40	272.20
	73-20-2	N/A	N/A	93.47	73-20-1	Min Slope Assumed			87.34	10	0.0028	PVC	0.013	520.36	260.18
	73-20-1	11.5	N/A	93.27	527-1	8.9	N/A	92.19	448.78	10	0.00241	PVC	0.013	482.41	241.21
Add in Flows from City of Helena Westside Phase 1 and 2	527-1	8.9	3905.25	3896.35	531-8	8.6	3901.75	3893.15	466.93	15	0.00685	Clay	0.014	2,228.77	1,114.39
	531-8	8.6	3901.75	3893.15	531-7	9.3	3900	3890.7	450.85	15	0.00543	Clay	0.014	1,984.65	992.33
	531-7	9.3	3900	3890.7	531-6	10.2	3898	3887.8	452.07	15	0.00641	Clay	0.014	2,156.32	1,078.16
	531-6	10.2	3898	3887.8	531-5	9.2	3893.5	3884.3	451.95	15	0.00774	Clay	0.014	2,369.22	1,184.61
	531-5	9.2	3893.5	3884.3	530-1	12.5	3895	3882.5	353.92	15	0.00509	Clay	0.014	1,920.00	960.00
	530-1	12.5	3895	3882.5	530-2	13	3894	3881	239.25	15	0.00627	Clay	0.014	2,131.75	1,065.88
	530-2	13	3894	3881	530-3	13.4	3892.2	3878.8	261.72	15	0.00841	Clay	0.014	2,468.37	1,234.18
	530-3	13.4	3892.2	3878.8	530-4	14.4	3888.3	3873.9	420.33	18	0.01166	Clay	0.014	4,726.83	2,363.41
	530-4	14.4	3888.3	3873.9	530-5	14.6	3885.9	3871.3	293.46	18	0.00886	Clay	0.014	4,120.78	2,060.39
	530-5	14.6	3885.9	3871.3	530-6	14.8	3885	3870.2	209.61	18	0.00525	RCP	0.013	3,415.40	1,707.70
	530-6	14.8	3885	3870.2	530-7A	10.9	3878.8	3867.9	262.19	18	0.00877	RCP	0.013	4,415.78	2,207.89
	530-7A	10.9	3878.8	3867.9	530-7	9.9	3876.6	3866.7	114.22	18	0.01051	Clay	0.014	4,487.32	2,243.66
	530-7	9.9	3876.6	3866.7	530-8	6.8	3872.1	3865.3	289.28	18	0.00484	Clay	0.014	3,045.59	1,522.80
	530-8	6.8	3872.1	3865.3	530-9	8	3873	3865	111.58	18	0.00269	Clay	0.014	2,270.05	1,135.02
	530-9	8	3873	3865	530-23	5.6	3870.1	3864.5	201.21	18	0.00248	Clay	0.014	2,182.36	1,091.18
	530-23	5.6	3870.1	3864.5	530-22	6.3	3870.2	3863.9	302.93	18	0.00198	RCP	0.013	2,098.25	1,049.12
	530-22	6.3	3870.2	3863.9	530-21	10.7	3873.8	3863.1	408.25	18	0.00196	RCP	0.013	2,087.05	1,043.53
	530-21	10.7	3873.8	3863.1	315-5	13	3875.4	3862.4	406.59	18	0.00172	Clay	0.014	1,816.51	908.25
	315-5	13	3875.4	3862.4	531-2	14.4	3876.5	3862.1	105.35	24	0.00285	RCP	0.013	5,418.33	2,709.16
	531-2	14.4	3876.5	3862.1	531-3	7.3	3868.25	3860.95	351.19	24	0.00327	RCP	0.013	5,810.31	2,905.16
	531-3	7.3	3868.25	3860.95	531-3A	7.3	3868.2	3860.9	7.00	24	0.00714	RCP	0.013	8,581.39	4,290.70
	531-3A	7.3	3868.2	3860.9	531-4	7	3867.4	3860.4	123.82	24	0.00404	RCP	0.013	6,452.25	3,226.13
	531-4	7	3867.4	3860.4	548-1	7.8	3865.9	3858.1	472.03	24	0.00487	RCP	0.013	7,087.63	3,543.81
	548-1	7.8	3865.9	3858.1	548-2	8.6	3865.8	3857.2	136.62	24	0.00659	RCP	0.013	8,241.11	4,120.56
	548-2	8.6	3865.8	3857.2	548-4	7	3863.75	3856.75	252.59	24	0.00178	RCP	0.013	4,285.68	2,142.84
	548-4	7	3863.75	3856.75	548-5	7.4	3864	3856.6	112.56	24	0.00133	RCP	0.013	3,706.60	1,853.30
	548-5	7.4	3864	3856.6	548-5A	8.1	3864.2	3856.1	225.74	24	0.00221	RCP	0.013	4,778.62	2,389.31
	548-5A	8.1	3864.2	3856.1	551-5B	5.2	3860	3854.8	272.34	24	0.00477	RCP	0.013	7,015.16	3,507.58
	551-5B	5.2	3860	3854.8	551-6A	8.7	3863	3854.3	415.66	24	0.0012	RCP	0.013	3,521.58	1,760.79
	551-6A	8.7	3863	3854.3	551-6B	N/A	Min Grade	N/A	413	24	0.0008	RCP	0.013	2,871.88	1,435.94
	551-6B	N/A	Min Grade Assumed		551-6	N/A	Min Grade	N/A	98.42	24	0.0008	RCP	0.013	2,871.88	1,435.94
	551-6	N/A	Min Grade Assumed		551-7	5.2	Min Grade	N/A	38.43	24	0.0008	RCP	0.013	2,871.88	1,435.94
	551-7	5.2	3861.7	3856.5	94-28-1	8.2	3861.5	3853.3	403.88	24	0.00792	RCP	0.013	9,037.96	4,518.98
	94-28-1	8.2	3861.5	3853.3	551-8	8.4	3861.5	3853.1	54.12	24	0.0037	RCP	0.013	6,172.45	3,086.23
	551-8	8.4	3861.5	3853.1	551-9	6.3	3858.7	3852.4	505.44	24	0.00138	RCP	0.013	3,778.64	1,889.32
	551-9	6.3	3858.7	3852.4	32-3-1	5.2	Min Grade	N/A	78	24	0.0008	RCP	0.013	2,871.88	1,435.94
	32-3-1	5.2	3859.7	3854.5	551-10	5.1	3858.7	3853.6	237	24	0.0038	RCP	0.013	6,257.04	3,128.52
	551-10	5.1	3858.7	3853.6	551-11	4.4	3856	3851.6	313.1	24	0.00639	RCP	0.013	8,115.12	4,057.56
	551-11	4.4	3856	3851.6	551-12	8.6	3859.9	3851.3	297.67	24	0.00101	RCP	0.013	3,223.40	1,611.70
	551-12	8.6	3859.9	3851.3	551-16	6	Min Grade	N/A	299.88	24	0.0008	RCP	0.013	2,871.88	1,435.94
	551-16	N/A	Min Grade Assumed		92-13-1	7.7	Min Grade	N/A	230.73	24	0.0008	RCP	0.013	2,871.88	1,435.94
	92-13-1	7.7	3855	3847.3	551-17	8.1	3854.25	3846.15	69.41	24	0.01657	RCP	0.013	13,069.52	6,534.76
	551-17	8.1	3854.25	3846.15	84-17-1	9.7	3850	3840.3	292.34	24	0.02001	RCP	0.013	14,363.34	7,181.67
	84-17-1	9.7	3850	3840.3	551-18	11.2	3849	3837.8	210.56	24	0.01187	RCP	0.013	11,063.79	5,531.89
	551-18	11.2	3849	3837.8	551-19	10	3843	3833	497.06	24	0.00966	RCP	0.013	9,977.87	4,988.94
	551-19	10	3843	3833	Custer 1	10.8	3836	3825.2	496.17	24	0.01572	RCP	0.013	12,730.74	6,365.37

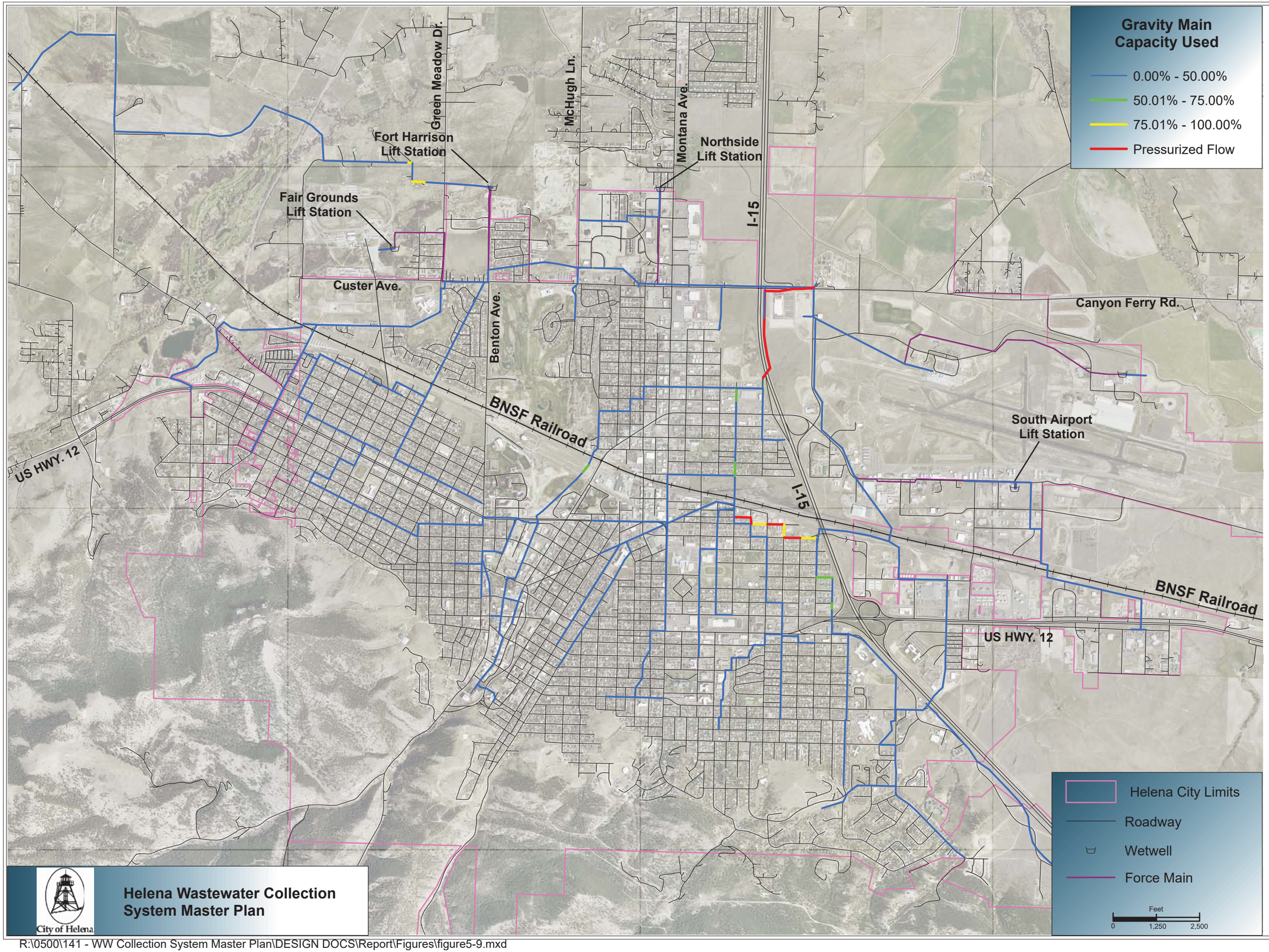
Upstream Manhole #	Description	Existing Granite Flow Contribution (GPM)	Overlook Estates Flow Contribution (GPM)	Commerical/Industrial Flow (GPM)	Montana WILD Flow (GPM)	Green Meadow County Club/Spring Meadow (GPM)	Country Club Ave. Residential Flow (GPM)	Joslyn Residential Flow (GPM)	City of Helena Phase 2 Flow Contribution (GPM)	Combined COH Phase 1 & 2 Flow Contribution (Includes All Phases) (GPM)	Total Existing Cumulative Flow* (GPM)	Phase 1 (Hauser) Flow Contribution Only (GPM)	Phase 1 (Overlook) Flow Contribution Only (GPM)	Phase 1 (Total) Flow Contribution Only (GPM)	Phase 2 Flow Contribution (Includes Previous Phases) (GPM)	Phase 3 Flow Contribution (Includes Previous Phases) (GPM)	Phase 4 Flow Contribution (Includes Previous Phases) (GPM)	Total Cumulative Flow (GPM)	Phase 1 Percent Full (% of Full Pipe Flow)	Phase 1 & 2 Percent Full (% of Full Pipe Flow)	Phase 1, 2, 3 Percent Full (% of Full Pipe Flow)	Full Build Out Percent Full (% of Full Pipe Flow)
	EDU Calculated Flow				3.52				106.84	315.59		31.14	11.81	42.95	23.51	33.95	33.77	134.18				
	Flow Meter at MH 99-14-6 = 66.72 gpm + 3.91 gpm for I&I		70.63																			
	Flow Meter at MH 73-20-4 = 90.63 gpm + 1.95 gpm for I&I			92.58																		
	Flow Meter at MH 531-6 = 492.45 gpm + 26.56 gpm for I&I				519.01																	
		Pipe Flowrate (Existing)										**Pipe Flowrate by Phase**										
3-05-33	HAUSER & KNIGHT 1S - HAUSER & KNIGHT		70.63								70.63	31.14						101.77	6.4%	6.4%	6.4%	6.4%
3-05-20	HAUSER & KNIGHT - HAUSER & KNIGHT 1E		70.63								70.63	31.14						101.77	11.4%	11.4%	11.4%	11.4%
3-05-19	HAUSER & KNIGHT 1E - GRANITE & KNIGHT 2W		70.63								70.63	31.14						101.77	22.5%	22.5%	22.5%	22.5%
3-05-18	GRANITE & KNIGHT 2W - GRANITE & KNIGHT 1W		70.63								70.63	31.14						101.77	19.6%	19.6%	19.6%	19.6%
3-05-17	GRANITE & KNIGHT 1W - GRANITE & KNIGHT		70.63								70.63	31.14						101.77	2.6%	2.6%	2.6%	2.6%
3-05-3	GRANITE & KNIGHT - GRANITE & OVERLOOK		70.63								70.63	31.14						101.77	7.1%	7.1%	7.1%	7.1%
3-05-32	OVERLOOK & KNIGHT 1S - OVERLOOK & KNIGHT		70.63								70.63		11.81		35.32	69.27	103.04	173.67	3.8%	4.9%	6.4%	8.0%
3-05-13	OVERLOOK & KNIGHT - OVERLOOK & KNIGHT 1N		70.63								70.63		11.81		35.32	69.27	103.04	173.67	13.9%	17.9%	23.6%	29.3%
3-05-12	OVERLOOK & KNIGHT 1N - OVERLOOK & HAUSER 2W		70.63								70.63		11.81		35.32	69.27	103.04	173.67	7.8%	10.1%	13.3%	16.5%
3-05-11	OVERLOOK & HAUSER 2W - OVERLIOOK & HAUSER 1W		70.63								70.63		11.81		35.32	69.27	103.04	173.67	23.8%	30.6%	40.4%	50.2%
3-05-10	HAUSER & OVERLOOK 1W -1E		70.63								70.63		11.81		35.32	69.27	103.04	173.67	21.1%	27.1%	35.8%	44.5%
3-05-9	HAUSER & OVERLOOK 1E - 2E		70.63								70.63		11.81		35.32	69.27	103.04	173.67	24.2%	31.2%	41.1%	51.1%
3-05-8	HAUSER & OVERLOOK 2E - GRANITE & OVERLOOK 3W		70.63								70.63		11.81		35.32	69.27	103.04	173.67	7.3%	9.4%	12.4%	15.4%
3-05-7	GRANITE & OVERLOOK 3W - 2W		70.63								70.63		11.81		35.32	69.27	103.04	173.67	13.1%	16.9%	22.3%	27.6%
3-05-6	GRANITE & OVERLOOK 2W - 1W		70.63								70.63		11.81		35.32	69.27	103.04	173.67	15.5%	19.9%	26.2%	32.6%
3-05-5	GRANITE & OVERLOOK 1W - GRANITE & OVERLOOK		70.63								70.63		11.81		35.32	69.27	103.04	173.67	11.8%	15.2%	20.1%	25.0%
0-30-52	GRANITE & OVERLOOK - GRANITE & OVERLOOK 1N		70.63								70.63			42.95	66.46	100.41	134.18	204.81	10.6%	12.8%	16.0%	19.1%
3-05-1	GRANITE & OVERLOOK 1N - GRANITE & HIGHWAY 12 1S WES		70.63								70.63			42.95	66.46	100.41	134.18	204.81	38.3%	46.2%	57.7%	69.1%
3-05-1A	GRANITE & HIGHWAY 12 SOUTH SIDE 1W - SOUTH SIDE 1E		70.63								70.63			42.95	66.46	100.41	134.18	204.81	25.7%	31.1%	38.8%	46.4%
99-14-3	Highway 12 & Granite 1S - 1N		70.63						106.84		177.47			42.95	66.46	100.41	134.18	311.65	19.4%	21.4%	24.4%	27.4%
99-14-4	Hwy 12 & Granite 1N - Kessler Road 1W		70.63						106.84		177.47			42.95	66.46	100.41	134.18	311.65	17.2%	19.1%	21.7%	24.4%
99-14-5	Hwy 12 & Kessler Road 1W - 2W		70.63						106.84		177.47			42.95	66.46	100.41	134.18	311.65	44.8%	49.6%	56.5%	63.4%
99-14-6	Hwy 12 & Kessler 2W - 2W 1N		70.63						106.84		177.47			42.95	66.46	100.41	134.18	311.65	47.4%	52.5%	59.8%	67.1%
99-14-7	Hwy 12 & Kessler Road 2W 1N - Mikal Foundation Yard		70.63						106.84		177.47			42.95	66.46	100.41	134.18	311.65	46.1%	51.0%	58.1%	65.2%
99-14-8	Mikal Foundation Yard - Mikal Foundation Yard 1E		70.63		3.52				106.84		180.99			42.95	66.46	100.41	134.18	315.17	41.3%	45.7%	51.9%	58.2%
99-14-9	Mikal Kellner Yard 1E - 2E		70.63		3.52				106.84		180.99			42.95	66.46	100.41	134.18	315.17	37.2%	41.1%	46.7%	52.3%
99-14-10	Mikal Kellner Yard 2E - 3E 1N		70.63		3.52				106.84		180.99			42.95	66.46	100.41	134.18	315.17	35.8%	39.6%	45.0%	50.4%
99-14-11	Mikal Kellner Yard 3E 1N - 4E 2N		70.63		3.52				106.84		180.99			42.95	66.46	100.41	134.18	315.17	45.7%	50.5%	57.5%	64.4%
99-14-12	Mikal Kellner Yard 4E 2N - Broadwater & Country Club 3E		70.63		3.52				106.84		180.99			42.95	66.46	100.41	134.18	315.17	45.9%	50.7%	57.6%	64.6%
73-20-10	Broadwater & Country Club 3E - Beckman & Lea			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	47.4%	52.0%	58.6%	65.2%
73-20-9	Beckman & Lea - Cutting & Lea			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	44.4%	48.7%	54.9%	61.1%
73-20-8	Cutting & Lea - 1E			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	47.3%	51.9%	58.5%	65.1%
73-20-7	Cutting & Lea 1E - 2E			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	43.8%	48.1%	54.2%	60.3%
73-20-6	Cutting & Lea 2E - 3E			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	47.8%	52.5%	59.2%	65.8%
73-20-5	Cutting Ave & Lea 3E - 4E			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	47.6%	52.3%	58.9%	65.6%
73-20-4	Cutting Ave & Lea 4E - 5E			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	42.5%	46.6%	52.5%	58.4%
73-20-3	Cutting Ave & Lea 5E - Brady & Joslyn 1W 1S			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	44.5%	48.8%	55.1%	61.3%
73-20-2	Brady & Joslyn 1W 1S - Brady & Joslyn 1W			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	46.6%	51.1%	57.6%	64.1%
73-20-1	Brady & Joslyn 1W - Brady & Joslyn			92.58					106.84		199.42			42.95	66.46	100.41	134.18	333.60	50.2%	55.1%	62.2%	69.2%
527-1	Brady & Joslyn East				519.01					315.59	834.60			42.95	66.46	100.41	134.18	968.78	39.4%	40.4%	42.0%	43.5%
531-8	Brady St East to Brady and Larson Drive				519.01					315.59	834.60			42.95	66.46	100.41	134.18	968.78	44.2%	45.4%	47.1%	48.8%
531-7	Brady St and Larson East				519.01					315.59	834.60			42.95	66.46	100.41	134.18	968.78	40.7%	41.8%	43.4%	44.9%
531-6	Brady St East of Larson to Brady & Henderson St.				519.01					315.59	834.60			42.95	66.46	100.41	134.18	968.78	37.0%	38.0%	39.5%	40.9%
531-5	Brady & Henderson St East to Brady & Sunhaven									315.59	1,275.59			42.95	66.46	100.41	134.18	1,409.77	68.7%	69.9%	71.7%	73.4%
530-1	Brady & Sunhaven East									315.59	1,381.47			42.95	66.46	100.41	134.18	1,515.65	66.8%	67.9%	69.5%	71.1%
530-2	Brady East of Sunhaven to Capital High Parking lot									315.59	1,549.77			42.95	66.46	100.41	134.18	1,683.95	64.5%	65.5%	66.9%	68.2%
530-3	Capital High to NW park									315.59	2,679.00			42.95	66.46	100.41	134.18	2,813.18	57.6%	58.1%	58.8%	59.5%
530-4	NW Park to NW Park									315.59	2,375.98			42.95	66.46	100.41	134.18	2,510.16	58.7%	59.3%	60.1%	60.9%
530-5	Brady St to Brady & Valley Drive									315.59	2,023.29			42.95	66.46	100.41	134.18	2,157.47	60.5%	61.2%	62.2%	63.2%
530-6	Brady St & Valley Drive North to N end of Sunhaven									315.59	2,523.48			42.95	66.46	100.41	134.18	2,657.66	58.1%	58.7%	59.4%	60.2%
530-7A	Valley Drive North									315.59	2,559.25			42.95	66.46	100.41	134.18	2,693.43	58.0%	58.5%	59.3%	60.0%
530-7	Valley Drive North to Valley and Wedgewood Lane									315.59	1,838.39			42.95	66.46	100.41	134.18	1,972.57	61.8%	62.5%	63.7%	64.8%
530-8	Valley and Wedgewood Lane East									315.59	1,450.61			42.95	66.46	100.41	134.18	1,584.79	65.8%	66.8%	68.3%	69.8%
530-9	Wedgewood Lane North to Custer Avenue									315.59	1,406.77			42.95	66.46	100.41	134.18	1,540.95	66.4%	67.5%	69.1%	70.6%
530-23	West Custer Avenue East									315.59	1,364.71			42.95	66.46	100.41	134.18	1,498.89	67.1%	68.2%	69.8%	71.4%
530-22	West Custer Avenue East									315.59	1,359.12			42.95	66.46	100.41	134.18	1,493.30	67.2%	68.3%	69.9%	71.6%
530-21	West Custer Avenue to Just West of Custer and Benton									315.59	1,223.84			42.95	66.46	100.41	134.18	1,358.02	69.7%	71.0%	72.9%	74.8%
315-5	Just West of Custer and Benton East to Custer and Benton									315.59	3,024.75			42.95	66.46	100.41	134.18	3,158.93	56.6%	57.1%	57.7%	58.3%
531-2	Custer and Benton North to Benton and Russell Lane									315.59	3,220.75			42.95	66.46	100.41	134.18	3,354.93	56.2%	56.6%	57.2%	57.7%
531-3	North Benton and Russel Lane 7 Feet East									315.59	4,606.29			42.95	66.46	100.41	134.18	4,740.47	54.2%	54.5%	54.8%	55.2%
531-3A	Russell Lane East									315.59	3,541.72			42.95	66.46	100.41	134.18	3,675.90	55.6%	55.9%	56.4%	57.0%
531-4	Russell Lane East to just West of Bridger Drive									315.59	3,859.40			42.95	66.46	100.41	134.18	3,993.58	55.1%	55.4%	55.9%	56.3%
548-1	Russell Lane East to Russell and Bridger Drive									315.59	4,436.15			42.95	66.46	100.41	134.18	4,570.33	54.4%	54.6%	55.0%	55.5%
548-2	Russell & Bridger Drive East to Russell & Vigilante Drive									315.59	2,458.43			42.95	66.46	100.41	134.18	2,592.61	58.4%	58.9%	59.7%	60.5%
548-4	Russell & Vigilante Drive East									315.59	2,168.89			42.95	66.46	100.41	134.18	2,303.07	59.7%	60.3%	61.2%	62.1%
548-5	Russell Lane East to East of Cooney Drive									315.59	2,704.90			42.95	66.46	100.41	134.18	2,839.08	57.5%	58.0%	58.7%	59.4%
548-5A	East to Junkyard Center									315.59	3,823.17			42.95	66.46	100.41	134.18	3,957.35	55.1%	55.4%	55.9%	56.4%
551-5B	Junkyard Center East									315.59	2,076.38			42.95	66.46	100.41	134.18	2,210.56	60.2%	60.8%	61.8%	62.8%
551-6A	East									315.59	1,751.53			42.95	66.46	100.41	134.18	1,885.71	62.5%	63.3%	64.5%	65.7%
551-6B	East to just west of McHugh lane									315.59	1,751.53			42.95	66.46	100.41	134.18	1,885.71	62.5%	63.3%	64.5%	65.7%
551-6	Just West of Mchugh to McHugh and River Rock Dr.									315.59	1,751.53			42.95	66.46	100.41	134.18	1,885.71	62.5%	63.3%	64.5%	65.7%
551-7	McHugh and River Rock East to Ptarmigan and River Rock									315.59	4,834.57			42.95	66.46	100.41	134.18	4,968.75	54.0%	54.2%	54.6%	55.0%
94-28-1	Ptarmigan and River Rock East									315.59	3,401.82			42.95	66.46	100.41	134.18	3,536.00	55.8%	56.2%	56.7%	57.3%
551-8	River Rock East									315.59	2,204.91			42.95	66.46	100.41	134.18	2,339.09	59.5%	60.1%	61.0%	61.9%
551-9	River Rock East									315.59	1,751.53			42.95	66.46	100.41	134.18	1,885.71	62.5%	63.3%	64.5%	65.7%
32-3-1	River Rock East Southeast									315.59	3,444.11			42.95	66.46	100.41	134.18	3,578.29	55.7%	56.1%	56.6%	57.2%
551-10	River Rock East Southeast									315.59	4,373.15			42.95	66.46	100.41	134.18	4,507.33	54.4%	54.7%	55.1%	55.5%
551-11	River Rock East Southeast to Custer West of National									315.59	1,927.29			42.95	66.46	100.41	134.18	2,061.47	61.1%	61.9%	62.9%	64.0%
551-12	Custer West of National to Custer East of National									315.59	1,751.53			42.95	66.46	100.41	134.18	1,885.71	62.5%	63.3%	64.5%	65.7%
551-16	Custer East of National to Custer East of Dredge									315.59	1,751.53			42.95	66.46	100.41	134.18	1,885.71	62.5%	63.3%	64.5%	65.7%
92-13-1	Custer East of Dredge East									315.59	6,850.35			42.95	66.46	100.41	134.18	6,984.53	52.7%	52.9%	53.2%	53.4%
551-17	Custer West of Montana to Custer and Montana									315.59	7,497.26			42.95	66.46	100.41	134.18	7,631.44	52.5%	52.7%	52.9%	53.1%
84-17-1	Custer and Montana East									315.59	5,847.48			42.95	66.46	100.41	134.18	5,981.66	53.2%	53.5%	53.8%	54.1%
551-18	Custer and Montana East to Power Townsend									315.59	5,304.53			42.95	66.46	100.41	134.18	5,438.71	53.6%	53.8%	54.2%	54.5%
551-19	Custer at Power Townsend East to West of Sanders St.									315.59	6,680.96			42.95	66.46	100.41	134.18	6,815.14	52.8%	53.0%	53.3%	53.5%

Upstream Manhole #	Upstream Manhole Depth, ft.	US Ground Surface Elevation, ft.	Upstream Invert Out Elevation, ft.	Downstream Manhole #	Downstream Manhole Depth, ft.	DS Ground Surface Elevation, ft.	Downstream Invert In Elevation, ft.	Length of Pipe Run, ft.	Pipe Dia., in.	Pipe Slope, ft./ft.	Pipe Material	Pipe Material Roughness Coefficient, n	Full Pipe Capacity GPM	Half Pipe Capacity GPM	Description	Existing Granite Flow Contribution (GPM)	Overlook Estates Flow Contribution (GPM)	Commericall Industrial Flow (GPM)	Montana WILD Flow (GPM)	Green Meadow County Club/Spring Meadow (GPM)	Country Club Ave. Residential Flow (GPM)	Joslyn Residential Flow (GPM)	City of Helena Phase 2 Flow Contribution (GPM)	Combined COH Phase 1 & 2 Flow Contribution (Includes All Phases) (GPM)	Total Existing Cumulative Flow* (GPM)	Phase 1 (Hauser) Flow Contribution Only (GPM)	Phase 1 (Overlook) Flow Contribution Only (GPM)	Phase 1 (Total) Flow Contribution Only (GPM)	Phase 2 Flow Contribution (Includes Previous Phases) (GPM)	Phase 3 Flow Contribution (Includes Previous Phases) (GPM)	Phase 4 Flow Contribution (Includes Previous Phases) (GPM)	Total Cumulative Flow (GPM)	Phase 1 Percent Full (% of Full Pipe Flow)	Phase 1 & 2 Percent Full (% of Full Pipe Flow)	Phase 1, 2, 3 Percent Full (% of Full Pipe Flow)	Full Build Out Percent Full (% of Full Pipe Flow)
															EDU Calculated Flow				3.52				106.84	315.59		31.14	11.81	42.95	23.51	33.95	33.77	134.18				
															Flow Meter at MH 99-14-6 = 66.72 gpm + 3.91 gpm for I&I		70.63																				
															Flow Meter at MH 73-20-4 = 90.63 gpm + 1.95 gpm for I&I			92.58																				
															Flow Meter at MH 531-6 = 492.45 gpm + 26.56 gpm for I&I				519.01																		
																Pipe Flowrate (Existing)										**Pipe Flowrate by Phase**									
SMH-1/Custer 1	11.45	3837.7	3826.25	SMH-2	14.82	3840.35	3825.53	229.13	36	0.00314	PVC	0.013	16,781.23	8,390.61	Custer West of Sanders to Custer East of Sanders									315.59	8,706.20			42.95	66.46	100.41	134.18	8,840.38	52.1%	52.3%	52.5%	52.7%
SMH-2	14.92	3840.35	3825.43	SMH-3	16.7	3841.77	3825.07	113.36	36	0.00318	PVC	0.013	16,870.18	8,435.09	Custer East of Sanders East									315.59	8,750.68			42.95	66.46	100.41	134.18	8,884.86	52.1%	52.3%	52.5%	52.7%
SMH-3	16.8	3841.77	3824.97	SMH-4	8.1	3832.54	3824.44	167.85	36	0.00316	PVC	0.013	16,821.92	8,410.96	Custer East of Sanders East									315.59	8,726.55			42.95	66.46	100.41	134.18	8,860.73	52.1%	52.3%	52.5%	52.7%
SMH-4	8.2	3832.54	3824.34	SMH-5	6.07	3829.29	3823.22	282.98	36	0.00396	PVC	0.013	18,833.43	9,416.72	Custer East of Sanders East to West of Interstate Off Ramp									315.59	9,732.31			42.95	66.46	100.41	134.18	9,866.49	51.9%	52.0%	52.2%	52.4%
SMH-5	6.17	3829.29	3823.12	SMH-6	7.43	3828.91	3821.48	414.67	36	0.00395	PVC	0.013	18,826.47	9,413.24	East of Interstate Off Ramp to just West of I-15									315.59	9,728.83			42.95	66.46	100.41	134.18	9,863.01	51.9%	52.0%	52.2%	52.4%
SMH-6	7.53	3828.91	3821.38	SMH-7	11.66	3829.89	3818.23	404.57	36	0.00779	PVC	0.013	26,415.38	13,207.69	West of I-15 to East of I-15									315.59	13,523.28			42.95	66.46	100.41	134.18	13,657.46	51.4%	51.4%	51.6%	51.7%
SMH-7	11.76	3829.89	3818.13	SMH-8	12.56	3829.79	3817.23	111.23	36	0.00809	PVC	0.013	26,928.28	13,464.14	East of I-15 East along Custer Avenue									315.59	13,779.73			42.95	66.46	100.41	134.18	13,913.91	51.3%	51.4%	51.5%	51.7%
SMH-8	12.66	3829.79	3817.13	SMH-20	12.35	3829.02	3816.67	160.75	36	0.00286	PVC	0.013	16,014.07	8,007.04	East of I-15 East along Custer Avenue									315.59	8,322.63			42.95	66.46	100.41	134.18	8,456.81	52.2%	52.4%	52.6%	52.8%
SMH-20	12.45	3829.02	3816.57	SMH-21	8.03	3823.5	3815.47	385	36	0.00286	PVC	0.013	16,001.64	8,000.82	East of I-15 East along Custer Avenue									315.59	8,316.41			42.95	66.46	100.41	134.18	8,450.59	52.2%	52.4%	52.6%	52.8%
SMH-21	8.13	3823.5	3815.37	SMH-21A	13.25	3828.44	3815.19	60.92	36	0.00295	PVC	0.013	16,272.52	8,136.26	East of I-15 Southeast along Custer Avenue									315.59	8,451.85			42.95	66.46	100.41	134.18	8,586.03	52.2%	52.3%	52.6%	52.8%
SMH-21A	13.35	3828.44	3815.09	SMH-22	9.55	3824.21	3814.66	158.91	36	0.00271	PVC	0.013	15,572.45	7,786.23	East of I-15 East along Custer Avenue									315.59	8,101.82			42.95	66.46	100.41	134.18	8,236.00	52.3%	52.5%	52.7%	52.9%
SMH-22	9.65	3824.21	3814.56	SMH-23	7.66	3821.54	3813.88	258.54	36	0.00263	PVC	0.013	15,352.85	7,676.42	East of I-15 East along Custer Avenue to Frontage Road West									315.59	7,992.01			42.95	66.46	100.41	134.18	8,126.19	52.3%	52.5%	52.7%	52.9%
SMH-23	7.76	3821.54	3813.78	SMH-24	6.13	3819.66	3813.53	81.56	36	0.00307	PVC	0.013	16,574.09	8,287.05	Frontage Road West to Frontage Road East									315.59	8,602.64			42.95	66.46	100.41	134.18	8,736.82	52.2%	52.3%	52.5%	52.7%
SMH-24	6.23	3819.66	3813.43	SMH-25	6.15	3819.54	3813.39	13.01	42	0.00307	RCP	0.013	25,038.86	12,519.43	Frontage Road West to WWTP Influent Pipe									315.59	12,835.02			42.95	66.46	100.41	134.18	12,969.20	51.4%	51.5%	51.7%	51.8%

Notes/Assumptions:

1. GIS data used for pipe grade calculations includes manhole rim elevation interpolated from contour data, and used in conjunction with manhole depth data, and pipe length, construction and age data. If data indicated a positive slope minimum grade was assumed.
2. As- Constructed plans were used for Custer Avenue Sewer grade calculations, taken from Montana Department of Transportation Plans IM-MT 15-4(107)193 City Project #09-24
3. Pipe capacities were calculated using the Manning Formula for uniform pipe flow at given flow and depth using the pipe coefficients given.

APPENDIX C
WASTEWATER MASTER PLAN FIGURE



MORRISON MAIERLE, INC.

Burns & McDonnell SINCE 1898

Figure 5-9
Wet Weather 10-Yr Storm Capacity
Helena Wastewater Collection System Master Plan

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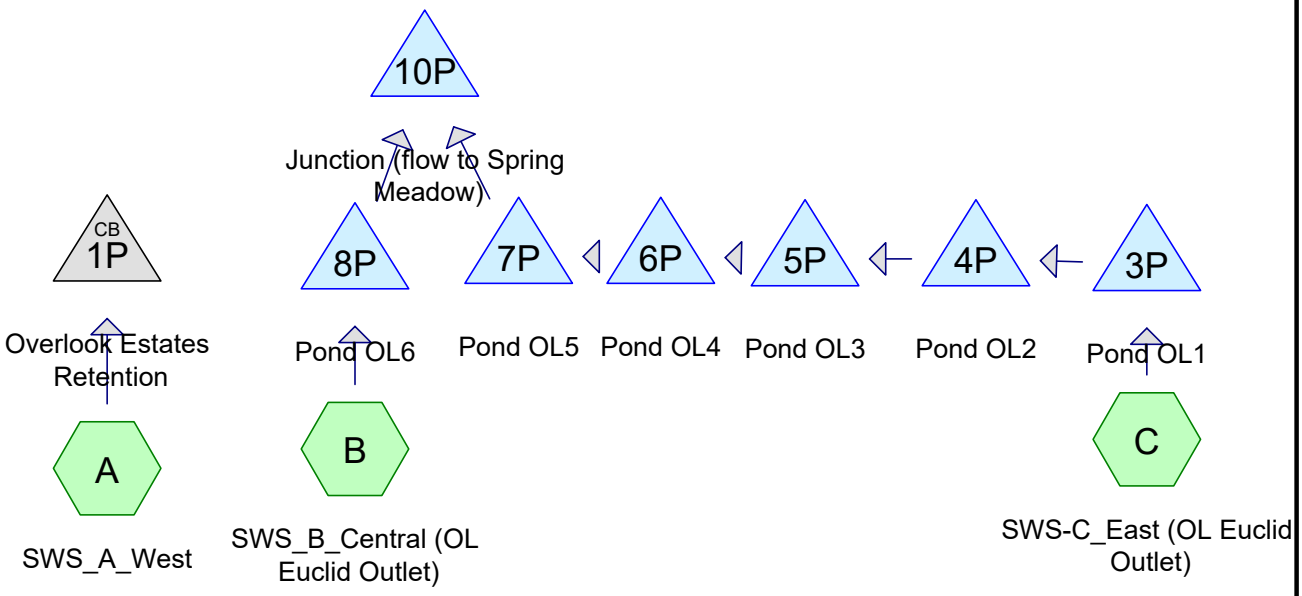
APPENDIX D
STORM WATER

STORM WATER EXISTING CONDITIONS



Subcat Reach Pond Link

Drainage Diagram for WestSideSub - ExistingCond

Prepared by {enter your company name here}, Printed 4/8/2021

Time span=0.00-75.00 hrs, dt=0.05 hrs, 1501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Muskingum-Cunge method - Pond routing by Dyn-Stor-Ind method

Subcatchment A: SWS_A_West Runoff Area=20.640 ac 0.00% Impervious Runoff Depth=0.39"
Flow Length=1,720' Slope=0.1540 '/' Tc=5.0 min CN=69 Runoff=3.32 cfs 0.677 af

Subcatchment B: SWS_B_Central (OL Runoff Area=277.490 ac 0.00% Impervious Runoff Depth=0.20"
Flow Length=8,690' Tc=24.4 min CN=62 Runoff=4.79 cfs 4.643 af

Subcatchment C: SWS-C_East (OL Runoff Area=234.200 ac 14.03% Impervious Runoff Depth=0.33"
Flow Length=7,666' Tc=52.5 min CN=67 Runoff=9.23 cfs 6.475 af

Pond 1P: Overlook Estates Retention Peak Elev=3,967.80' Inflow=3.32 cfs 0.677 af
Outflow=3.32 cfs 0.677 af

Pond 3P: Pond OL1 Peak Elev=3,956.79' Storage=11,920 cf Inflow=9.23 cfs 6.475 af
Outflow=9.02 cfs 6.423 af

Pond 4P: Pond OL2 Peak Elev=3,953.78' Storage=7,153 cf Inflow=9.02 cfs 6.423 af
Outflow=8.91 cfs 6.394 af

Pond 5P: Pond OL3 Peak Elev=3,950.77' Storage=7,105 cf Inflow=8.91 cfs 6.394 af
Outflow=8.63 cfs 6.364 af

Pond 6P: Pond OL4 Peak Elev=3,949.73' Storage=10,999 cf Inflow=8.63 cfs 6.364 af
Outflow=7.90 cfs 6.299 af

Pond 7P: Pond OL5 Peak Elev=3,948.65' Storage=4,074 cf Inflow=7.90 cfs 6.299 af
24.0" Round Culvert n=0.013 L=158.0' S=0.0449 '/' Outflow=7.82 cfs 6.265 af

Pond 8P: Pond OL6 Peak Elev=3,947.00' Storage=7,135 cf Inflow=4.79 cfs 4.643 af
Outflow=4.79 cfs 4.505 af

Pond 10P: Junction (flow to Spring Meadow) Inflow=12.48 cfs 10.770 af
Primary=12.48 cfs 10.770 af

Total Runoff Area = 532.330 ac Runoff Volume = 11.795 af Average Runoff Depth = 0.27"
93.83% Pervious = 499.480 ac 6.17% Impervious = 32.850 ac

Summary for Subcatchment A: SWS_A_West

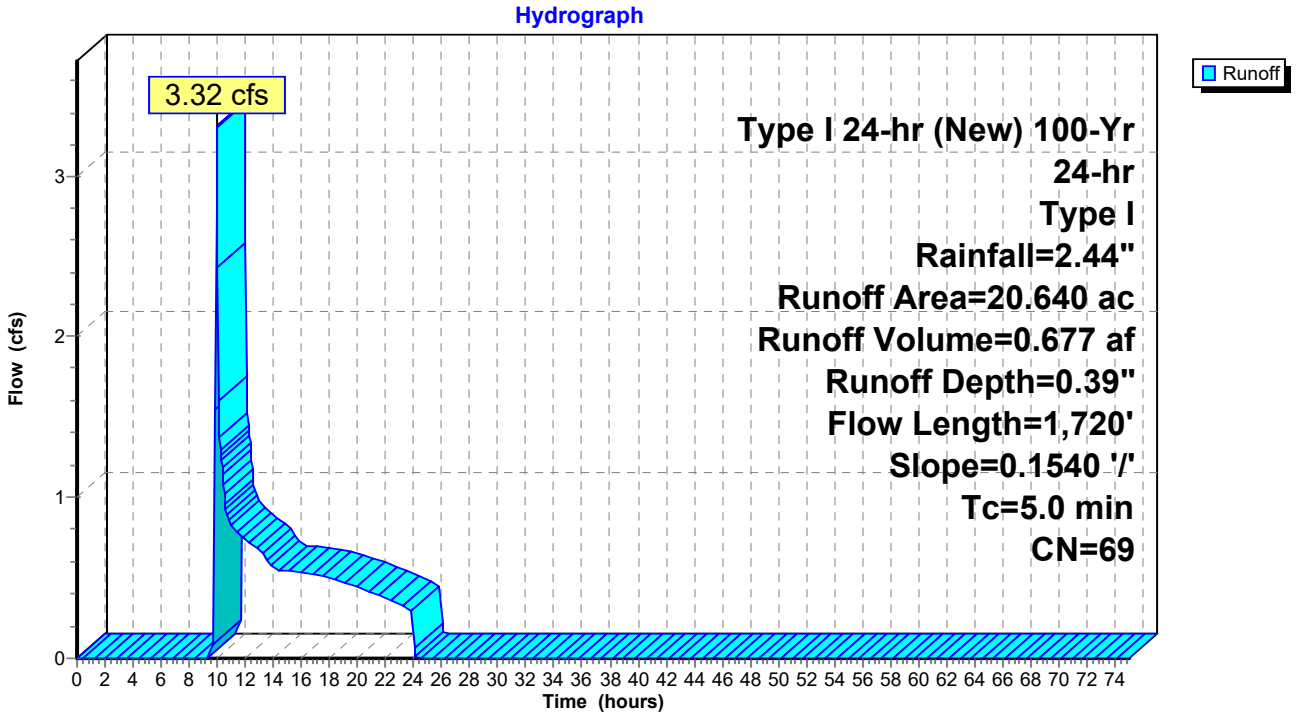
Runoff = 3.32 cfs @ 9.99 hrs, Volume= 0.677 af, Depth= 0.39"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	20.640	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	0.000	75	1/4 ac lot, SoilG B / Fair, HEC 22 Table 3-6
	20.640	69	Weighted Average
	20.640		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	1,720	0.1540	5.89		**Shallow Concentrated Flow, Channel** Grassed Waterway Kv= 15.0 fps
4.9	1,720	Total, Increased to minimum Tc = 5.0 min			

Subcatchment A: SWS_A_West



Summary for Subcatchment B: SWS_B_Central (OL Euclid Outlet)

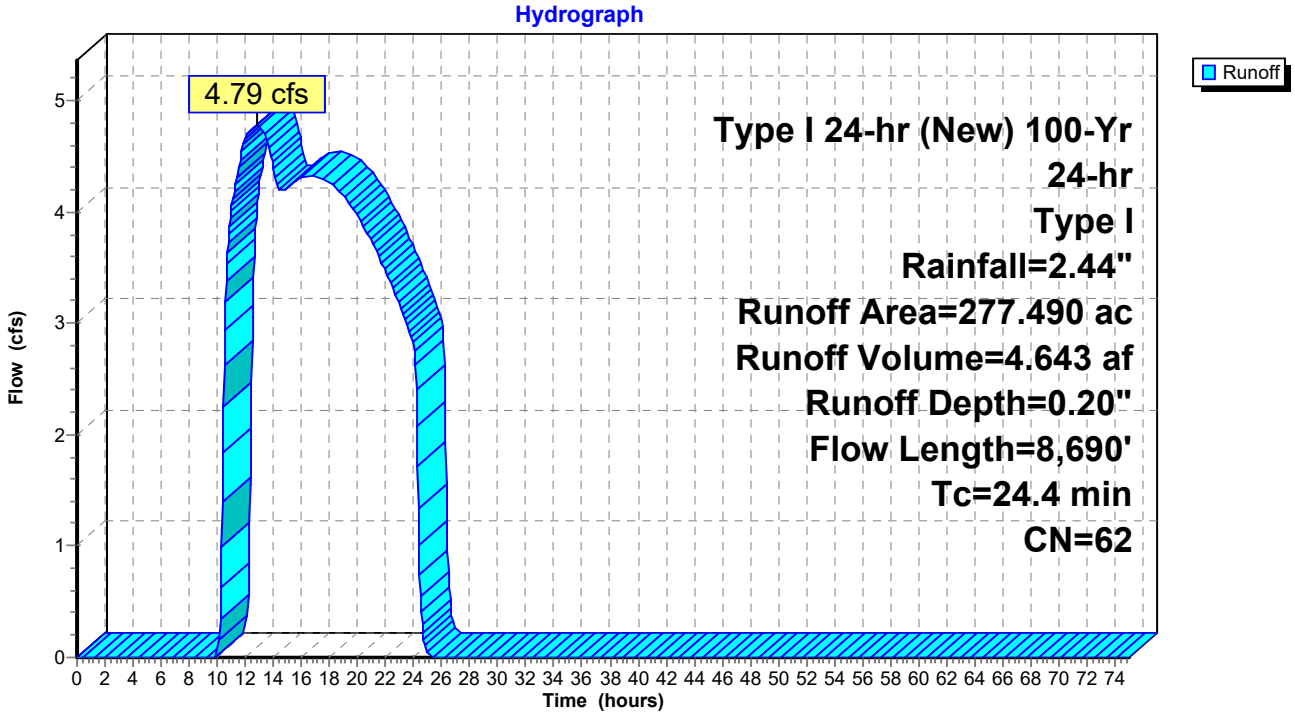
Runoff = 4.79 cfs @ 12.85 hrs, Volume= 4.643 af, Depth= 0.20"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	13.000	75	1/4 ac lot, SoilG B, HEC 22 Table 3-6
*	236.400	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
*	19.000	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	7.280	75	Overlook - 1/4 ac lot, SoilG B, HEC 22 Table 3-6
*	1.810	69	Overlook - Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	277.490	62	Weighted Average
	277.490		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2	250	0.4000	0.20		**Sheet Flow, Upper Portion of WS** Woods: Light underbrush n= 0.400 P2= 1.30"
3.2	8,440	0.1440	43.55	8,710.44	**Channel Flow, Drainage channel** Area= 200.0 sf Perim= 45.0' r= 4.44' n= 0.035 Earth, dense weeds
24.4	8,690	Total			

Subcatchment B: SWS_B_Central (OL Euclid Outlet)



Summary for Subcatchment C: SWS-C_East (OL Euclid Outlet)

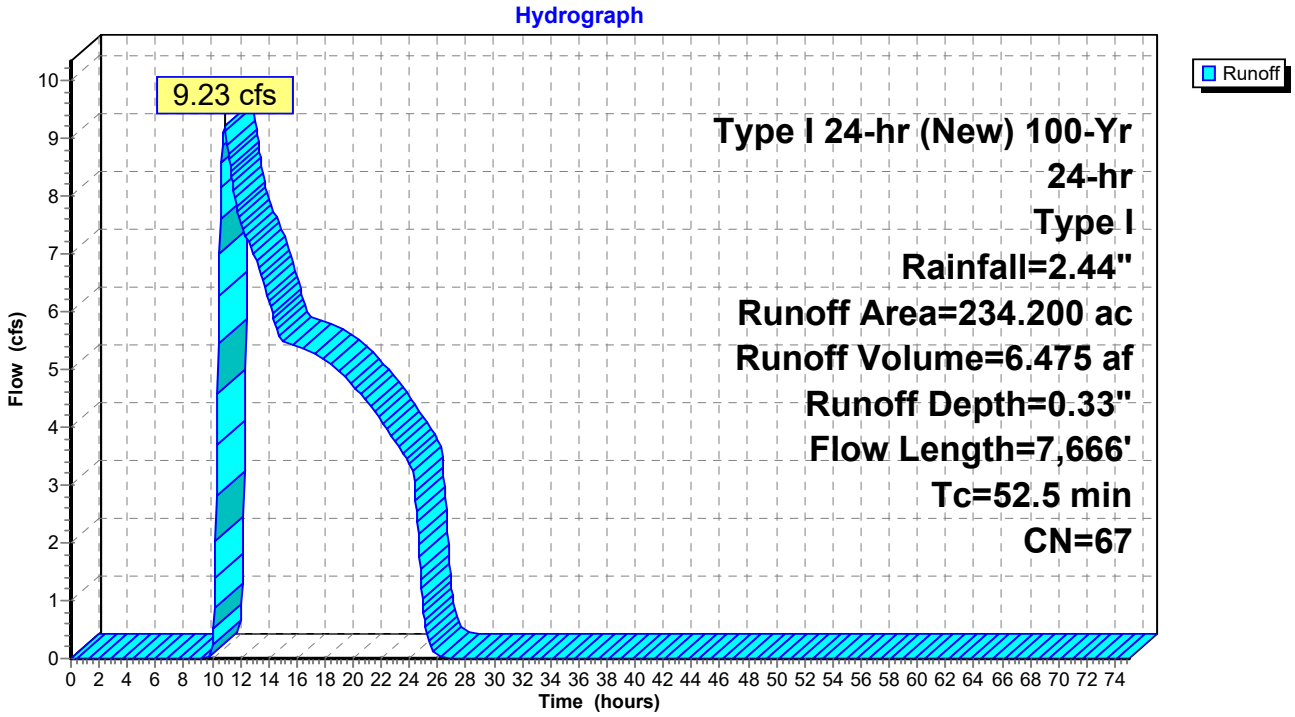
Runoff = 9.23 cfs @ 10.90 hrs, Volume= 6.475 af, Depth= 0.33"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	86.800	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
*	12.300	75	Overlook - 1/4 ac lot, SoilG B, HEC 22 Table 3-6
	131.400	70	1/2 acre lots, 25% imp, HSG B
*	3.700	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	234.200	67	Weighted Average
	201.350		85.97% Pervious Area
	32.850		14.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.2	200	0.5000	0.21		**Sheet Flow, Upper Watershed** Woods: Light underbrush n= 0.400 P2= 1.30"
22.8	3,613	0.2800	2.65		**Shallow Concentrated Flow, Channel** Woodland Kv= 5.0 fps
12.1	2,811	0.0670	3.88		**Shallow Concentrated Flow, Neighborhoods** Grassed Waterway Kv= 15.0 fps
1.4	1,042	0.0420	12.79	40.18	**Pipe Channel, Storm Drain** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.015 Concrete sewer w/manholes & inlets
52.5	7,666	Total			

Subcatchment C: SWS-C_East (OL Euclid Outlet)



Summary for Pond 1P: Overlook Estates Retention

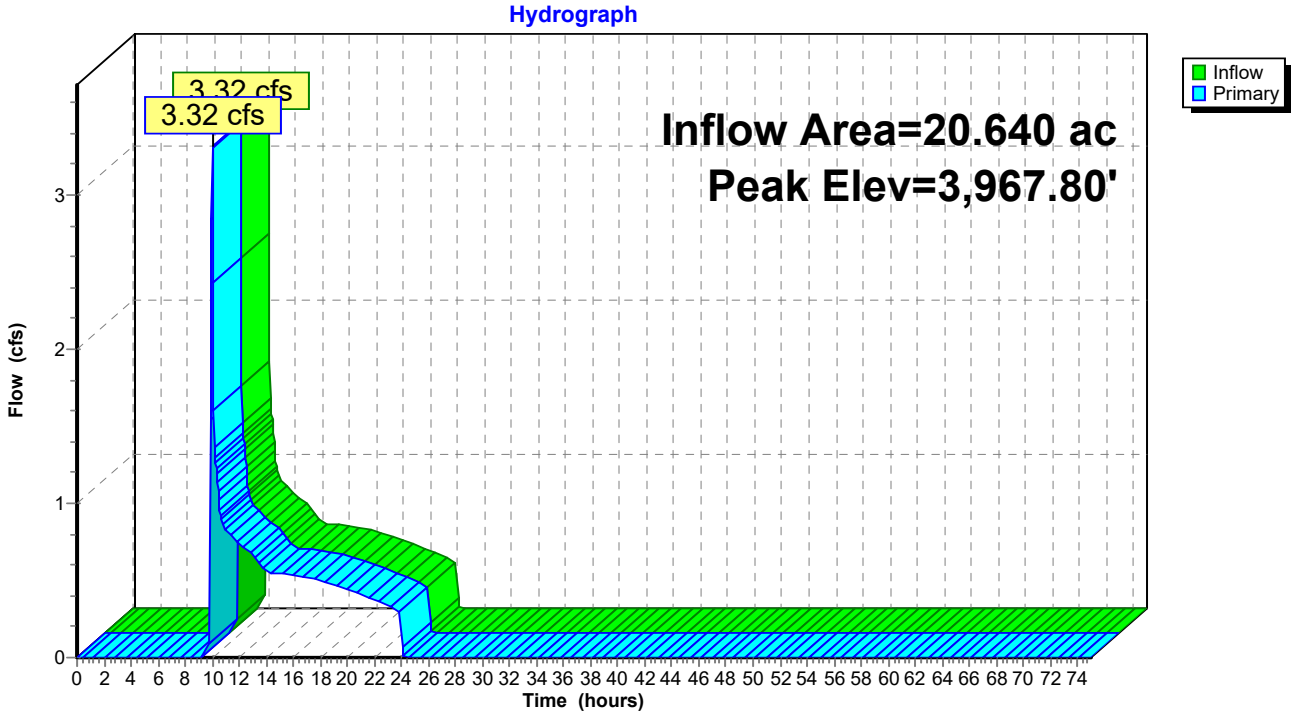
Inflow Area = 20.640 ac, 0.00% Impervious, Inflow Depth = 0.39" for (New) 100-Yr, 24-hr, Type I event
Inflow = 3.32 cfs @ 9.99 hrs, Volume= 0.677 af
Outflow = 3.32 cfs @ 9.99 hrs, Volume= 0.677 af, Atten= 0%, Lag= 0.0 min
Primary = 3.32 cfs @ 9.99 hrs, Volume= 0.677 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,967.80' @ 9.99 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	3,959.50'	**18.0" Round Culvert** L= 850.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3,959.50' / 3,955.00' S= 0.0053 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Device 1	3,964.50'	**18.0" Round Culvert** L= 120.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3,964.50' / 3,959.50' S= 0.0417 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#3	Device 2	3,967.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=3.23 cfs @ 9.99 hrs HW=3,967.79' (Free Discharge)
└**1=Culvert** (Passes 3.23 cfs of 14.57 cfs potential flow)
└**2=Culvert** (Passes 3.23 cfs of 13.56 cfs potential flow)
└**3=Orifice/Grate** (Weir Controls 3.23 cfs @ 1.76 fps)

Pond 1P: Overlook Estates Retention



Summary for Pond 3P: Pond OL1

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 9.23 cfs @ 10.90 hrs, Volume= 6.475 af
Outflow = 9.02 cfs @ 11.06 hrs, Volume= 6.423 af, Atten= 2%, Lag= 9.8 min
Primary = 9.02 cfs @ 11.06 hrs, Volume= 6.423 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,956.79' @ 11.06 hrs Surf.Area= 0 sf Storage= 11,920 cf

Plug-Flow detention time= 39.3 min calculated for 6.423 af (99% of inflow)
Center-of-Mass det. time= 34.6 min (1,024.3 - 989.7)

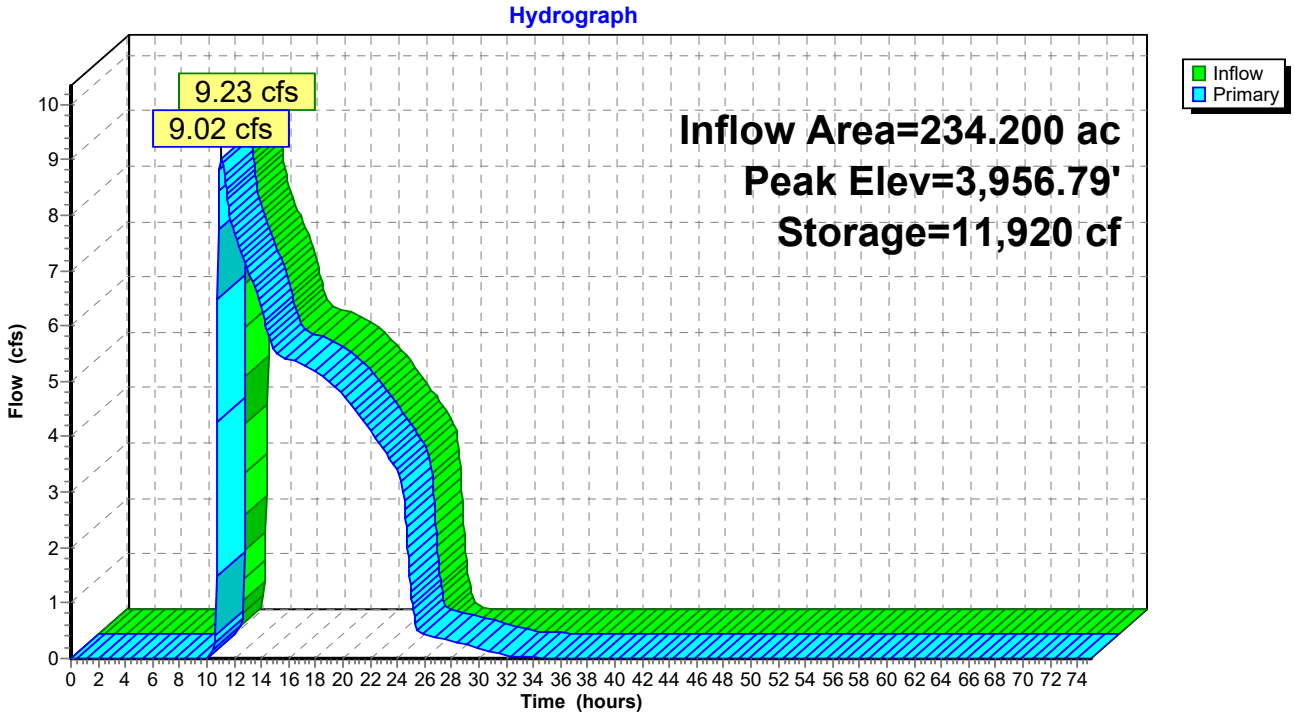
Volume	Invert	Avail.Storage	Storage Description
#1	3,953.00'	15,203 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,953.00	0
3,953.50	1,018
3,954.00	2,234
3,954.50	3,615
3,955.00	5,144
3,955.50	6,824
3,956.00	8,661
3,956.50	10,657
3,957.00	12,828
3,957.50	15,203

Device	Routing	Invert	Outlet Devices
#1	Primary	3,954.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,954.00' / 3,951.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,956.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=9.02 cfs @ 11.06 hrs HW=3,956.79' TW=3,953.74' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.54 cfs @ 6.16 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 8.48 cfs @ 2.38 fps)

Pond 3P: Pond OL1



Summary for Pond 4P: Pond OL2

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 9.02 cfs @ 11.06 hrs, Volume= 6.423 af
Outflow = 8.91 cfs @ 11.18 hrs, Volume= 6.394 af, Atten= 1%, Lag= 7.4 min
Primary = 8.91 cfs @ 11.18 hrs, Volume= 6.394 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,953.78' @ 11.18 hrs Surf.Area= 0 sf Storage= 7,153 cf

Plug-Flow detention time= 27.5 min calculated for 6.394 af (100% of inflow)
Center-of-Mass det. time= 22.7 min (1,047.0 - 1,024.3)

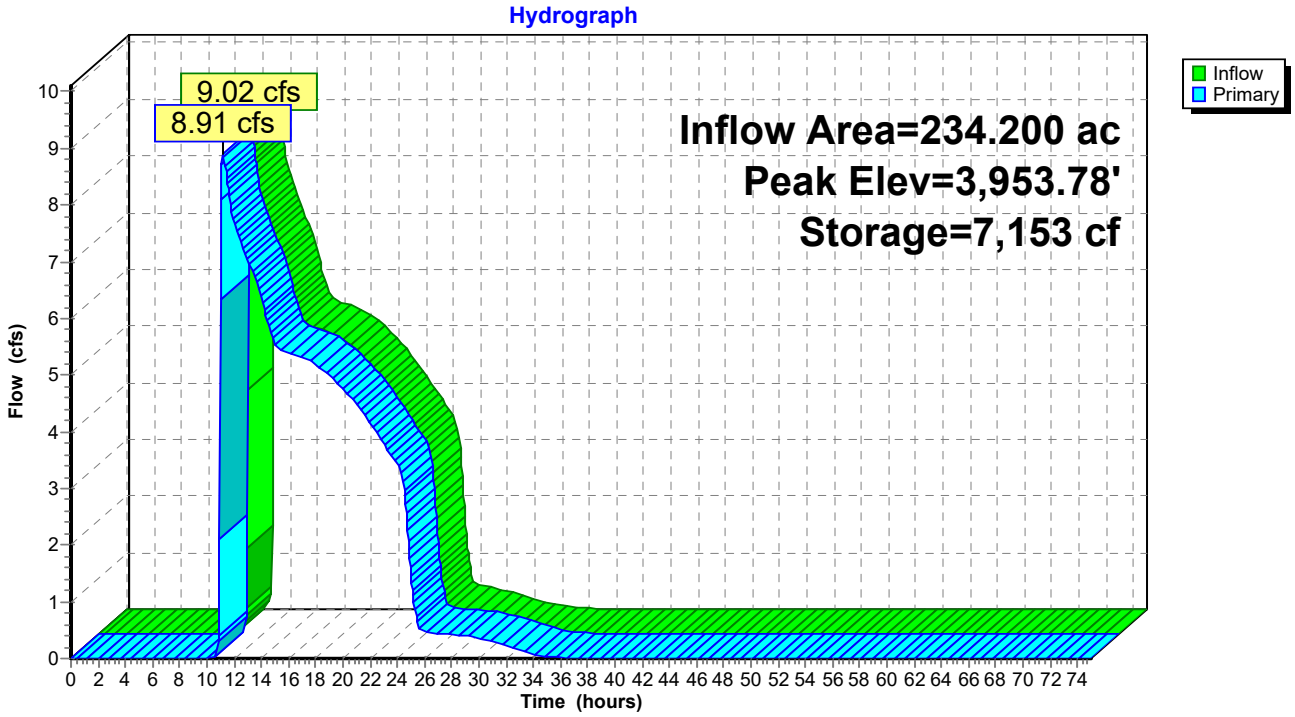
Volume	Invert	Avail.Storage	Storage Description
#1	3,950.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,950.00	0
3,950.50	567
3,951.00	1,263
3,951.50	2,070
3,952.00	2,987
3,952.50	4,015
3,953.00	5,148
3,953.50	6,390
3,954.00	7,734
3,954.50	9,177
3,955.00	10,719
3,955.50	12,359
3,956.00	14,099
3,956.50	15,947
3,957.00	17,922
3,957.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,951.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,951.00' / 3,948.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,953.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=8.90 cfs @ 11.18 hrs HW=3,953.78' TW=3,950.35' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.54 cfs @ 6.15 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 8.36 cfs @ 2.37 fps)

Pond 4P: Pond OL2



Summary for Pond 5P: Pond OL3

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 8.91 cfs @ 11.18 hrs, Volume= 6.394 af
Outflow = 8.63 cfs @ 11.38 hrs, Volume= 6.364 af, Atten= 3%, Lag= 11.8 min
Primary = 8.63 cfs @ 11.38 hrs, Volume= 6.364 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,950.77' @ 11.38 hrs Surf.Area= 0 sf Storage= 7,105 cf

Plug-Flow detention time= 30.8 min calculated for 6.360 af (99% of inflow)
Center-of-Mass det. time= 26.4 min (1,073.4 - 1,047.0)

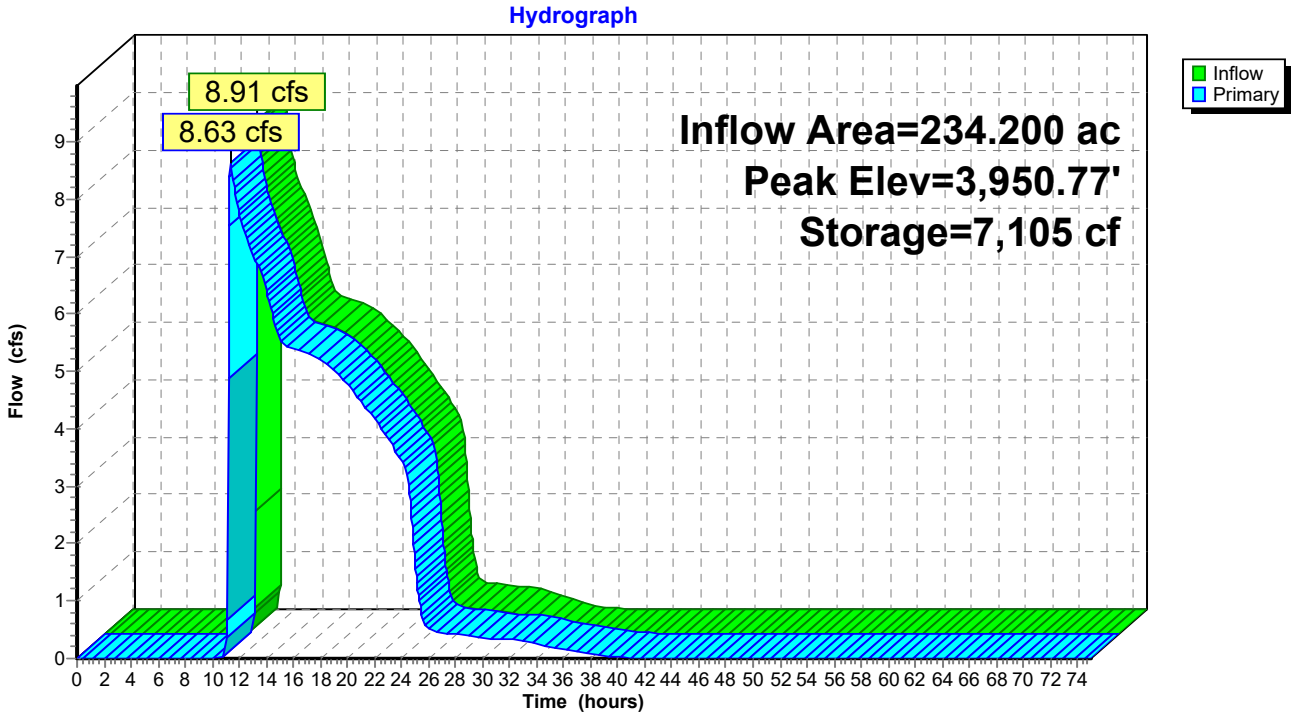
Volume	Invert	Avail.Storage	Storage Description
#1	3,947.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,947.00	0
3,947.50	567
3,948.00	1,263
3,948.50	2,070
3,949.00	2,987
3,949.50	4,015
3,950.00	5,148
3,950.50	6,390
3,951.00	7,734
3,951.50	9,177
3,952.00	10,719
3,952.50	12,359
3,953.00	14,099
3,953.50	15,947
3,954.00	17,922
3,954.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,948.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,948.00' / 3,946.00' S= 0.1000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,950.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=8.61 cfs @ 11.38 hrs HW=3,950.77' TW=3,948.28' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.52 cfs @ 6.00 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 8.09 cfs @ 2.35 fps)

Pond 5P: Pond OL3



Summary for Pond 6P: Pond OL4

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 8.63 cfs @ 11.38 hrs, Volume= 6.364 af
Outflow = 7.90 cfs @ 11.85 hrs, Volume= 6.299 af, Atten= 8%, Lag= 28.4 min
Primary = 7.90 cfs @ 11.85 hrs, Volume= 6.299 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,949.73' @ 11.86 hrs Surf.Area= 0 sf Storage= 10,999 cf

Plug-Flow detention time= 53.2 min calculated for 6.299 af (99% of inflow)
Center-of-Mass det. time= 40.7 min (1,114.2 - 1,073.4)

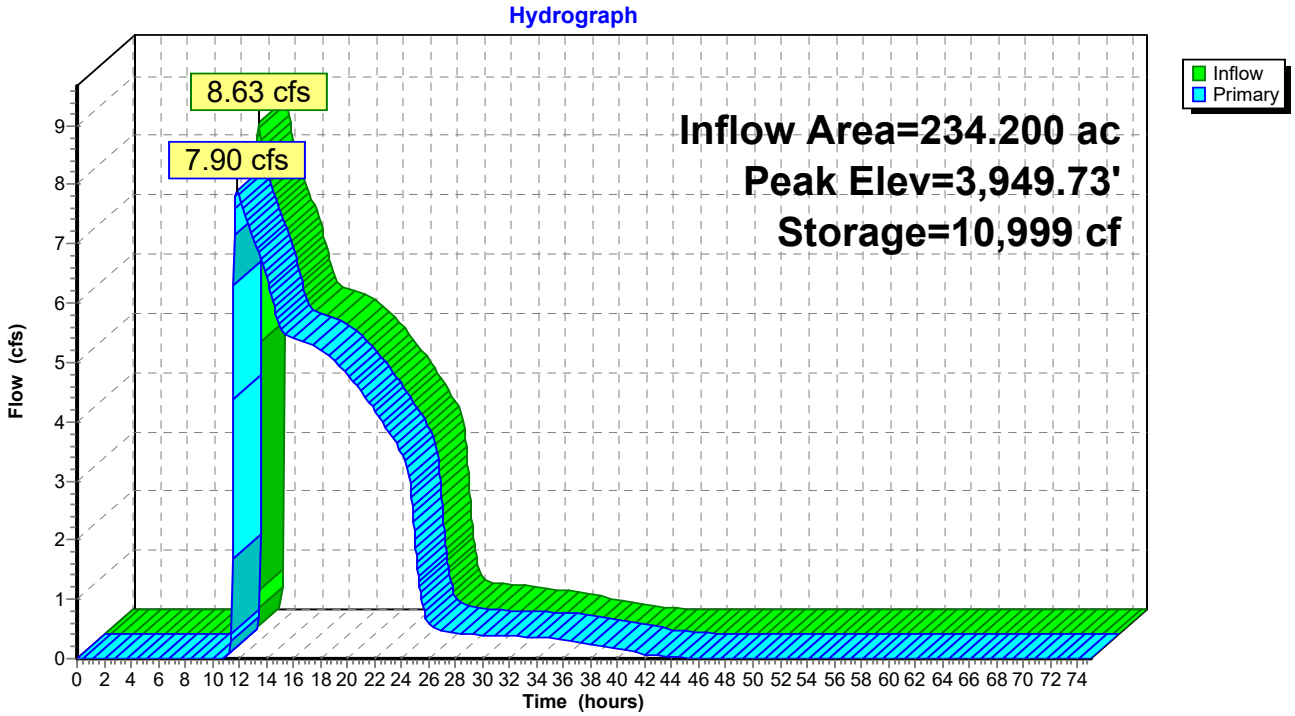
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	55,314 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	761
3,947.00	1,811
3,947.50	3,099
3,948.00	4,591
3,948.50	6,260
3,949.00	8,076
3,949.50	10,034
3,950.00	12,127
3,950.50	14,353
3,951.00	16,711
3,951.50	19,197
3,952.00	21,811
3,952.50	24,551
3,953.00	27,420
3,953.50	30,417
3,954.00	33,546
3,954.50	36,810
3,955.00	40,213
3,955.50	43,758
3,956.00	47,453
3,956.50	51,302
3,957.00	55,314

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,947.00' / 3,946.00' S= 0.0500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,949.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=7.90 cfs @ 11.85 hrs HW=3,949.73' TW=3,948.62' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 0.35 cfs @ 4.00 fps)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 7.55 cfs @ 2.30 fps)

Pond 6P: Pond OL4



Summary for Pond 7P: Pond OL5

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth > 0.32" for (New) 100-Yr, 24-hr, Type I event
Inflow = 7.90 cfs @ 11.85 hrs, Volume= 6.299 af
Outflow = 7.82 cfs @ 12.00 hrs, Volume= 6.265 af, Atten= 1%, Lag= 8.8 min
Primary = 7.82 cfs @ 12.00 hrs, Volume= 6.265 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,948.65' @ 12.00 hrs Surf.Area= 0 sf Storage= 4,074 cf

Plug-Flow detention time= 17.0 min calculated for 6.261 af (99% of inflow)
Center-of-Mass det. time= 9.7 min (1,123.8 - 1,114.2)

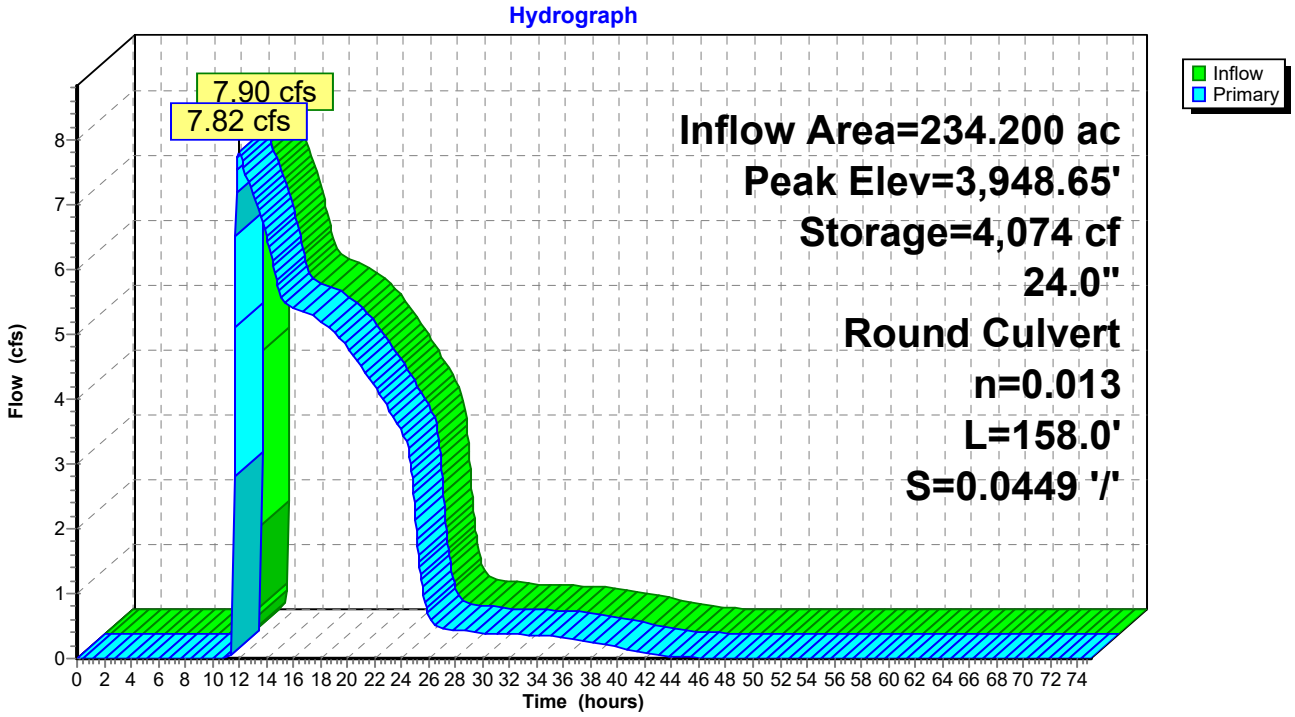
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	56,530 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	300
3,947.00	827
3,947.50	1,596
3,948.00	2,549
3,948.50	3,687
3,949.00	5,013
3,949.50	6,529
3,950.00	8,234
3,950.50	10,134
3,951.00	12,319
3,951.50	14,829
3,952.00	17,598
3,952.50	20,588
3,953.00	23,779
3,953.50	27,169
3,954.00	30,757
3,954.50	34,542
3,955.00	38,525
3,955.50	42,711
3,956.00	47,103
3,956.50	51,706
3,957.00	56,530

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.40'	**24.0" Round Culvert** L= 158.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,947.40' / 3,940.30' S= 0.0449 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections

Primary OutFlow Max=7.82 cfs @ 12.00 hrs HW=3,948.65' TW=0.00' (Dynamic Tailwater)
1=Culvert (Inlet Controls 7.82 cfs @ 3.80 fps)

Pond 7P: Pond OL5



Summary for Pond 8P: Pond OL6

Inflow Area = 277.490 ac, 0.00% Impervious, Inflow Depth = 0.20" for (New) 100-Yr, 24-hr, Type I event
Inflow = 4.79 cfs @ 12.85 hrs, Volume= 4.643 af
Outflow = 4.79 cfs @ 12.90 hrs, Volume= 4.505 af, Atten= 0%, Lag= 2.9 min
Primary = 4.79 cfs @ 12.90 hrs, Volume= 4.505 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,947.00' @ 12.90 hrs Surf.Area= 0 sf Storage= 7,135 cf

Plug-Flow detention time= 28.9 min calculated for 4.502 af (97% of inflow)
Center-of-Mass det. time= 15.9 min (1,034.5 - 1,018.6)

Volume	Invert	Avail.Storage	Storage Description
#1	3,945.00'	150,009 cf	**Custom Stage Data** Listed below

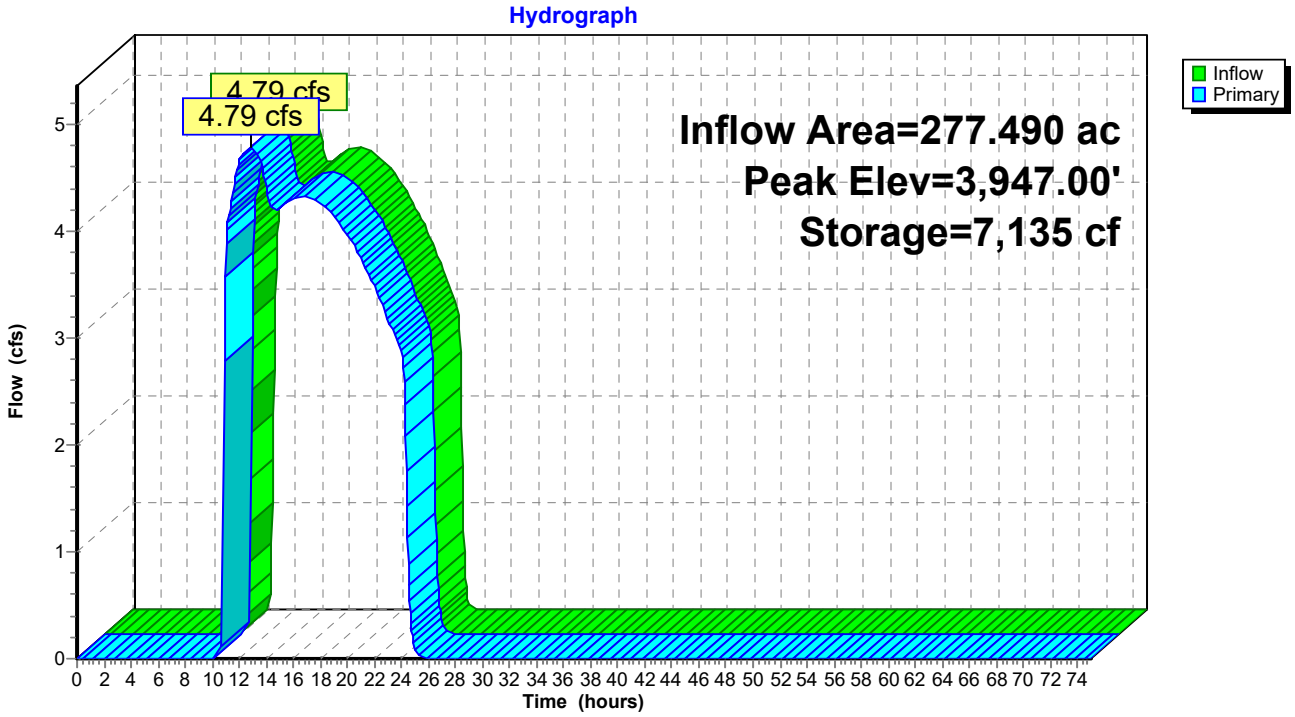
Elevation (feet)	Cum.Store (cubic-feet)
3,945.00	0
3,945.50	1,241
3,946.00	2,907
3,946.50	4,876
3,947.00	7,132
3,947.50	9,707
3,948.00	12,610
3,948.50	15,850
3,949.00	19,436
3,949.50	23,393
3,950.00	27,772
3,950.50	32,645
3,951.00	37,997
3,951.50	43,750
3,952.00	49,862
3,952.50	56,323
3,953.00	63,123
3,953.50	70,242
3,954.00	77,678
3,954.50	85,443
3,955.00	93,551
3,955.50	102,017
3,956.00	110,852
3,956.50	120,062
3,957.00	129,654
3,957.50	139,634
3,958.00	150,009

Device	Routing	Invert	Outlet Devices
#1	Primary	3,944.96'	**18.0" Round Culvert** L= 153.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,944.96' / 3,942.08' S= 0.0188 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	3,946.75'	**15.0' long x 11.0' breadth Broad-Crested Rectangular Weir**

Head (feet)	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60
Coef. (English)	2.53	2.59	2.70	2.68	2.67	2.68	2.66	2.64

Primary OutFlow Max=4.79 cfs @ 12.90 hrs HW=3,947.00' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 4.79 cfs of 9.67 cfs potential flow)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 4.79 cfs @ 1.27 fps)

Pond 8P: Pond OL6

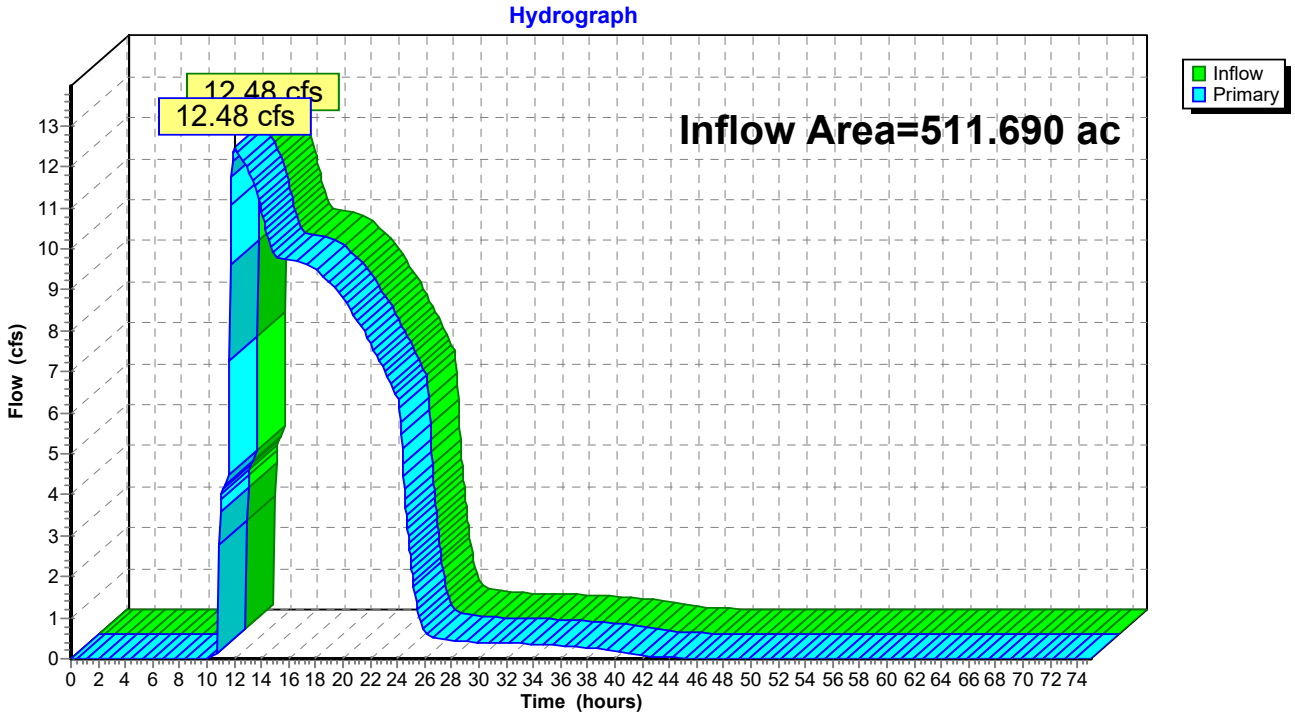


Summary for Pond 10P: Junction (flow to Spring Meadow)

Inflow Area = 511.690 ac, 6.42% Impervious, Inflow Depth = 0.25" for (New) 100-Yr, 24-hr, Type I event
Inflow = 12.48 cfs @ 12.02 hrs, Volume= 10.770 af
Primary = 12.48 cfs @ 12.02 hrs, Volume= 10.770 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs

Pond 10P: Junction (flow to Spring Meadow)



Time span=0.00-75.00 hrs, dt=0.05 hrs, 1501 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Muskingum-Cunge method - Pond routing by Dyn-Stor-Ind method

Subcatchment A: SWS_A_West Runoff Area=20.640 ac 0.00% Impervious Runoff Depth=0.09"
Flow Length=1,720' Slope=0.1540 '/' Tc=5.0 min CN=69 Runoff=0.15 cfs 0.150 af

Subcatchment B: SWS_B_Central (OL Runoff Area=277.490 ac 0.00% Impervious Runoff Depth=0.02"
Flow Length=8,690' Tc=24.4 min CN=62 Runoff=0.69 cfs 0.423 af

Subcatchment C: SWS-C_East (OL Runoff Area=234.200 ac 14.03% Impervious Runoff Depth=0.06"
Flow Length=7,666' Tc=52.5 min CN=67 Runoff=1.36 cfs 1.212 af

Pond 1P: Overlook Estates Retention Peak Elev=3,967.54' Inflow=0.15 cfs 0.150 af
Outflow=0.15 cfs 0.150 af

Pond 3P: Pond OL1 Peak Elev=3,956.19' Storage=9,420 cf Inflow=1.36 cfs 1.212 af
Outflow=1.36 cfs 1.160 af

Pond 4P: Pond OL2 Peak Elev=3,953.19' Storage=5,620 cf Inflow=1.36 cfs 1.160 af
Outflow=1.36 cfs 1.131 af

Pond 5P: Pond OL3 Peak Elev=3,950.21' Storage=5,663 cf Inflow=1.36 cfs 1.131 af
Outflow=1.35 cfs 1.101 af

Pond 6P: Pond OL4 Peak Elev=3,949.20' Storage=8,858 cf Inflow=1.35 cfs 1.101 af
Outflow=1.33 cfs 1.035 af

Pond 7P: Pond OL5 Peak Elev=3,947.87' Storage=2,308 cf Inflow=1.33 cfs 1.035 af
24.0" Round Culvert n=0.013 L=158.0' S=0.0449 '/' Outflow=1.33 cfs 1.002 af

Pond 8P: Pond OL6 Peak Elev=3,946.82' Storage=6,315 cf Inflow=0.69 cfs 0.423 af
Outflow=0.69 cfs 0.285 af

Pond 10P: Junction (flow to Spring Meadow) Inflow=2.01 cfs 1.287 af
Primary=2.01 cfs 1.287 af

Total Runoff Area = 532.330 ac Runoff Volume = 1.785 af Average Runoff Depth = 0.04"
93.83% Pervious = 499.480 ac 6.17% Impervious = 32.850 ac

Summary for Subcatchment A: SWS_A_West

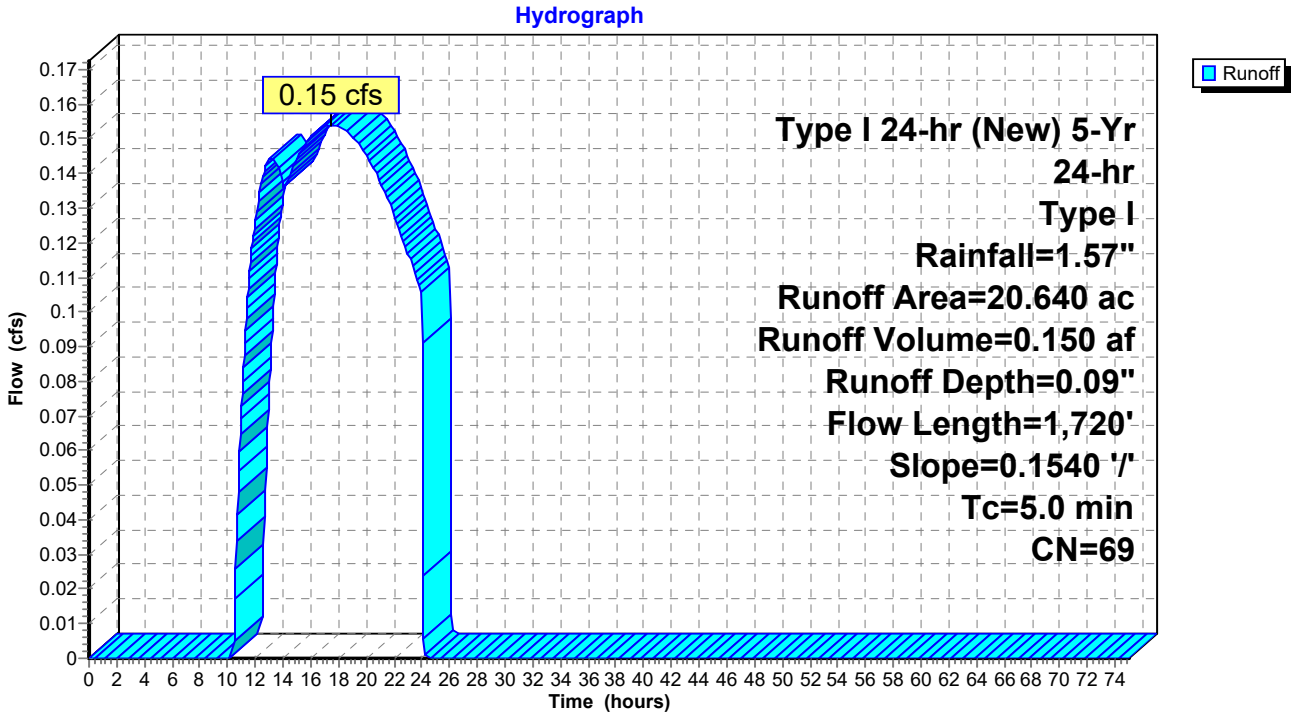
Runoff = 0.15 cfs @ 17.45 hrs, Volume= 0.150 af, Depth= 0.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	20.640	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	0.000	75	1/4 ac lot, SoilG B / Fair, HEC 22 Table 3-6
	20.640	69	Weighted Average
	20.640		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	1,720	0.1540	5.89		**Shallow Concentrated Flow, Channel** Grassed Waterway Kv= 15.0 fps
4.9	1,720	Total, Increased to minimum Tc = 5.0 min			

Subcatchment A: SWS_A_West



Summary for Subcatchment B: SWS_B_Central (OL Euclid Outlet)

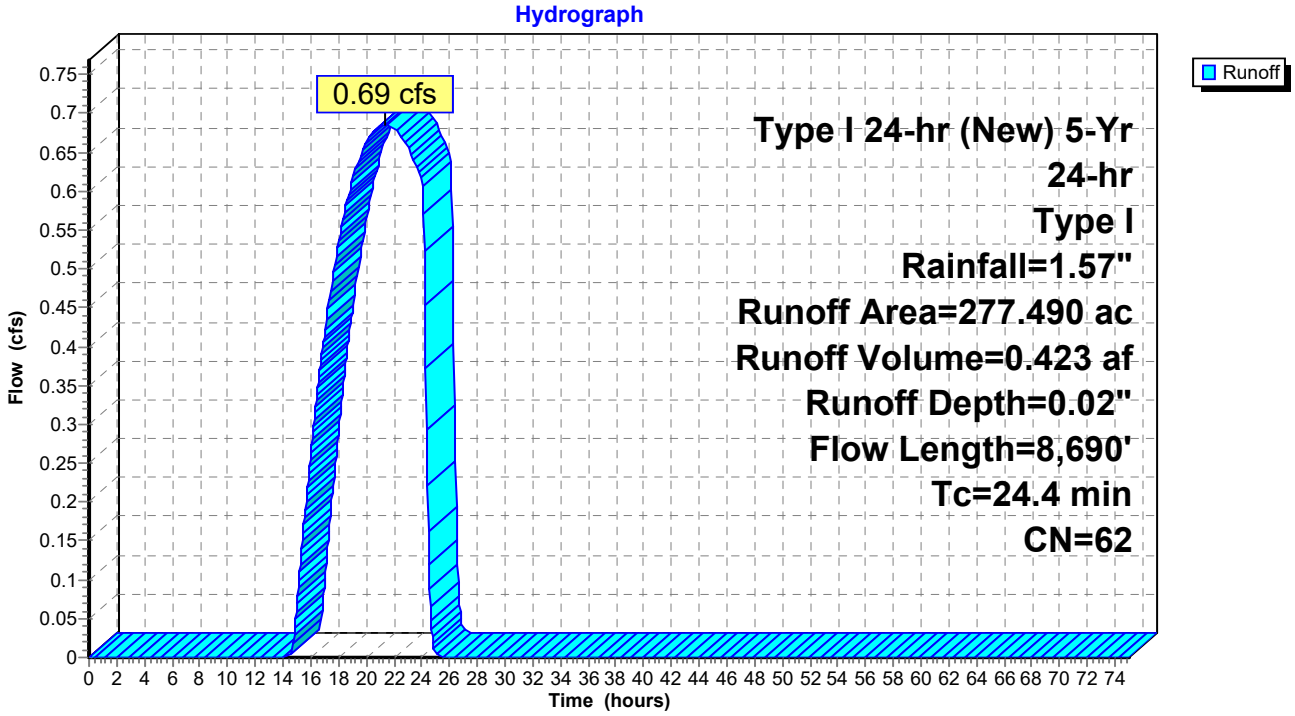
Runoff = 0.69 cfs @ 21.36 hrs, Volume= 0.423 af, Depth= 0.02"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	13.000	75	1/4 ac lot, SoilG B, HEC 22 Table 3-6
*	236.400	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
*	19.000	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	7.280	75	Overlook - 1/4 ac lot, SoilG B, HEC 22 Table 3-6
*	1.810	69	Overlook - Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	277.490	62	Weighted Average
	277.490		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
21.2	250	0.4000	0.20		**Sheet Flow, Upper Portion of WS** Woods: Light underbrush n= 0.400 P2= 1.30"
3.2	8,440	0.1440	43.55	8,710.44	**Channel Flow, Drainage channel** Area= 200.0 sf Perim= 45.0' r= 4.44' n= 0.035 Earth, dense weeds
24.4	8,690	Total			

Subcatchment B: SWS_B_Central (OL Euclid Outlet)



Summary for Subcatchment C: SWS-C_East (OL Euclid Outlet)

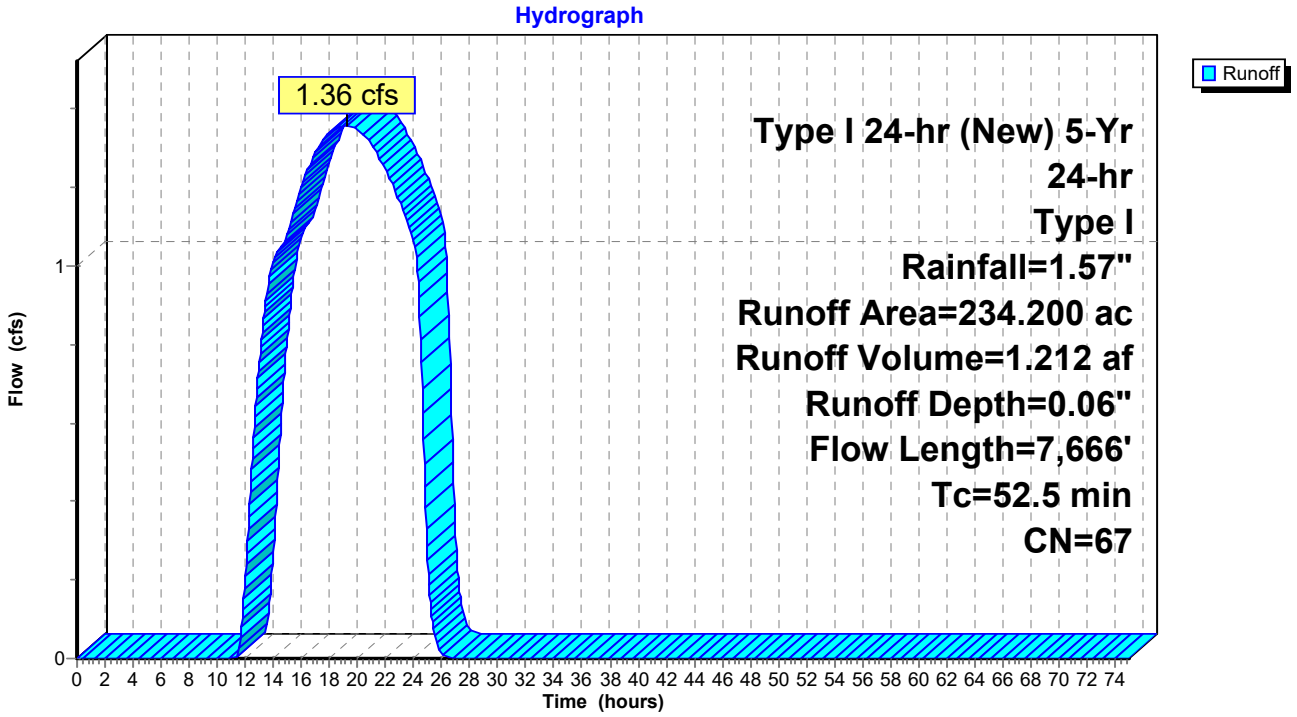
Runoff = 1.36 cfs @ 19.19 hrs, Volume= 1.212 af, Depth= 0.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	86.800	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
*	12.300	75	Overlook - 1/4 ac lot, SoilG B, HEC 22 Table 3-6
	131.400	70	1/2 acre lots, 25% imp, HSG B
*	3.700	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	234.200	67	Weighted Average
	201.350		85.97% Pervious Area
	32.850		14.03% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.2	200	0.5000	0.21		**Sheet Flow, Upper Watershed** Woods: Light underbrush n= 0.400 P2= 1.30"
22.8	3,613	0.2800	2.65		**Shallow Concentrated Flow, Channel** Woodland Kv= 5.0 fps
12.1	2,811	0.0670	3.88		**Shallow Concentrated Flow, Neighborhoods** Grassed Waterway Kv= 15.0 fps
1.4	1,042	0.0420	12.79	40.18	**Pipe Channel, Storm Drain** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.015 Concrete sewer w/manholes & inlets
52.5	7,666	Total			

Subcatchment C: SWS-C_East (OL Euclid Outlet)



Summary for Pond 1P: Overlook Estates Retention

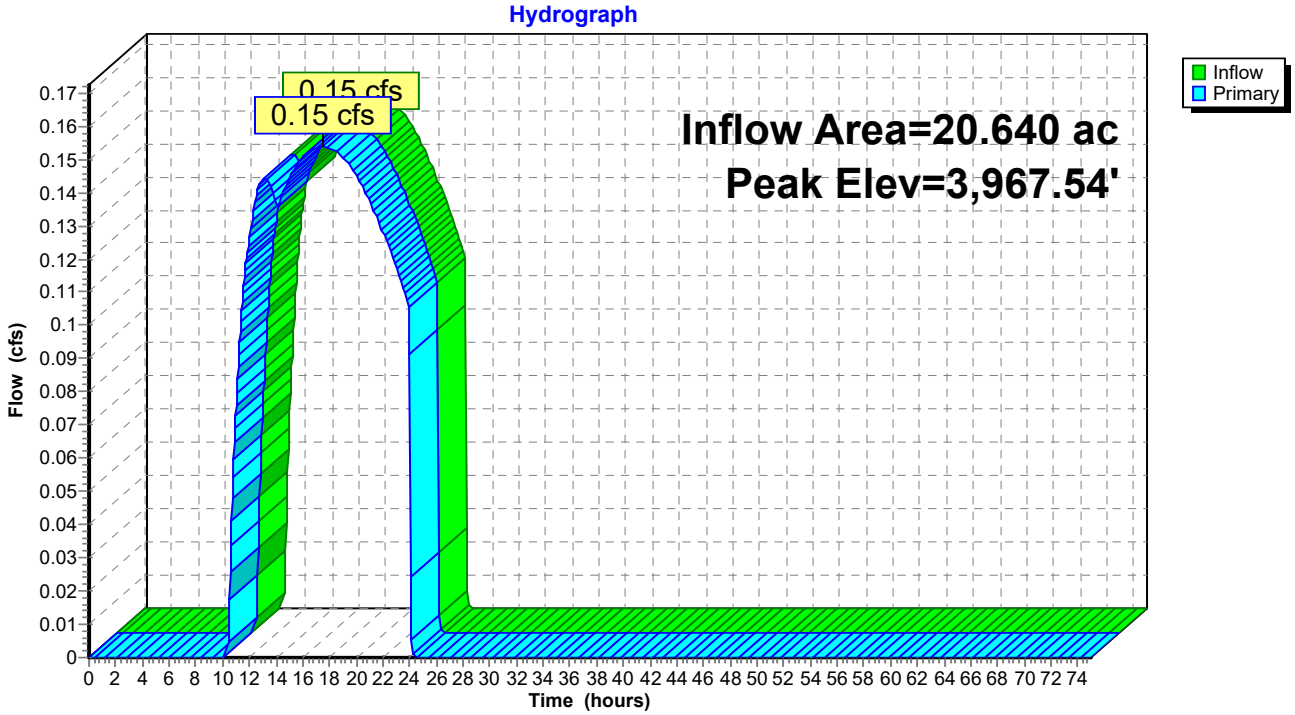
Inflow Area = 20.640 ac, 0.00% Impervious, Inflow Depth = 0.09" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.15 cfs @ 17.45 hrs, Volume= 0.150 af
Outflow = 0.15 cfs @ 17.45 hrs, Volume= 0.150 af, Atten= 0%, Lag= 0.0 min
Primary = 0.15 cfs @ 17.45 hrs, Volume= 0.150 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,967.54' @ 17.45 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	3,959.50'	**18.0" Round Culvert** L= 850.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3,959.50' / 3,955.00' S= 0.0053 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Device 1	3,964.50'	**18.0" Round Culvert** L= 120.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 3,964.50' / 3,959.50' S= 0.0417 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#3	Device 2	3,967.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=0.15 cfs @ 17.45 hrs HW=3,967.54' (Free Discharge)
└**1=Culvert** (Passes 0.15 cfs of 14.40 cfs potential flow)
└**2=Culvert** (Passes 0.15 cfs of 12.87 cfs potential flow)
└**3=Orifice/Grate** (Weir Controls 0.15 cfs @ 0.64 fps)

Pond 1P: Overlook Estates Retention



Summary for Pond 3P: Pond OL1

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth = 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.36 cfs @ 19.19 hrs, Volume= 1.212 af
Outflow = 1.36 cfs @ 19.23 hrs, Volume= 1.160 af, Atten= 0%, Lag= 2.4 min
Primary = 1.36 cfs @ 19.23 hrs, Volume= 1.160 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,956.19' @ 19.23 hrs Surf.Area= 0 sf Storage= 9,420 cf

Plug-Flow detention time= 146.1 min calculated for 1.160 af (96% of inflow)
Center-of-Mass det. time= 130.3 min (1,256.6 - 1,126.4)

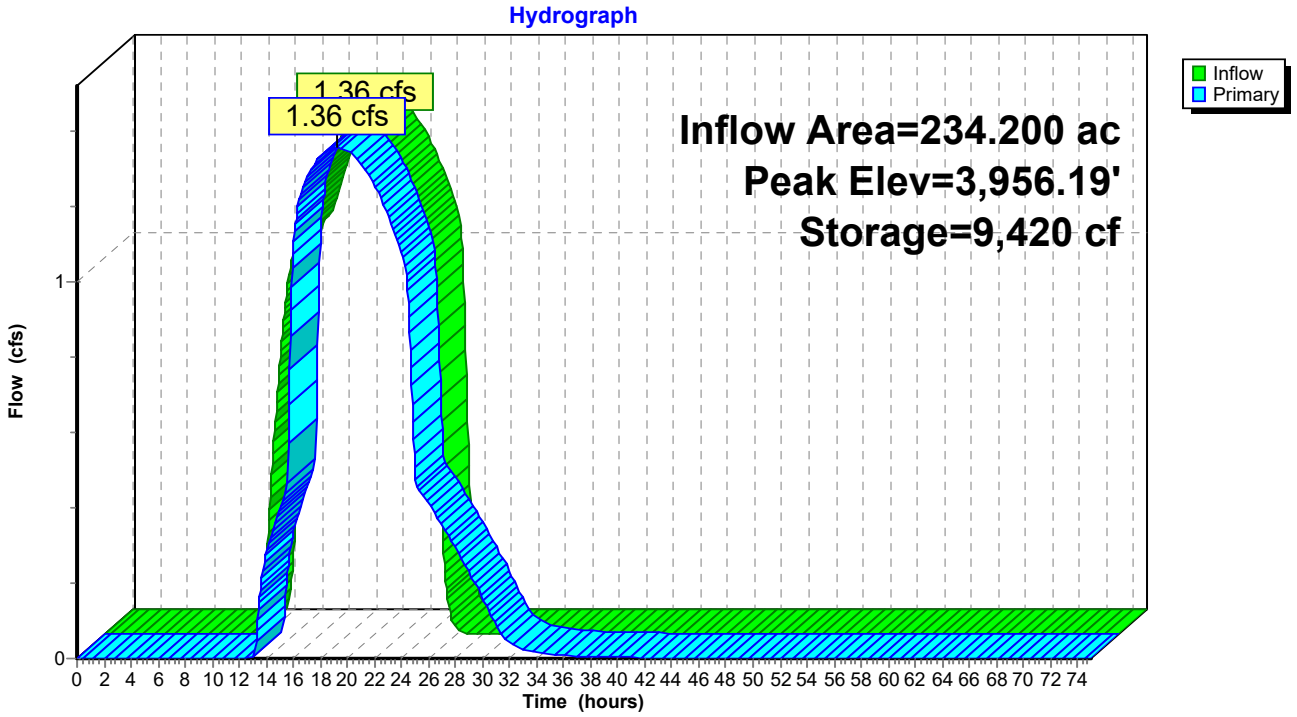
Volume	Invert	Avail.Storage	Storage Description
#1	3,953.00'	15,203 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,953.00	0
3,953.50	1,018
3,954.00	2,234
3,954.50	3,615
3,955.00	5,144
3,955.50	6,824
3,956.00	8,661
3,956.50	10,657
3,957.00	12,828
3,957.50	15,203

Device	Routing	Invert	Outlet Devices
#1	Primary	3,954.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,954.00' / 3,951.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,956.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.36 cfs @ 19.23 hrs HW=3,956.19' TW=3,953.19' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.47 cfs @ 5.41 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 0.88 cfs @ 1.03 fps)

Pond 3P: Pond OL1



Summary for Pond 4P: Pond OL2

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth > 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.36 cfs @ 19.23 hrs, Volume= 1.160 af
Outflow = 1.36 cfs @ 19.34 hrs, Volume= 1.131 af, Atten= 0%, Lag= 6.3 min
Primary = 1.36 cfs @ 19.34 hrs, Volume= 1.131 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,953.19' @ 19.34 hrs Surf.Area= 0 sf Storage= 5,620 cf

Plug-Flow detention time= 101.3 min calculated for 1.130 af (97% of inflow)
Center-of-Mass det. time= 84.2 min (1,340.9 - 1,256.6)

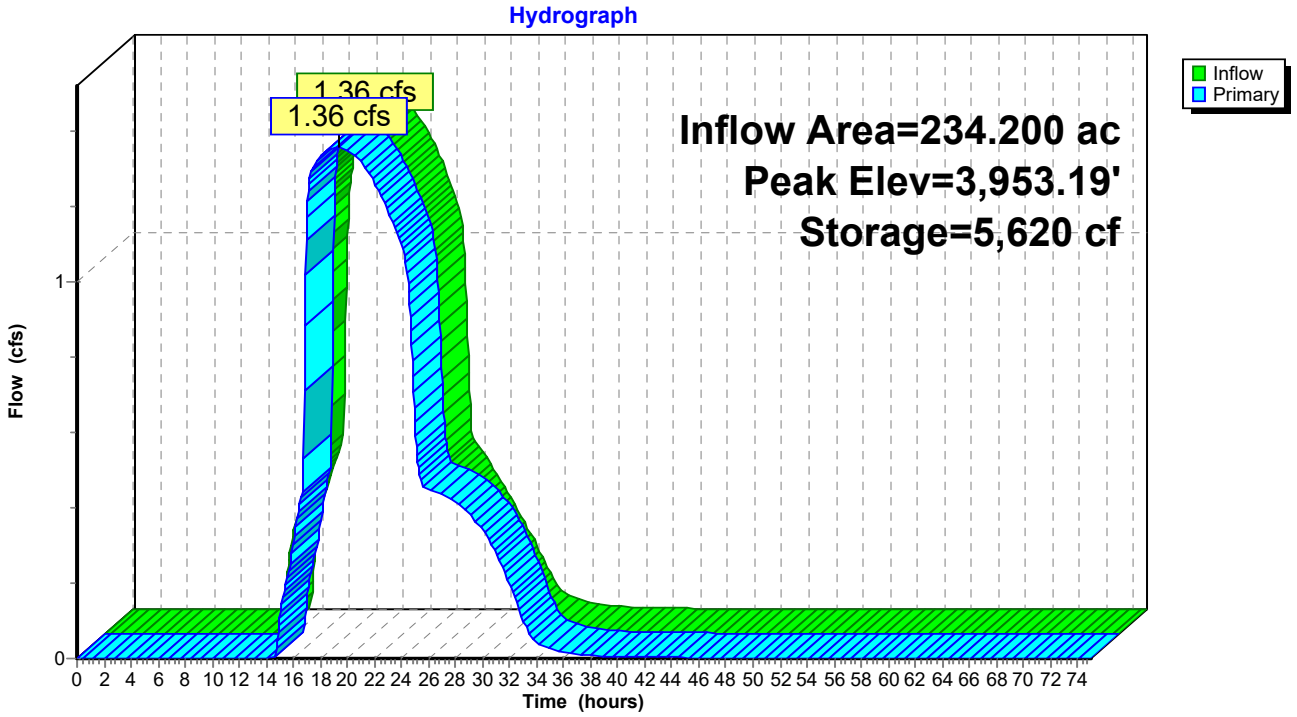
Volume	Invert	Avail.Storage	Storage Description
#1	3,950.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,950.00	0
3,950.50	567
3,951.00	1,263
3,951.50	2,070
3,952.00	2,987
3,952.50	4,015
3,953.00	5,148
3,953.50	6,390
3,954.00	7,734
3,954.50	9,177
3,955.00	10,719
3,955.50	12,359
3,956.00	14,099
3,956.50	15,947
3,957.00	17,922
3,957.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,951.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,951.00' / 3,948.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,953.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.36 cfs @ 19.34 hrs HW=3,953.19' TW=3,950.20' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.47 cfs @ 5.41 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 0.88 cfs @ 1.03 fps)

Pond 4P: Pond OL2



Summary for Pond 5P: Pond OL3

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth > 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.36 cfs @ 19.34 hrs, Volume= 1.131 af
Outflow = 1.35 cfs @ 18.87 hrs, Volume= 1.101 af, Atten= 0%, Lag= 0.0 min
Primary = 1.35 cfs @ 18.87 hrs, Volume= 1.101 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,950.21' @ 20.24 hrs Surf.Area= 0 sf Storage= 5,663 cf

Plug-Flow detention time= 120.9 min calculated for 1.100 af (97% of inflow)
Center-of-Mass det. time= 101.2 min (1,442.1 - 1,340.9)

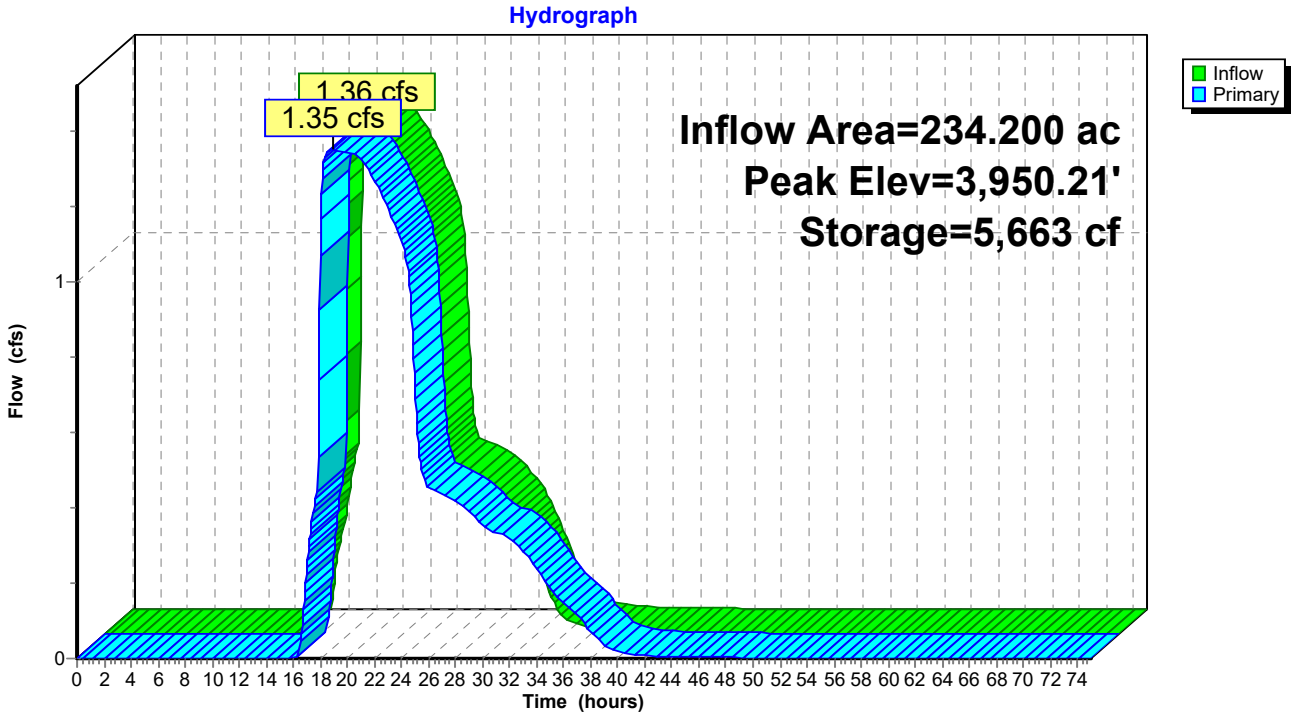
Volume	Invert	Avail.Storage	Storage Description
#1	3,947.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,947.00	0
3,947.50	567
3,948.00	1,263
3,948.50	2,070
3,949.00	2,987
3,949.50	4,015
3,950.00	5,148
3,950.50	6,390
3,951.00	7,734
3,951.50	9,177
3,952.00	10,719
3,952.50	12,359
3,953.00	14,099
3,953.50	15,947
3,954.00	17,922
3,954.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,948.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,948.00' / 3,946.00' S= 0.1000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,950.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.35 cfs @ 18.87 hrs HW=3,950.19' TW=3,948.20' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.47 cfs @ 5.36 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 0.88 cfs @ 1.03 fps)

Pond 5P: Pond OL3



Summary for Pond 6P: Pond OL4

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth > 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.35 cfs @ 18.87 hrs, Volume= 1.101 af
Outflow = 1.33 cfs @ 20.66 hrs, Volume= 1.035 af, Atten= 1%, Lag= 107.6 min
Primary = 1.33 cfs @ 20.66 hrs, Volume= 1.035 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,949.20' @ 20.67 hrs Surf.Area= 0 sf Storage= 8,858 cf

Plug-Flow detention time= 205.2 min calculated for 1.035 af (94% of inflow)
Center-of-Mass det. time= 156.8 min (1,598.9 - 1,442.1)

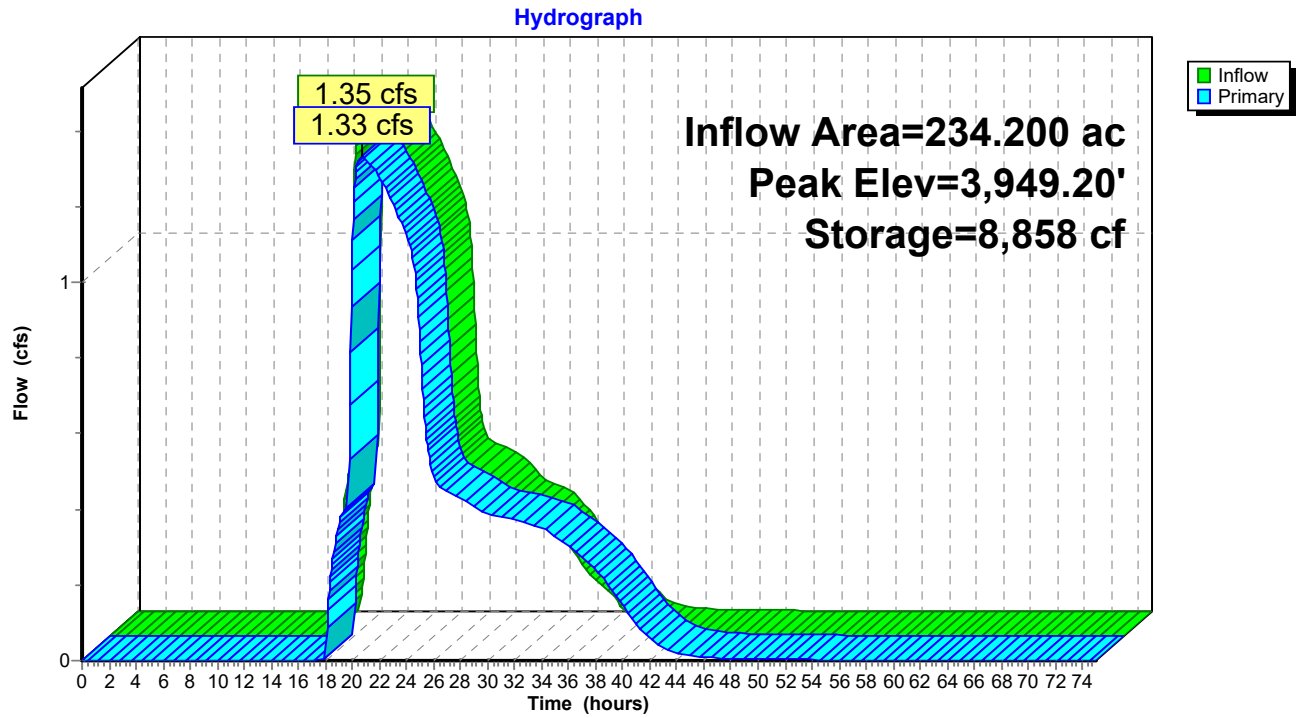
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	55,314 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	761
3,947.00	1,811
3,947.50	3,099
3,948.00	4,591
3,948.50	6,260
3,949.00	8,076
3,949.50	10,034
3,950.00	12,127
3,950.50	14,353
3,951.00	16,711
3,951.50	19,197
3,952.00	21,811
3,952.50	24,551
3,953.00	27,420
3,953.50	30,417
3,954.00	33,546
3,954.50	36,810
3,955.00	40,213
3,955.50	43,758
3,956.00	47,453
3,956.50	51,302
3,957.00	55,314

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,947.00' / 3,946.00' S= 0.0500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,949.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.33 cfs @ 20.66 hrs HW=3,949.20' TW=3,947.87' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 0.38 cfs @ 4.38 fps)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 0.95 cfs @ 1.06 fps)

Pond 6P: Pond OL4



Summary for Pond 7P: Pond OL5

Inflow Area = 234.200 ac, 14.03% Impervious, Inflow Depth > 0.05" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.33 cfs @ 20.66 hrs, Volume= 1.035 af
Outflow = 1.33 cfs @ 20.81 hrs, Volume= 1.002 af, Atten= 0%, Lag= 8.6 min
Primary = 1.33 cfs @ 20.81 hrs, Volume= 1.002 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,947.87' @ 20.81 hrs Surf.Area= 0 sf Storage= 2,308 cf

Plug-Flow detention time= 64.5 min calculated for 1.002 af (97% of inflow)
Center-of-Mass det. time= 31.2 min (1,630.1 - 1,598.9)

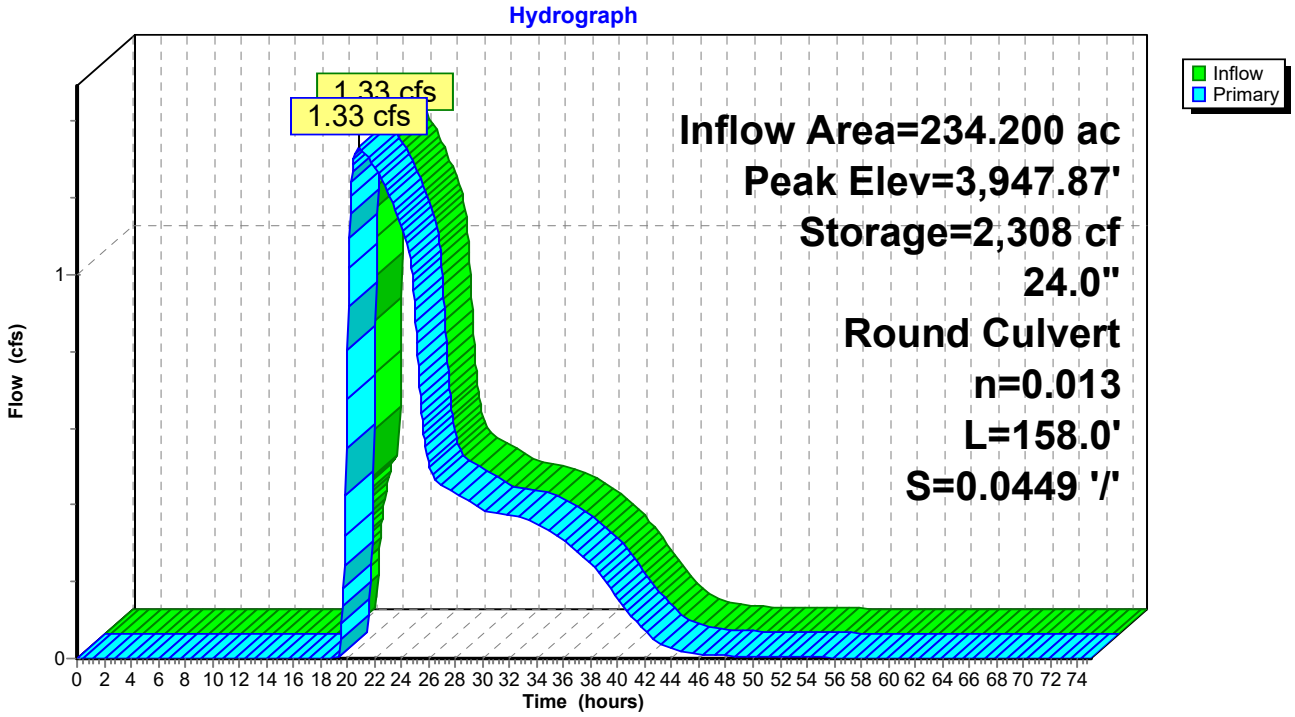
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	56,530 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	300
3,947.00	827
3,947.50	1,596
3,948.00	2,549
3,948.50	3,687
3,949.00	5,013
3,949.50	6,529
3,950.00	8,234
3,950.50	10,134
3,951.00	12,319
3,951.50	14,829
3,952.00	17,598
3,952.50	20,588
3,953.00	23,779
3,953.50	27,169
3,954.00	30,757
3,954.50	34,542
3,955.00	38,525
3,955.50	42,711
3,956.00	47,103
3,956.50	51,706
3,957.00	56,530

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.40'	**24.0" Round Culvert** L= 158.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,947.40' / 3,940.30' S= 0.0449 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections

Primary OutFlow Max=1.33 cfs @ 20.81 hrs HW=3,947.87' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 1.33 cfs @ 2.34 fps)

Pond 7P: Pond OL5



Summary for Pond 8P: Pond OL6

Inflow Area = 277.490 ac, 0.00% Impervious, Inflow Depth = 0.02" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.69 cfs @ 21.36 hrs, Volume= 0.423 af
Outflow = 0.69 cfs @ 21.44 hrs, Volume= 0.285 af, Atten= 0%, Lag= 5.0 min
Primary = 0.69 cfs @ 21.44 hrs, Volume= 0.285 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs
Peak Elev= 3,946.82' @ 21.44 hrs Surf.Area= 0 sf Storage= 6,315 cf

Plug-Flow detention time= 168.4 min calculated for 0.285 af (67% of inflow)
Center-of-Mass det. time= 90.2 min (1,312.0 - 1,221.7)

Volume	Invert	Avail.Storage	Storage Description
#1	3,945.00'	150,009 cf	**Custom Stage Data** Listed below

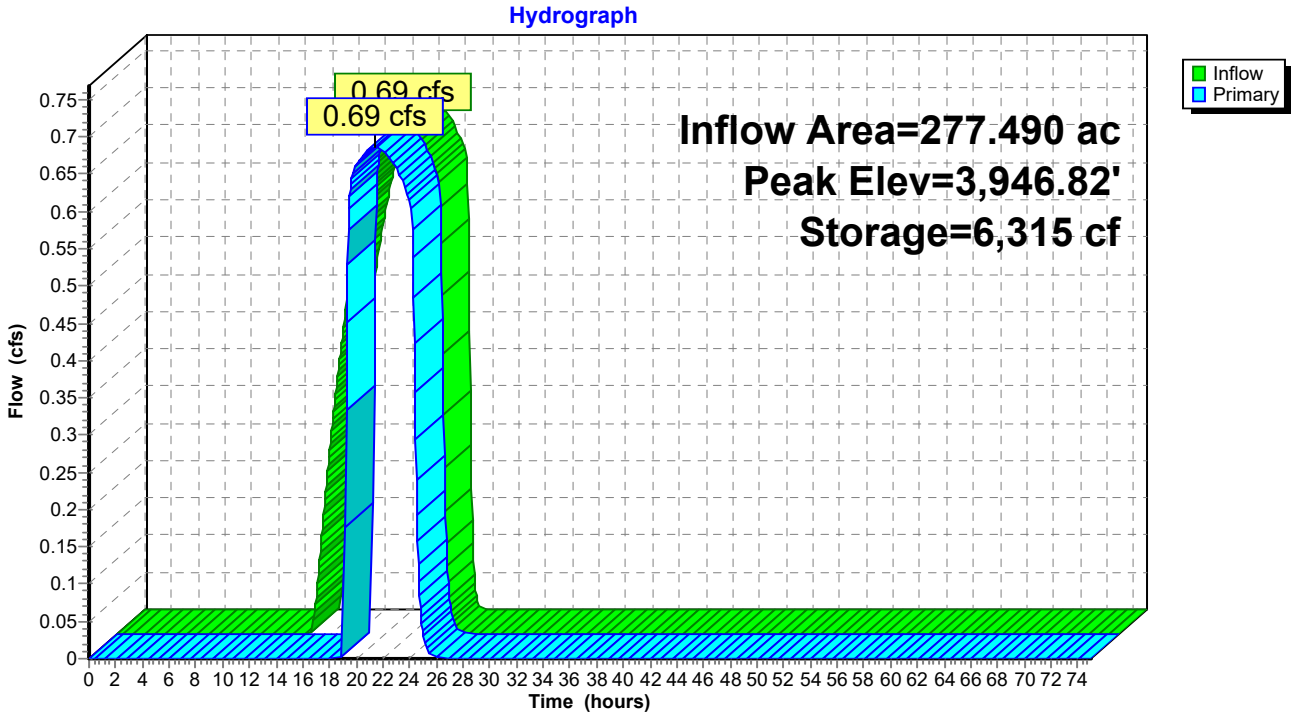
Elevation (feet)	Cum.Store (cubic-feet)
3,945.00	0
3,945.50	1,241
3,946.00	2,907
3,946.50	4,876
3,947.00	7,132
3,947.50	9,707
3,948.00	12,610
3,948.50	15,850
3,949.00	19,436
3,949.50	23,393
3,950.00	27,772
3,950.50	32,645
3,951.00	37,997
3,951.50	43,750
3,952.00	49,862
3,952.50	56,323
3,953.00	63,123
3,953.50	70,242
3,954.00	77,678
3,954.50	85,443
3,955.00	93,551
3,955.50	102,017
3,956.00	110,852
3,956.50	120,062
3,957.00	129,654
3,957.50	139,634
3,958.00	150,009

Device	Routing	Invert	Outlet Devices
#1	Primary	3,944.96'	**18.0" Round Culvert** L= 153.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,944.96' / 3,942.08' S= 0.0188 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	3,946.75'	**15.0' long x 11.0' breadth Broad-Crested Rectangular Weir**

Head (feet)	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60
Coef. (English)	2.53	2.59	2.70	2.68	2.67	2.68	2.66	2.64

Primary OutFlow Max=0.69 cfs @ 21.44 hrs HW=3,946.82' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.69 cfs of 8.96 cfs potential flow)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 0.69 cfs @ 0.66 fps)

Pond 8P: Pond OL6

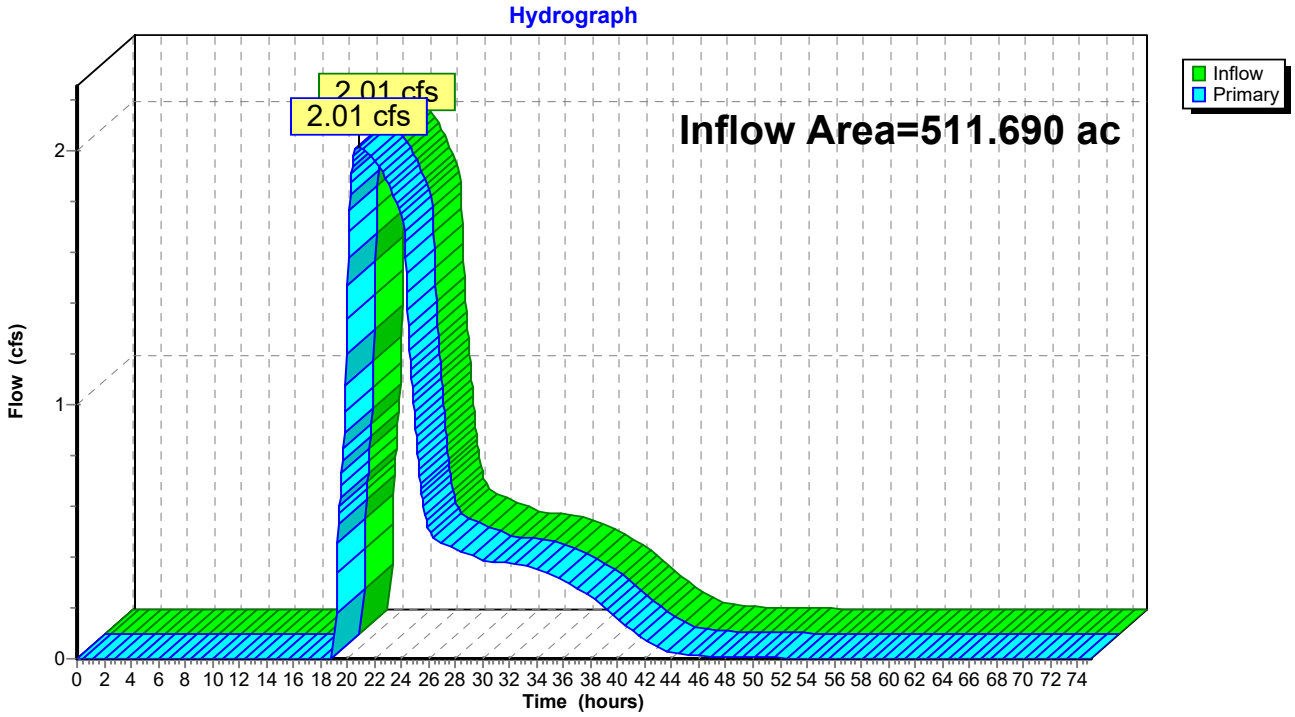


Summary for Pond 10P: Junction (flow to Spring Meadow)

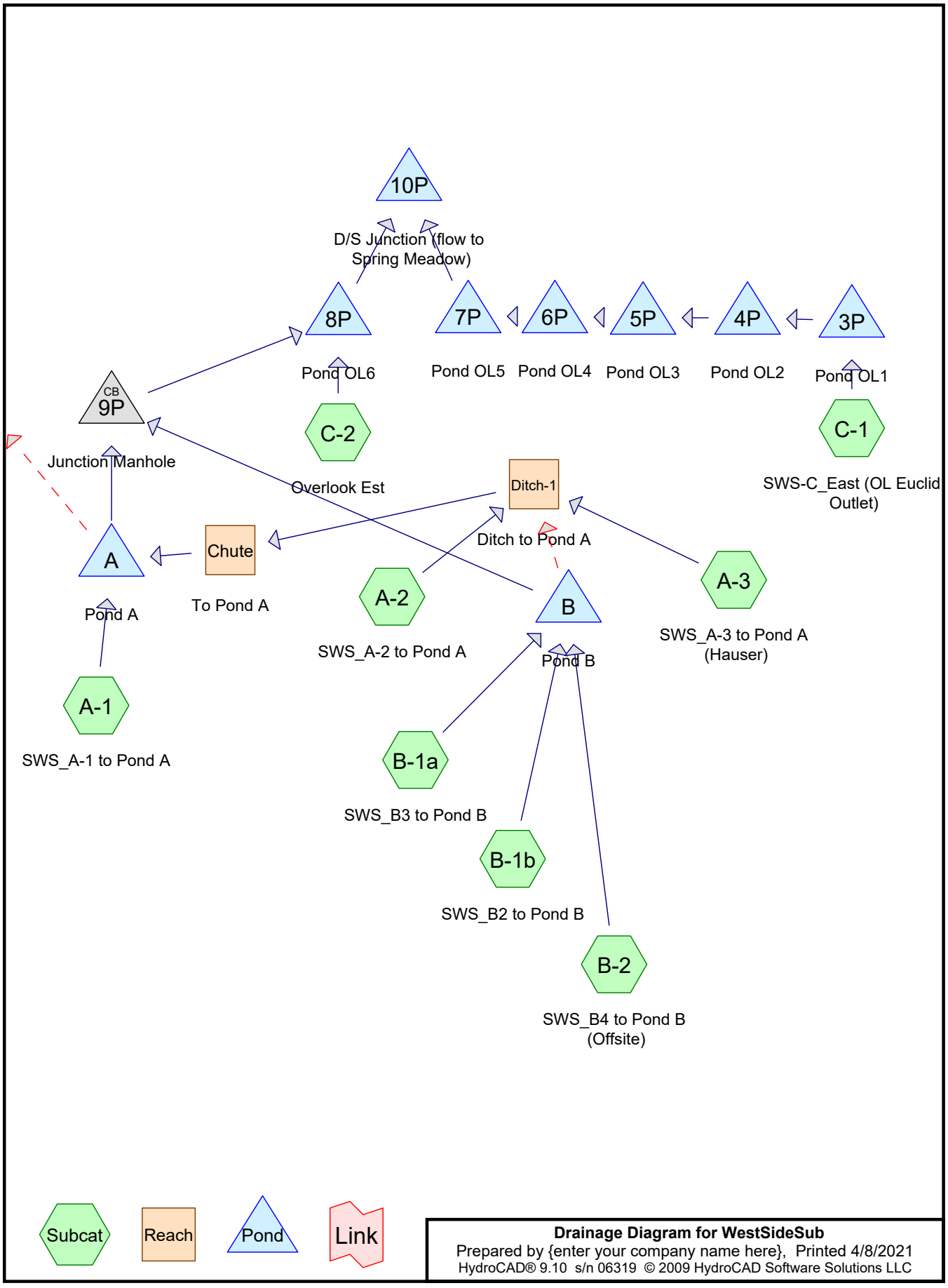
Inflow Area = 511.690 ac, 6.42% Impervious, Inflow Depth > 0.03" for (New) 5-Yr, 24-hr, Type I event
Inflow = 2.01 cfs @ 20.88 hrs, Volume= 1.287 af
Primary = 2.01 cfs @ 20.88 hrs, Volume= 1.287 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-75.00 hrs, dt= 0.05 hrs

Pond 10P: Junction (flow to Spring Meadow)



STORM WATER PROPOSED CONDITIONS



Drainage Diagram for WestSideSub

Prepared by {enter your company name here}, Printed 4/8/2021

Time span=0.00-84.00 hrs, dt=0.05 hrs, 1681 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Muskingum-Cunge method - Pond routing by Dyn-Stor-Ind method

Subcatchment A-1: SWS_A-1 to Pond A Runoff Area=12.670 ac 8.29% Impervious Runoff Depth=0.57"
Flow Length=1,400' Tc=22.0 min CN=74 Runoff=2.59 cfs 0.607 af

Subcatchment A-2: SWS_A-2 to Pond A Runoff Area=2.950 ac 26.54% Impervious Runoff Depth=0.50"
Flow Length=230' Slope=0.1000 '/' Tc=22.9 min CN=72 Runoff=0.44 cfs 0.122 af

Subcatchment A-3: SWS_A-3 to Pond A Runoff Area=10.880 ac 0.00% Impervious Runoff Depth=0.54"
Flow Length=1,165' Tc=16.5 min CN=73 Runoff=2.26 cfs 0.485 af

Subcatchment B-1a: SWS_B3 to Pond B Runoff Area=9.630 ac 30.00% Impervious Runoff Depth=0.50"
Flow Length=1,675' Tc=18.4 min CN=72 Runoff=1.63 cfs 0.399 af

Subcatchment B-1b: SWS_B2 to Pond B Runoff Area=32.940 ac 23.34% Impervious Runoff Depth=0.39"
Flow Length=2,110' Tc=15.9 min CN=69 Runoff=3.41 cfs 1.081 af

Subcatchment B-2: SWS_B4 to Pond B Runoff Area=225.100 ac 0.00% Impervious Runoff Depth=0.16"
Flow Length=5,300' Tc=35.3 min CN=60 Runoff=2.92 cfs 2.955 af

Subcatchment C-1: SWS-C_East (OL Runoff Area=230.500 ac 14.25% Impervious Runoff Depth=0.33"
Flow Length=7,666' Tc=52.5 min CN=67 Runoff=9.09 cfs 6.373 af

Subcatchment C-2: Overlook Est Runoff Area=10.150 ac 0.00% Impervious Runoff Depth=0.54"
Flow Length=1,510' Tc=32.4 min CN=73 Runoff=1.45 cfs 0.453 af

Reach Chute: To Pond A Avg. Flow Depth=0.15' Max Vel=5.72 fps Inflow=2.64 cfs 0.608 af
n=0.150 L=75.0' S=0.2000 '/' Capacity=28.53 cfs Outflow=2.64 cfs 0.608 af

Reach Ditch-1: Ditch to Pond A Avg. Flow Depth=0.45' Max Vel=7.19 fps Inflow=2.63 cfs 0.608 af
n=0.022 L=700.0' S=0.0100 '/' Capacity=23.29 cfs Outflow=2.64 cfs 0.608 af

Pond 3P: Pond OL1 Peak Elev=3,956.78' Storage=11,879 cf Inflow=9.09 cfs 6.373 af
Outflow=8.87 cfs 6.321 af

Pond 4P: Pond OL2 Peak Elev=3,953.77' Storage=7,127 cf Inflow=8.87 cfs 6.321 af
Outflow=8.76 cfs 6.292 af

Pond 5P: Pond OL3 Peak Elev=3,950.76' Storage=7,079 cf Inflow=8.76 cfs 6.292 af
Outflow=8.48 cfs 6.262 af

Pond 6P: Pond OL4 Peak Elev=3,949.72' Storage=10,958 cf Inflow=8.48 cfs 6.262 af
Outflow=7.76 cfs 6.197 af

Pond 7P: Pond OL5 Peak Elev=3,948.63' Storage=4,038 cf Inflow=7.76 cfs 6.197 af
24.0" Round Culvert n=0.013 L=158.0' S=0.0449 '/' Outflow=7.68 cfs 6.163 af

Pond 8P: Pond OL6 Peak Elev=3,947.01' Storage=7,206 cf Inflow=5.20 cfs 6.103 af
Outflow=5.20 cfs 5.966 af

Pond 9P: Junction Manhole Peak Elev=3,985.76' Inflow=4.88 cfs 5.651 af
Outflow=4.88 cfs 5.651 af

Pond 10P: D/S Junction (flow to Spring Meadow) Inflow=11.40 cfs 12.129 af
Primary=11.40 cfs 12.129 af

Pond A: Pond A Peak Elev=3,994.09' Storage=0.609 af Inflow=5.20 cfs 1.215 af
Primary=0.85 cfs 1.215 af Secondary=0.00 cfs 0.000 af Outflow=0.85 cfs 1.215 af

Pond B: Pond B Peak Elev=4,040.85' Storage=0.740 af Inflow=5.03 cfs 4.436 af
Primary=4.14 cfs 4.436 af Secondary=0.00 cfs 0.000 af Outflow=4.14 cfs 4.436 af

Total Runoff Area = 534.820 ac Runoff Volume = 12.476 af Average Runoff Depth = 0.28"
91.54% Pervious = 489.561 ac 8.46% Impervious = 45.259 ac

Summary for Subcatchment A-1: SWS_A-1 to Pond A

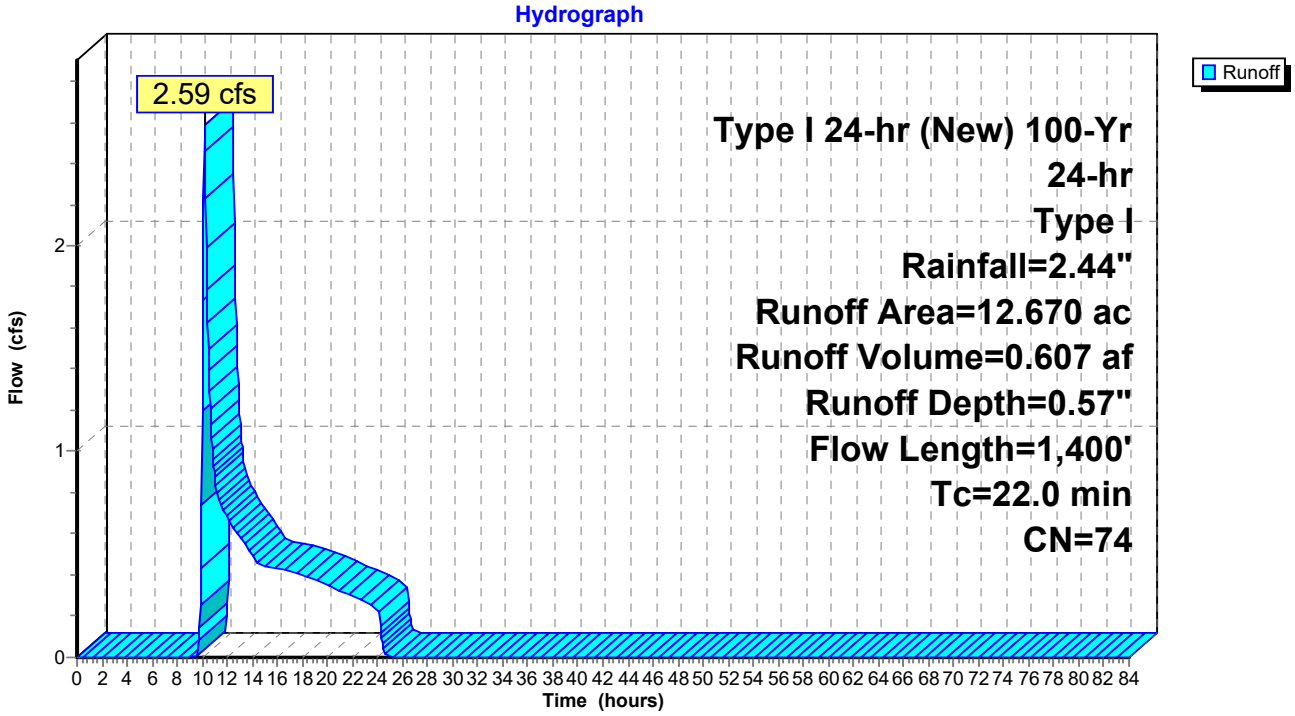
Runoff = 2.59 cfs @ 10.19 hrs, Volume= 0.607 af, Depth= 0.57"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	1.380	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	7.790	75	1/4 ac lot, SoilG B / Fair, HEC 22 Table 3-6
	3.500	72	1/3 acre lots, 30% imp, HSG B
	12.670	74	Weighted Average
	11.620		91.71% Pervious Area
	1.050		8.29% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.6	250	0.2000	0.22		**Sheet Flow, Lot** Grass: Dense n= 0.240 P2= 1.30"
3.4	1,150	0.0750	5.56		**Shallow Concentrated Flow, Roads** Paved Kv= 20.3 fps
22.0	1,400	Total			

Subcatchment A-1: SWS_A-1 to Pond A



Summary for Subcatchment A-2: SWS_A-2 to Pond A

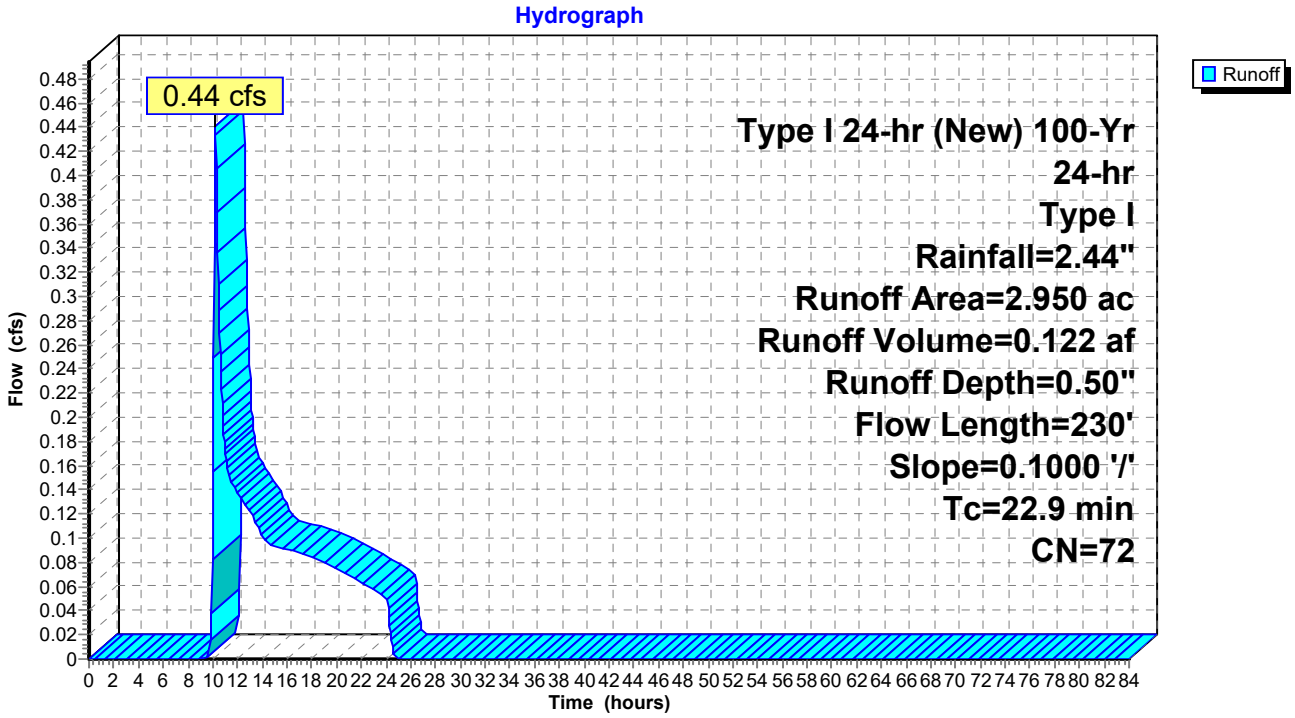
Runoff = 0.44 cfs @ 10.22 hrs, Volume= 0.122 af, Depth= 0.50"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	0.340	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	2.610	72	1/3 acre lots, 30% imp, HSG B
	2.950	72	Weighted Average
	2.167		73.46% Pervious Area
	0.783		26.54% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	230	0.1000	0.17		**Sheet Flow, Lot** Grass: Dense n= 0.240 P2= 1.30"

Subcatchment A-2: SWS_A-2 to Pond A



Summary for Subcatchment A-3: SWS_A-3 to Pond A (Hauser)

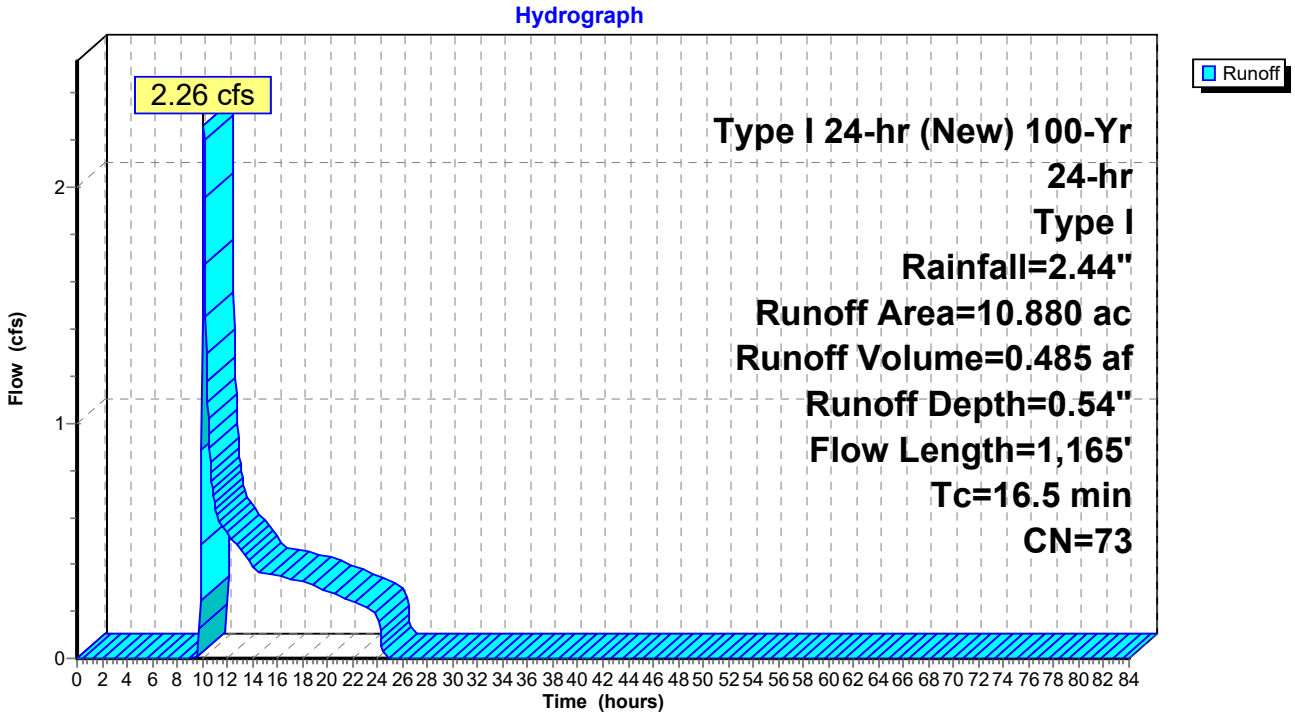
Runoff = 2.26 cfs @ 10.12 hrs, Volume= 0.485 af, Depth= 0.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	4.500	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	6.380	75	1/4 ac lot, SoilG B / Fair, HEC 22 Table 3-6
	10.880	73	Weighted Average
	10.880		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	150	0.2000	0.20		**Sheet Flow, Upper Portion Watershed** Grass: Dense n= 0.240 P2= 1.30"
4.2	1,015	0.0400	4.06		**Shallow Concentrated Flow, Roads** Paved Kv= 20.3 fps
16.5	1,165	Total			

Subcatchment A-3: SWS_A-3 to Pond A (Hauser)



Summary for Subcatchment B-1a: SWS_B3 to Pond B

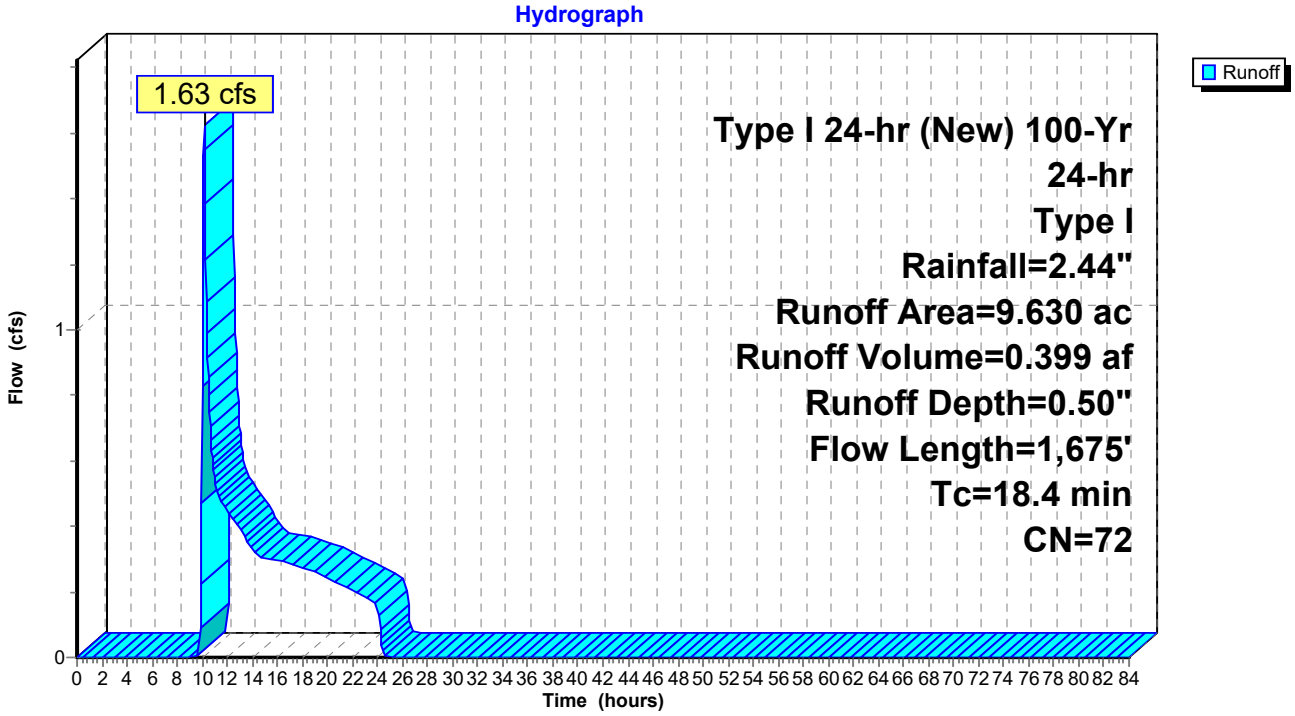
Runoff = 1.63 cfs @ 10.15 hrs, Volume= 0.399 af, Depth= 0.50"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

Area (ac)	CN	Description
9.630	72	1/3 acre lots, 30% imp, HSG B
6.741		70.00% Pervious Area
2.889		30.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.3	165	0.3000	0.24		**Sheet Flow, Upper Lots** Grass: Dense n= 0.240 P2= 1.30"
6.3	565	0.0100	1.50		**Shallow Concentrated Flow, Ditch** Grassed Waterway Kv= 15.0 fps
0.8	945	0.0900	20.53	25.19	**Pipe Channel, Strom Drain** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.010 PVC, smooth interior
18.4	1,675	Total			

Subcatchment B-1a: SWS_B3 to Pond B



Summary for Subcatchment B-1b: SWS_B2 to Pond B

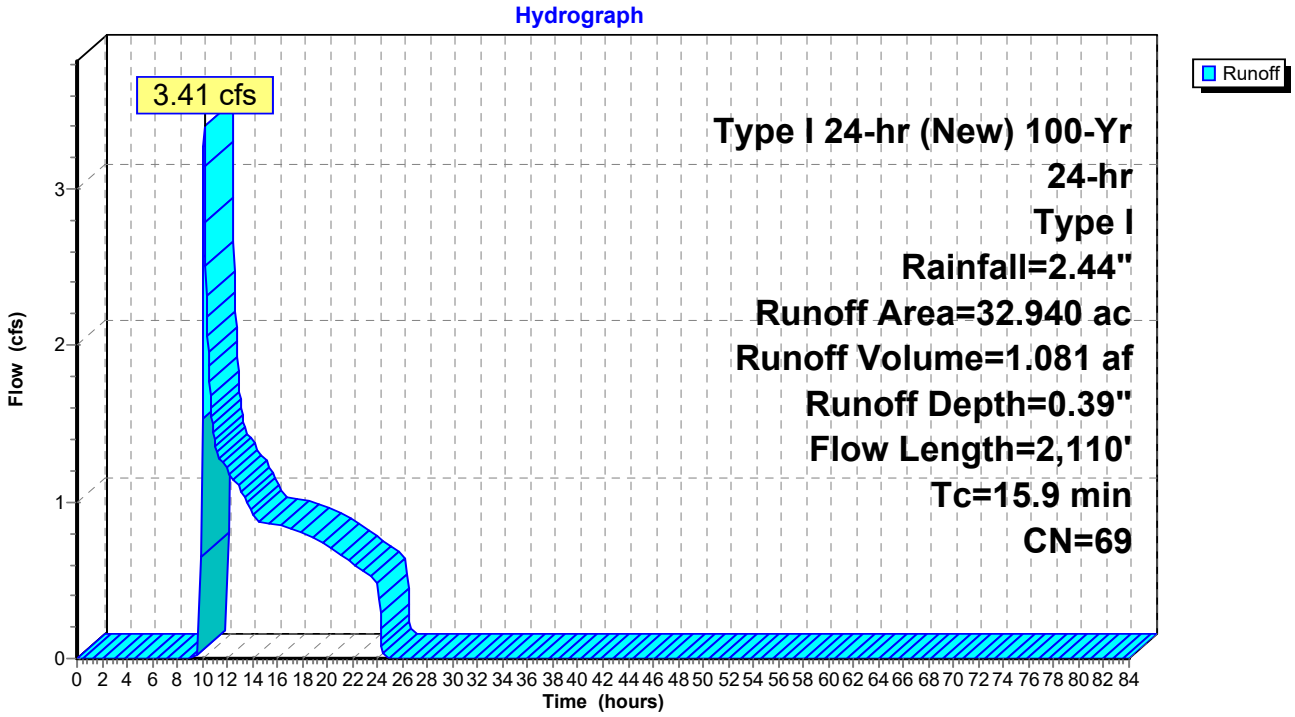
Runoff = 3.41 cfs @ 10.14 hrs, Volume= 1.081 af, Depth= 0.39"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
	18.540	72	1/3 acre lots, 30% imp, HSG B
*	5.900	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
	8.500	70	1/2 acre lots, 25% imp, HSG B
	32.940	69	Weighted Average
	25.253		76.66% Pervious Area
	7.687		23.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.7	185	0.2800	0.24		**Sheet Flow, Upper Portion of WS** Grass: Dense n= 0.240 P2= 1.30"
2.5	725	0.0590	4.93		**Shallow Concentrated Flow, Streets** Paved Kv= 20.3 fps
0.3	400	0.0700	20.45	36.13	**Pipe Channel, Storm Drain** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.010 PVC, smooth interior
0.4	800	0.0700	35.43	7,085.25	**Channel Flow, Drainage channel** Area= 200.0 sf Perim= 45.0' r= 4.44' n= 0.030 Earth, grassed & winding
15.9	2,110	Total			

Subcatchment B-1b: SWS_B2 to Pond B



Summary for Subcatchment B-2: SWS_B4 to Pond B (Offsite)

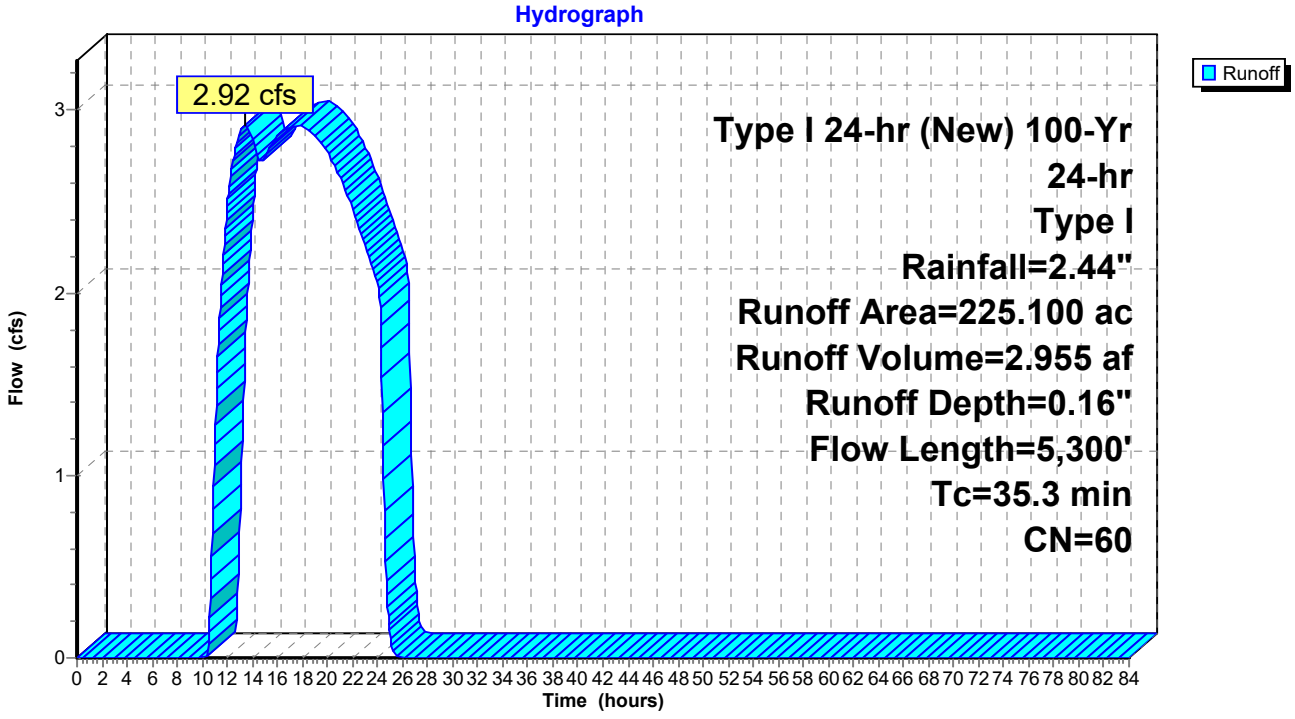
Runoff = 2.92 cfs @ 13.44 hrs, Volume= 2.955 af, Depth= 0.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	225.100	60	Woods, SoilG B / Fair, TR-55 Table 2-2c
	225.100		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.5	300	0.3000	0.18		**Sheet Flow, Upper Portion of WS** Woods: Light underbrush n= 0.400 P2= 1.30"
6.1	1,000	0.3000	2.74		**Shallow Concentrated Flow, Upper Reach** Woodland Kv= 5.0 fps
1.7	4,000	0.1200	39.76	7,951.51	**Channel Flow, Drainage Channel** Area= 200.0 sf Perim= 45.0' r= 4.44' n= 0.035 Earth, dense weeds
35.3	5,300	Total			

Subcatchment B-2: SWS_B4 to Pond B (Offsite)



Summary for Subcatchment C-1: SWS-C_East (OL Euclid Outlet)

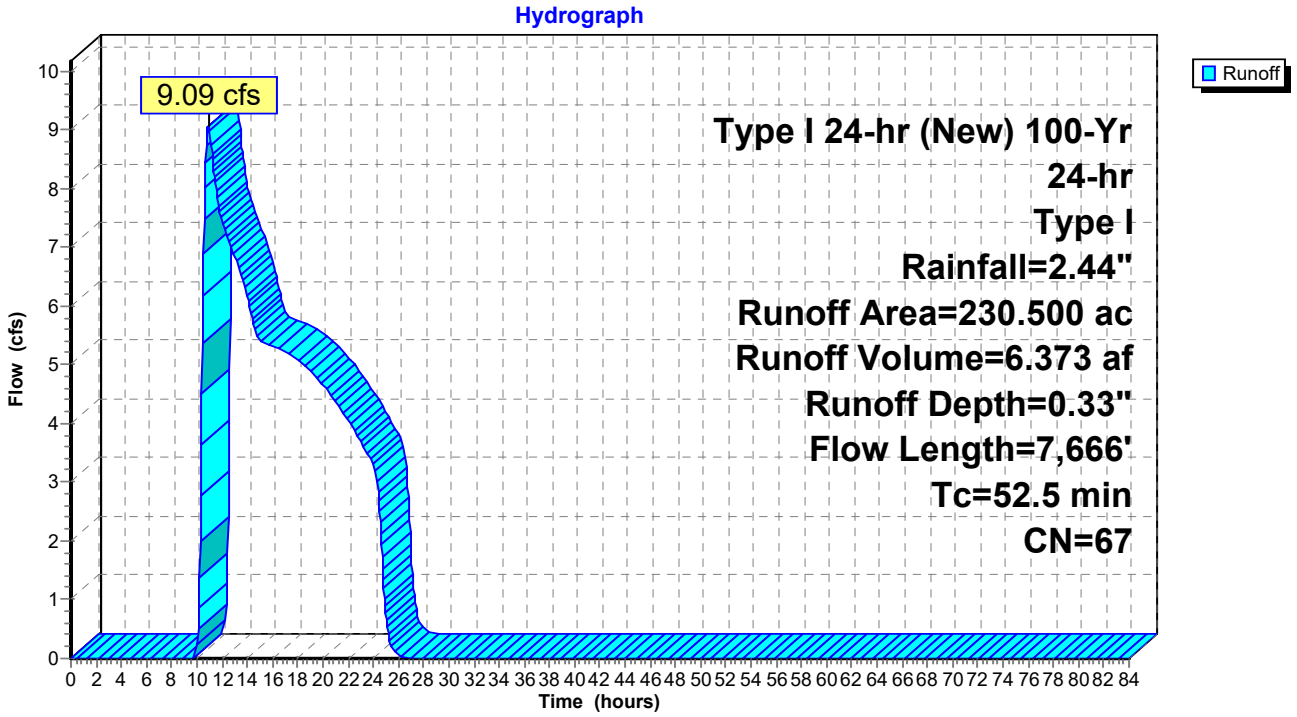
Runoff = 9.09 cfs @ 10.90 hrs, Volume= 6.373 af, Depth= 0.33"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	86.800	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
*	12.300	75	Overlook - 1/4 ac lot, SoilG B, HEC 22 Table 3-6
	131.400	70	1/2 acre lots, 25% imp, HSG B
	230.500	67	Weighted Average
	197.650		85.75% Pervious Area
	32.850		14.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.2	200	0.5000	0.21		**Sheet Flow, Upper Watershed** Woods: Light underbrush n= 0.400 P2= 1.30"
22.8	3,613	0.2800	2.65		**Shallow Concentrated Flow, Channel** Woodland Kv= 5.0 fps
12.1	2,811	0.0670	3.88		**Shallow Concentrated Flow, Neighborhoods** Grassed Waterway Kv= 15.0 fps
1.4	1,042	0.0420	12.79	40.18	**Pipe Channel, Storm Drain** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.015 Concrete sewer w/manholes & inlets
52.5	7,666	Total			

Subcatchment C-1: SWS-C_East (OL Euclid Outlet)



Summary for Subcatchment C-2: Overlook Est

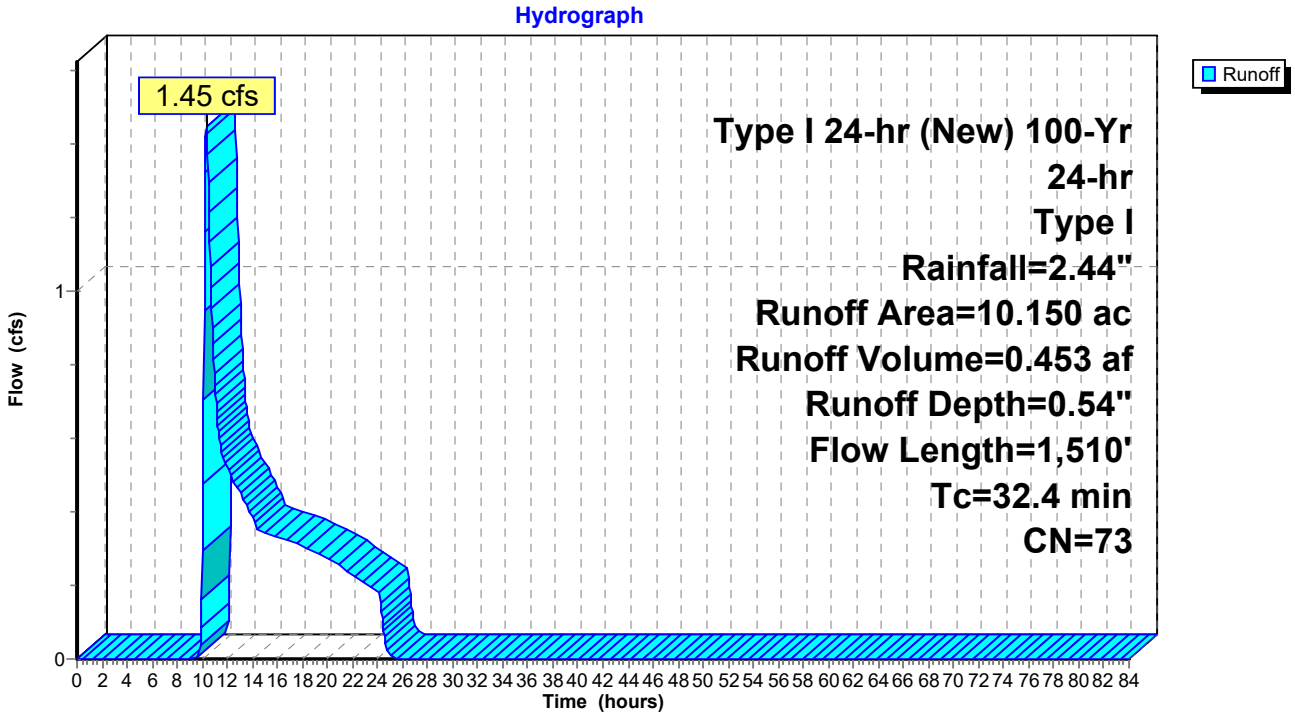
Runoff = 1.45 cfs @ 10.36 hrs, Volume= 0.453 af, Depth= 0.54"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 100-Yr, 24-hr, Type I Rainfall=2.44"

	Area (ac)	CN	Description
*	7.280	75	1/4 ac lot, SoilG B, HEC 22 Table 3-6
*	2.870	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	10.150	73	Weighted Average
	10.150		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.9	180	0.0160	0.11		**Sheet Flow, Upper Watershed** Grass: Short n= 0.150 P2= 1.30"
3.3	510	0.0160	2.57		**Shallow Concentrated Flow, Street** Paved Kv= 20.3 fps
1.8	400	0.0350	3.80		**Shallow Concentrated Flow, Street 2** Paved Kv= 20.3 fps
0.4	420	0.0800	17.65	55.45	**Pipe Channel, Storm Pipe** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.015 Concrete sewer w/manholes & inlets
32.4	1,510	Total			

Subcatchment C-2: Overlook Est



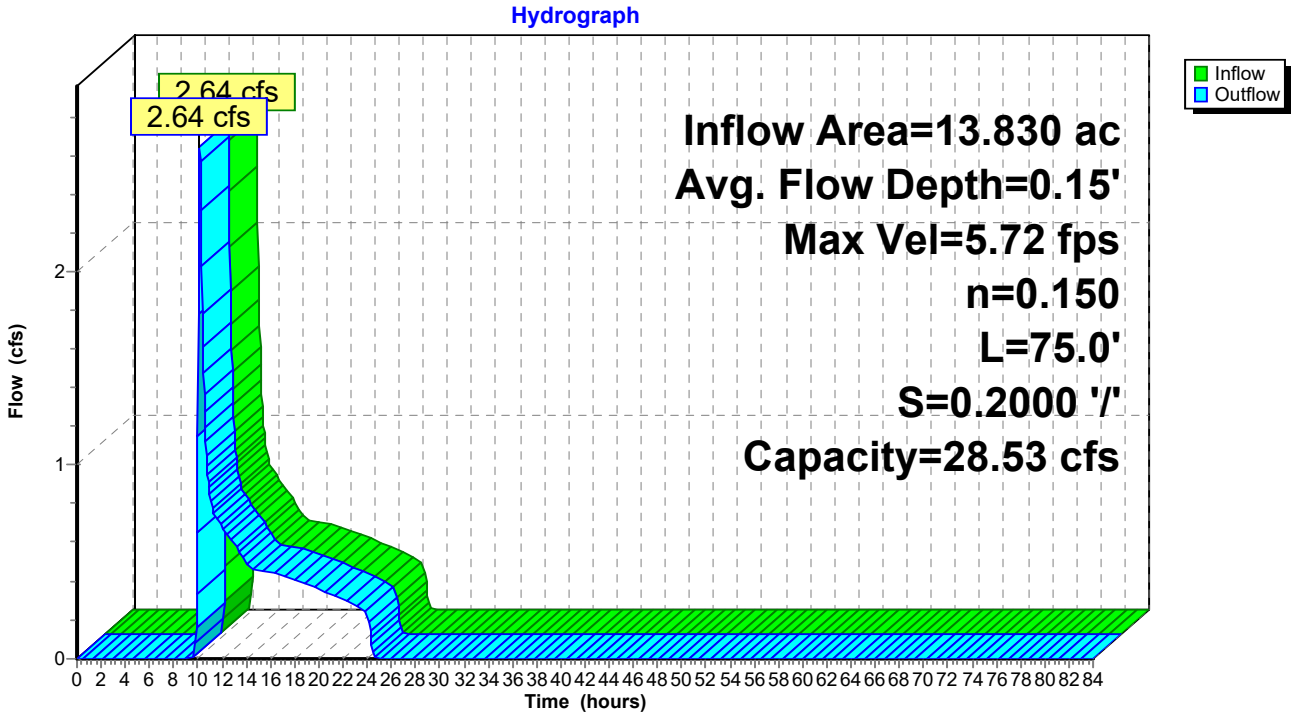
Summary for Reach Chute: To Pond A

Inflow Area = 13.830 ac, 5.66% Impervious, Inflow Depth = 0.53" for (New) 100-Yr, 24-hr, Type I event
Inflow = 2.64 cfs @ 10.16 hrs, Volume= 0.608 af
Outflow = 2.64 cfs @ 10.17 hrs, Volume= 0.608 af, Atten= 0%, Lag= 0.2 min

Routing by Dyn-Muskingum-Cunge method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Reference Flow= 21.40 cfs Estimated Depth= 1.28' Velocity= 3.91 fps
m= 1.441, c= 5.63 fps, dt= 3.0 min, dx= 75.0' / 1 = 75.0', K= 0.2 min, X= 0.470
Max. Velocity= 5.72 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 5.63 fps, Avg. Travel Time= 0.2 min

Peak Storage= 35 cf @ 10.16 hrs
Average Depth at Peak Storage= 0.15'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 28.53 cfs

3.00' x 1.50' deep channel, n= 0.150
Side Slope Z-value= 1.0 '/' Top Width= 6.00'
Length= 75.0' Slope= 0.2000 '/'
Inlet Invert= 4,012.00', Outlet Invert= 3,997.00'



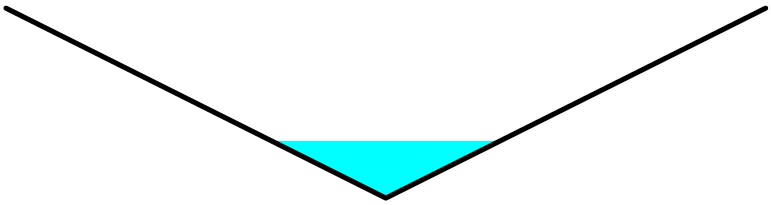
Summary for Reach Ditch-1: Ditch to Pond A

Inflow Area = 13.830 ac, 5.66% Impervious, Inflow Depth = 0.53" for (New) 100-Yr, 24-hr, Type I event
Inflow = 2.63 cfs @ 10.13 hrs, Volume= 0.608 af
Outflow = 2.64 cfs @ 10.16 hrs, Volume= 0.608 af, Atten= 0%, Lag= 1.9 min

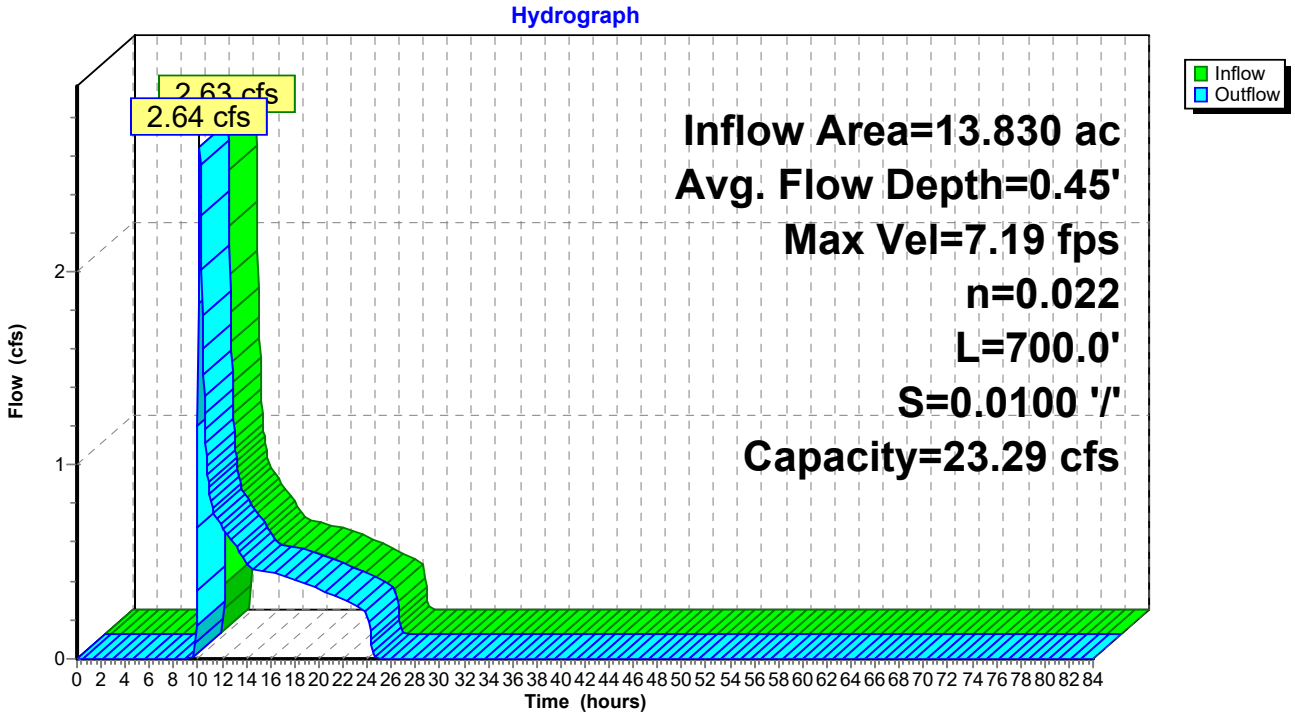
Routing by Dyn-Muskingum-Cunge method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Reference Flow= 17.47 cfs Estimated Depth= 1.35' Velocity= 4.82 fps
m= 1.333, c= 6.42 fps, dt= 3.0 min, dx= 700.0' / 1 = 700.0', K= 1.8 min, X= 0.428
Max. Velocity= 7.19 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 6.43 fps, Avg. Travel Time= 1.8 min

Peak Storage= 286 cf @ 10.15 hrs
Average Depth at Peak Storage= 0.45'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 23.29 cfs

0.00' x 1.50' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 2.0 '/' Top Width= 6.00'
Length= 700.0' Slope= 0.0100 '/'
Inlet Invert= 4,020.00', Outlet Invert= 4,013.00'



Reach Ditch-1: Ditch to Pond A



Summary for Pond 3P: Pond OL1

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 9.09 cfs @ 10.90 hrs, Volume= 6.373 af
Outflow = 8.87 cfs @ 11.06 hrs, Volume= 6.321 af, Atten= 2%, Lag= 10.0 min
Primary = 8.87 cfs @ 11.06 hrs, Volume= 6.321 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,956.78' @ 11.06 hrs Surf.Area= 0 sf Storage= 11,879 cf

Plug-Flow detention time= 38.7 min calculated for 6.317 af (99% of inflow)
Center-of-Mass det. time= 35.1 min (1,024.9 - 989.7)

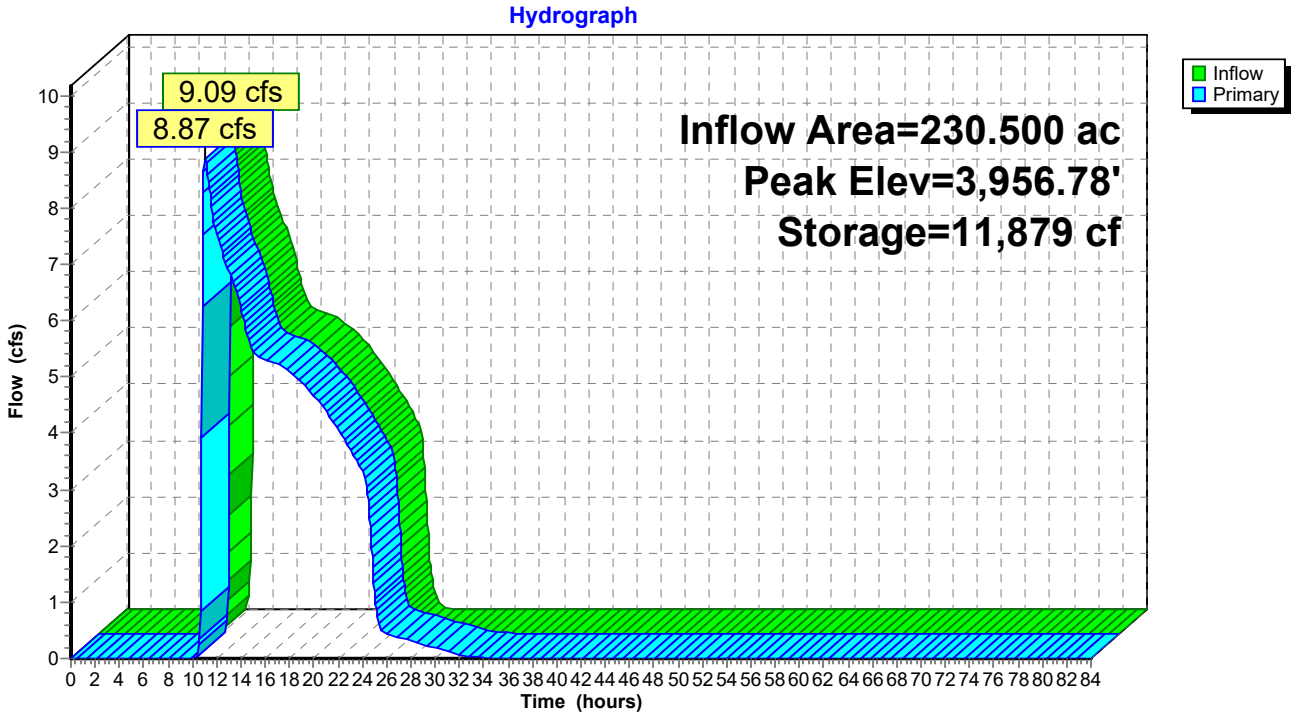
Volume	Invert	Avail.Storage	Storage Description
#1	3,953.00'	15,203 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,953.00	0
3,953.50	1,018
3,954.00	2,234
3,954.50	3,615
3,955.00	5,144
3,955.50	6,824
3,956.00	8,661
3,956.50	10,657
3,957.00	12,828
3,957.50	15,203

Device	Routing	Invert	Outlet Devices
#1	Primary	3,954.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,954.00' / 3,951.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,956.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=8.87 cfs @ 11.06 hrs HW=3,956.78' TW=3,953.72' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.54 cfs @ 6.15 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 8.33 cfs @ 2.37 fps)

Pond 3P: Pond OL1



Summary for Pond 4P: Pond OL2

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 8.87 cfs @ 11.06 hrs, Volume= 6.321 af
Outflow = 8.76 cfs @ 11.19 hrs, Volume= 6.292 af, Atten= 1%, Lag= 7.7 min
Primary = 8.76 cfs @ 11.19 hrs, Volume= 6.292 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,953.77' @ 11.19 hrs Surf.Area= 0 sf Storage= 7,127 cf

Plug-Flow detention time= 26.9 min calculated for 6.288 af (99% of inflow)
Center-of-Mass det. time= 23.0 min (1,047.9 - 1,024.9)

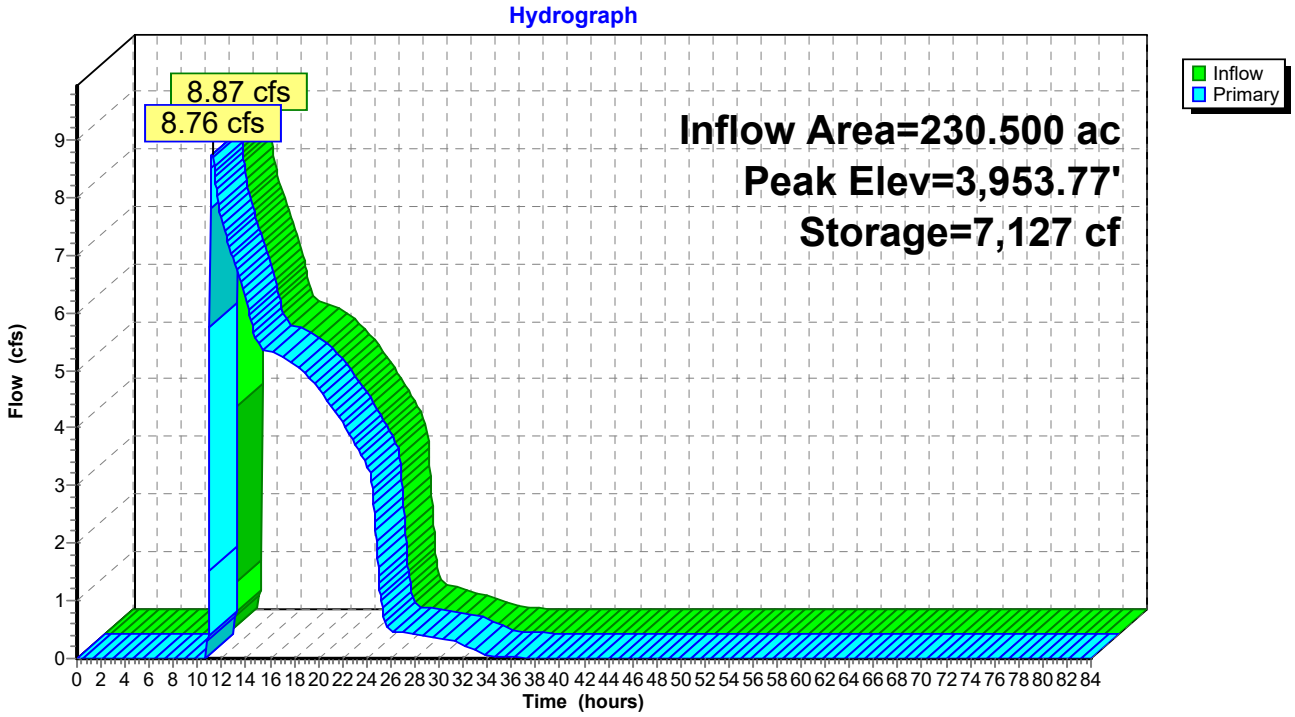
Volume	Invert	Avail.Storage	Storage Description
#1	3,950.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,950.00	0
3,950.50	567
3,951.00	1,263
3,951.50	2,070
3,952.00	2,987
3,952.50	4,015
3,953.00	5,148
3,953.50	6,390
3,954.00	7,734
3,954.50	9,177
3,955.00	10,719
3,955.50	12,359
3,956.00	14,099
3,956.50	15,947
3,957.00	17,922
3,957.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,951.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,951.00' / 3,948.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,953.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=8.75 cfs @ 11.19 hrs HW=3,953.77' TW=3,950.34' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.54 cfs @ 6.14 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 8.22 cfs @ 2.36 fps)

Pond 4P: Pond OL2



Summary for Pond 5P: Pond OL3

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 8.76 cfs @ 11.19 hrs, Volume= 6.292 af
Outflow = 8.48 cfs @ 11.39 hrs, Volume= 6.262 af, Atten= 3%, Lag= 12.1 min
Primary = 8.48 cfs @ 11.39 hrs, Volume= 6.262 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,950.76' @ 11.40 hrs Surf.Area= 0 sf Storage= 7,079 cf

Plug-Flow detention time= 31.3 min calculated for 6.259 af (99% of inflow)
Center-of-Mass det. time= 26.8 min (1,074.7 - 1,047.9)

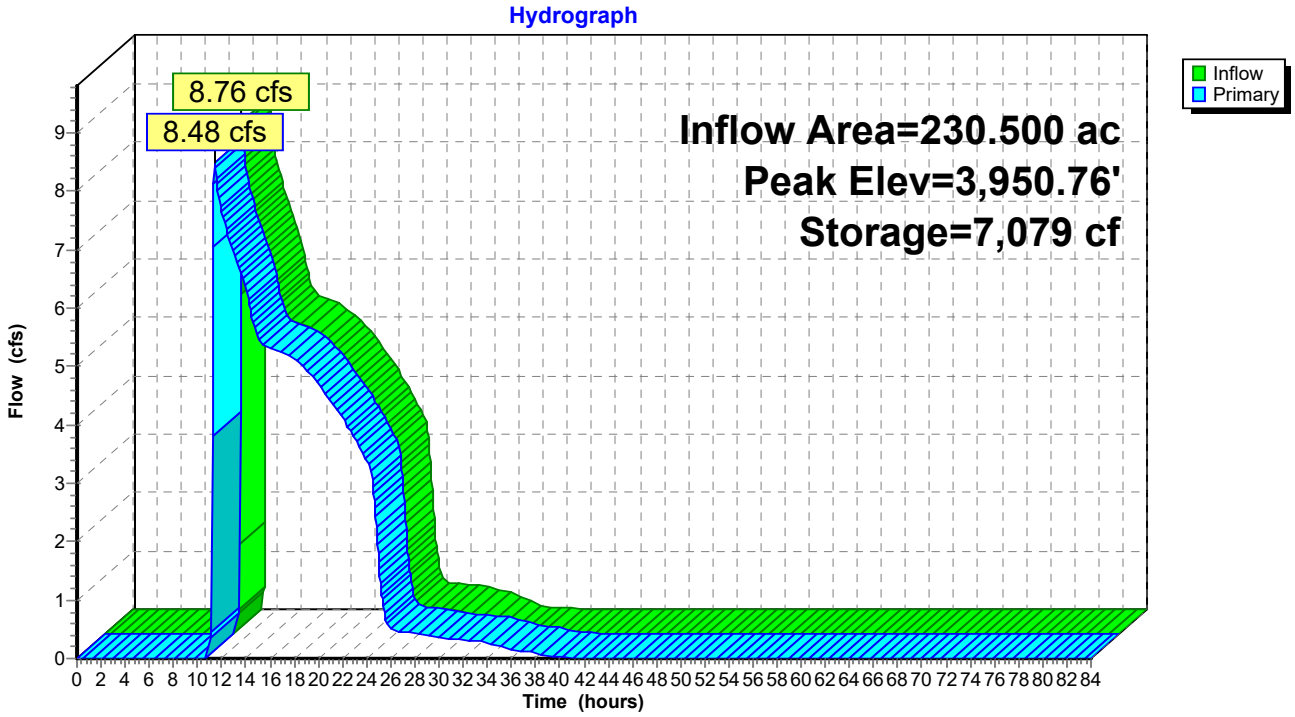
Volume	Invert	Avail.Storage	Storage Description
#1	3,947.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,947.00	0
3,947.50	567
3,948.00	1,263
3,948.50	2,070
3,949.00	2,987
3,949.50	4,015
3,950.00	5,148
3,950.50	6,390
3,951.00	7,734
3,951.50	9,177
3,952.00	10,719
3,952.50	12,359
3,953.00	14,099
3,953.50	15,947
3,954.00	17,922
3,954.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,948.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,948.00' / 3,946.00' S= 0.1000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,950.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=8.46 cfs @ 11.39 hrs HW=3,950.76' TW=3,948.28' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.52 cfs @ 5.98 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 7.94 cfs @ 2.33 fps)

Pond 5P: Pond OL3



Summary for Pond 6P: Pond OL4

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.33" for (New) 100-Yr, 24-hr, Type I event
Inflow = 8.48 cfs @ 11.39 hrs, Volume= 6.262 af
Outflow = 7.76 cfs @ 11.87 hrs, Volume= 6.197 af, Atten= 8%, Lag= 28.5 min
Primary = 7.76 cfs @ 11.87 hrs, Volume= 6.197 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,949.72' @ 11.88 hrs Surf.Area= 0 sf Storage= 10,958 cf

Plug-Flow detention time= 53.0 min calculated for 6.193 af (99% of inflow)
Center-of-Mass det. time= 41.3 min (1,116.1 - 1,074.7)

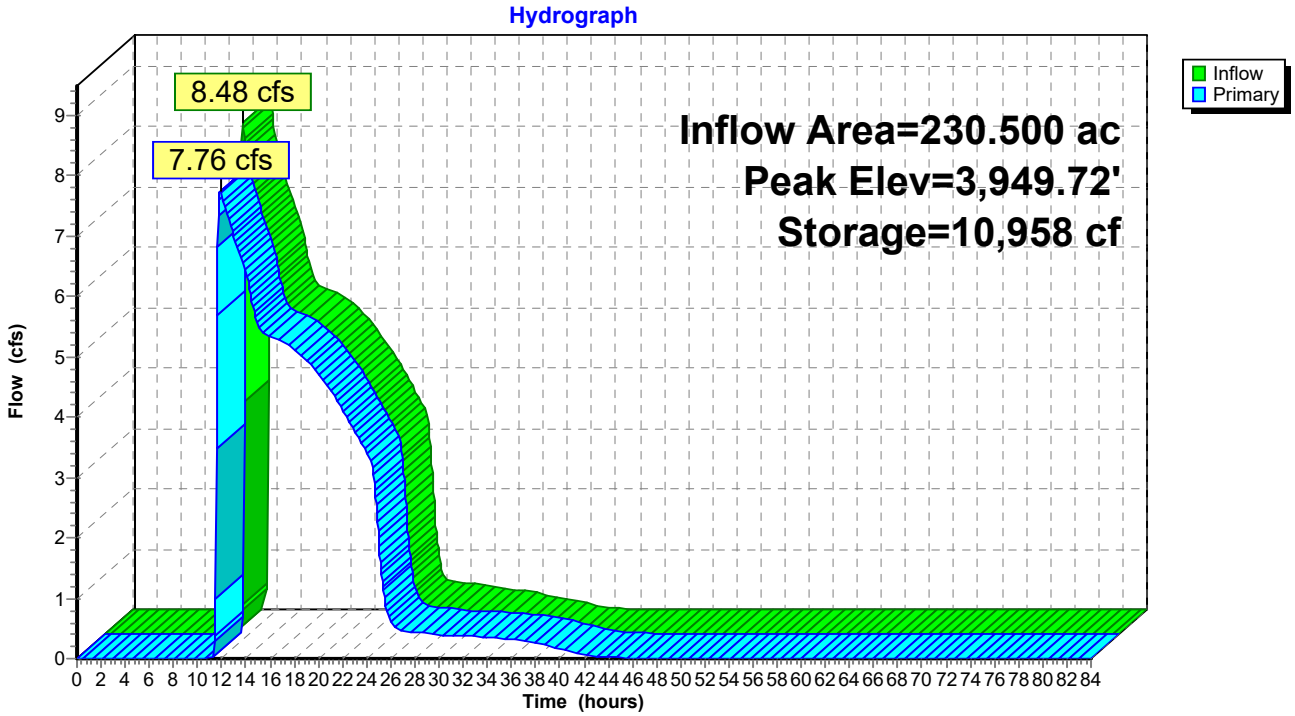
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	55,314 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	761
3,947.00	1,811
3,947.50	3,099
3,948.00	4,591
3,948.50	6,260
3,949.00	8,076
3,949.50	10,034
3,950.00	12,127
3,950.50	14,353
3,951.00	16,711
3,951.50	19,197
3,952.00	21,811
3,952.50	24,551
3,953.00	27,420
3,953.50	30,417
3,954.00	33,546
3,954.50	36,810
3,955.00	40,213
3,955.50	43,758
3,956.00	47,453
3,956.50	51,302
3,957.00	55,314

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,947.00' / 3,946.00' S= 0.0500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,949.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=7.75 cfs @ 11.87 hrs HW=3,949.72' TW=3,948.61' (Dynamic Tailwater)
└**1=Culvert** (Inlet Controls 0.35 cfs @ 4.01 fps)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 7.40 cfs @ 2.28 fps)

Pond 6P: Pond OL4



Summary for Pond 7P: Pond OL5

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.32" for (New) 100-Yr, 24-hr, Type I event
Inflow = 7.76 cfs @ 11.87 hrs, Volume= 6.197 af
Outflow = 7.68 cfs @ 12.02 hrs, Volume= 6.163 af, Atten= 1%, Lag= 8.9 min
Primary = 7.68 cfs @ 12.02 hrs, Volume= 6.163 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,948.63' @ 12.02 hrs Surf.Area= 0 sf Storage= 4,038 cf

Plug-Flow detention time= 17.3 min calculated for 6.159 af (99% of inflow)
Center-of-Mass det. time= 9.8 min (1,125.9 - 1,116.1)

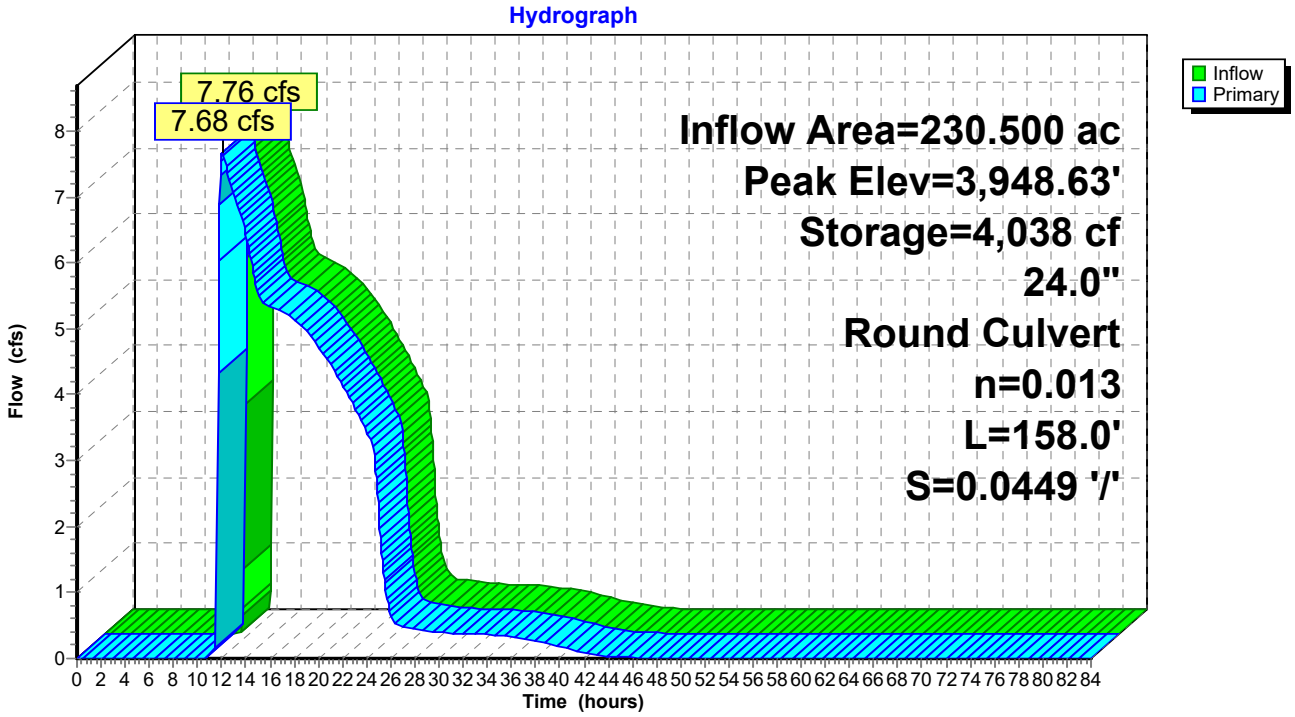
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	56,530 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	300
3,947.00	827
3,947.50	1,596
3,948.00	2,549
3,948.50	3,687
3,949.00	5,013
3,949.50	6,529
3,950.00	8,234
3,950.50	10,134
3,951.00	12,319
3,951.50	14,829
3,952.00	17,598
3,952.50	20,588
3,953.00	23,779
3,953.50	27,169
3,954.00	30,757
3,954.50	34,542
3,955.00	38,525
3,955.50	42,711
3,956.00	47,103
3,956.50	51,706
3,957.00	56,530

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.40'	**24.0" Round Culvert** L= 158.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,947.40' / 3,940.30' S= 0.0449 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections

Primary OutFlow Max=7.67 cfs @ 12.02 hrs HW=3,948.63' TW=0.00' (Dynamic Tailwater)
1=Culvert (Inlet Controls 7.67 cfs @ 3.78 fps)

Pond 7P: Pond OL5



Summary for Pond 8P: Pond OL6

Inflow Area = 304.320 ac, 4.08% Impervious, Inflow Depth = 0.24" for (New) 100-Yr, 24-hr, Type I event
Inflow = 5.20 cfs @ 16.94 hrs, Volume= 6.103 af
Outflow = 5.20 cfs @ 16.99 hrs, Volume= 5.966 af, Atten= 0%, Lag= 3.0 min
Primary = 5.20 cfs @ 16.99 hrs, Volume= 5.966 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,947.01' @ 16.99 hrs Surf.Area= 0 sf Storage= 7,206 cf

Plug-Flow detention time= 60.2 min calculated for 5.962 af (98% of inflow)
Center-of-Mass det. time= 19.7 min (1,288.5 - 1,268.9)

Volume	Invert	Avail.Storage	Storage Description
#1	3,945.00'	150,009 cf	**Custom Stage Data** Listed below

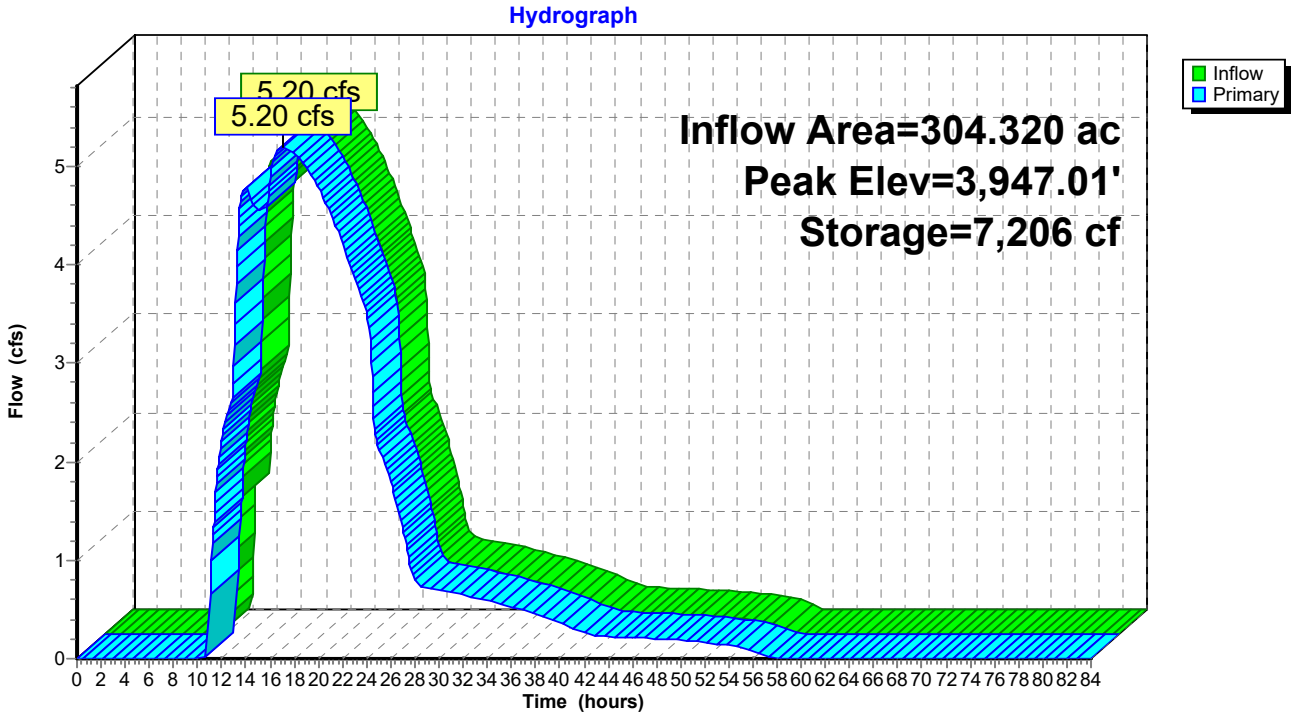
Elevation (feet)	Cum.Store (cubic-feet)
3,945.00	0
3,945.50	1,241
3,946.00	2,907
3,946.50	4,876
3,947.00	7,132
3,947.50	9,707
3,948.00	12,610
3,948.50	15,850
3,949.00	19,436
3,949.50	23,393
3,950.00	27,772
3,950.50	32,645
3,951.00	37,997
3,951.50	43,750
3,952.00	49,862
3,952.50	56,323
3,953.00	63,123
3,953.50	70,242
3,954.00	77,678
3,954.50	85,443
3,955.00	93,551
3,955.50	102,017
3,956.00	110,852
3,956.50	120,062
3,957.00	129,654
3,957.50	139,634
3,958.00	150,009

Device	Routing	Invert	Outlet Devices
#1	Primary	3,944.96'	**24.0" Round Culvert** L= 153.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,944.96' / 3,942.08' S= 0.0188 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	3,946.75'	**15.0' long x 11.0' breadth Broad-Crested Rectangular Weir**

Head (feet)	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60
Coef. (English)	2.53	2.59	2.70	2.68	2.67	2.68	2.66	2.64

Primary OutFlow Max=5.20 cfs @ 16.99 hrs HW=3,947.01' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 5.20 cfs of 15.53 cfs potential flow)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 5.20 cfs @ 1.31 fps)

Pond 8P: Pond OL6



Summary for Pond 9P: Junction Manhole

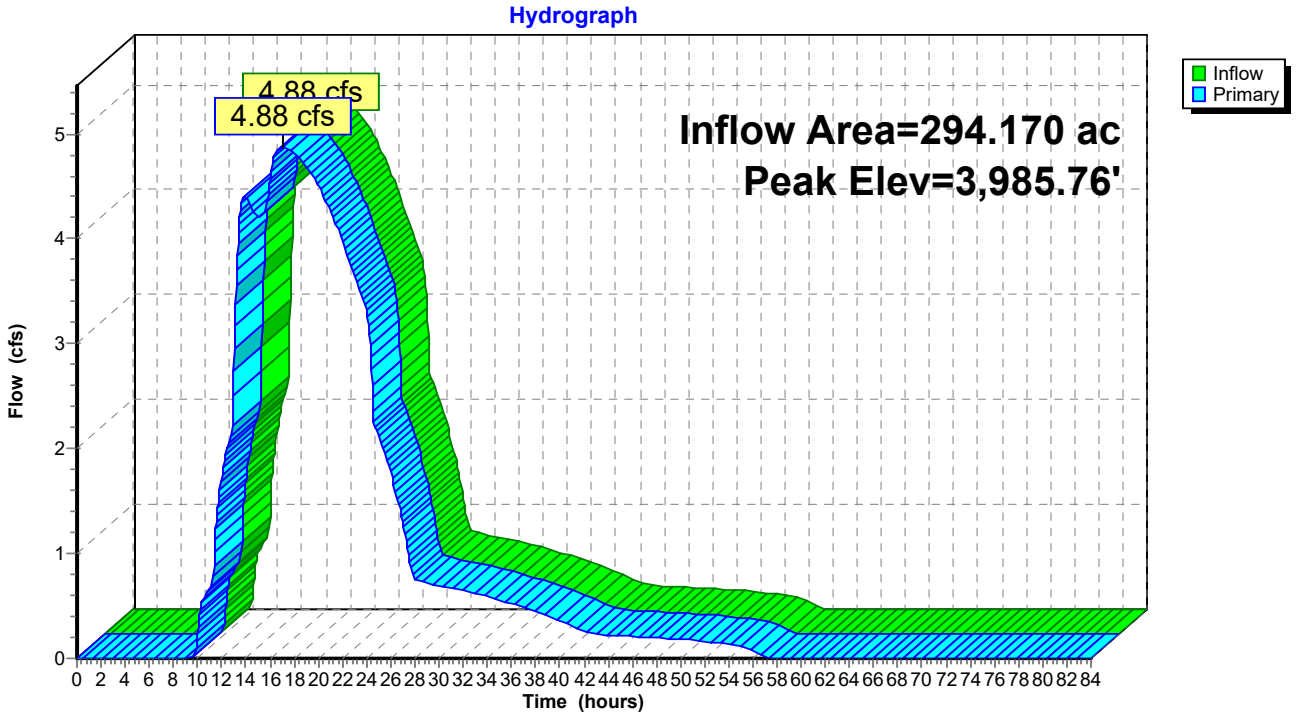
Inflow Area = 294.170 ac, 4.22% Impervious, Inflow Depth = 0.23" for (New) 100-Yr, 24-hr, Type I event
Inflow = 4.88 cfs @ 17.01 hrs, Volume= 5.651 af
Outflow = 4.88 cfs @ 17.01 hrs, Volume= 5.651 af, Atten= 0%, Lag= 0.0 min
Primary = 4.88 cfs @ 17.01 hrs, Volume= 5.651 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,985.76' @ 17.01 hrs
Flood Elev= 3,986.50'

Device	Routing	Invert	Outlet Devices
#1	Device 2	3,984.50'	**18.0" Round Culvert** L= 820.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 3,984.50' / 3,980.00' S= 0.0055 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets
#2	Primary	3,980.00'	**24.0" Round Culvert** L= 420.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 3,980.00' / 3,946.40' S= 0.0800 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets

Primary OutFlow Max=4.88 cfs @ 17.01 hrs HW=3,985.76' TW=3,947.01' (Dynamic Tailwater)
└─**2=Culvert** (Passes 4.88 cfs of 45.00 cfs potential flow)
└─**1=Culvert** (Barrel Controls 4.88 cfs @ 4.16 fps)

Pond 9P: Junction Manhole

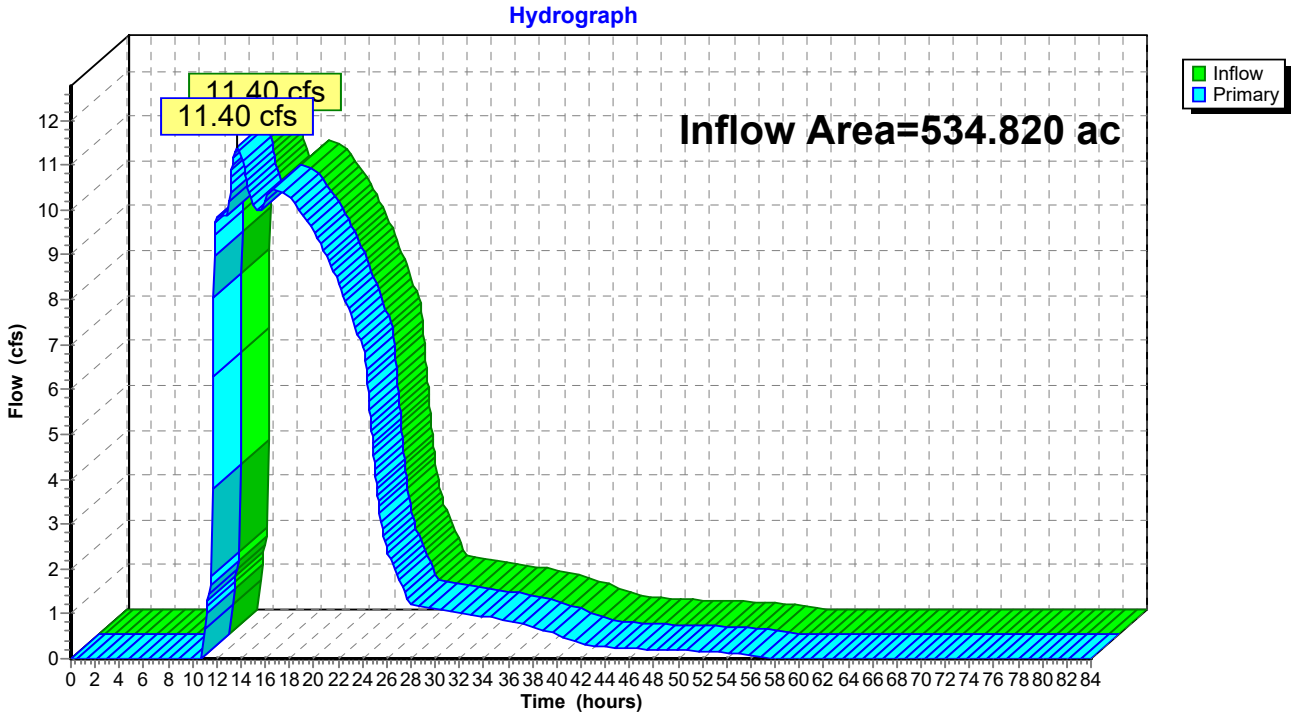


Summary for Pond 10P: D/S Junction (flow to Spring Meadow)

Inflow Area = 534.820 ac, 8.46% Impervious, Inflow Depth = 0.27" for (New) 100-Yr, 24-hr, Type I event
Inflow = 11.40 cfs @ 13.68 hrs, Volume= 12.129 af
Primary = 11.40 cfs @ 13.68 hrs, Volume= 12.129 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs

Pond 10P: D/S Junction (flow to Spring Meadow)



Summary for Pond A: Pond A

Inflow Area = 26.500 ac, 6.92% Impervious, Inflow Depth = 0.55" for (New) 100-Yr, 24-hr, Type I event
Inflow = 5.20 cfs @ 10.18 hrs, Volume= 1.215 af
Outflow = 0.85 cfs @ 16.95 hrs, Volume= 1.215 af, Atten= 84%, Lag= 406.2 min
Primary = 0.85 cfs @ 16.95 hrs, Volume= 1.215 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,994.09' @ 16.95 hrs Surf.Area= 0.193 ac Storage= 0.609 af
Flood Elev= 3,994.50' Surf.Area= 0.208 ac Storage= 0.690 af

Plug-Flow detention time= 784.5 min calculated for 1.214 af (100% of inflow)
Center-of-Mass det. time= 785.2 min (1,693.5 - 908.3)

Volume	Invert	Avail.Storage	Storage Description
#1	3,986.50'	0.918 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
3,986.50	0.004	0.000	0.000
3,987.00	0.009	0.003	0.003
3,987.50	0.016	0.006	0.009
3,988.00	0.023	0.010	0.019
3,988.50	0.031	0.013	0.033
3,989.00	0.041	0.018	0.051
3,989.50	0.051	0.023	0.074
3,990.00	0.063	0.028	0.102
3,990.50	0.076	0.035	0.137
3,991.00	0.089	0.041	0.178
3,991.50	0.104	0.048	0.226
3,992.00	0.120	0.056	0.283
3,992.50	0.136	0.064	0.347
3,993.00	0.154	0.072	0.419
3,993.50	0.172	0.081	0.500
3,994.00	0.190	0.090	0.591
3,994.50	0.208	0.099	0.690
3,995.00	0.228	0.109	0.799
3,995.50	0.244	0.118	0.918

Device	Routing	Invert	Outlet Devices
#1	Primary	3,985.50'	**18.0" Round 18" RCP Culvert** L= 45.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 3,985.50' / 3,984.50' S= 0.0222 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	3,994.00'	**24.0" Horiz. 24" Orifice/Grate (MH Lid)** C= 0.600 in 24.0" Grate Limited to weir flow at low heads
#3	Secondary	3,994.50'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#4	Device 1	3,986.00'	**12.0" Round 12" Culvert Inlet Pipe** L= 15.0' CPP, projecting, no headwall, Ke= 0.900

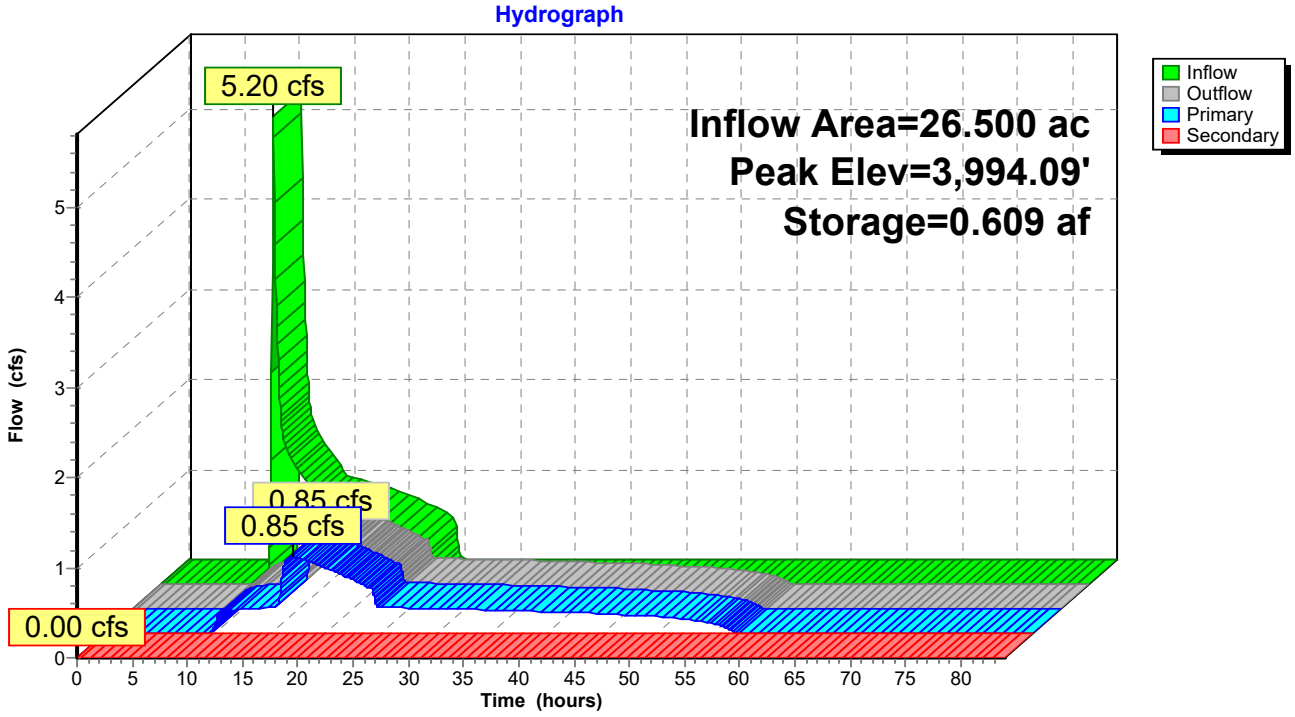
Inlet / Outlet Invert= 3,986.00' / 3,985.75' S= 0.0167 '/' Cc= 0.900
n= 0.010

#5 Device 4 3,986.40' **2.0" Vert. 2" Orifice/Grate (Low)** C= 0.600

Primary OutFlow Max=0.85 cfs @ 16.95 hrs HW=3,994.09' TW=3,985.76' (Dynamic Tailwater)
└─**1=18" RCP Culvert** (Passes 0.85 cfs of 28.36 cfs potential flow)
  └─**2=24" Orifice/Grate (MH Lid)** (Weir Controls 0.56 cfs @ 0.98 fps)
  └─**4=12" Culvert Inlet Pipe** (Passes 0.29 cfs of 8.23 cfs potential flow)
    └─**5=2" Orifice/Grate (Low)** (Orifice Controls 0.29 cfs @ 13.28 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=3,986.50' TW=3,959.50' (Dynamic Tailwater)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond A: Pond A



Summary for Pond B: Pond B

Inflow Area = 267.670 ac, 3.95% Impervious, Inflow Depth = 0.20" for (New) 100-Yr, 24-hr, Type I event
Inflow = 5.03 cfs @ 10.15 hrs, Volume= 4.436 af
Outflow = 4.14 cfs @ 13.90 hrs, Volume= 4.436 af, Atten= 18%, Lag= 225.3 min
Primary = 4.14 cfs @ 13.90 hrs, Volume= 4.436 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 4,040.85' @ 13.90 hrs Surf.Area= 0.218 ac Storage= 0.740 af
Flood Elev= 4,041.00' Surf.Area= 0.224 ac Storage= 0.773 af

Plug-Flow detention time= 173.0 min calculated for 4.433 af (100% of inflow)
Center-of-Mass det. time= 173.5 min (1,188.0 - 1,014.5)

Volume	Invert	Avail.Storage	Storage Description
#1	4,034.50'	1.023 af	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
4,034.50	0.034	0.000	0.000
4,035.00	0.061	0.024	0.024
4,035.50	0.069	0.032	0.056
4,036.00	0.077	0.036	0.093
4,036.50	0.085	0.040	0.133
4,037.00	0.094	0.045	0.178
4,037.50	0.104	0.049	0.227
4,038.00	0.114	0.054	0.282
4,038.50	0.126	0.060	0.342
4,039.00	0.141	0.067	0.409
4,039.50	0.162	0.076	0.484
4,040.00	0.182	0.086	0.570
4,040.50	0.203	0.096	0.667
4,041.00	0.224	0.107	0.773
4,041.50	0.249	0.118	0.892
4,042.00	0.278	0.132	1.023

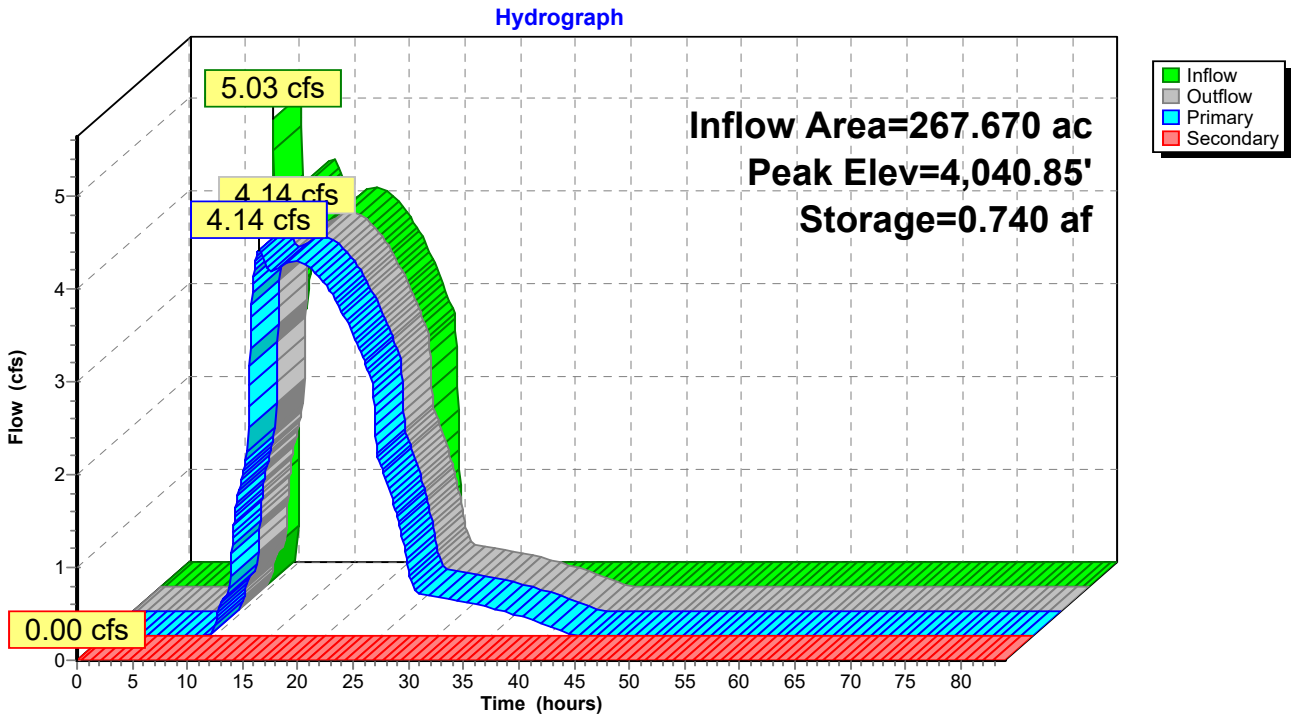
Device	Routing	Invert	Outlet Devices
#1	Primary	4,033.70'	**18.0" Round 18" Culvert** L= 825.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 4,033.70' / 4,005.00' S= 0.0348 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets
#2	Device 1	4,040.50'	**12.0" Horiz. 12" Orifice/Grate (Manhole Lid)** C= 0.600 in 12.0" Grate Limited to weir flow at low heads
#3	Secondary	4,041.00'	**5.0' long x 12.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64
#4	Device 1	4,034.00'	**12.0" Round 12" Culvert (Inlet)** L= 15.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4,034.00' / 4,033.80' S= 0.0133 '/' Cc= 0.900 n= 0.010
#5	Device 4	4,034.40'	**3.0" Vert. 3" Orifice/Grate (Low)** C= 0.600

#6 Device 1 4,038.25' **6.0" Vert. 6" Orifice/Grate** C= 0.600

Primary OutFlow Max=4.14 cfs @ 13.90 hrs HW=4,040.85' TW=3,985.68' (Dynamic Tailwater)
- **1=18" Culvert** (Passes 4.14 cfs of 18.01 cfs potential flow)
  - **2=12" Orifice/Grate (Manhole Lid)** (Weir Controls 2.10 cfs @ 1.93 fps)
  - **4=12" Culvert (Inlet)** (Passes 0.59 cfs of 7.52 cfs potential flow)
    - **5=3" Orifice/Grate (Low)** (Orifice Controls 0.59 cfs @ 12.11 fps)
  - **6=6" Orifice/Grate** (Orifice Controls 1.45 cfs @ 7.38 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=4,034.50' TW=4,020.00' (Dynamic Tailwater)
- **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B: Pond B



Time span=0.00-84.00 hrs, dt=0.05 hrs, 1681 points
Runoff by SCS TR-20 method, UH=SCS
Reach routing by Dyn-Muskingum-Cunge method - Pond routing by Dyn-Stor-Ind method

Subcatchment A-1: SWS_A-1 to Pond A Runoff Area=12.670 ac 8.29% Impervious Runoff Depth=0.17"
Flow Length=1,400' Tc=22.0 min CN=74 Runoff=0.23 cfs 0.181 af

Subcatchment A-2: SWS_A-2 to Pond A Runoff Area=2.950 ac 26.54% Impervious Runoff Depth=0.13"
Flow Length=230' Slope=0.1000 '/' Tc=22.9 min CN=72 Runoff=0.03 cfs 0.033 af

Subcatchment A-3: SWS_A-3 to Pond A Runoff Area=10.880 ac 0.00% Impervious Runoff Depth=0.15"
Flow Length=1,165' Tc=16.5 min CN=73 Runoff=0.15 cfs 0.138 af

Subcatchment B-1a: SWS_B3 to Pond B Runoff Area=9.630 ac 30.00% Impervious Runoff Depth=0.13"
Flow Length=1,675' Tc=18.4 min CN=72 Runoff=0.11 cfs 0.108 af

Subcatchment B-1b: SWS_B2 to Pond B Runoff Area=32.940 ac 23.34% Impervious Runoff Depth=0.09"
Flow Length=2,110' Tc=15.9 min CN=69 Runoff=0.25 cfs 0.240 af

Subcatchment B-2: SWS_B4 to Pond B Runoff Area=225.100 ac 0.00% Impervious Runoff Depth=0.01"
Flow Length=5,300' Tc=35.3 min CN=60 Runoff=0.33 cfs 0.152 af

Subcatchment C-1: SWS-C_East (OL Runoff Area=230.500 ac 14.25% Impervious Runoff Depth=0.06"
Flow Length=7,666' Tc=52.5 min CN=67 Runoff=1.34 cfs 1.193 af

Subcatchment C-2: Overlook Est Runoff Area=10.150 ac 0.00% Impervious Runoff Depth=0.15"
Flow Length=1,510' Tc=32.4 min CN=73 Runoff=0.14 cfs 0.129 af

Reach Chute: To Pond A Avg. Flow Depth=0.01' Max Vel=5.71 fps Inflow=0.18 cfs 0.171 af
n=0.150 L=75.0' S=0.2000 '/' Capacity=28.53 cfs Outflow=0.18 cfs 0.171 af

Reach Ditch-1: Ditch to Pond A Avg. Flow Depth=0.12' Max Vel=7.13 fps Inflow=0.18 cfs 0.171 af
n=0.022 L=700.0' S=0.0100 '/' Capacity=23.29 cfs Outflow=0.18 cfs 0.171 af

Pond 3P: Pond OL1 Peak Elev=3,956.19' Storage=9,408 cf Inflow=1.34 cfs 1.193 af
Outflow=1.33 cfs 1.141 af

Pond 4P: Pond OL2 Peak Elev=3,953.19' Storage=5,613 cf Inflow=1.33 cfs 1.141 af
Outflow=1.33 cfs 1.112 af

Pond 5P: Pond OL3 Peak Elev=3,950.20' Storage=5,655 cf Inflow=1.33 cfs 1.112 af
Outflow=1.33 cfs 1.082 af

Pond 6P: Pond OL4 Peak Elev=3,949.20' Storage=8,845 cf Inflow=1.33 cfs 1.082 af
Outflow=1.31 cfs 1.016 af

Pond 7P: Pond OL5 Peak Elev=3,947.87' Storage=2,299 cf Inflow=1.31 cfs 1.016 af
24.0" Round Culvert n=0.013 L=158.0' S=0.0449 '/' Outflow=1.31 cfs 0.983 af

Pond 8P: Pond OL6 Peak Elev=3,946.82' Storage=6,310 cf Inflow=0.67 cfs 0.980 af
Outflow=0.67 cfs 0.843 af

Pond 9P: Junction Manhole Peak Elev=3,984.90' Inflow=0.60 cfs 0.852 af
Outflow=0.60 cfs 0.852 af

Pond 10P: D/S Junction (flow to Spring Meadow) Inflow=1.95 cfs 1.826 af
Primary=1.95 cfs 1.826 af

Pond A: Pond A Peak Elev=3,990.47' Storage=0.135 af Inflow=0.41 cfs 0.352 af
Primary=0.21 cfs 0.352 af Secondary=0.00 cfs 0.000 af Outflow=0.21 cfs 0.352 af

Pond B: Pond B Peak Elev=4,037.21' Storage=0.198 af Inflow=0.61 cfs 0.499 af
Primary=0.39 cfs 0.499 af Secondary=0.00 cfs 0.000 af Outflow=0.39 cfs 0.499 af

Total Runoff Area = 534.820 ac Runoff Volume = 2.173 af Average Runoff Depth = 0.05"
91.54% Pervious = 489.561 ac 8.46% Impervious = 45.259 ac

Summary for Subcatchment A-1: SWS_A-1 to Pond A

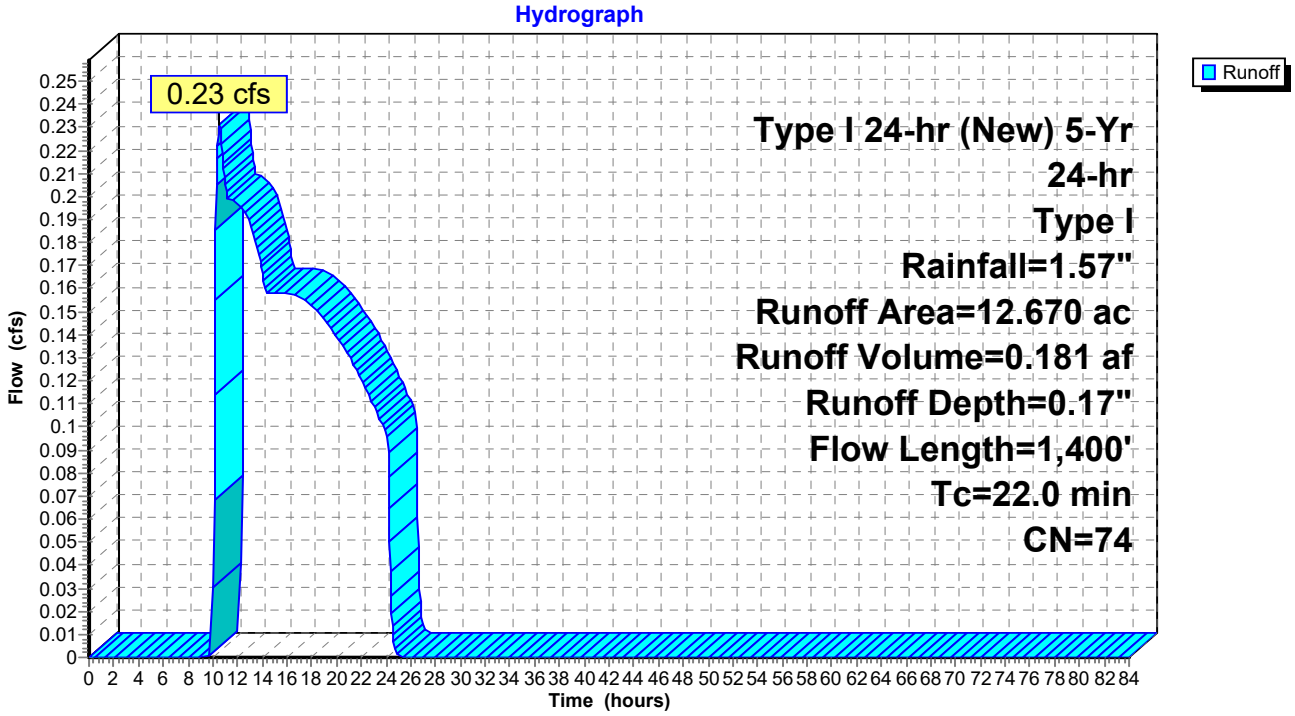
Runoff = 0.23 cfs @ 10.55 hrs, Volume= 0.181 af, Depth= 0.17"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	1.380	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	7.790	75	1/4 ac lot, SoilG B / Fair, HEC 22 Table 3-6
	3.500	72	1/3 acre lots, 30% imp, HSG B
	12.670	74	Weighted Average
	11.620		91.71% Pervious Area
	1.050		8.29% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
18.6	250	0.2000	0.22		**Sheet Flow, Lot** Grass: Dense n= 0.240 P2= 1.30"
3.4	1,150	0.0750	5.56		**Shallow Concentrated Flow, Roads** Paved Kv= 20.3 fps
22.0	1,400	Total			

Subcatchment A-1: SWS_A-1 to Pond A



Summary for Subcatchment A-2: SWS_A-2 to Pond A

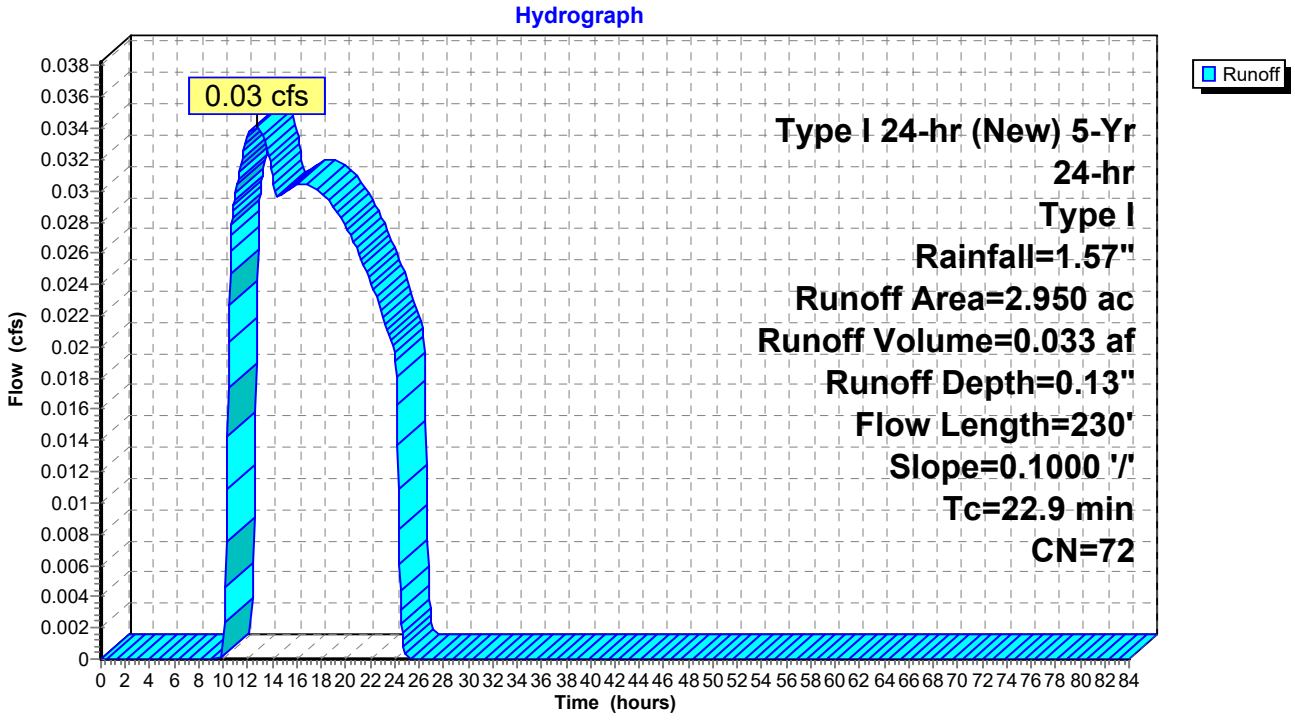
Runoff = 0.03 cfs @ 12.76 hrs, Volume= 0.033 af, Depth= 0.13"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	0.340	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	2.610	72	1/3 acre lots, 30% imp, HSG B
	2.950	72	Weighted Average
	2.167		73.46% Pervious Area
	0.783		26.54% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
22.9	230	0.1000	0.17		**Sheet Flow, Lot** Grass: Dense n= 0.240 P2= 1.30"

Subcatchment A-2: SWS_A-2 to Pond A



Summary for Subcatchment A-3: SWS_A-3 to Pond A (Hauser)

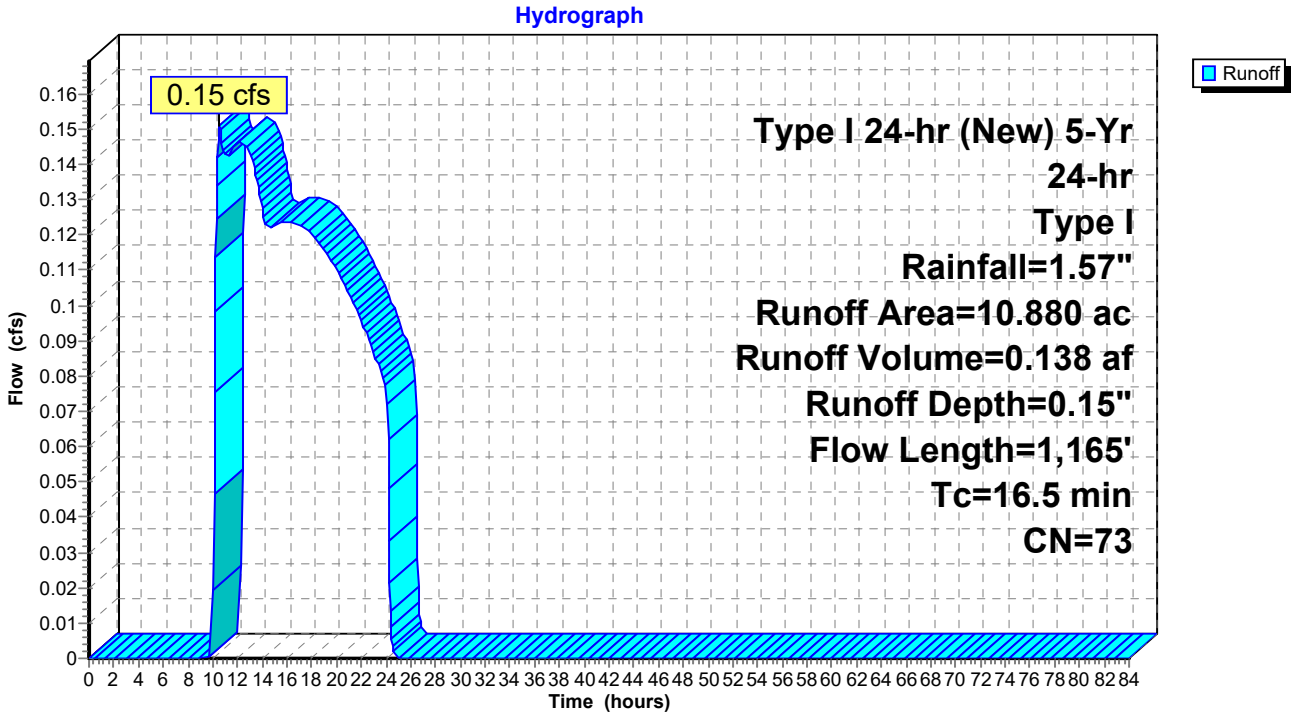
Runoff = 0.15 cfs @ 10.55 hrs, Volume= 0.138 af, Depth= 0.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	4.500	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
*	6.380	75	1/4 ac lot, SoilG B / Fair, HEC 22 Table 3-6
	10.880	73	Weighted Average
	10.880		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	150	0.2000	0.20		**Sheet Flow, Upper Portion Watershed** Grass: Dense n= 0.240 P2= 1.30"
4.2	1,015	0.0400	4.06		**Shallow Concentrated Flow, Roads** Paved Kv= 20.3 fps
16.5	1,165	Total			

Subcatchment A-3: SWS_A-3 to Pond A (Hauser)



Summary for Subcatchment B-1a: SWS_B3 to Pond B

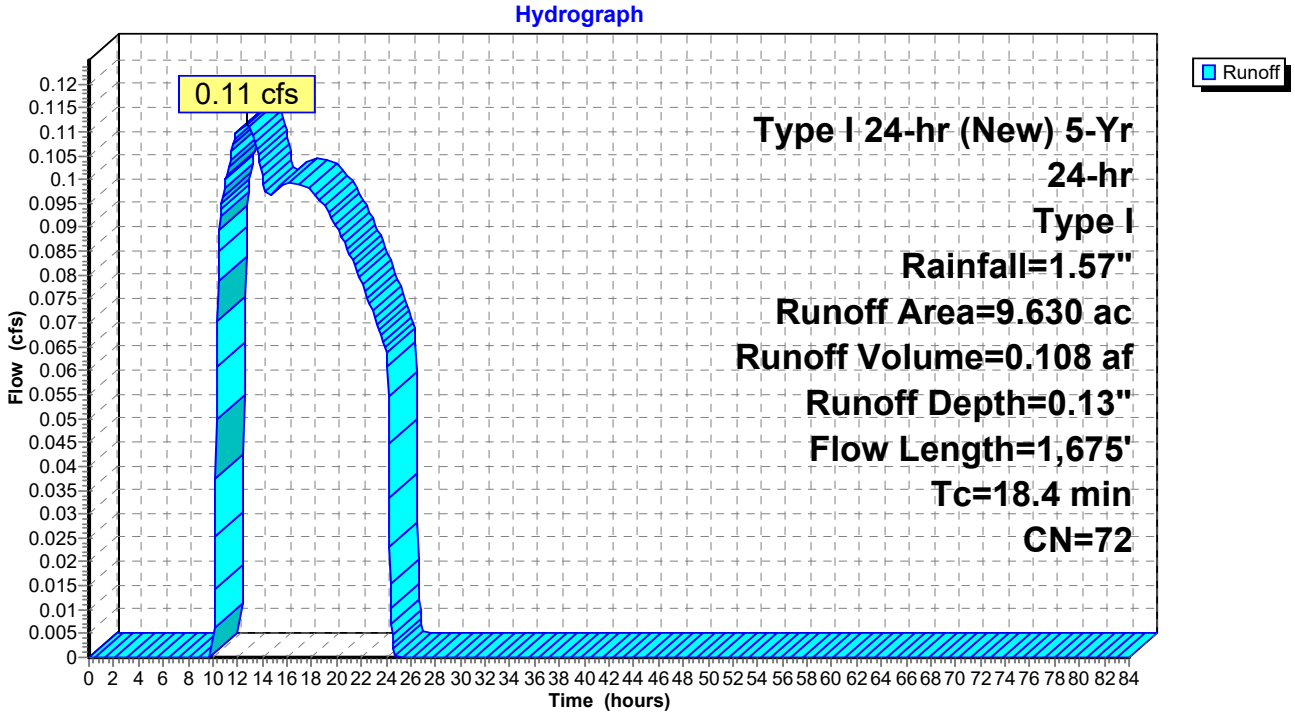
Runoff = 0.11 cfs @ 12.72 hrs, Volume= 0.108 af, Depth= 0.13"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

Area (ac)	CN	Description
9.630	72	1/3 acre lots, 30% imp, HSG B
6.741		70.00% Pervious Area
2.889		30.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.3	165	0.3000	0.24		**Sheet Flow, Upper Lots** Grass: Dense n= 0.240 P2= 1.30"
6.3	565	0.0100	1.50		**Shallow Concentrated Flow, Ditch** Grassed Waterway Kv= 15.0 fps
0.8	945	0.0900	20.53	25.19	**Pipe Channel, Strom Drain** 15.0" Round Area= 1.2 sf Perim= 3.9' r= 0.31' n= 0.010 PVC, smooth interior
18.4	1,675	Total			

Subcatchment B-1a: SWS_B3 to Pond B



Summary for Subcatchment B-1b: SWS_B2 to Pond B

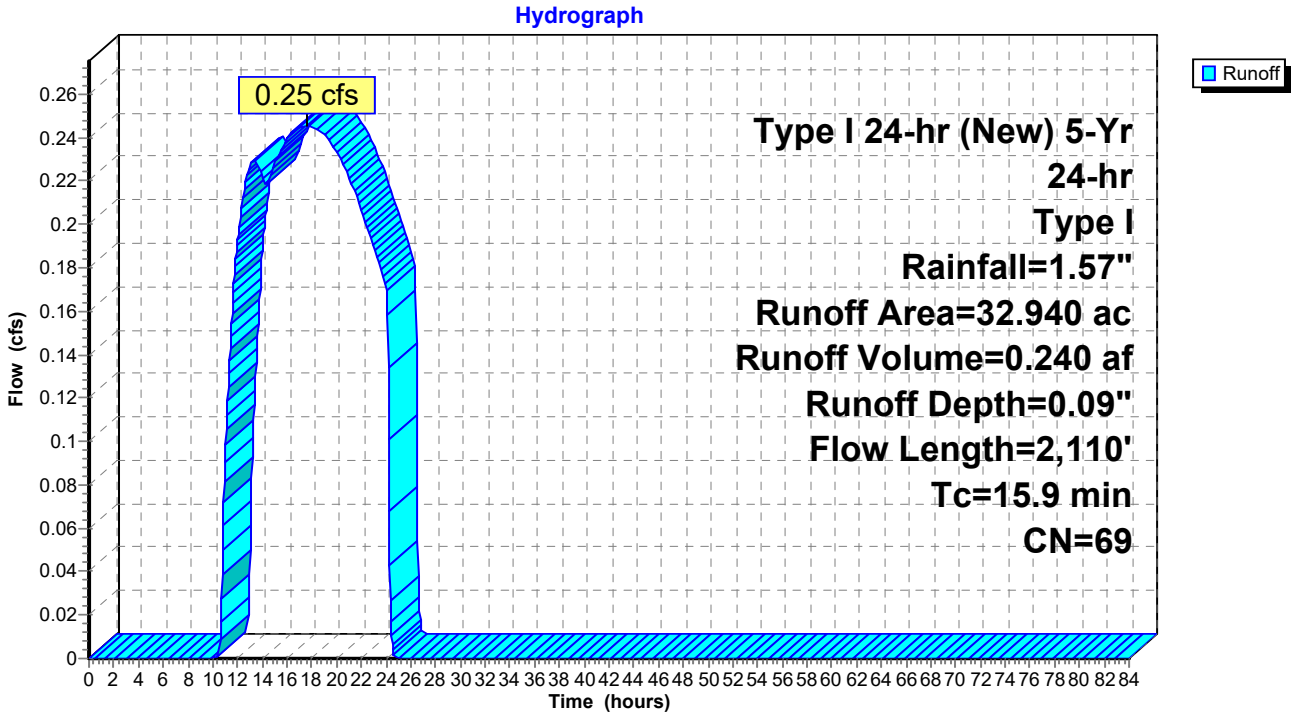
Runoff = 0.25 cfs @ 17.60 hrs, Volume= 0.240 af, Depth= 0.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
	18.540	72	1/3 acre lots, 30% imp, HSG B
*	5.900	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
	8.500	70	1/2 acre lots, 25% imp, HSG B
	32.940	69	Weighted Average
	25.253		76.66% Pervious Area
	7.687		23.34% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.7	185	0.2800	0.24		**Sheet Flow, Upper Portion of WS** Grass: Dense n= 0.240 P2= 1.30"
2.5	725	0.0590	4.93		**Shallow Concentrated Flow, Streets** Paved Kv= 20.3 fps
0.3	400	0.0700	20.45	36.13	**Pipe Channel, Storm Drain** 18.0" Round Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.010 PVC, smooth interior
0.4	800	0.0700	35.43	7,085.25	**Channel Flow, Drainage channel** Area= 200.0 sf Perim= 45.0' r= 4.44' n= 0.030 Earth, grassed & winding
15.9	2,110	Total			

Subcatchment B-1b: SWS_B2 to Pond B



Summary for Subcatchment B-2: SWS_B4 to Pond B (Offsite)

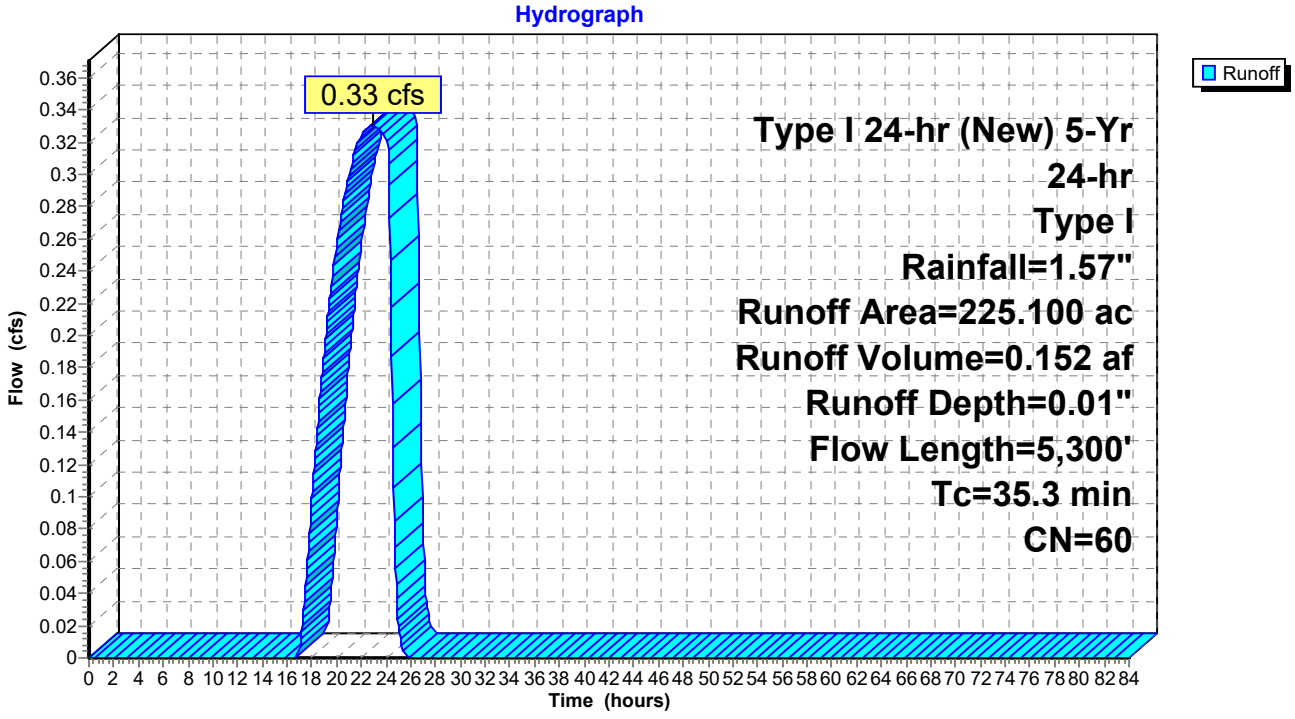
Runoff = 0.33 cfs @ 22.95 hrs, Volume= 0.152 af, Depth= 0.01"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	225.100	60	Woods, SoilG B / Fair, TR-55 Table 2-2c
	225.100		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
27.5	300	0.3000	0.18		**Sheet Flow, Upper Portion of WS** Woods: Light underbrush n= 0.400 P2= 1.30"
6.1	1,000	0.3000	2.74		**Shallow Concentrated Flow, Upper Reach** Woodland Kv= 5.0 fps
1.7	4,000	0.1200	39.76	7,951.51	**Channel Flow, Drainage Channel** Area= 200.0 sf Perim= 45.0' r= 4.44' n= 0.035 Earth, dense weeds
35.3	5,300	Total			

Subcatchment B-2: SWS_B4 to Pond B (Offsite)



Summary for Subcatchment C-1: SWS-C_East (OL Euclid Outlet)

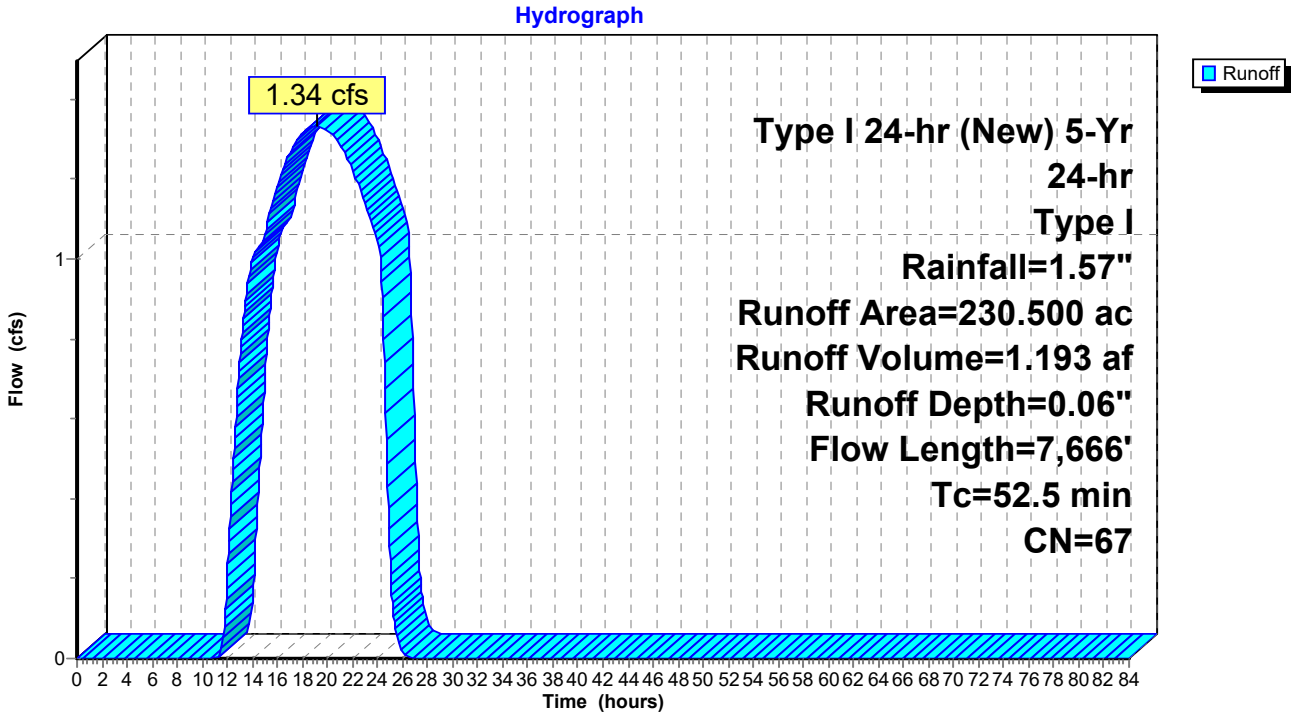
Runoff = 1.34 cfs @ 19.19 hrs, Volume= 1.193 af, Depth= 0.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	86.800	60	Woods, SoilG B/ Fair, TR-55 Table 2-2c
*	12.300	75	Overlook - 1/4 ac lot, SoilG B, HEC 22 Table 3-6
	131.400	70	1/2 acre lots, 25% imp, HSG B
	230.500	67	Weighted Average
	197.650		85.75% Pervious Area
	32.850		14.25% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.2	200	0.5000	0.21		**Sheet Flow, Upper Watershed** Woods: Light underbrush n= 0.400 P2= 1.30"
22.8	3,613	0.2800	2.65		**Shallow Concentrated Flow, Channel** Woodland Kv= 5.0 fps
12.1	2,811	0.0670	3.88		**Shallow Concentrated Flow, Neighborhoods** Grassed Waterway Kv= 15.0 fps
1.4	1,042	0.0420	12.79	40.18	**Pipe Channel, Storm Drain** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.015 Concrete sewer w/manholes & inlets
52.5	7,666	Total			

Subcatchment C-1: SWS-C_East (OL Euclid Outlet)



Summary for Subcatchment C-2: Overlook Est

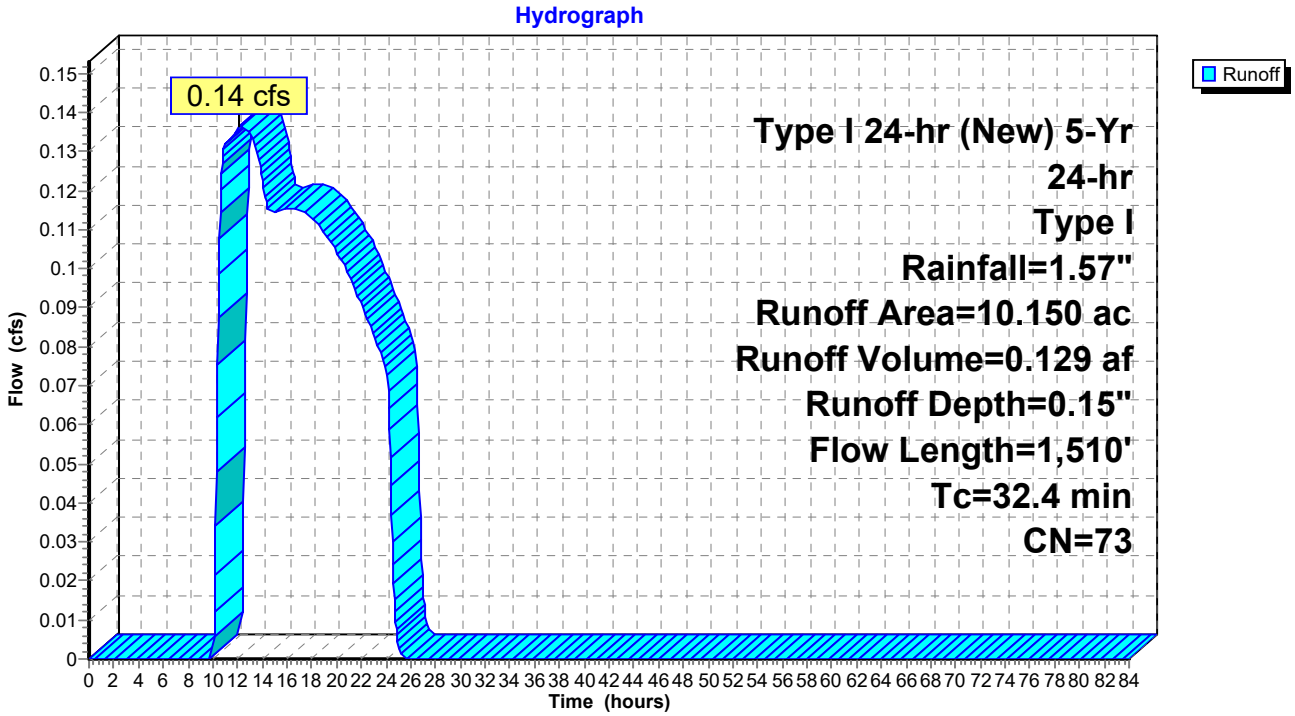
Runoff = 0.14 cfs @ 12.15 hrs, Volume= 0.129 af, Depth= 0.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Type I 24-hr (New) 5-Yr, 24-hr, Type I Rainfall=1.57"

	Area (ac)	CN	Description
*	7.280	75	1/4 ac lot, SoilG B, HEC 22 Table 3-6
*	2.870	69	Pasture, SoilG B/ Fair, TR-55 Table 2-2c
	10.150	73	Weighted Average
	10.150		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.9	180	0.0160	0.11		**Sheet Flow, Upper Watershed** Grass: Short n= 0.150 P2= 1.30"
3.3	510	0.0160	2.57		**Shallow Concentrated Flow, Street** Paved Kv= 20.3 fps
1.8	400	0.0350	3.80		**Shallow Concentrated Flow, Street 2** Paved Kv= 20.3 fps
0.4	420	0.0800	17.65	55.45	**Pipe Channel, Storm Pipe** 24.0" Round Area= 3.1 sf Perim= 6.3' r= 0.50' n= 0.015 Concrete sewer w/manholes & inlets
32.4	1,510	Total			

Subcatchment C-2: Overlook Est



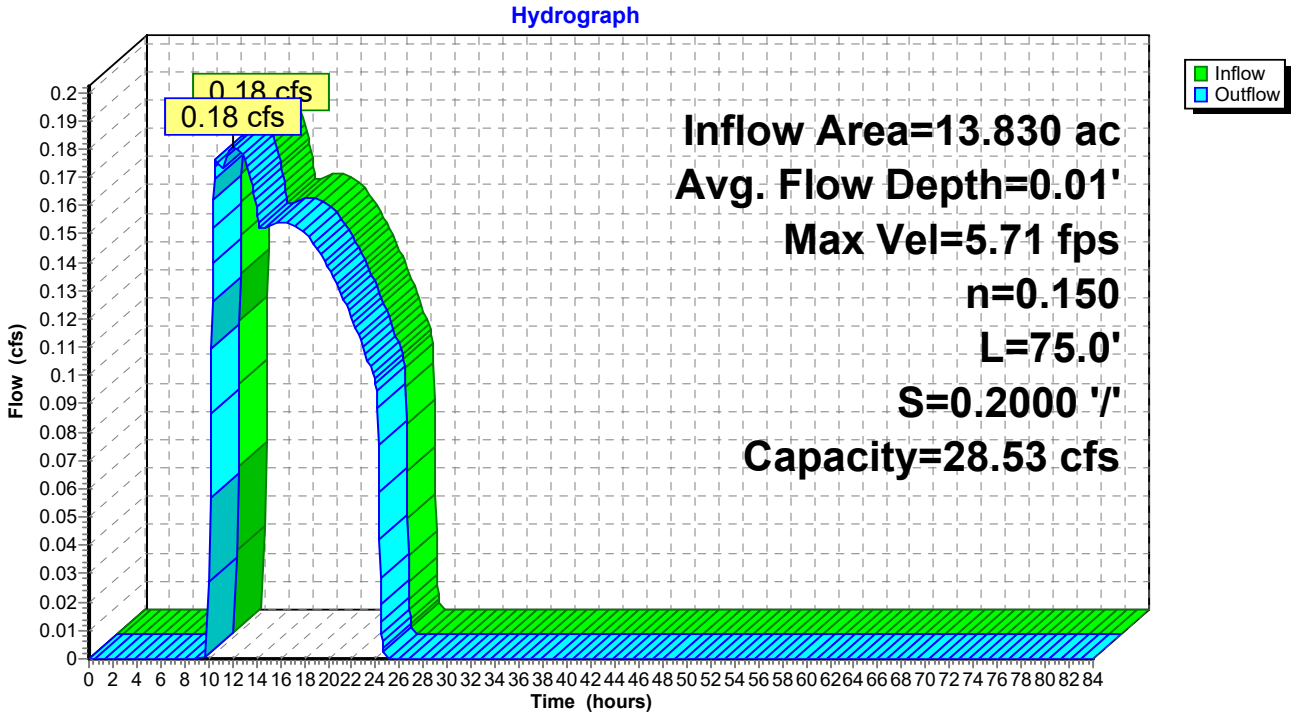
Summary for Reach Chute: To Pond A

Inflow Area = 13.830 ac, 5.66% Impervious, Inflow Depth = 0.15" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.18 cfs @ 11.98 hrs, Volume= 0.171 af
Outflow = 0.18 cfs @ 11.99 hrs, Volume= 0.171 af, Atten= 0%, Lag= 0.2 min

Routing by Dyn-Muskingum-Cunge method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Reference Flow= 21.40 cfs Estimated Depth= 1.28' Velocity= 3.91 fps
m= 1.441, c= 5.63 fps, dt= 3.0 min, dx= 75.0' / 1 = 75.0', K= 0.2 min, X= 0.470
Max. Velocity= 5.71 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 5.63 fps, Avg. Travel Time= 0.2 min

Peak Storage= 2 cf @ 11.99 hrs
Average Depth at Peak Storage= 0.01'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 28.53 cfs

3.00' x 1.50' deep channel, n= 0.150
Side Slope Z-value= 1.0 '/' Top Width= 6.00'
Length= 75.0' Slope= 0.2000 '/'
Inlet Invert= 4,012.00', Outlet Invert= 3,997.00'



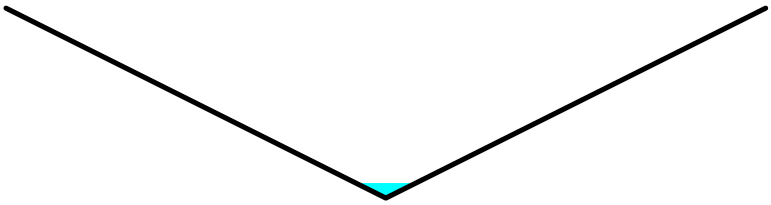
Summary for Reach Ditch-1: Ditch to Pond A

Inflow Area = 13.830 ac, 5.66% Impervious, Inflow Depth = 0.15" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.18 cfs @ 11.95 hrs, Volume= 0.171 af
Outflow = 0.18 cfs @ 11.98 hrs, Volume= 0.171 af, Atten= 0%, Lag= 2.1 min

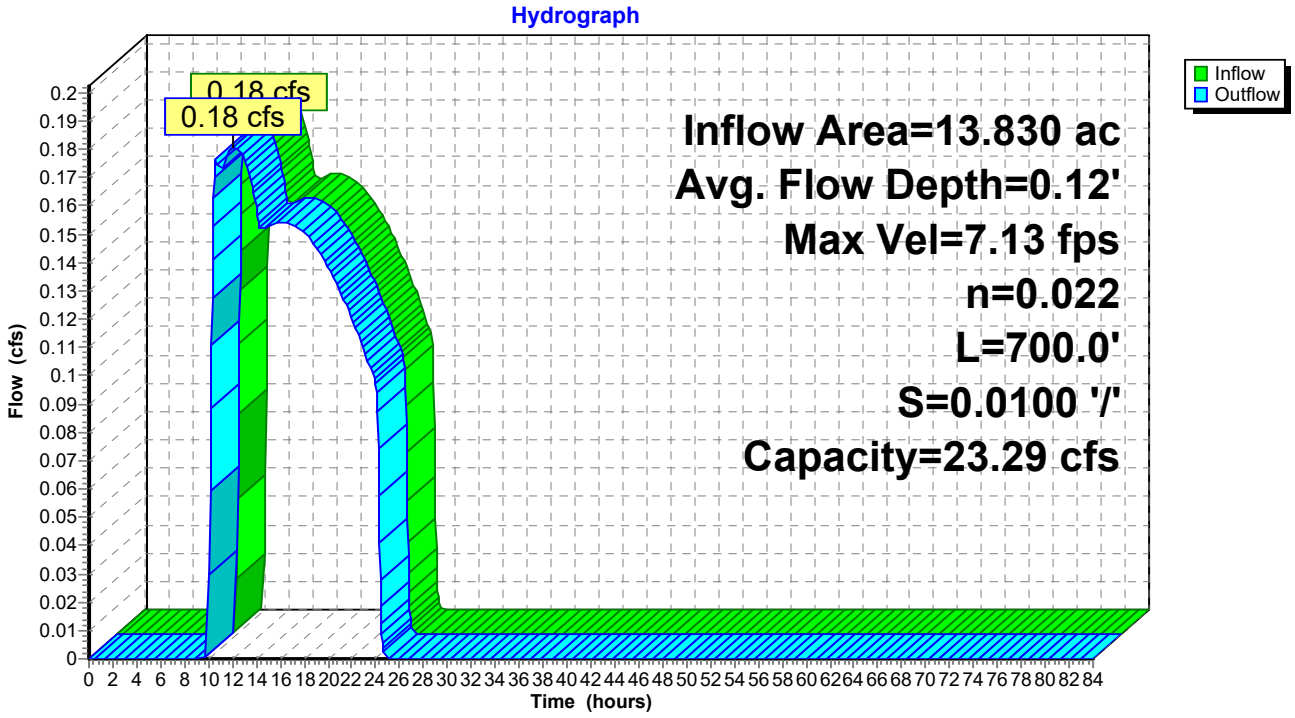
Routing by Dyn-Muskingum-Cunge method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Reference Flow= 17.47 cfs Estimated Depth= 1.35' Velocity= 4.82 fps
m= 1.333, c= 6.42 fps, dt= 3.0 min, dx= 700.0' / 1 = 700.0', K= 1.8 min, X= 0.428
Max. Velocity= 7.13 fps, Min. Travel Time= 1.6 min
Avg. Velocity = 6.43 fps, Avg. Travel Time= 1.8 min

Peak Storage= 20 cf @ 11.97 hrs
Average Depth at Peak Storage= 0.12'
Bank-Full Depth= 1.50', Capacity at Bank-Full= 23.29 cfs

0.00' x 1.50' deep channel, n= 0.022 Earth, clean & straight
Side Slope Z-value= 2.0 '/' Top Width= 6.00'
Length= 700.0' Slope= 0.0100 '/'
Inlet Invert= 4,020.00', Outlet Invert= 4,013.00'



Reach Ditch-1: Ditch to Pond A



Summary for Pond 3P: Pond OL1

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.34 cfs @ 19.19 hrs, Volume= 1.193 af
Outflow = 1.33 cfs @ 19.24 hrs, Volume= 1.141 af, Atten= 0%, Lag= 2.5 min
Primary = 1.33 cfs @ 19.24 hrs, Volume= 1.141 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,956.19' @ 19.24 hrs Surf.Area= 0 sf Storage= 9,408 cf

Plug-Flow detention time= 148.3 min calculated for 1.141 af (96% of inflow)
Center-of-Mass det. time= 132.2 min (1,258.6 - 1,126.4)

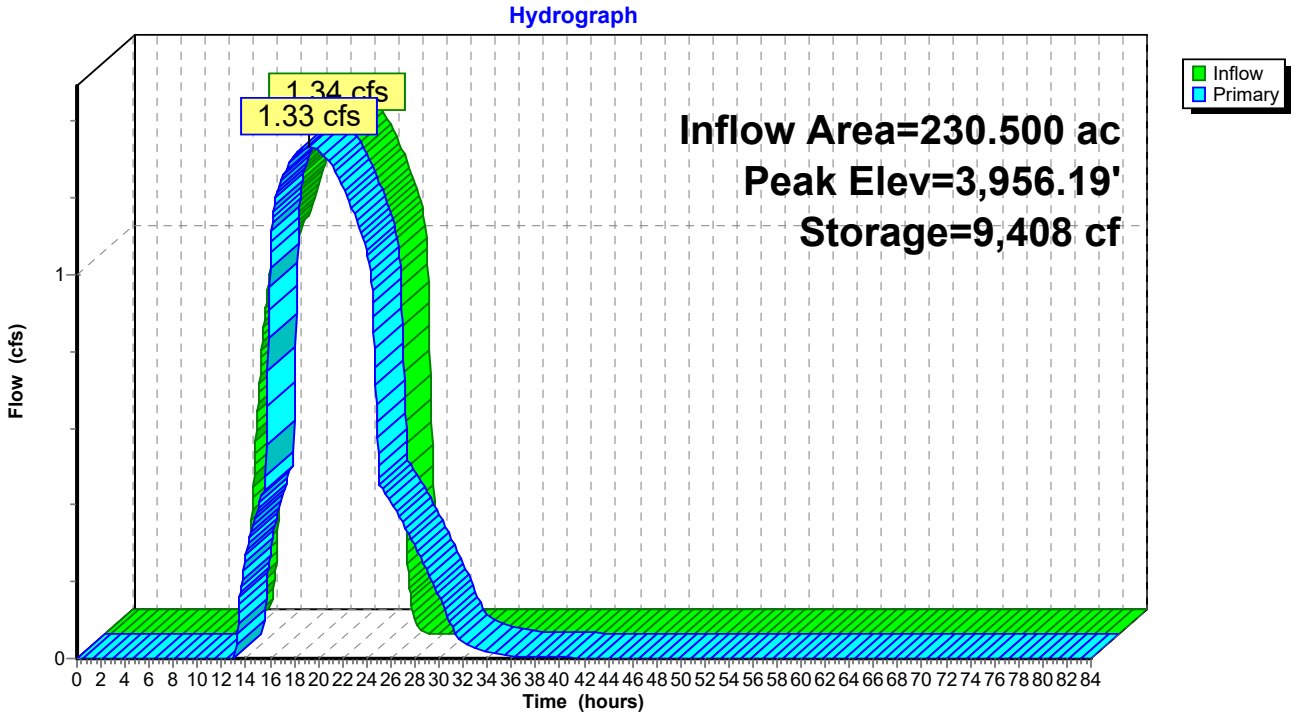
Volume	Invert	Avail.Storage	Storage Description
#1	3,953.00'	15,203 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,953.00	0
3,953.50	1,018
3,954.00	2,234
3,954.50	3,615
3,955.00	5,144
3,955.50	6,824
3,956.00	8,661
3,956.50	10,657
3,957.00	12,828
3,957.50	15,203

Device	Routing	Invert	Outlet Devices
#1	Primary	3,954.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,954.00' / 3,951.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,956.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.33 cfs @ 19.24 hrs HW=3,956.19' TW=3,953.19' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.47 cfs @ 5.40 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 0.86 cfs @ 1.03 fps)

Pond 3P: Pond OL1



Summary for Pond 4P: Pond OL2

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth = 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.33 cfs @ 19.24 hrs, Volume= 1.141 af
Outflow = 1.33 cfs @ 19.34 hrs, Volume= 1.112 af, Atten= 0%, Lag= 6.3 min
Primary = 1.33 cfs @ 19.34 hrs, Volume= 1.112 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,953.19' @ 19.34 hrs Surf.Area= 0 sf Storage= 5,613 cf

Plug-Flow detention time= 103.0 min calculated for 1.111 af (97% of inflow)
Center-of-Mass det. time= 85.5 min (1,344.1 - 1,258.6)

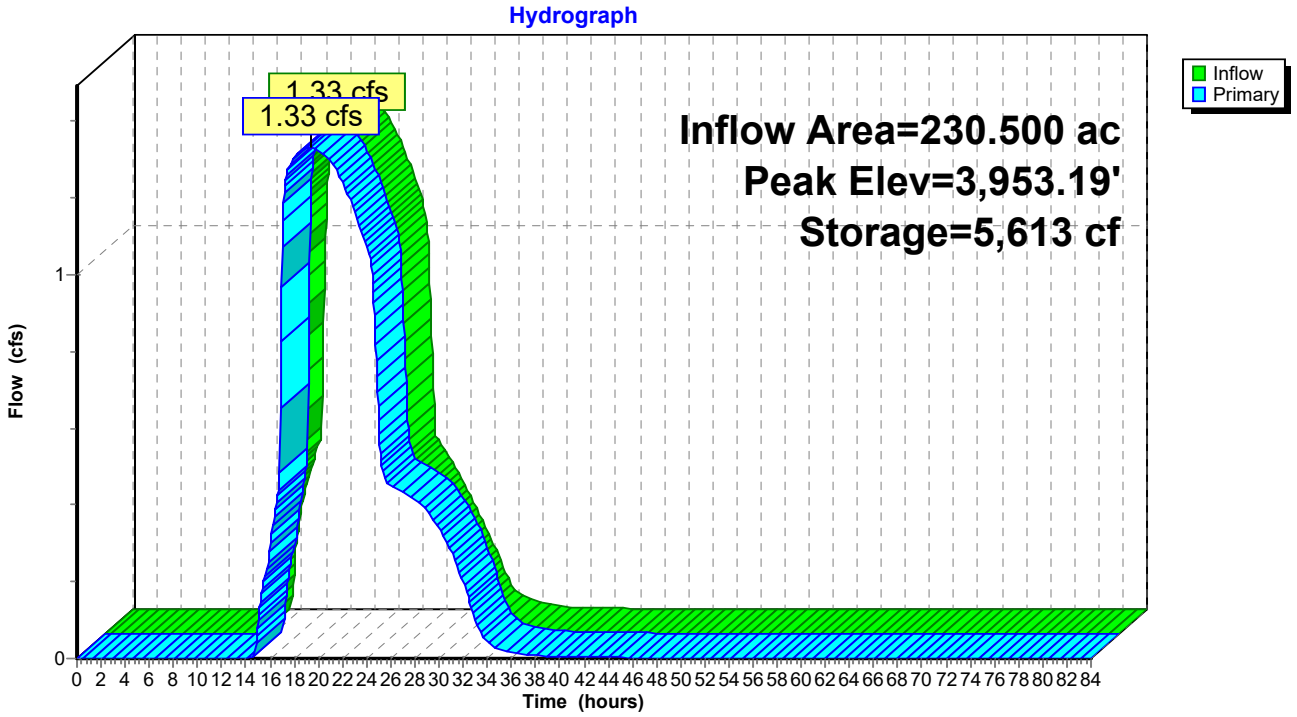
Volume	Invert	Avail.Storage	Storage Description
#1	3,950.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,950.00	0
3,950.50	567
3,951.00	1,263
3,951.50	2,070
3,952.00	2,987
3,952.50	4,015
3,953.00	5,148
3,953.50	6,390
3,954.00	7,734
3,954.50	9,177
3,955.00	10,719
3,955.50	12,359
3,956.00	14,099
3,956.50	15,947
3,957.00	17,922
3,957.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,951.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,951.00' / 3,948.00' S= 0.1500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,953.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.33 cfs @ 19.34 hrs HW=3,953.19' TW=3,950.19' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.47 cfs @ 5.40 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 0.86 cfs @ 1.03 fps)

Pond 4P: Pond OL2



Summary for Pond 5P: Pond OL3

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth > 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.33 cfs @ 19.34 hrs, Volume= 1.112 af
Outflow = 1.33 cfs @ 18.94 hrs, Volume= 1.082 af, Atten= 0%, Lag= 0.0 min
Primary = 1.33 cfs @ 18.94 hrs, Volume= 1.082 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,950.20' @ 20.33 hrs Surf.Area= 0 sf Storage= 5,655 cf

Plug-Flow detention time= 124.5 min calculated for 1.082 af (97% of inflow)
Center-of-Mass det. time= 102.9 min (1,447.0 - 1,344.1)

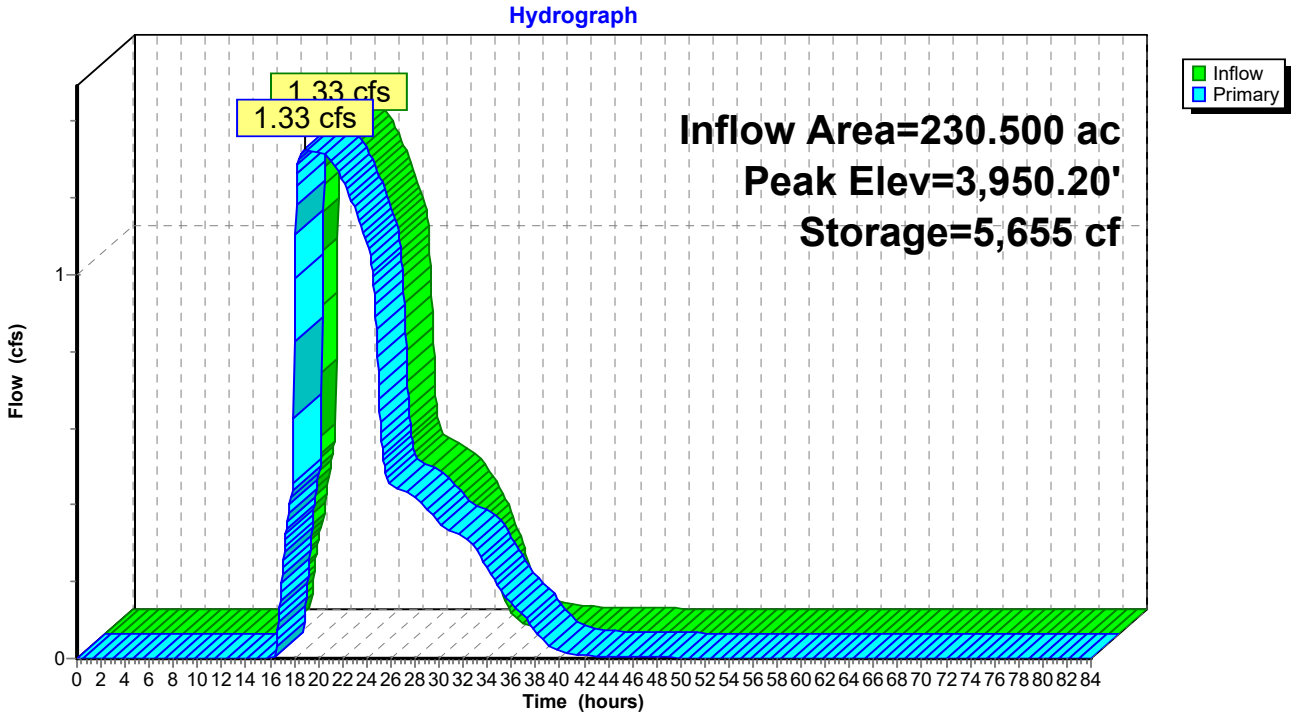
Volume	Invert	Avail.Storage	Storage Description
#1	3,947.00'	20,053 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,947.00	0
3,947.50	567
3,948.00	1,263
3,948.50	2,070
3,949.00	2,987
3,949.50	4,015
3,950.00	5,148
3,950.50	6,390
3,951.00	7,734
3,951.50	9,177
3,952.00	10,719
3,952.50	12,359
3,953.00	14,099
3,953.50	15,947
3,954.00	17,922
3,954.50	20,053

Device	Routing	Invert	Outlet Devices
#1	Primary	3,948.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,948.00' / 3,946.00' S= 0.1000 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,950.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.33 cfs @ 18.94 hrs HW=3,950.19' TW=3,948.18' (Dynamic Tailwater)
1=Culvert (Inlet Controls 0.47 cfs @ 5.38 fps)
2=Broad-Crested Rectangular Weir (Weir Controls 0.86 cfs @ 1.02 fps)

Pond 5P: Pond OL3



Summary for Pond 6P: Pond OL4

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth > 0.06" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.33 cfs @ 18.94 hrs, Volume= 1.082 af
Outflow = 1.31 cfs @ 20.76 hrs, Volume= 1.016 af, Atten= 2%, Lag= 109.1 min
Primary = 1.31 cfs @ 20.76 hrs, Volume= 1.016 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,949.20' @ 20.77 hrs Surf.Area= 0 sf Storage= 8,845 cf

Plug-Flow detention time= 208.7 min calculated for 1.016 af (94% of inflow)
Center-of-Mass det. time= 159.3 min (1,606.3 - 1,447.0)

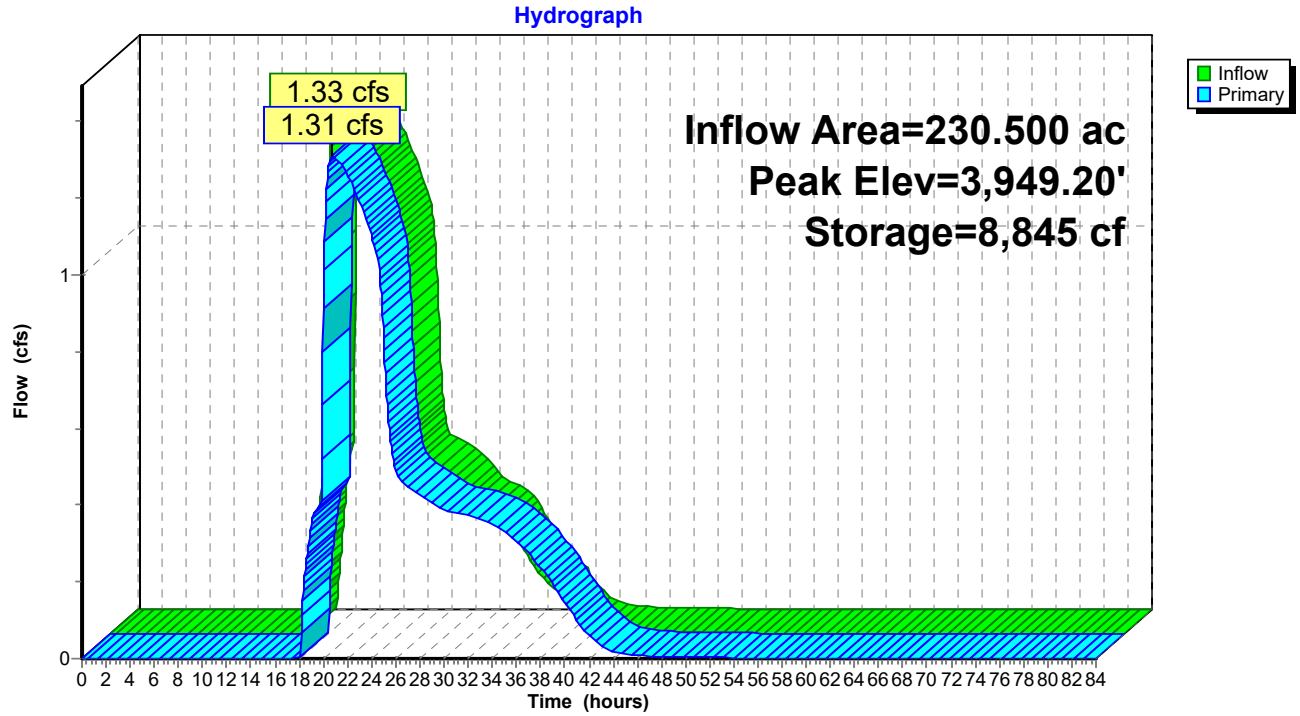
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	55,314 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	761
3,947.00	1,811
3,947.50	3,099
3,948.00	4,591
3,948.50	6,260
3,949.00	8,076
3,949.50	10,034
3,950.00	12,127
3,950.50	14,353
3,951.00	16,711
3,951.50	19,197
3,952.00	21,811
3,952.50	24,551
3,953.00	27,420
3,953.50	30,417
3,954.00	33,546
3,954.50	36,810
3,955.00	40,213
3,955.50	43,758
3,956.00	47,453
3,956.50	51,302
3,957.00	55,314

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.00'	**4.0" Round Culvert** L= 20.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 3,947.00' / 3,946.00' S= 0.0500 '/' Cc= 0.900 n= 0.010 PVC, smooth interior
#2	Primary	3,949.00'	**4.5' long x 6.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.37 2.51 2.70 2.68 2.68 2.67 2.65 2.65 2.65 2.65 2.66 2.66 2.67 2.69 2.72 2.76 2.83

Primary OutFlow Max=1.31 cfs @ 20.76 hrs HW=3,949.20' TW=3,947.87' (Dynamic Tailwater)
└─**1=Culvert** (Inlet Controls 0.38 cfs @ 4.38 fps)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 0.93 cfs @ 1.05 fps)

Pond 6P: Pond OL4



Summary for Pond 7P: Pond OL5

Inflow Area = 230.500 ac, 14.25% Impervious, Inflow Depth > 0.05" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.31 cfs @ 20.76 hrs, Volume= 1.016 af
Outflow = 1.31 cfs @ 20.90 hrs, Volume= 0.983 af, Atten= 0%, Lag= 8.6 min
Primary = 1.31 cfs @ 20.90 hrs, Volume= 0.983 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,947.87' @ 20.90 hrs Surf.Area= 0 sf Storage= 2,299 cf

Plug-Flow detention time= 66.4 min calculated for 0.983 af (97% of inflow)
Center-of-Mass det. time= 31.9 min (1,638.3 - 1,606.3)

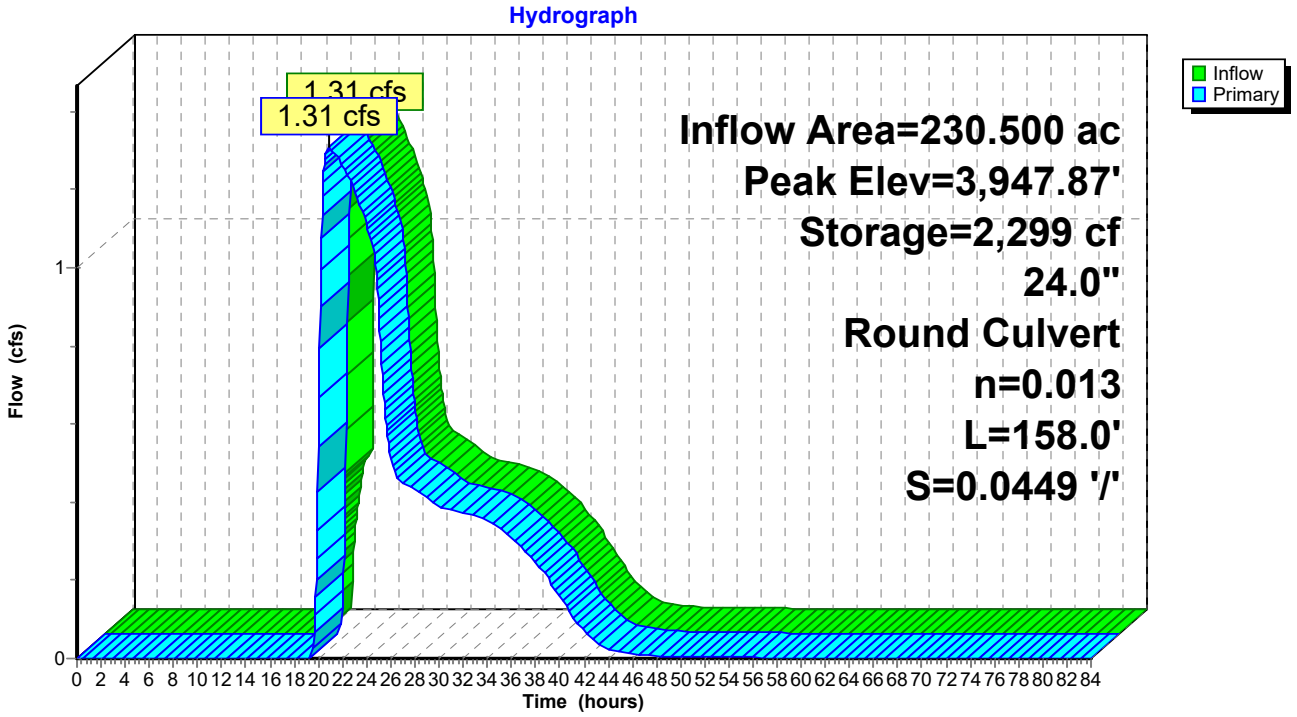
Volume	Invert	Avail.Storage	Storage Description
#1	3,946.00'	56,530 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
3,946.00	0
3,946.50	300
3,947.00	827
3,947.50	1,596
3,948.00	2,549
3,948.50	3,687
3,949.00	5,013
3,949.50	6,529
3,950.00	8,234
3,950.50	10,134
3,951.00	12,319
3,951.50	14,829
3,952.00	17,598
3,952.50	20,588
3,953.00	23,779
3,953.50	27,169
3,954.00	30,757
3,954.50	34,542
3,955.00	38,525
3,955.50	42,711
3,956.00	47,103
3,956.50	51,706
3,957.00	56,530

Device	Routing	Invert	Outlet Devices
#1	Primary	3,947.40'	**24.0" Round Culvert** L= 158.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,947.40' / 3,940.30' S= 0.0449 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections

Primary OutFlow Max=1.31 cfs @ 20.90 hrs HW=3,947.87' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 1.31 cfs @ 2.33 fps)

Pond 7P: Pond OL5



Summary for Pond 8P: Pond OL6

Inflow Area = 304.320 ac, 4.08% Impervious, Inflow Depth = 0.04" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.67 cfs @ 24.00 hrs, Volume= 0.980 af
Outflow = 0.67 cfs @ 24.04 hrs, Volume= 0.843 af, Atten= 0%, Lag= 2.5 min
Primary = 0.67 cfs @ 24.04 hrs, Volume= 0.843 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,946.82' @ 24.04 hrs Surf.Area= 0 sf Storage= 6,310 cf

Plug-Flow detention time= 193.0 min calculated for 0.843 af (86% of inflow)
Center-of-Mass det. time= 98.2 min (1,395.4 - 1,297.2)

Volume	Invert	Avail.Storage	Storage Description
#1	3,945.00'	150,009 cf	**Custom Stage Data** Listed below

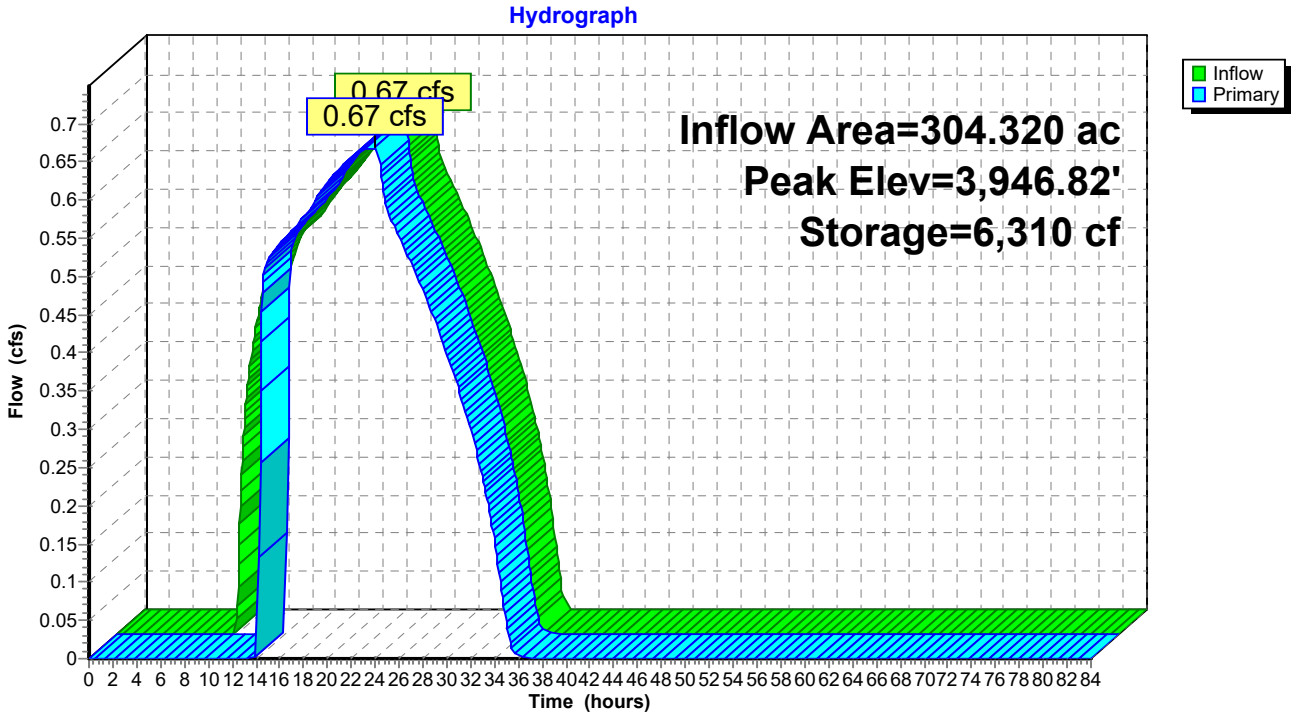
Elevation (feet)	Cum.Store (cubic-feet)
3,945.00	0
3,945.50	1,241
3,946.00	2,907
3,946.50	4,876
3,947.00	7,132
3,947.50	9,707
3,948.00	12,610
3,948.50	15,850
3,949.00	19,436
3,949.50	23,393
3,950.00	27,772
3,950.50	32,645
3,951.00	37,997
3,951.50	43,750
3,952.00	49,862
3,952.50	56,323
3,953.00	63,123
3,953.50	70,242
3,954.00	77,678
3,954.50	85,443
3,955.00	93,551
3,955.50	102,017
3,956.00	110,852
3,956.50	120,062
3,957.00	129,654
3,957.50	139,634
3,958.00	150,009

Device	Routing	Invert	Outlet Devices
#1	Primary	3,944.96'	**24.0" Round Culvert** L= 153.0' RCP, sq.cut end projecting, Ke= 0.500 Inlet / Outlet Invert= 3,944.96' / 3,942.08' S= 0.0188 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	3,946.75'	**15.0' long x 11.0' breadth Broad-Crested Rectangular Weir**

Head (feet)	0.20	0.40	0.60	0.80	1.00	1.20	1.40	1.60
Coef. (English)	2.53	2.59	2.70	2.68	2.67	2.68	2.66	2.64

Primary OutFlow Max=0.67 cfs @ 24.04 hrs HW=3,946.82' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 0.67 cfs of 14.12 cfs potential flow)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 0.67 cfs @ 0.66 fps)

Pond 8P: Pond OL6



Summary for Pond 9P: Junction Manhole

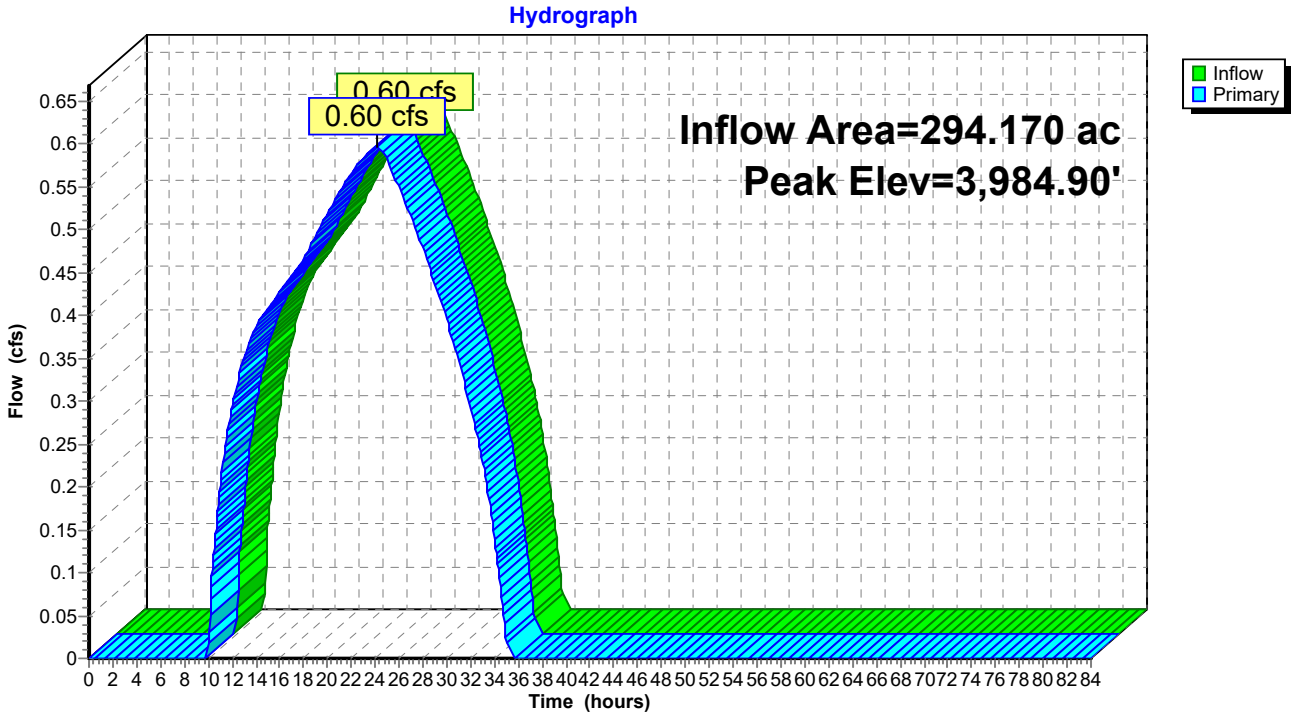
Inflow Area = 294.170 ac, 4.22% Impervious, Inflow Depth = 0.03" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.60 cfs @ 24.22 hrs, Volume= 0.852 af
Outflow = 0.60 cfs @ 24.22 hrs, Volume= 0.852 af, Atten= 0%, Lag= 0.0 min
Primary = 0.60 cfs @ 24.22 hrs, Volume= 0.852 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,984.90' @ 24.22 hrs
Flood Elev= 3,986.50'

Device	Routing	Invert	Outlet Devices
#1	Device 2	3,984.50'	**18.0" Round Culvert** L= 820.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 3,984.50' / 3,980.00' S= 0.0055 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets
#2	Primary	3,980.00'	**24.0" Round Culvert** L= 420.0' RCP, rounded edge headwall, Ke= 0.100 Inlet / Outlet Invert= 3,980.00' / 3,946.40' S= 0.0800 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets

Primary OutFlow Max=0.60 cfs @ 24.22 hrs HW=3,984.90' TW=3,946.82' (Dynamic Tailwater)
└**2=Culvert** (Passes 0.60 cfs of 40.75 cfs potential flow)
└**1=Culvert** (Barrel Controls 0.60 cfs @ 2.35 fps)

Pond 9P: Junction Manhole

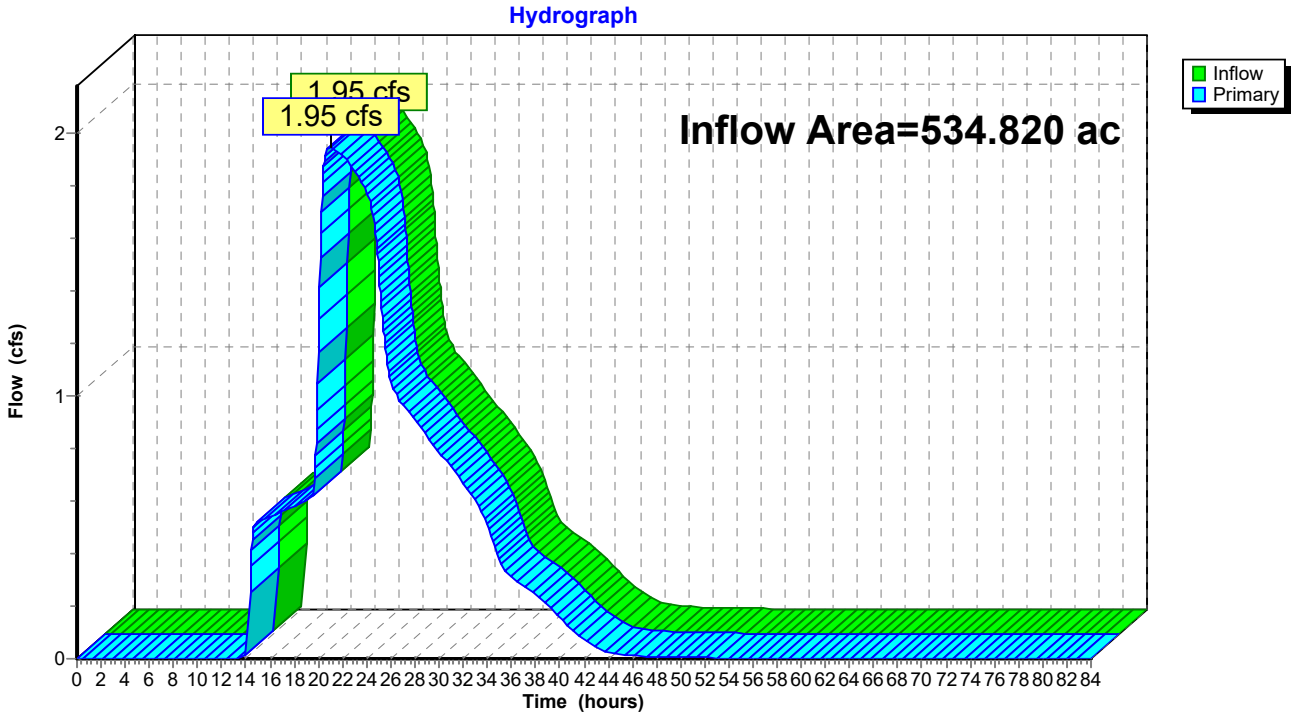


Summary for Pond 10P: D/S Junction (flow to Spring Meadow)

Inflow Area = 534.820 ac, 8.46% Impervious, Inflow Depth > 0.04" for (New) 5-Yr, 24-hr, Type I event
Inflow = 1.95 cfs @ 21.00 hrs, Volume= 1.826 af
Primary = 1.95 cfs @ 21.00 hrs, Volume= 1.826 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs

Pond 10P: D/S Junction (flow to Spring Meadow)



Summary for Pond A: Pond A

Inflow Area = 26.500 ac, 6.92% Impervious, Inflow Depth = 0.16" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.41 cfs @ 10.58 hrs, Volume= 0.352 af
Outflow = 0.21 cfs @ 23.38 hrs, Volume= 0.352 af, Atten= 48%, Lag= 767.6 min
Primary = 0.21 cfs @ 23.38 hrs, Volume= 0.352 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 3,990.47' @ 23.38 hrs Surf.Area= 0.075 ac Storage= 0.135 af
Flood Elev= 3,994.50' Surf.Area= 0.208 ac Storage= 0.690 af

Plug-Flow detention time= 324.3 min calculated for 0.352 af (100% of inflow)
Center-of-Mass det. time= 324.5 min (1,316.2 - 991.7)

Volume	Invert	Avail.Storage	Storage Description
#1	3,986.50'	0.918 af	**Custom Stage Data (Prismatic)** Listed below

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
3,986.50	0.004	0.000	0.000
3,987.00	0.009	0.003	0.003
3,987.50	0.016	0.006	0.009
3,988.00	0.023	0.010	0.019
3,988.50	0.031	0.013	0.033
3,989.00	0.041	0.018	0.051
3,989.50	0.051	0.023	0.074
3,990.00	0.063	0.028	0.102
3,990.50	0.076	0.035	0.137
3,991.00	0.089	0.041	0.178
3,991.50	0.104	0.048	0.226
3,992.00	0.120	0.056	0.283
3,992.50	0.136	0.064	0.347
3,993.00	0.154	0.072	0.419
3,993.50	0.172	0.081	0.500
3,994.00	0.190	0.090	0.591
3,994.50	0.208	0.099	0.690
3,995.00	0.228	0.109	0.799
3,995.50	0.244	0.118	0.918

Device	Routing	Invert	Outlet Devices
#1	Primary	3,985.50'	**18.0" Round 18" RCP Culvert** L= 45.0' RCP, groove end projecting, Ke= 0.200 Inlet / Outlet Invert= 3,985.50' / 3,984.50' S= 0.0222 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections
#2	Device 1	3,994.00'	**24.0" Horiz. 24" Orifice/Grate (MH Lid)** C= 0.600 in 24.0" Grate Limited to weir flow at low heads
#3	Secondary	3,994.50'	**5.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#4	Device 1	3,986.00'	**12.0" Round 12" Culvert Inlet Pipe** L= 15.0' CPP, projecting, no headwall, Ke= 0.900

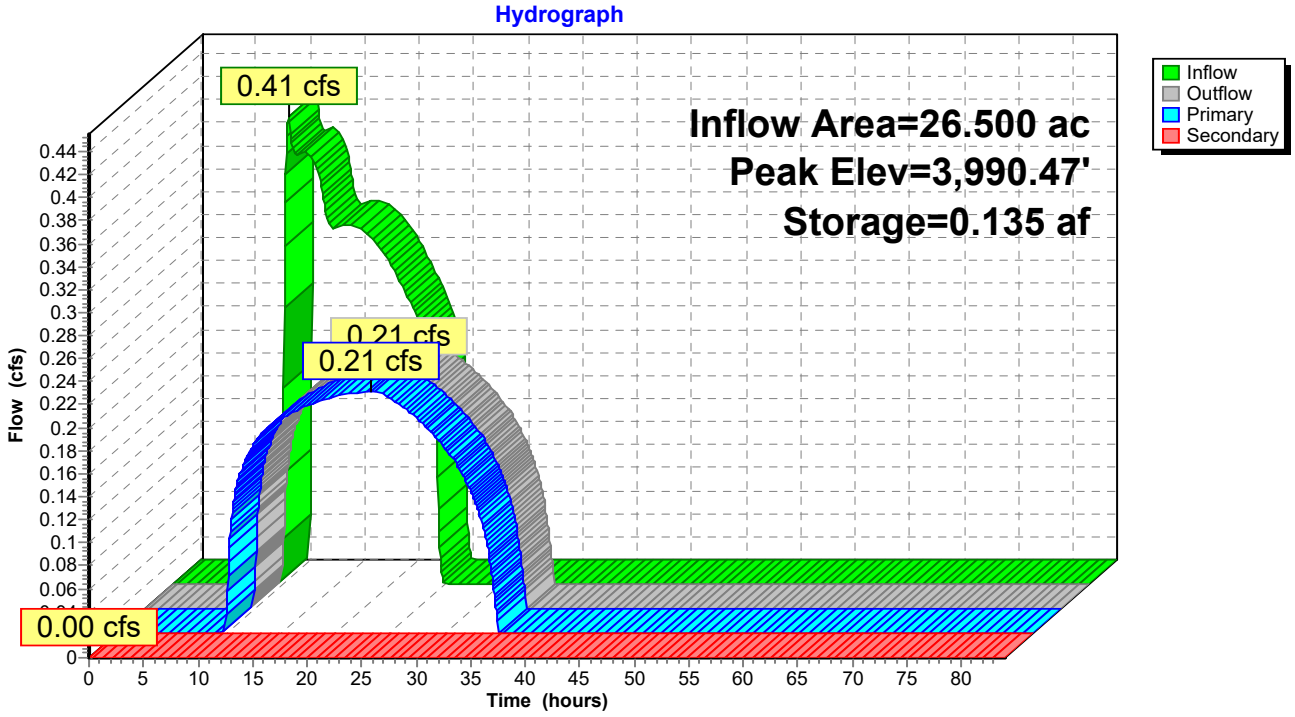
Inlet / Outlet Invert= 3,986.00' / 3,985.75' S= 0.0167 '/' Cc= 0.900
n= 0.010

#5 Device 4 3,986.40' **2.0" Vert. 2" Orifice/Grate (Low)** C= 0.600

Primary OutFlow Max=0.21 cfs @ 23.38 hrs HW=3,990.47' TW=3,984.90' (Dynamic Tailwater)
└─**1=18" RCP Culvert** (Passes 0.21 cfs of 21.08 cfs potential flow)
  └─**2=24" Orifice/Grate (MH Lid)** (Controls 0.00 cfs)
  └─**4=12" Culvert Inlet Pipe** (Passes 0.21 cfs of 5.95 cfs potential flow)
    └─**5=2" Orifice/Grate (Low)** (Orifice Controls 0.21 cfs @ 9.61 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=3,986.50' TW=3,959.50' (Dynamic Tailwater)
└─**3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond A: Pond A



Summary for Pond B: Pond B

Inflow Area = 267.670 ac, 3.95% Impervious, Inflow Depth = 0.02" for (New) 5-Yr, 24-hr, Type I event
Inflow = 0.61 cfs @ 21.70 hrs, Volume= 0.499 af
Outflow = 0.39 cfs @ 24.26 hrs, Volume= 0.499 af, Atten= 37%, Lag= 153.4 min
Primary = 0.39 cfs @ 24.26 hrs, Volume= 0.499 af
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-84.00 hrs, dt= 0.05 hrs
Peak Elev= 4,037.21' @ 24.26 hrs Surf.Area= 0.098 ac Storage= 0.198 af
Flood Elev= 4,041.00' Surf.Area= 0.224 ac Storage= 0.773 af

Plug-Flow detention time= 240.2 min calculated for 0.499 af (100% of inflow)
Center-of-Mass det. time= 240.4 min (1,358.4 - 1,118.0)

Volume	Invert	Avail.Storage	Storage Description
#1	4,034.50'	1.023 af	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
4,034.50	0.034	0.000	0.000
4,035.00	0.061	0.024	0.024
4,035.50	0.069	0.032	0.056
4,036.00	0.077	0.036	0.093
4,036.50	0.085	0.040	0.133
4,037.00	0.094	0.045	0.178
4,037.50	0.104	0.049	0.227
4,038.00	0.114	0.054	0.282
4,038.50	0.126	0.060	0.342
4,039.00	0.141	0.067	0.409
4,039.50	0.162	0.076	0.484
4,040.00	0.182	0.086	0.570
4,040.50	0.203	0.096	0.667
4,041.00	0.224	0.107	0.773
4,041.50	0.249	0.118	0.892
4,042.00	0.278	0.132	1.023

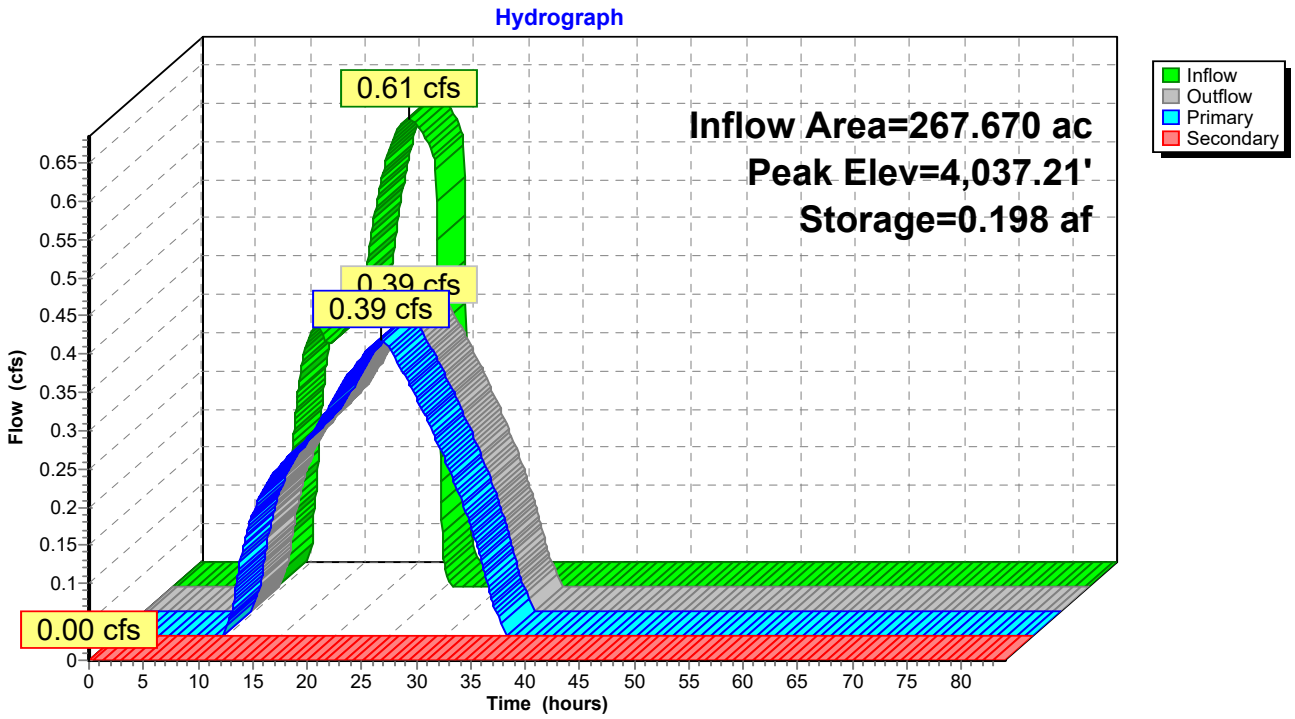
Device	Routing	Invert	Outlet Devices
#1	Primary	4,033.70'	**18.0" Round 18" Culvert** L= 825.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 4,033.70' / 4,005.00' S= 0.0348 '/' Cc= 0.900 n= 0.015 Concrete sewer w/manholes & inlets
#2	Device 1	4,040.50'	**12.0" Horiz. 12" Orifice/Grate (Manhole Lid)** C= 0.600 in 12.0" Grate Limited to weir flow at low heads
#3	Secondary	4,041.00'	**5.0' long x 12.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.57 2.62 2.70 2.67 2.66 2.67 2.66 2.64
#4	Device 1	4,034.00'	**12.0" Round 12" Culvert (Inlet)** L= 15.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 4,034.00' / 4,033.80' S= 0.0133 '/' Cc= 0.900 n= 0.010
#5	Device 4	4,034.40'	**3.0" Vert. 3" Orifice/Grate (Low)** C= 0.600

#6 Device 1 4,038.25' **6.0" Vert. 6" Orifice/Grate** C= 0.600

Primary OutFlow Max=0.39 cfs @ 24.26 hrs HW=4,037.21' TW=3,984.90' (Dynamic Tailwater)
- **1=18" Culvert** (Passes 0.39 cfs of 17.03 cfs potential flow)
  - **2=12" Orifice/Grate (Manhole Lid)** (Controls 0.00 cfs)
  - **4=12" Culvert (Inlet)** (Passes 0.39 cfs of 4.91 cfs potential flow)
    - **5=3" Orifice/Grate (Low)** (Orifice Controls 0.39 cfs @ 7.89 fps)
  - **6=6" Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=4,034.50' TW=4,020.00' (Dynamic Tailwater)
- **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond B: Pond B



HYDRAULICS

Broadwater RCP Pipe

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.013
Channel Slope	0.005 ft/ft
Normal Depth	24.0 in
Diameter	30.0 in

Results	
Discharge	28.35 cfs
Flow Area	4.2 ft²
Wetted Perimeter	5.5 ft
Hydraulic Radius	9.1 in
Top Width	2.00 ft
Critical Depth	21.8 in
Percent Full	80.0 %
Critical Slope	0.006 ft/ft
Velocity	6.73 ft/s
Velocity Head	0.70 ft
Specific Energy	2.70 ft
Froude Number	0.818
Maximum Discharge	31.20 cfs
Discharge Full	29.00 cfs
Slope Full	0.005 ft/ft
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	0.0 %
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	24.0 in
Critical Depth	21.8 in
Channel Slope	0.005 ft/ft
Critical Slope	0.006 ft/ft

Downstream Channel to Spring Meadow

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data		
Roughness Coefficient	0.030	
Channel Slope	0.007	ft/ft
Normal Depth	20.0	in
Left Side Slope	3.000	H:V
Right Side Slope	3.000	H:V
Bottom Width	2.00	ft

Results		
Discharge	46.07	cfs
Flow Area	11.7	ft²
Wetted Perimeter	12.5	ft
Hydraulic Radius	11.2	in
Top Width	12.00	ft
Critical Depth	17.0	in
Critical Slope	0.015	ft/ft
Velocity	3.95	ft/s
Velocity Head	0.24	ft
Specific Energy	1.91	ft
Froude Number	0.706	
Flow Type	Subcritical	

GVF Input Data		
Downstream Depth	0.0	in
Length	0.0	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.0	in
Profile Description	N/A	
Profile Headloss	0.00	ft
Downstream Velocity	(N/A)	ft/s
Upstream Velocity	(N/A)	ft/s
Normal Depth	20.0	in
Critical Depth	17.0	in
Channel Slope	0.007	ft/ft
Critical Slope	0.015	ft/ft

Worksheet for Downstream Detention Outlet

Project Description	
Solve For	Discharge

Input Data	
Headwater Elevation	6.00 ft
Centroid Elevation	5.00 ft
Tailwater Elevation	0.00 ft
Discharge Coefficient	0.600
Diameter	24.0 in

Results	
Discharge	15.12 cfs
Headwater Height Above Centroid	1.00 ft
Tailwater Height Above Centroid	-5.00 ft
Flow Area	3.1 ft^2
Velocity	4.81 ft/s

HDPE Approach Culvert

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data		
Roughness Coefficient	0.010	
Channel Slope	0.005	ft/ft
Normal Depth	19.0	in
Diameter	24.0	in

Results		
Discharge	20.11	cfs
Flow Area	2.7	ft²
Wetted Perimeter	4.4	ft
Hydraulic Radius	7.3	in
Top Width	1.62	ft
Critical Depth	19.3	in
Percent Full	79.2	%
Critical Slope	0.005	ft/ft
Velocity	7.54	ft/s
Velocity Head	0.88	ft
Specific Energy	2.47	ft
Froude Number	1.037	
Maximum Discharge	22.37	cfs
Discharge Full	20.79	cfs
Slope Full	0.005	ft/ft
Flow Type	Supercritical	

GVF Input Data		
Downstream Depth	0.0	in
Length	0.0	ft
Number Of Steps	0	

GVF Output Data		
Upstream Depth	0.0	in
Profile Description	N/A	
Profile Headloss	0.00	ft
Average End Depth Over Rise	0.0	%
Normal Depth Over Rise	79.2	%
Downstream Velocity	Infinity	ft/s
Upstream Velocity	Infinity	ft/s
Normal Depth	19.0	in
Critical Depth	19.3	in
Channel Slope	0.005	ft/ft
Critical Slope	0.005	ft/ft

Worksheet for Overlook Pipes

Project Description	
Friction Method	Manning Formula
Solve For	Discharge

Input Data	
Roughness Coefficient	0.015
Channel Slope	0.005 ft/ft
Normal Depth	19.0 in
Diameter	24.0 in

Results	
Discharge	13.41 cfs
Flow Area	2.7 ft²
Wetted Perimeter	4.4 ft
Hydraulic Radius	7.3 in
Top Width	1.62 ft
Critical Depth	15.8 in
Percent Full	79.2 %
Critical Slope	0.008 ft/ft
Velocity	5.03 ft/s
Velocity Head	0.39 ft
Specific Energy	1.98 ft
Froude Number	0.692
Maximum Discharge	14.91 cfs
Discharge Full	13.86 cfs
Slope Full	0.005 ft/ft
Flow Type	Subcritical

GVF Input Data	
Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data	
Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	0.0 %
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	19.0 in
Critical Depth	15.8 in
Channel Slope	0.005 ft/ft
Critical Slope	0.008 ft/ft

Worksheet for Pond A Downstream

Project Description

Friction Method	Manning Formula
Solve For	Discharge

Input Data

Roughness Coefficient	0.015
Channel Slope	0.005 ft/ft
Normal Depth	14.5 in
Diameter	18.0 in

Results

Discharge	6.33 cfs
Flow Area	1.5 ft²
Wetted Perimeter	3.3 ft
Hydraulic Radius	5.5 in
Top Width	1.19 ft
Critical Depth	11.7 in
Percent Full	80.6 %
Critical Slope	0.009 ft/ft
Velocity	4.15 ft/s
Velocity Head	0.27 ft
Specific Energy	1.48 ft
Froude Number	0.646
Maximum Discharge	6.92 cfs
Discharge Full	6.44 cfs
Slope Full	0.005 ft/ft
Flow Type	Subcritical

GVF Input Data

Downstream Depth	0.0 in
Length	0.0 ft
Number Of Steps	0

GVF Output Data

Upstream Depth	0.0 in
Profile Description	N/A
Profile Headloss	0.00 ft
Average End Depth Over Rise	0.0 %
Normal Depth Over Rise	0.0 %
Downstream Velocity	0.00 ft/s
Upstream Velocity	0.00 ft/s
Normal Depth	14.5 in
Critical Depth	11.7 in
Channel Slope	0.005 ft/ft
Critical Slope	0.009 ft/ft

OVERLOOK AS-BUILTS

INTERMOUNTAIN
CONSULTING ENGINEERS LLC

June 24, 2008

Ryan Leland, P.E.
City Engineer
City of Helena Engineering Division
316 North Park Ave
Helena, MT 59602

RE: Overlook Estates Subdivision
Street and Drainage Certification

Dear Ryan,

The purpose of this letter is to certify that the streets and drainage systems constructed for Overlook Estates Subdivision have been completed in substantial compliance with the approved plans and specifications.

Please contact me should you have any questions or comments via telephone at (406) 227-5704 or email at tjprothero@mt.net.

Sincerely,

INTERMOUNTAIN CONSULTING ENGINEERS LLC

Tony J. Prothero, PE

C:\2004 Projects\04-04 Overlook Estates\correspondence\ltr.leland.street certification.6-24-08 tjp.doc

03-05

Montana Department of Transportation
2701 Prospect Avenue
PO Box 201001
Helena MT 59620-1001

Jim Lynch, Director
Brian Schweitzer, Governor

February 1, 2006

Tony J. Prothero, P.E.
Intermountain Consulting
PO Box 7542
Helena, MT 59604

Subject: Overlook Estates Subdivision - Helena

The Montana Department of Transportation (MDT) has reviewed the Drainage and Hydraulics Report dated January 2006 prepared by Intermountain Consulting Engineers for the subject project. The hydraulic calculations in the report effectively address our concerns related to providing adequate detention volume required to limit flows to the historic peak. However, we do have the following comment:

Drainage A Detention Ponds:

1. A small drainpipe through the check dams may be required to drain low flows.
2. Since the check dams are constructed entirely of riprap, there is a concern that water flowing through the rock may erode the underlying soil and adjacent embankment. We recommend that the core of check structures be constructed with compacted soil and the outer layer be protected with a layer of geotextile and riprap.
3. An inlet calculation will be required on Granite Street to show that the water can actually get in the detention pond. The single existing inlet may not be enough so, a curb cut or other option may be required.
4. Detail 2 on Sheet C1 shows a 14-foot minimum bottom. We assume ditch section will be expanded south and not towards the roadway embankment. Cutting or modifying the slope of the existing roadway embankments will not be allowed.
5. Does the developer have a plan to maintain the grass height, and clean sediment and debris from the ponds?

If you have any questions please call me at (406) 444-4383.

Sincerely,

Ed Ereth, System Impact Action Supervisor
Program & Policy Analysis Section
Rail, Transit & Planning Division

Copies: Jeff Ebert, P.E., Butte District Administrator
Paul Ferry, P.E., Highways Engineer
Kevin Brewer, Butte Maintenance
Mark Goodman. P.E., Hydraulics Engineering
Dave Hedstrom, P.E., Hydraulics Engineering
Quentin Miller, Helena Maintenance
John Rundquist, P.E., City of Helena
Ryan Leland, P.E., City of Helena
File

INTERMOUNTAIN
CONSULTING ENGINEERS LLC

January 23, 2006

Mr. Ed Ereth
System Impact Action Supervisor
Montana Department of Transportation
2701 Prospect Avenue
P.O. Box 201001
Helena, MT 59620-1001

RE: Overlook Estates Subdivision Drainage
Helena, MT

Dear Ed,

Please find enclosed a copy of the proposed drainage design for Overlook Estates Subdivision. This design is in response to our meeting with MDT on October 12, 2005 where concerns were stated regarding the adequacy of the proposed detention pond design.

The design was completed using HEC-HMS 3.0 software. Digital HEC-HMS files are provided with this design on CD along with a copy of the software (if necessary). Please distribute the enclosed materials as required. We are anxious for a speedy resolution to this issue - if possible, we would like to begin construction of the proposed improvements early this spring and prior to any significant runoff events. You will also notice that the proposed design for the easterly drainage (Drainage A) is situated within the MDT right of way in the form of a series of step down detention ponds. This is located as shown based on input received at our meeting.

Please contact me should you have any questions or comments via telephone at (406) 227-5704 or email at tjprothero@mt.net.

Sincerely,

INTERMOUNTAIN CONSULTING ENGINEERS LLC

Tony J. Prothero, PE

Enclosures:

Drainage and Hydraulics Report - Overlook Estates Subdivision - Helena, MT

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Drainage and Hydraulics Report

Overlook Estates Subdivision

Helena, Montana

PREPARED FOR:

Helena Development LLC
201 East Lyndale, PMB 105
Helena, MT 59601

JANUARY, 2006

INTERMOUNTAIN
CONSULTING ENGINEERS LLC

CIVIL • WATER RESOURCES • TRANSPORTATION
P.O. BOX 7542 HELENA, MT 59604 (406) 227-5704 FAX 227-5925

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Executive Summary

The purpose of this report is to summarize the proposed storm drainage design criteria and design elements for the proposed Overlook Estates Subdivision located adjacent to US Highway 12 and Granite Street in Helena, Montana. The proposed subdivision consists of 56 lots of single family and multi-family residential lots and associated access streets. The total area of the subdivision is slightly greater than 20 acres.

Construction plans for the subdivision have been developed by two different entities - Clear Creek Hydrology of Bozeman and Intermountain Consulting Engineers LLC of Helena. The original storm drainage design was completed by Clear Creek Hydrology who also submitted construction plans that were approved by the City of Helena and the Montana Department of Transportation. These plans were officially approved in the fall of 2003.

The construction plans for the subdivision were revised because of a revised grading scheme proposed by new ownership, including the storm drainage design. The revised plans were approved by the City of Helena in the spring of 2005. The main revisions to the plans were related to grading and drainage, including the location and sizing of proposed detention ponds. The revised storm drainage design is consistent with the City of Helena ordinance; however, MDT has stated concerns that some of the proposed detention ponds are not adequately sized for their respective drainages. As such, this report will provide a detailed analysis and recommendations for additional storm drainage modifications (if required) to mitigate increased runoff resulting from the additional impervious areas within the subdivision.

There are three major drainage basins associated with this subdivision. These major drainage basins are graphically displayed in Appendix A and also described in the following bulleted items:

- **Drainage Basin A.** This is the most easterly drainage basin which is most significantly impacted by Overlook Estates. The basin has an area of 225 acres and is composed of both undeveloped land in addition to land that is developed within the City of Helena. The outlet of this drainage is a 24-inch diameter RCP culvert under US Highway 12. Following the development of this subdivision, this drainage is divided into three sub drainage basins named A1, A2, and A3.

- **Drainage Basin B.** This central drainage area is 292 acres of which the northernmost portion is within Overlook Estates. The outlet to this drainage is an existing 18-inch diameter RCP culvert under US Highway 12.

- **Drainage Basin C.** This westerly drainage is the smallest drainage with a total contributing drainage area of 24-acres of which approximately 2 acres is within Overlook Estates. The outlet to this drainage is an existing open channel that drains onto US Highway 12 and into an existing storm drain.

Additional details regarding each drainage, the drainage outlet, and drainage flow paths near the outlet are also provided in Appendix D, Sheets C1 and C2. The proposed grading of Overlook Estates does slightly modify the drainage boundaries within the subdivision limits; however, the total predevelopment and post development drainage areas do not change significantly.

US Highway 12 also contributes runoff to each basin outlet; however, it appears that the majority of runoff is captured by an existing storm drain system that drains directly into the existing culverts situated at the outlets of Drainage Basins A and B. The majority of this runoff does not appear within Overlook Estates; rather, it is captured by the storm drain system and directed to the north of the highway. This report assumes that the portion of excess rainfall generated by the highway will have no impact - or an insignificant impact - to the proposed drainage improvements associated with Overlook Estates Subdivision.

Hydrology

The selected design methodology for the proposed design is the SCS Curve Number Method using HEC-HMS version 3.0 software. This software was developed by the United States Army Corps of Engineers (USACE) to simulate watershed, channel, and water control structure behavior. The software is able to predict flows, stage and timing of runoff events.

All input data was developed in accordance with Chapter 7.2 of the MDT Hydraulics Manual and the HEC-HMS Technical Reference Manual. The SCS Curve Number Method was chosen because of it's applicability to the project drainages in addition to its ability to model predevelopment and post-development conditions.

In most cases the rational method would be considered as a comparison tool for the SCS Curve Number Method; however, the rational method is only applicable to drainages smaller than 200 acres. The rational method should also be used with caution if the time of concentration exceeds 30 minutes. Both Drainages A and B

exceed the maximum area and time of concentration guidelines; therefore it was determined that this method should not be considered. For the sake of consistency, the rational method was also not considered on Drainage C although it is technically a valid analytical tool for this drainage.

The purpose of the design is to mitigate the increased runoff created by the impervious area of Overlook Estates. The pre-development condition is analyzed to determine the peak runoff rate which becomes the design criteria for the post development condition. In accordance with State of Montana standards, the design storm will be the 2-year, one hour event as shown in Chapter 7, Appendix B of the MDT Hydraulics Manual. The proposed design is also analyzed for the 100-year event to determine if significant impacts occur resulting from the proposed design.

Using 5-minute increments, the incremental rainfall depths of the design storms are presented in Table 1.

Table 1. 2-Year, 1-Hour and 100-Year, 1-Hour Incremental Precipitation

Time Increment (min)	2-year Rainfall Depth (in)	100-year Rainfall Depth (in)
0	0	0
5	0.22	0.49
10	0.10	0.22
15	0.05	0.17
20	0.03	0.06
25	0.03	0.06
30	0.03	0.06
35	0.01	0.03
40	0.01	0.03
45	0.01	0.03
50	0.01	0.03
55	0.01	0.03
60	0.01	0.03
Total Depth	**0.52**	**1.25**

Curve Number (CN). Based on our research of NRCS soil survey data, the soils within the drainage are primarily Hydrologic Soils Group B. The predevelopment existing land uses include undeveloped area in the uppermost drainage area south of the city of Helena. This area was assigned a curve number of 71 (hydrologic soils group B, fair condition, herbaceous cover type). The remaining areas in each drainage are

developed areas within and adjacent to Helena city limits. The estimated curve number of this developed area is 72 (hydrologic soils group B, urban residential districts with 1/3 acre average lot size).

The post-development curve number does not account for interconnected impervious area. Rather, interconnected impervious area is specified as a percentage of the sub-basin where 100% of the rainfall becomes runoff. Landscaping areas within the subdivision limits are assumed to have a curve number of 61.

The assumptions used to determine the area of post development impervious area are summarized in the following:

DRAINAGE A1

New impervious area is approximately 50% of Granite Street including asphalt, curb, and sidewalk.

Total new impervious area = 0.4 ac.

Total new landscaped area = 0 ac.

DRAINAGE A2

New Impervious Area

- Streets, sidewalk, and curb area = 2.32 ac
- 19 residential lots @ 3,500 s.f. each = 1.53 ac
- 11 multifamily lots @ 70% of total area (2.18 ac) = 1.53 ac

Total new impervious area = 5.38 ac.

New Landscaped Area

- Remaining residential lot area is landscaped (4.28 ac - 1.53 ac) = 2.75 ac
- 11 multifamily lots @ 30% of total area (2.18 ac) = 0.65 ac

Total new landscaped area = 3.4 ac

DRAINAGE A3

New impervious area is proposed development of large multifamily residential lot (Block 1-Lot 10); areas are based on preliminary site plan of lot.

Total new impervious area = 2 ac

Total new landscaped area = 1 ac

DRAINAGE B

New Impervious Area

- Streets, sidewalk, and curb area = 1.61 ac
- 11 residential lots @ 3,500 s.f. each = 0.88 ac
- 13 multifamily lots @ 70% of total area (2.63 ac) = 1.84 ac

Total new impervious area = 4.73 ac

New Landscaped Area

- Remaining residential lot area is landscaped (2.07 ac - 0.88 ac) = 1.19 ac
- 13 multifamily lots @ 30% of total area (2.63 ac) = 0.79 ac

Total new landscaped area = 1.98 ac

DRAINAGE C

New impervious area is proposed development on one multifamily lot (Block 1, Lot 1); areas are based on preliminary site plan of lot.

Total new impervious area = 0.9 ac

Total new landscaped area = 0.4 ac

Weighted curve number calculations and impervious area calculations are provided in Appendix B.

Initial Abstraction (Ia). For average soil moisture conditions, Ia is estimated to be 20% of the potential maximum retention (S). Please note that according to Chapter 7.2 of the MDT Hydraulics Manual, the ratio of Ia to precipitation (P); or the Ia/P ratio should range from 0.1 to 0.5. Precipitation is also based on the depth of rainfall for a 24-hour storm of the design frequency (2 or 100 years).

From the NOAA Atlas, the magnitude of the 2-year 24-hour storm is 1.3 inches. The calculated Ia value for the 2-year event is approximately 0.8 for all drainages resulting in an Ia/P ratio that is greater than 0.5. As directed in the MDT Hydraulics Manual for circumstances when the calculated Ia/P ratio is greater than 0.5, the Ia/P ratio is assumed to be 0.5 resulting in an estimated Ia value of 0.65 inches. The 100-yr, 24 hour rainfall depth for the Helena area is 3 inches. The Ia/P ratio for the 100-year storm is therefore approximately 0.8/3, or 0.27, or within the recommended range. The calculated value for Ia used for 100-year event calculations is therefore *approximately* 0.8. Detailed calculations of S and Ia are also provided in Appendix B.

Time of Concentration (Tc) and Lag Time (Tlag). The time of concentration was estimated to be the sum of overland sheet flow travel time (up to a maximum length of 300 feet), shallow concentrated flow travel time, and open channel flow time. These travel times were estimated using the procedure described in Chapter 7, Appendix D of the MDT Hydraulics Manual. The value for Tlag is 60% of the time of concentration. Detailed Tc and Tlag calculations are provided in Appendix C.

Drainage A

Pre-development. The predevelopment conditions of Drainage A are a combination of undeveloped and developed area. The area near the outlet (24" RCP culvert) also has significant storage capacity which must be considered to determine the peak predevelopment discharge rate.

The predevelopment conditions assume the following parameters:

- Drainage Area = 225 ac
- Weighted CN = 71.4
- 2 year Ia = 0.65 in
- 100 year Ia = 0.80 in
- Tc = 40.66 min
- Tlag = 27.24 min

For the 2 year event, our analysis indicates that there is no excess rainfall since Ia exceeds the amount of precipitation (0.65 in > 0.52 in); therefore the estimated predevelopment peak discharge rate is 0 cfs. This is reasonably consistent with our field observations of runoff during the spring/summer of 2005 as no significant measurable flows were observed at the basin outlet.

For the 100 year event, our calculations indicate the total excess rainfall volume to be 0.85 ac-ft. The peak routed predevelopment discharge rate is estimated to be 9 cfs.

Post Development. As previously described, the development of Overlook Estates will require Drainage A to be divided into three sub-basins to accurately assess the impacts to runoff flow rates and volumes. Additionally, the routing capacity of the predevelopment configuration is replaced by a series of four detention ponds near the basin outlet. To match predevelopment conditions (zero excess rainfall), the volume of runoff for the 2-year event must be stored on site within the detention ponds. The parameters used for each sub-basin are described in the following:

<u>DRAINAGE A1</u>

- Drainage Area = 183 ac
- Weighted CN = 71.4
- 2 year Ia = 0.65 in
- 100 year Ia = 0.80 in
- Tc = 38.85 min
- Tlag = 26.03 min
- % impervious = 0.22%

DRAINAGE A2

- Drainage Area = 37 ac
- Weighted CN = 70.7
- 2 year Ia = 0.65 in
- 100 year Ia = 0.83 in
- Tc = 29.40 min
- Tlag = 19.70 min
- % impervious = 14.54%

DRAINAGE A3

- Drainage Area = 3 ac
- Weighted CN = 67.7
- 2 year Ia = 0.65 in
- 100 year Ia = 0.96 in
- Tc = 7.80 min
- Tlag = 5.23 min
- % impervious = 66.67%

For the 2-year event our analysis indicates that the increase in impervious area results in excess rainfall and subsequent runoff. The peak discharge rate and excess rainfall associated with each sub-basin is detailed in Table 2 below; however, as noted previously, the entire volume of excess rainfall will be stored within detention ponds; thereby resulting in a net runoff volume of 0 ac-ft.

Table 2. Drainage A 2-Year, 1-Hour Post Development Runoff Volumes

Basin ID	Peak Flow (cfs)	Excess Rainfall (ac-ft)	Excess Rainfall (c.f.)
A1	0.42	0.03	1,307
A2	3.64	0.23	10,019
A3	2.59	0.09	3,920
	Total	**0.35**	**15,246**

For the 100-year event our analysis indicates a cumulative peak outflow rate to be 16.4 cfs, as compared to the predevelopment peak flow of 9 cfs. The total runoff volume is 1.65 ac-ft; however since 0.35 ac-ft is stored in the proposed detention ponds, the net total runoff volume is 1.30 ac-ft resulting in a volume increase of 0.45 acre feet. The peak discharge rate and total volumes of excess rainfall for each sub basin are provided in Table 3.

Table 3. Drainage A 100-Year, 1-Hour Post Development Runoff Volumes

Basin ID	Peak Flow (cfs)	Excess Rainfall (ac-ft)	Excess Rainfall (c.f.)
A1	10.92	0.77	33,541
A2	9.14	0.66	28,750
A3	6.65	0.22	9583
	Total	**1.65**	**71,874**

Recommendations. To mitigate the excess rainfall generated by the proposed development, the total storage volume of the detention ponds must be equal to the total excess rainfall volume. Based on the values provided in Table 2, the minimum total volume of the detention ponds must be at least 0.35 ac-ft (15,246 c.f.). The configuration of the proposed detention ponds is shown in Appendix D, Sheet C1.

The 100-year event indicates a significant increase in both runoff volume and peak discharge flow rate. Culvert capacity is not an issue as the maximum estimated headwater depth is approximately 2.3 feet, or 0.3 feet above the top of the pipe opening.

The culvert discharges to an existing drainage channel that flows through a parcel owned by Derek Brown Construction. The drainage channel is not located within the developed portion of this tract. Further downstream the drainage crosses Broadwater Avenue through an existing culvert and eventually flows into Spring Meadow Lake. It does not appear that any existing structures or essential facilities will be inundated or otherwise damaged as a result of the increased runoff.

Drainage B

Pre-development. Drainage B is currently undeveloped with negligible existing impervious area. The area near the outlet (18-inch RCP culvert) has some storage routing capacity that is considered when determining the pre-development peak discharge rate.

The pre-development conditions assume the following parameters:

- Drainage Area = 292 ac
- Weighted CN = 71
- 2 year Ia = 0.65 in
- 100 year Ia = 0.82 in

- Tc = 41.54 min
- Tlag = 27.83 min

For the 2 year event, our analysis indicates once again that there is no excess rainfall; therefore the estimated peak discharge rate is 0 cfs. The 100 year event resulted in a total excess rainfall of 1 ac-ft and a peak routed discharge rate of 13.6 cfs.

Post-Development. The outlet of the pre-development condition is modified to include a detention pond whose outlet is the existing 1.5-foot diameter RCP culvert. To match predevelopment conditions, the detention pond must have capacity to store the entire volume of excess rainfall of the 2-year event. The proposed detention pond also greatly increases the storage routing capacity of the basin outlet.

The assumptions used in each sub-basin are described in the following:

- Drainage Area = 292 ac
- Weighted CN = 70.9
- 2 year Ia = 0.65 in
- 100 year Ia = 0.82 in
- Tc = 41.35 min
- Tlag = 27.71 min
- % impervious = 1.62%

The 2 year event calculation resulted in a total excess rainfall volume of 0.2 ac-ft; however this entire volume of runoff will be stored in the detention pond thereby resulting in a net runoff volume of 0 ac-ft.

The 100 year event calculation indicated a total excess rainfall volume of 1.47 acre feet compared to the predevelopment volume of 1 ac-ft. Assuming 0.2 ac-ft are stored within the detention pond, the total net runoff volume is 1.27 ac-ft which results in a net increased runoff volume of 0.27 ac-ft.

The added routing capacity of the detention pond also reduced the peak discharge rate from 13.6 cfs (predevelopment) to 12.7 cfs (post-development).

Recommendations. The proposed detention pond configuration with a volume of 0.2 ac-ft (8,712 c.f.) adequately mitigates the impact of the increased impervious area resulting from the development of this subdivision for the 2-year event. Additionally, the routing capacity of the proposed detention pond reduced peak flows for the 100 year event.

It should be noted that Derek Brown Construction is located on the downstream side of the basin outlet. Although it is not known what the exact natural configuration of this drainage was prior to the development of this parcel, it appears that drainage flowed through the developed portion of this lot. In the current configuration, drainage from this culvert is combined with the outlet of Drainage A which eventually flows into Spring Meadow Lake.

It is our understanding that there have been historical complaints regarding flows from this culvert that were perceived to be excessive and possibly impacting the operations of Derek Brown Construction. It appears that the main source of historical runoff in this area is the impervious area and storm drain system associated with US Highway 12. Based on our analysis, it appears that the area of Drainage B should not have generated a significant quantity of runoff upstream for most rainfall events. However, US Highway 12 consists of a significant amount of interconnected impervious area; therefore nearly 100% of the rainfall over this area will become runoff.

For the larger rainfall events, the increased routing capacity created by the detention pond will function to reduce the peak runoff flow rate; however, most storms less than or equal to the 2-year event, the proposed detention pond will likely have no impact to the historical runoff flow rates at the outlet of this culvert.

Drainage C

Pre-development. Drainage C is also entirely undeveloped. The outlet to this basin is a direct open channel flow discharge onto US Highway 12 which in turn flows into an existing storm drain. There is no storage routing capacity associated with the predevelopment configuration.

The predevelopment conditions assume the following parameters:

- Drainage Area = 23 ac
- Weighted CN = 71
- 2 year Ia = 0.65 in
- 100 year Ia = 0.82 in
- Tc = 21.28 min
- Tlag = 14.25 min

For the 2 year, our analysis again indicates that there is no excess rainfall; therefore the estimated peak discharge rate is 0 cfs. The model for the 100 year event indicates

a total excess rainfall of 0.08 ac-ft. The peak discharge rate is estimated to be 1.67 cfs.

Post Development. The outlet of the predevelopment condition is modified to include a detention pond that will discharge to the existing open-channel which in turn discharges onto US Highway 12. This outlet was modeled as a broad-crested weir. The assumptions used in each sub-basin are described in the following:

- Drainage Area = 23 ac
- Weighted CN = 70.8
- 2 year Ia = 0.65 in
- 100 year Ia = 0.82 in
- Tc = 21.13 min
- Tlag = 14.16 min
- % impervious = 0.9%

For the 2 year event, the estimated peak flow rate into the detention pond is 0.7 cfs and the total runoff volume is 0.04 ac-ft. The minimum required storage volume in the detention pond is therefore the total volume of runoff (0.04 ac-ft or 1,742 c.f.).

The 100 year event calculation resulted in a gross excess rainfall volume of 0.17 ac-ft compared to the predevelopment volume of .08 ac-ft. Assuming 0.04 ac-ft is stored within the detention pond, the net excess rainfall volume is 0.13 ac-ft. The peak discharge rate increased from 1.67 cfs (predevelopment) to 2.05 cfs.

Recommendations. The excess rainfall for the 2-year event is adequately mitigated with the proposed detention pond since the entire volume of excess rain is stored. The peak flow rate increases by approximately 0.4 cfs for the 100-year event and will not cause any structures to be inundated nor otherwise damage any existing essential facilities.

Summary and Conclusion

As expected, although the previously approved plans do meet the requirements of the City of Helena, additional modifications were required to comply with MDT's drainage guidelines. All detention ponds were designed to mitigate increased peak flows resulting from the 2-year event within their contributing drainage areas. The detention ponds were also analyzed for potential impacts from the 100-year event.

Drainage A. Of the three drainages affected by the proposed development activity, Drainage A is the most significantly impacted drainage. Additionally, the placement of

fill upstream of the basin outlet significantly decreased the routing capacity of this area. Proposed mitigation includes the installation of four "step down" detention ponds to mitigate the increased flow rate and runoff volume. The minimum required storage volume of the detention ponds is approximately 0.35 ac-ft.

Although these detention ponds work to mitigate flows from the 2-year event, they do not have significant routing capacity to mitigate the 100-year event; however, the increased flow does not appear to damage or inundate any existing downstream structures or essential facilities prior to discharge into Spring Meadow Lake.

Drainage B. The proposed detention pond is sized to store the entire volume of excess runoff without discharge. Additionally, this pond provides increased routing capacity to reduce the peak flow from the 100-year event below predevelopment conditions. The minimum required storage volume within the detention pond is 0.20 ac-ft.

Drainage C. The proposed detention pond is also sized to store the entire volume of excess rainfall without discharge. The pond does not have routing capacity to reduce peak flows from the 100-year event. The minimum required storage volume within this detention pond is 0.04 ac-ft.

LEGEND

- EXISTING MONUMENT
- EXTERIOR BOUNDARY
- LOT BOUNDARY
- MAINTENANCE EASEMENT GRANTED TO CITY OF HELENA FOR WATER, SEWER, AND STORM DRAINAGE FACILITIES
- EXISTING OVERHEAD POWER
- EXISTING BURIED NATURAL GAS
- EXISTING LIGHT POLE
- EXISTING WATER
- EXISTING SEWER

US HIGHWAY 12

S 86°26' 23" W 253.63

Arc L= 1373.51

R= 2865.00

10
4.19 ac.
182567 s.f.

230.11

433.41

OVERLOOK BLVD

726.71

GRANITE STREET

N 0° 14' 35" E

S 58° 9' 55" W 316.70

S 44° 7' 31" W 41.22

N 29° 33' 29" E 96.19

357.63

N 89° 32' 34" W 970.18

N 89° 17' 41" W 921.19

HAUSER BLVD

KNIGHT ST

1
1.70 ac.
74116 s.f.

2
0.20 ac.
8863 s.f.

3
0.21 ac.
9255 s.f.

4
0.21 ac.
9356 s.f.

5
0.21 ac.
9332 s.f.

6
0.22 ac.
9528 s.f.

7
0.22 ac.
9528 s.f.

8
0.22 ac.
9528 s.f.

9
0.22 ac.
9529 s.f.

1
0.22 ac.
9500 s.f.

2
0.17 ac.
7447 s.f.

3
0.17 ac.
7511 s.f.

4
0.17 ac.
7560 s.f.

5
0.17 ac.
7613 s.f.

6
0.23 ac.
10007 s.f.

7
0.17 ac.
7409 s.f.

8
0.17 ac.
7459 s.f.

9
0.17 ac.
7509 s.f.

10
0.17 ac.
7559 s.f.

11
0.17 ac.
7601 s.f.

1
0.40 ac.
8722 s.f.

2
0.20 ac.
8620 s.f.

3
0.20 ac.
8522 s.f.

4
0.19 ac.
8424 s.f.

5
0.19 ac.
8328 s.f.

3
0.33 ac.
14362 s.f.

1
0.17 ac.
7247 s.f.

2
0.32 ac.
13887 s.f.

14
0.36 ac.
15676 s.f.

12
0.24 ac.
10270 s.f.

13
0.30 ac.
13239 s.f.

4
0.17 ac.
7231 s.f.

5
0.17 ac.
7441 s.f.

6
0.17 ac.
7441 s.f.

7
0.17 ac.
7441 s.f.

8
0.17 ac.
7442 s.f.

9
0.17 ac.
7442 s.f.

10
0.17 ac.
7443 s.f.

11
0.18 ac.
7642 s.f.

15
0.26 ac.
11481 s.f.

16
0.22 ac.
9591 s.f.

17
0.22 ac.
9564 s.f.

18
0.22 ac.
9564 s.f.

19
0.22 ac.
9564 s.f.

20
0.22 ac.
9738 s.f.

1
0.16 ac.
7145 s.f.

2
0.16 ac.
7046 s.f.

3
0.16 ac.
7017 s.f.

4
0.17 ac.
7594 s.f.

5
0.21 ac.
9154 s.f.

6
0.23 ac.
9900 s.f.

7
0.23 ac.
9885 s.f.

8
0.23 ac.
9871 s.f.

9
0.23 ac.
9856 s.f.

10
0.23 ac.
9991 s.f.

PWR GAS PWR PWR PWR PWR PWR PWR PWR PWR PWR

GAS

GAS

NOTE:

1. IMPROVEMENTS TO GRANITE STREET (EXCEPT UTILITIES) NOT PART OF THIS PROJECT.
2. CONDOMINIUMS SHOWN ON LOTS 1 AND 10 OF BLOCK 1 ARE CONCEPTUAL AND SHOWN FOR INFORMATIONAL PURPOSES ONLY.

REVISIONS		
DESCRIPTION	DATE	BY

DATE: 02/2005

0 60 120 180
SCALE IN FEET

MONTANA
TONY J. PROTHERO
No. 12567PE
LICENSED PROFESSIONAL ENGINEER

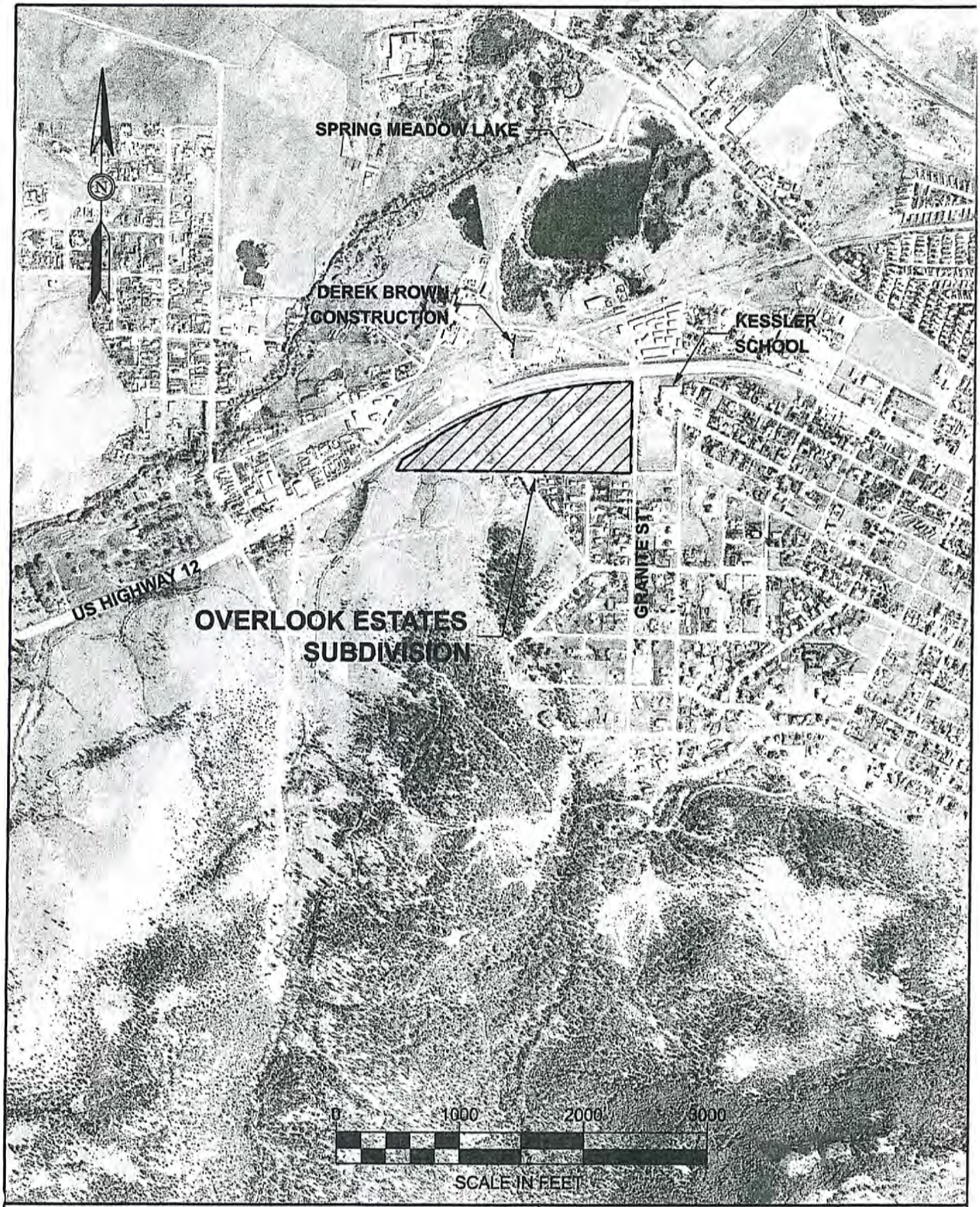
INTERMOUNTAIN CONSULTING ENGINEERS LLC
CIVIL • WATER RESOURCES • TRANSPORTATION
P.O. Box 7542 HELENA, MT 59604 (406) 227-5704 FAX 227-1925

Overlook Estates Subdivision
PRELIMINARY PLAT (REVISED)
HELENA, MONTANA

04-04
FIGURE
2

Appendix A

Drainage Exhibit



Overlook Estates Subdivision
VICINITY MAP
Helena, Montana

INTERMOUNTAIN
CONSULTING ENGINEERS LLC
CIVIL • WATER RESOURCES • TRANSPORTATION
P.O. Box 7542 Helena, MT 59604 (406) 227-5704 FAX 227-5925

FIGURE 1

DRAWN BY:	TJP
PROJECT ENGR:	TJP
PROJECT #:	04-04
	01/2006

Appendix B

SCS Curve Number Worksheets

SCS CURVE NUMBER WORKSHEET

Project: Overlook Estates Subdivision
Location: Helena, Montana

Drainage Basin ID: A (for existing conditions, pre development)

Total Area: 225 acres
0.352 sq. mi.

1. Determine weighted curve number of watershed:

#	Area	CN	Description
1	139	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element
2	86	72	B soil group - Residential districts with 1/3 acre average lot size

Weighted CN: 71.4

New Impervious Area: 0 acres
% of watershed: 0.00 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.01	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.80	inches	Initial abstraction value for 100 year event

Drainage Basin ID: A1 (post development)

Total Area: 183 acres
0.286 sq. mi.

1. Determine weighted curve number of watershed:

#	Area	CN	Description
1	105	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element
2	78	72	B soil group - Residential districts with 1/3 acre average lot size

Weighted CN: 71.4

New Impervious Area: 0.4 acres
% of watershed: 0.22 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.00	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.80	inches	Initial abstraction value for 100 year event

Drainage Basin ID: A2 (post development)

Total Area: 37 acres
0.058 sq. mi.

1. Determine weighted curve number of watershed:

#	Area	CN	Description
1	10.6	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element
2	23	72	B soil group - Residential districts with 1/3 acre average lot size
3	3.4	61	Fair Condition, B soil group - open space (lawns) in good condition

Weighted CN: 70.7

New Impervious Area: 5.38 acres
% of watershed: 14.54 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.14	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.83	inches	Initial abstraction value for 100 year event

SCS CURVE NUMBER WORKSHEET

Project: Overlook Estates Subdivision
Location: Helena, Montana

Drainage Basin ID: A3 (post development)

Total Area: 3 acres
0.005 sq. mi.

1. Determine weighted curve number of existing watershed:

#	Area	CN	Description
1	2	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element
	1	61	Fari Condition, B soil group - open space (lawns) in good condition

Weighted CN: 67.7

New Impervious Area: 2 acres
% of watershed: 66.67 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.78	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.96	inches	Initial abstraction value for 100 year event

Drainage Basin ID: B (for existing conditions, pre development)

Total Area: 292 acres
0.456 sq. mi.

1. Determine weighted curve number of existing watershed:

#	Area	CN	Description
1	292	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element

Weighted CN: 71.0

New Impervious Area: 0 acres
% of watershed: 0.00 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.08	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.82	inches	Initial abstraction value for 100 year event

Drainage Basin ID: B (post development)

Total Area: 292 acres
0.456 sq. mi.

1. Determine weighted curve number of existing watershed:

#	Area	CN	Description
1	290.02	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element
	1.98	61	Fari Condition, B soil group - open space (lawns) in good condition

Weighted CN: 70.9

New Impervious Area: 4.73 acres
% of watershed: 1.62 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.10	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.82	inches	Initial abstraction value for 100 year event

SCS CURVE NUMBER WORKSHEET

Project: Overlook Estates Subdivision
Location: Helena, Montana

Drainage Basin ID: C (for existing conditions, pre development)

Total Area: 23 acres
0.036 sq. mi.

1. Determine weighted curve number of existing watershed:

#	Area	CN	Description
1	23	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element

Weighted CN: 71.0

New Impervious Area: 0 acres
% of watershed: 0.00 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.08	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.82	inches	Initial abstraction value for 100 year event

Drainage Basin ID: C (post development)

Total Area: 23 acres
0.036 sq. mi.

1. Determine weighted curve number of existing watershed:

#	Area	CN	Description
1	22.6	71	Fair Condition, B soil group - herbaceous--mixture of grass, weeds, and low growing brush, with brush the minor element
2	0.4	61	Fair Condition, B soil group - open space (lawns) in good condition

Weighted CN: 70.8

New Impervious Area: 0.9 acres
% of watershed: 3.91 %

2. Initial Abstraction (Ia):

P2:	1.30	inches	2 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
P100:	3.00	inches	100 Year, 24 Hr Rainfall Depth (NOAA Atlas Volume 2 - Montana)
S:	4.12	inches	(potential maximum retention)
Ia (2):	0.65	inches	Initial abstraction value for 2 year event
Ia (100):	0.82	inches	Initial abstraction value for 100 year event

Appendix C

Time of Concentration Calculation Worksheets

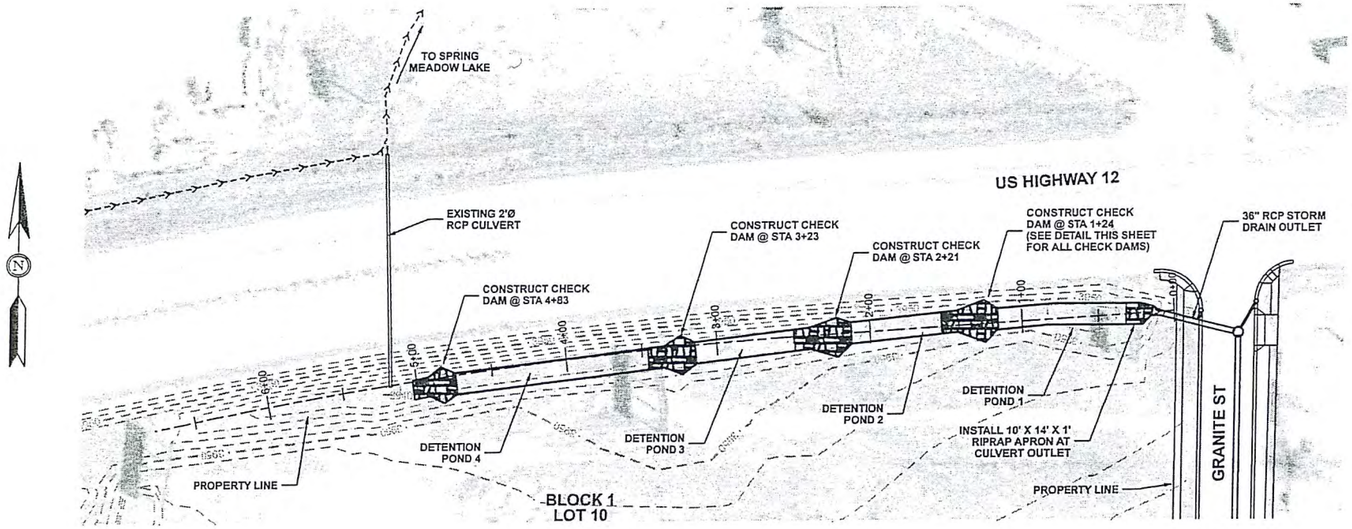
TIME OF CONCENTRATION CALCULATION WORKSHEET

Project: Overlook Estates Subdivision
Location: Helena, Montana

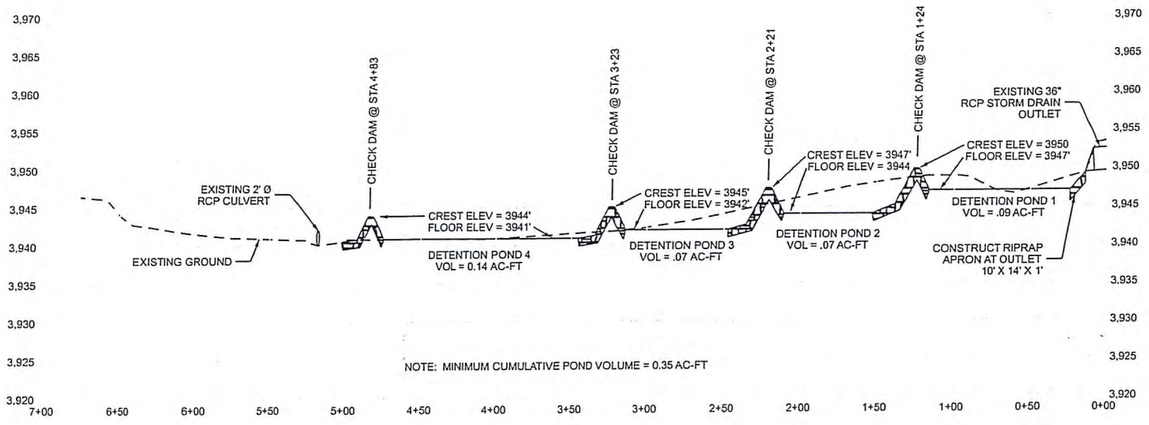
Basin ID	sub reach	Overland Flow: Mannings n	Begin Elev ft	End Elev ft	Length ft	Slope ft/ft	Travel Time (hr)	Travel Time (min)	Shallow Concentrated Flow (P24 = 1.25 in): Begin Elev ft	End Elev ft	Length ft	Slope ft/ft	Velocity ft/sec	Travel Time (min)	Channelized Flow (R = 0.6 ft): Mannings n	Begin Elev ft	End Elev ft	Length ft	Slope ft/ft	Velocity ft/sec	Travel Time (min)
A predevel	1	0.4	5320	5200	300	0.40	0.42	24.96													
	2								5200	4800	690	0.58	12.28	0.94							
	3								4800	4270	2265	0.23	7.80	4.84							
	4														0.035	4270	3950	4703	0.07	7.90	9.92
		Time of Concentration (min)			*40.66*	*min*															
		Tlag(min)			*27.24*	*min*															
A1 postdevel	1	0.4	5320	5200	300	0.40	0.42	24.96													
	2																				
	3								5200	4800	690	0.58	12.28	0.94							
	4								4800	4270	2265	0.23	7.80	4.84							
	5														0.035	4270	4000	3693	0.07	8.19	7.52
															0.011	4000	3970	712	0.04	19.78	0.60
		Time of Concentration (min)			*38.85*	*min*															
		Tlag(min)			*26.03*	*min*															
A2 postdevel	1	0.15	4160	4140	300	0.07	0.39	23.32													
	2																				
	3								4140	4060	800	0.10	5.10	2.61							
	4														0.030	4060	4006	929	0.06	8.52	1.82
	5														0.011	4006	3970	747	0.05	21.15	0.59
	6														0.011	3970	3964	510	0.01	10.45	0.81
															0.011	3964	3950	302	0.05	20.74	0.24
		Time of Concentration (min)			*29.40*	*min*															
		Tlag(min)			*19.70*	*min*															
A3 postdevel	1	0.15	3970	3964	30	0.20	0.04	2.38													
	2																				
	3								3964	3952	500	0.01	2.03	4.10							
															0.012	3952	3950	700	0.01	8.83	1.32
		Time of Concentration (min)			*7.80*	*min*															
		Tlag(min)			*5.23*	*min*															
B predevel	1	0.4	5320	5200	300	0.40	0.42	24.96													
	2																				
	3								5200	4720	1140	0.42	10.47	1.81							
	4														0.035	4720	4400	1872	0.17	12.52	2.49
	5														0.035	4400	4200	2248	0.09	9.03	4.15
	6														0.035	4200	3996	3124	0.07	7.74	6.73
															0.035	3996	3945	689	0.07	8.24	1.39
		Time of Concentration (min)			*41.54*	*min*															
		Tlag(min)			*27.83*	*min*															
B postdevel	1	0.4	5320	5200	300	0.40	0.42	24.96													
	2																				
	3								5200	4720	1140	0.42	10.47	1.81							
	4														0.035	4720	4400	1872	0.17	12.52	2.49
	5														0.035	4400	4200	2248	0.09	9.03	4.15
	6														0.035	4200	3996	3124	0.07	7.74	6.73
	7														0.011	3997	3994	259	0.01	9.47	0.46
	8														0.011	3994	3980	427	0.03	17.75	0.40
	9														0.011	3977	3967	304	0.03	17.47	0.29
															0.011	3967	3941	145	0.18	40.80	0.06
		Time of Concentration (min)			*41.35*	*min*															
		Tlag(min)			*27.71*	*min*															
C predevel	1	0.15	4240	4200	300	0.13	0.29	17.68													
	2																				
	3								4200	4040	974	0.16	6.54	2.48							
															0.035	4040	3965	676	0.11	10.09	1.12
		Time of Concentration (min)			*21.28*	*min*															
		Tlag(min)			*14.25*	*min*															
C postdevel	1	0.15	4240	4200	300	0.13	0.29	17.68													
	2																				
	3								4200	4040	974	0.16	6.54	2.48							
	4														0.035	4040	3980	546	0.11	10.04	0.91
															0.011	3980	3965	130	0.12	32.73	0.07
		Time of Concentration (min)			*21.13*	*min*															
		Tlag(min)			*14.16*	*min*															

Appendix D

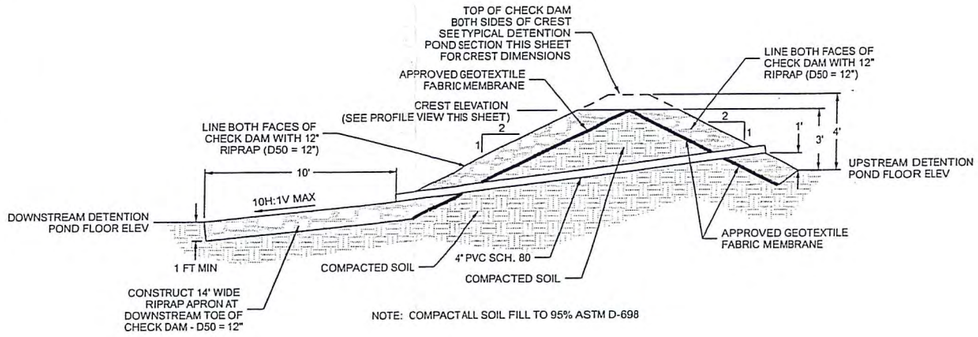
Drawings



PLAN VIEW

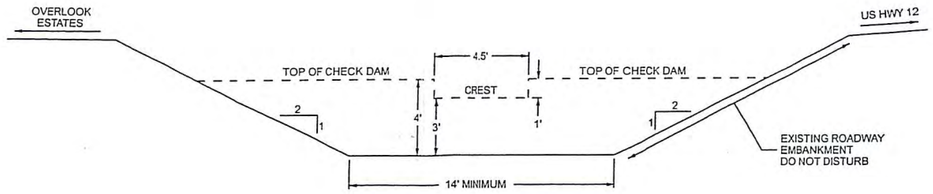


PROFILE VIEW



NOTE: COMPACT ALL SOIL FILL TO 95% ASTM D-698

C1/1 DETAIL
TYPICAL CHECK DAM



NOTES:

1. VEGETATE DETENTION POND SIDEWALLS AND FLOOR WITH NATIVE GRASS. MAINTAIN GRASS HEIGHT BELOW 8 INCHES.
2. INSPECT DETENTION POND FOR SEDIMENT BUILDUP AFTER ALL MAJOR RUNOFF EVENTS. REMOVE SIGNIFICANT SEDIMENT BUILDUP AS NECESSARY.

C1/2 DETAIL
DETENTION POND SECTION

REVISIONS		
DESCRIPTION	DATE	BY

DATE: 01/2006

HORIZONTAL 0 50 100
VERTICAL 0 10 20
SCALE IN FEET

MONTANA PROFESSIONAL ENGINEER
TONY J. PROTHERO
No. 12567PE
LICENSED

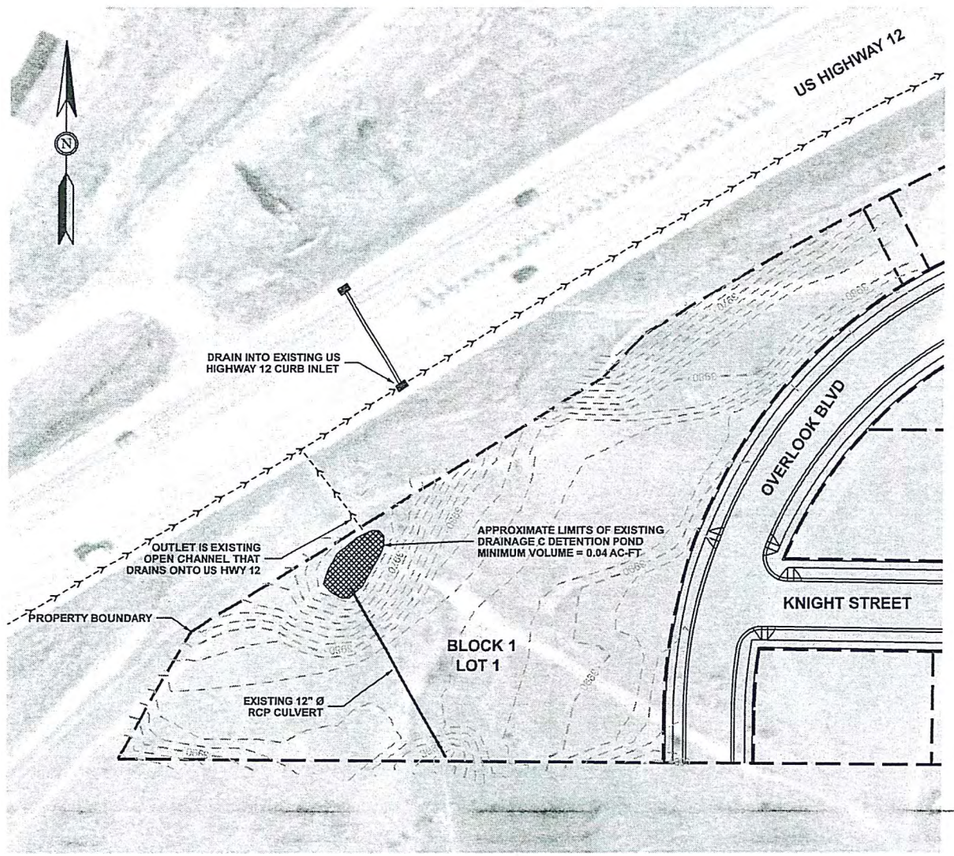
INTERMOUNTAIN CONSULTING ENGINEERS LLC
CIVIL • WATER RESOURCES • TRANSPORTATION
P.O. BOX 7542 HELENA, MT 59604 (406) 227-5704 FAX 227-5925

Overlook Estates Subdivision

DRAINAGE A DETENION PONDS

Helena, Montana

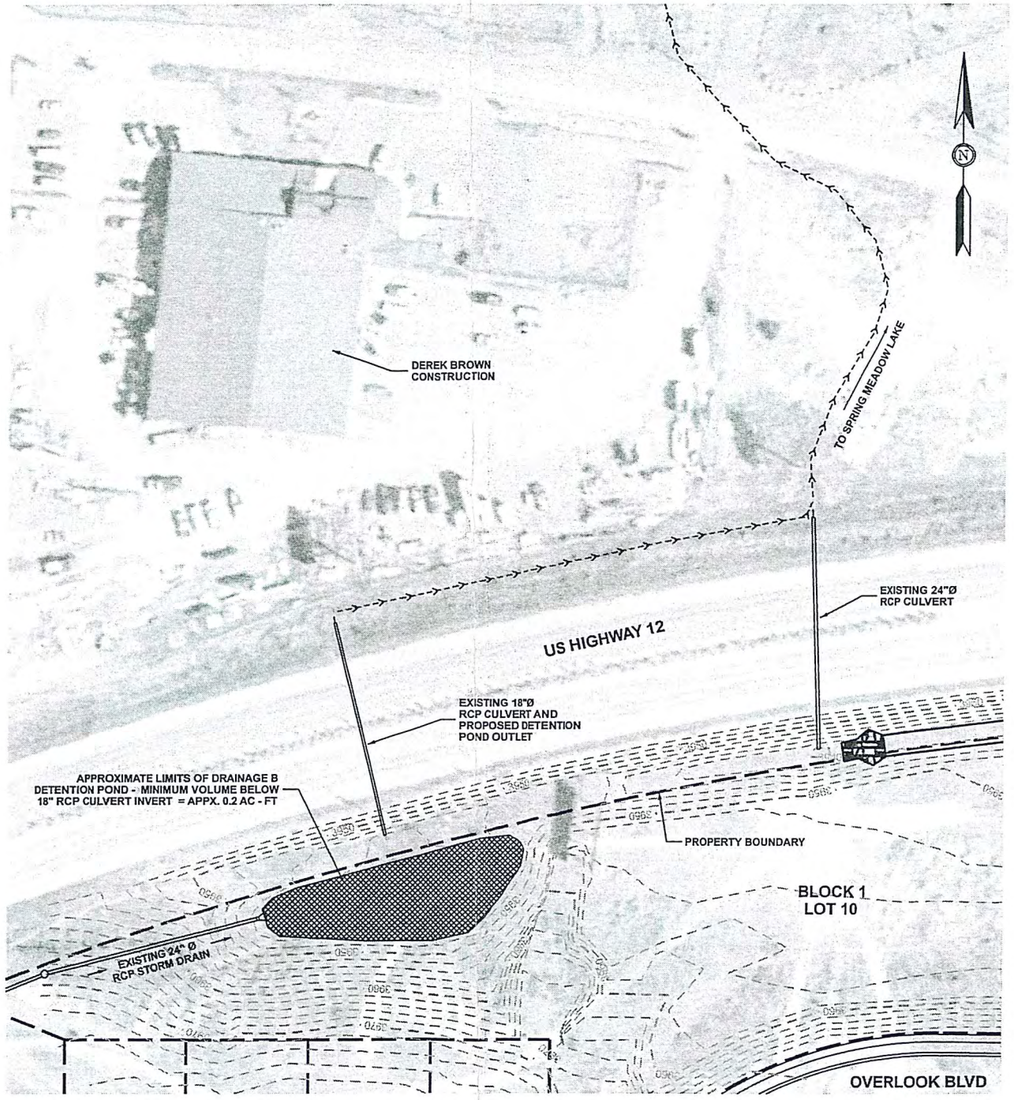
04-04
SHEET ID
C1



PLAN VIEW - DRAINAGE C DETENTION POND

NOTES:

1. DETENTION POND OUTLET IS OVERFLOW DISCHARGE TO EXISTING OPEN CHANNEL.
2. MINIMUM POND VOLUME BELOW OUTLET IS 0.04 AC-FT.
3. VEGETATE DETENTION POND SIDEWALLS AND FLOOR WITH NATIVE GRASS. MAINTAIN GRASS HEIGHT BELOW 8 INCHES.
4. INSPECT DETENTION POND FOR SEDIMENT BUILDUP, TRASH, AND DEBRIS AFTER MAJOR RUNOFF EVENTS. CLEAN AS NECESSARY.



PLAN VIEW - DRAINAGE B DETENTION POND

NOTES:

1. DETENTION POND OUTLET IS OVERFLOW DISCHARGE TO EXISTING 18" RCP CULVERT UNDER US HIGHWAY 12.
2. MINIMUM POND VOLUME BELOW OUTLET IS 0.2 AC-FT.
3. VEGETATE DETENTION POND SIDEWALLS AND FLOOR WITH NATIVE GRASS. MAINTAIN GRASS HEIGHT BELOW 8 INCHES.
4. INSPECT DETENTION POND FOR SEDIMENT BUILDUP, TRASH, AND DEBRIS. AFTER MAJOR RUNOFF EVENTS. CLEAN AS NECESSARY.

REVISIONS

DESCRIPTION	DATE	BY

DATE: 01/2006

0 50 100 150
SCALE IN FEET

MONTANA PROFESSIONAL ENGINEER
TONY J. PROTHERO
No. 12567PE
LICENSED

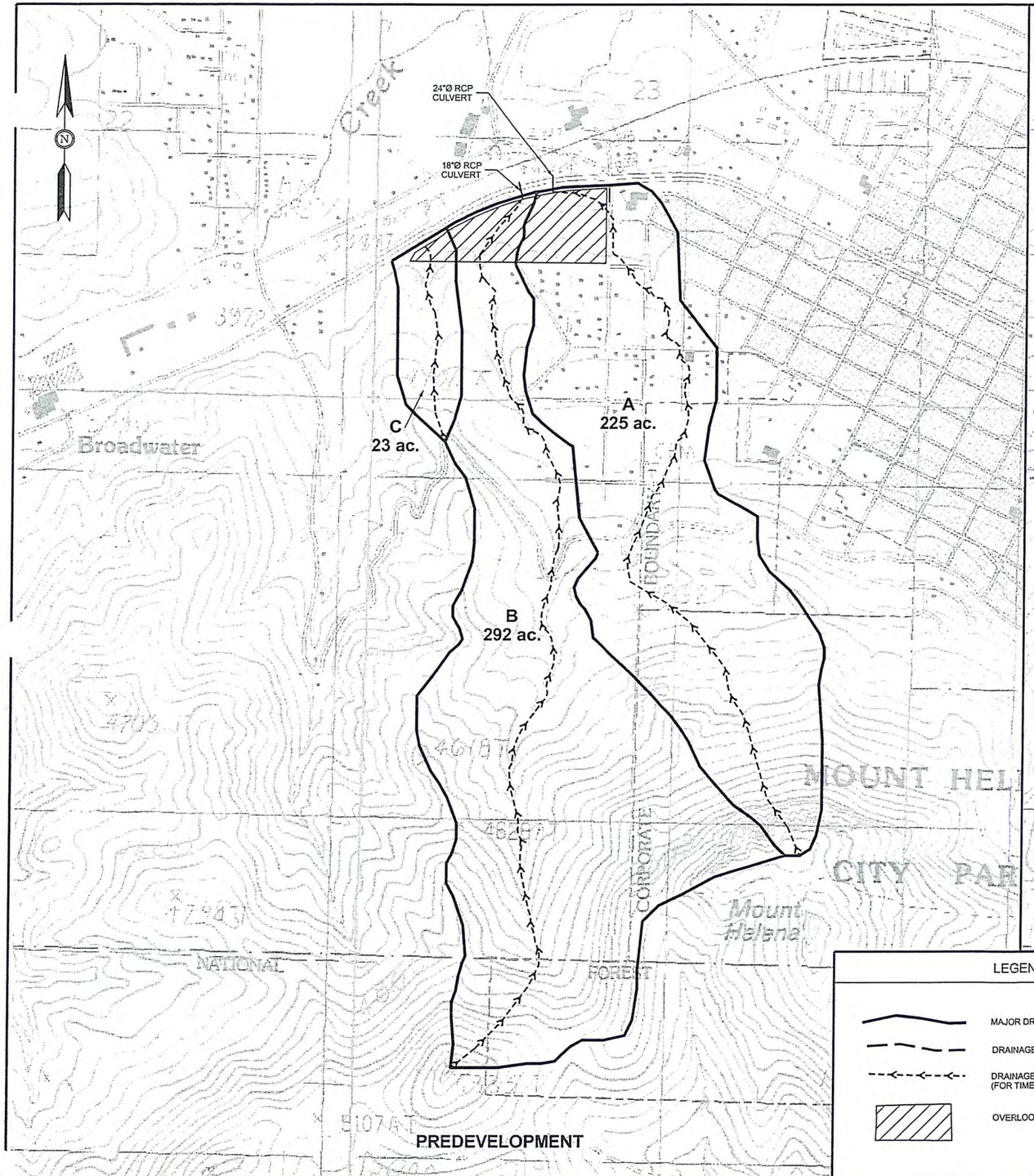
INTERMOUNTAIN CONSULTING ENGINEERS LLC
CIVIL • WATER RESOURCES • TRANSPORTATION
P.O. Box 7542 HELENA, MT 59604 (406) 227-5704 FAX 227-5925

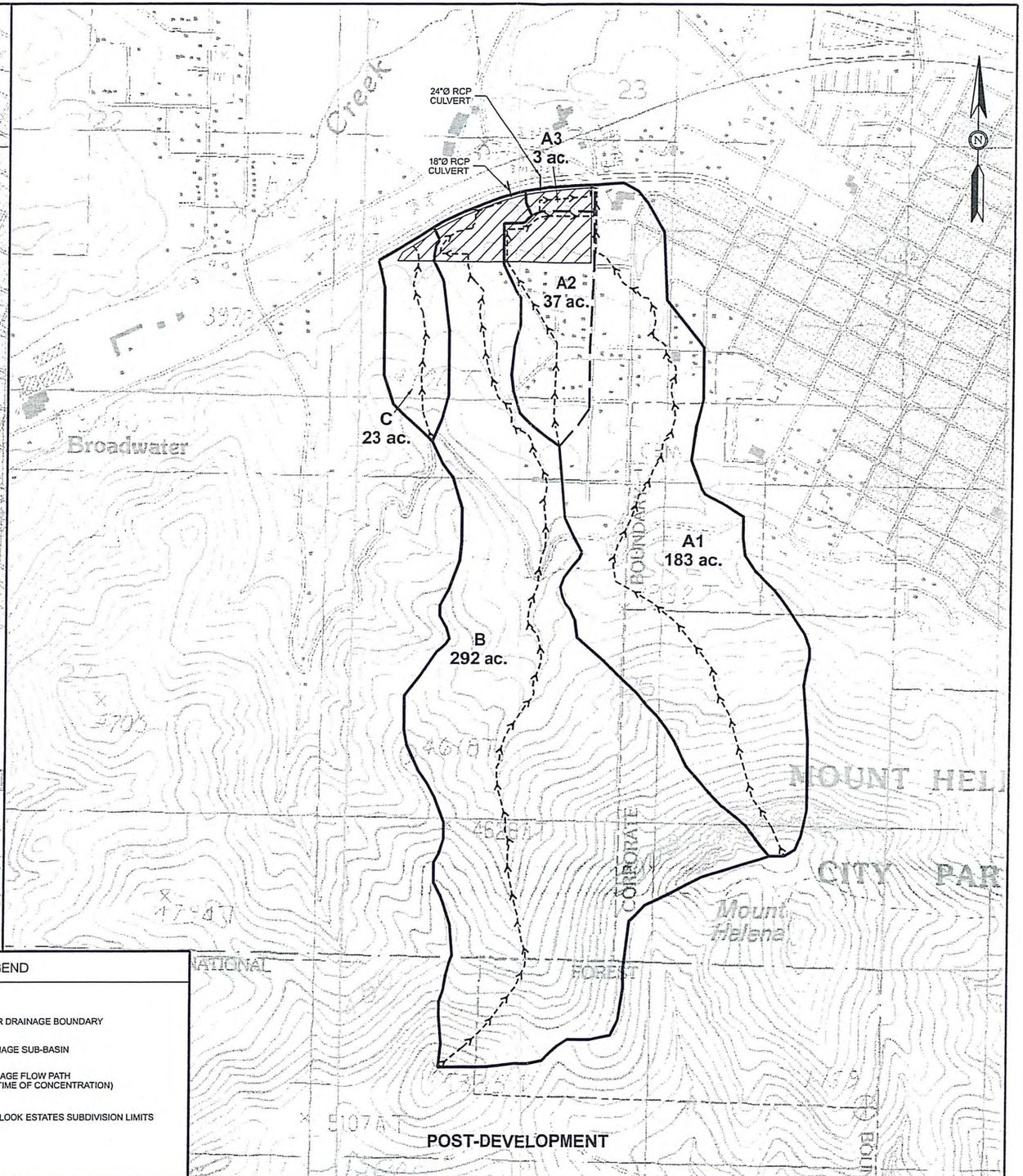
Overlook Estates Subdivision

DRAINAGE B AND C DETENION PONDS

Helena, Montana

04-04
SHEET ID
C2





LEGEND

- MAJOR DRAINAGE BOUNDARY
- DRAINAGE SUB-BASIN
- DRAINAGE FLOW PATH (FOR TIME OF CONCENTRATION)
- OVERLOOK ESTATES SUBDIVISION LIMITS

REVISIONS		
DESCRIPTION	DATE	BY

DATE: 01/2006

0 600 1200 1800
SCALE IN FEET

MONTANA PROFESSIONAL ENGINEER
TONY J. PROTHERO
No. 12567PE
LICENSED

INTERMOUNTAIN
CONSULTING ENGINEERS LLC
CIVIL • WATER RESOURCES • TRANSPORTATION
P.O. Box 7542 Helena, MT 59604 (406) 227-5704 FAX 227-5925

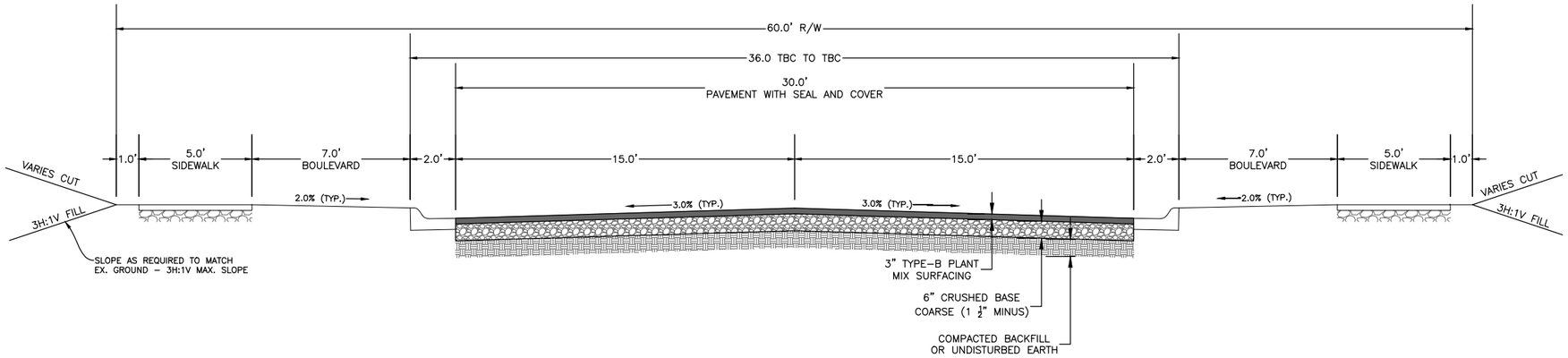
Overlook Estates Subdivision

DRAINAGE AREA EXHIBIT

Helena, Montana

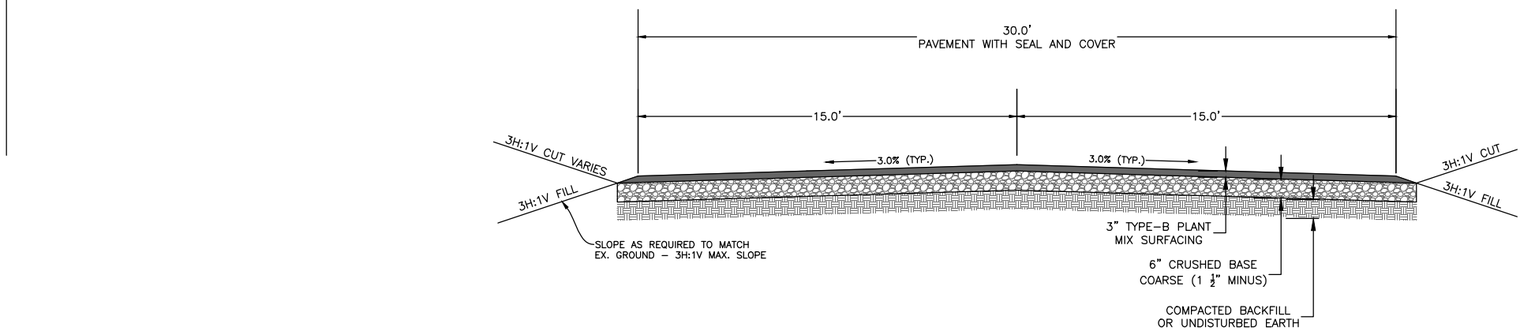
04-04
EXHIBIT
1

APPENDIX E
TYPICAL SECTIONS



LOCAL ROAD - TYPICAL #1

SCALE 1" – 6'
APPLIES TO LIVEZY AVE., LIVEZEY COURT, LEE CT., LEE DR., HAUSER BLVD., BRAKEMAN BLVD., BRAKEMAN CT, CROWLEY CT., AND FLOWERREE CT.



LOCAL ROAD AND MINOR COLLECTOR - TYPICAL #2

SCALE 1" – 6'
APPLIES TO PARK DR. AND HAUSER BLVD.

0 3 6
SCALE IN FEET

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT: 2022-292
DESIGNED: DDP
DRAWN: DDP
CHECKED: KJG
APPROVED: STH
DATE: AUGUST 12, 2022

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

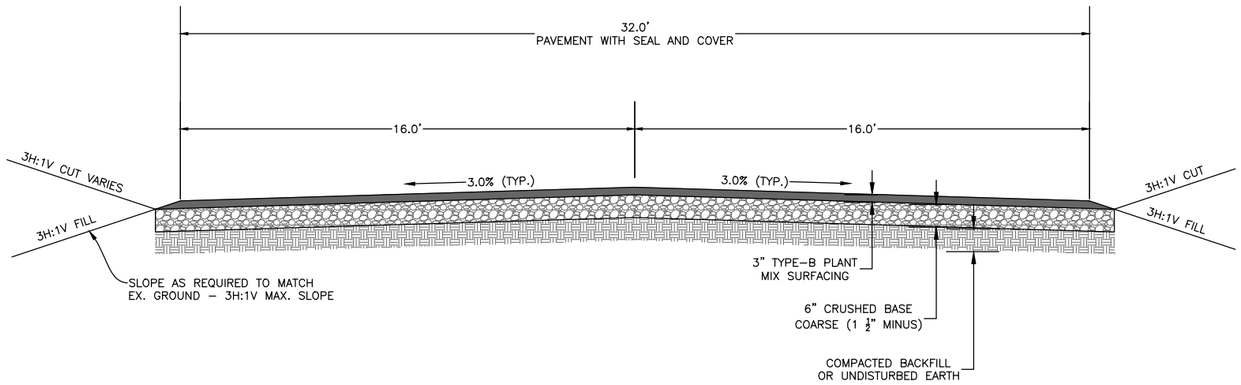
ECO DEVELOPMENT, LLC

WEST SIDE WOODS MAJOR SUBDIVISION

ROAD TYPICAL SECTIONS

SHEET NO.
1

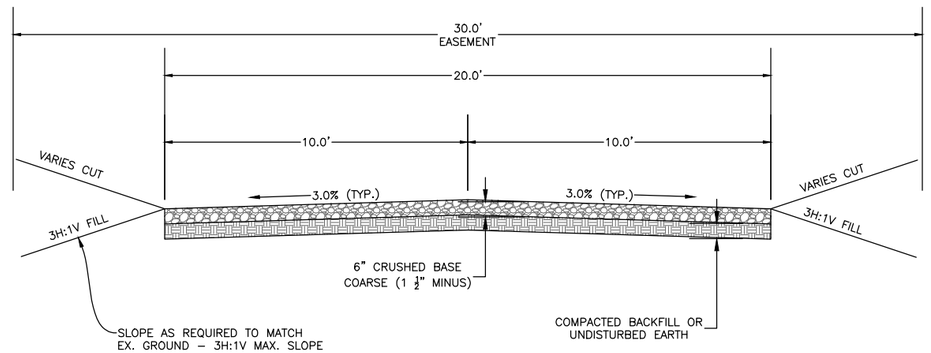
K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\Design Report\22292-ROAD-TYP.dwg



LOCAL ROAD AND MINOR COLLECTOR - TYPICAL #3

SCALE 1" – 6'

APPLIES TO HAUSER BLVD. (BETWEEN PARK DR. AND GRANITE AVE.)



EMERGENCY ACCESS ROAD - TYPICAL #4

SCALE 1" – 5'

0 2.5 5
SCALE IN FEET

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\Design Report\22292-ROAD-TYP.dwg

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT: 2022-292
DESIGNED: DDP
DRAWN: DDP
CHECKED: KJG
APPROVED: STH
DATE: AUGUST 12, 2022

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

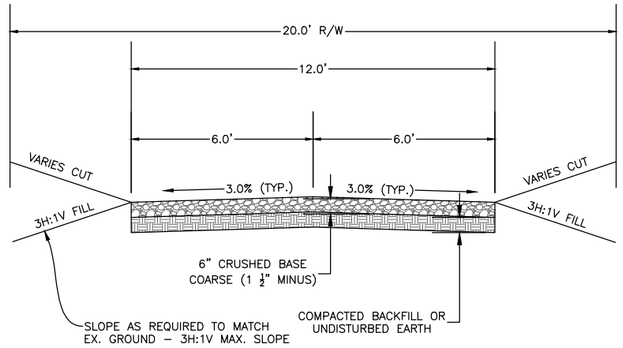
ECO DEVELOPMENT, LLC

WEST SIDE WOODS MAJOR SUBDIVISION

ROAD TYPICAL SECTIONS

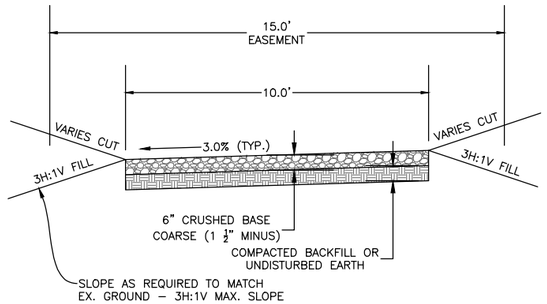
SHEET NO.

2



STORMWATER ACCESS ROAD - TYPICAL #5

SCALE 1" – 5'



PEDESTRIAN TRAIL

SCALE 1" – 5'

0 2.5 5

SCALE IN FEET

NO.	REVISION DESCRIPTION	BY	DATE

PROJECT: 2022-292
DESIGNED: DDP
DRAWN: DDP
CHECKED: KJG
APPROVED: STH
DATE: AUGUST 12, 2022

WWC ENGINEERING
1275 MAPLE STREET, SUITE F
HELENA, MT 59601
(406) 443-3962

ECO DEVELOPMENT, LLC

WEST SIDE WOODS MAJOR SUBDIVISION

ROAD TYPICAL SECTIONS

SHEET NO.

3

K:\Helena\ECO DEVELOPMENT LLC\2022292 West Side Subdivision 2nd Submittal\05CAD\Sheets\Exhibits\Design Report\22292-ROAD-TYP.dwg

APPENDIX F

SOILS

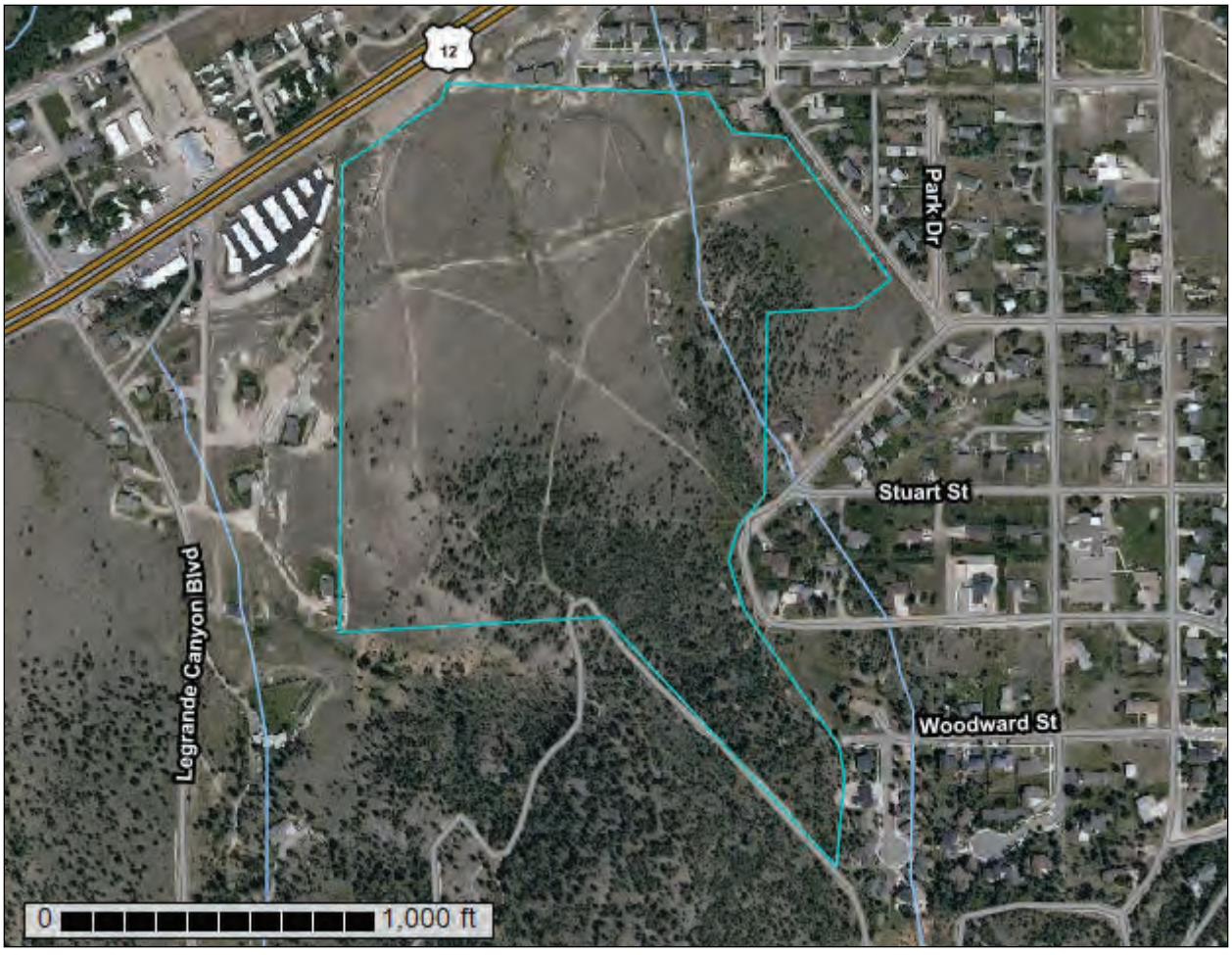
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Lewis and Clark County Area, Montana



July 22, 2020

Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Custom Soil Resource Report
Soil Map

Map Scale: 1:4,440 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 12N WGS84

MAP LEGEND

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

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

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 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

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: Lewis and Clark County Area, Montana
Survey Area Data: Version 15, Jun 4, 2020

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

Date(s) aerial images were photographed: Jul 24, 2019—Jul 27, 2019

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.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
137B	Musselshell-Crago complex, 2 to 8 percent slopes	0.2	0.3%
164E	Windham-Lap channery loams, 8 to 45 percent slopes	43.4	73.0%
433E	Crago-Musselshell gravelly loams, 4 to 35 percent slopes	5.2	8.8%
664E	Windham-Whitecow-Lap channery loams, 15 to 45 percent slopes	10.7	17.9%
Totals for Area of Interest		**59.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however, onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Lewis and Clark County Area, Montana

137B—Musselshell-Crago complex, 2 to 8 percent slopes

Map Unit Setting

National map unit symbol: 4yph
Elevation: 3,600 to 4,500 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 105 to 120 days
Farmland classification: Farmland of local importance

Map Unit Composition

Musselshell and similar soils: 70 percent
Crago and similar soils: 25 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Musselshell

Setting

Landform: Alluvial fans, hillsides, plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy alluvium derived from limestone; coarse-loamy slope alluvium derived from limestone

Typical profile

A - 0 to 4 inches: loam
Bk1 - 4 to 34 inches: gravelly loam
Bk2 - 34 to 60 inches: very gravelly sandy loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 60 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.6 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 4e
Hydrologic Soil Group: B
Ecological site: Limy (Ly) LRU 44B-A (R044BA030MT)
Hydric soil rating: No

Description of Crago

Setting

Landform: Alluvial fans, hillsides, escarpments, plains
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly alluvium derived from limestone; gravelly colluvium derived from limestone; gravelly slope alluvium derived from limestone

Typical profile

A - 0 to 4 inches: gravelly loam
Bk1 - 4 to 32 inches: very gravelly clay loam
Bk2 - 32 to 60 inches: extremely gravelly loam

Properties and qualities

Slope: 2 to 8 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 70 percent
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): 4e
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Limy (Ly) LRU 44B-A (R044BA030MT)
Hydric soil rating: No

Minor Components

Amesha

Percent of map unit: 2 percent
Landform: Hillsides, plains, knolls, alluvial fans
Landform position (two-dimensional): Footslope, toeslope
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 10-14" p.z. (R044XC457MT)
Hydric soil rating: No

Crago, cobbly

Percent of map unit: 2 percent
Landform: Alluvial fans, hillsides, escarpments, plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 10-14" p.z. (R044XC457MT)
Hydric soil rating: No

Delpoint

Percent of map unit: 1 percent
Landform: Escarpments, hills, knolls
Down-slope shape: Linear
Across-slope shape: Linear

Ecological site: Draft Silty (Si) RRU 46-N 13-19" p.z. (R046XN252MT)
Hydric soil rating: No

164E—Windham-Lap channery loams, 8 to 45 percent slopes

Map Unit Setting

National map unit symbol: 4ypy
Elevation: 4,000 to 5,500 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Not prime farmland

Map Unit Composition

Windham and similar soils: 75 percent
Lap and similar soils: 20 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Windham

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly colluvium derived from limestone

Typical profile

A - 0 to 7 inches: channery loam
Bk1 - 7 to 30 inches: very gravelly loam
Bk2 - 30 to 60 inches: extremely gravelly loam

Properties and qualities

Slope: 8 to 45 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 60 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B

Ecological site: Draft Limy (Ly) RRU 46-N 13-17" p.z. (R046XN254MT)
Hydric soil rating: No

Description of Lap

Setting

Landform: Hills
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Residuum weathered from limestone

Typical profile

A - 0 to 6 inches: channery loam
Bk1 - 6 to 8 inches: very channery loam
Bk2 - 8 to 14 inches: extremely channery loam
R - 14 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 8 to 45 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 60 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: Shallow Grassland (R043BP810MT)
Hydric soil rating: No

Minor Components

Beanlake

Percent of map unit: 1 percent
Landform: Outwash fans, alluvial fans, moraines
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 15-19" p.z. (R044XC473MT)
Hydric soil rating: No

Soils with bedrock at 20 to 40 inches

Percent of map unit: 1 percent
Landform: Escarpments, hillsides, hillsides, ridges, ridges, divides
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Droughty-Steep (SiDrStp) 15-19" p.z. (R043BS720MT)
Hydric soil rating: No

Rock outcrop

Percent of map unit: 1 percent

Hydric soil rating: No

Lap, very shallow

Percent of map unit: 1 percent
Landform: Ridges, divides, escarpments, hillsides, hillsides, ridges
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow (Sw) 15-19" p.z. (R044XC469MT)
Hydric soil rating: No

Whitecow

Percent of map unit: 1 percent
Landform: Ridges, divides, escarpments, hillsides, hillsides, ridges
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

433E—Crago-Musselshell gravelly loams, 4 to 35 percent slopes

Map Unit Setting

National map unit symbol: 4yt8
Elevation: 3,600 to 5,000 feet
Mean annual precipitation: 10 to 14 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 105 to 120 days
Farmland classification: Not prime farmland

Map Unit Composition

Crago and similar soils: 50 percent
Musselshell and similar soils: 40 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Crago

Setting

Landform: Escarpments, plains, alluvial fans, hillsides
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly alluvium derived from limestone; gravelly colluvium derived from limestone; gravelly slope alluvium derived from limestone

Typical profile

A - 0 to 4 inches: gravelly loam
Bk1 - 4 to 32 inches: very gravelly clay loam
Bk2 - 32 to 60 inches: extremely gravelly loam

Properties and qualities

Slope: 4 to 35 percent
Depth to restrictive feature: More than 80 inches

Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 70 percent
Available water storage in profile: Low (about 3.8 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Limy Grassland (R043BP804MT)
Hydric soil rating: No

Description of Musselshell

Setting

Landform: Hillsides, plains, alluvial fans
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Coarse-loamy alluvium derived from limestone; coarse-loamy slope alluvium derived from limestone

Typical profile

A - 0 to 4 inches: gravelly loam
Bk1 - 4 to 34 inches: gravelly loam
Bk2 - 34 to 60 inches: very gravelly sandy loam

Properties and qualities

Slope: 4 to 35 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 60 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Moderate (about 7.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 6e
Hydrologic Soil Group: B
Ecological site: Limy Grassland (R043BP804MT)
Hydric soil rating: No

Minor Components

Amesha

Percent of map unit: 3 percent
Landform: Alluvial fans, hillsides, plains, knolls
Landform position (two-dimensional): Footslope, toeslope

Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 10-14" p.z. (R044XC457MT)
Hydric soil rating: No

Crago, greater slope
Percent of map unit: 3 percent
Landform: Alluvial fans, hillsides, escarpments, plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 10-14" p.z. (R044XC457MT)
Hydric soil rating: No

Crago, cobbly
Percent of map unit: 2 percent
Landform: Alluvial fans, hillsides, escarpments, plains
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 10-14" p.z. (R044XC457MT)
Hydric soil rating: No

Crago, stony
Percent of map unit: 1 percent
Landform: Plains, alluvial fans, hillsides, escarpments
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Limy (SiLy) 10-14" p.z. (R044XC457MT)
Hydric soil rating: No

Pensore
Percent of map unit: 1 percent
Landform: Hillsides, escarpments, ridges, knolls, strath terraces
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow (Sw) 10-14" p.z. (R044XC452MT)
Hydric soil rating: No

664E—Windham-Whitecow-Lap channery loams, 15 to 45 percent slopes

Map Unit Setting
National map unit symbol: 4ywd
Elevation: 4,000 to 5,000 feet
Mean annual precipitation: 15 to 19 inches
Mean annual air temperature: 37 to 45 degrees F
Frost-free period: 90 to 110 days
Farmland classification: Not prime farmland

Map Unit Composition
Windham and similar soils: 45 percent
Whitecow and similar soils: 35 percent

Lap and similar soils: 15 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Windham

Setting

Landform: Ridges, divides, escarpments, hillsides
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly colluvium derived from limestone

Typical profile

A - 0 to 7 inches: channery loam
Bk1 - 7 to 30 inches: very gravelly loam
Bk2 - 30 to 60 inches: extremely gravelly loam

Properties and qualities

Slope: 15 to 45 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 60 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: Draft Limy (Ly) RRU 46-N 13-17" p.z. (R046XN254MT)
Hydric soil rating: No

Description of Whitecow

Setting

Landform: Ridges, divides, escarpments, hillsides
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly colluvium derived from limestone

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 3 inches: channery loam
Bk1 - 3 to 25 inches: very gravelly loam
Bk2 - 25 to 60 inches: extremely channery loam

Properties and qualities

Slope: 15 to 45 percent
Depth to restrictive feature: More than 80 inches
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)

Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 50 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Low (about 4.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: B
Ecological site: Limy Cool Woodland (F043BP912MT)
Other vegetative classification: Douglas-fir/bluebunch wheatgrass (PK210), Douglas-fir/rough fescue (PK230)
Hydric soil rating: No

Description of Lap

Setting

Landform: Ridges, divides, escarpments, hillsides
Down-slope shape: Linear
Across-slope shape: Linear
Parent material: Gravelly colluvium over residuum weathered from limestone; gravelly residuum weathered from limestone

Typical profile

A - 0 to 6 inches: channery loam
Bk1 - 6 to 8 inches: very channery loam
Bk2 - 8 to 14 inches: extremely channery loam
R - 14 to 60 inches: unweathered bedrock

Properties and qualities

Slope: 15 to 45 percent
Depth to restrictive feature: 10 to 20 inches to lithic bedrock
Natural drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to high (0.57 to 1.98 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum in profile: 60 percent
Salinity, maximum in profile: Nonsaline to very slightly saline (0.0 to 2.0 mmhos/cm)
Available water storage in profile: Very low (about 1.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7e
Hydrologic Soil Group: D
Ecological site: Limy Warm Woodland (F043BP913MT)
Hydric soil rating: No

Minor Components

Lap, very shallow

Percent of map unit: 2 percent

Landform: Divides, escarpments, hillsides, ridges
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Shallow (Sw) 15-19" p.z. (R044XC469MT)
Hydric soil rating: No

Whitecow, greater slope

Percent of map unit: 2 percent
Landform: Hillsides, ridges, divides, escarpments
Down-slope shape: Linear
Across-slope shape: Linear
Hydric soil rating: No

Maiden

Percent of map unit: 1 percent
Landform: Escarpments, hillsides, ridges, divides
Down-slope shape: Linear
Across-slope shape: Linear
Ecological site: Silty-Droughty-Steep (SiDrStp) 15-19" p.z. (R043BS720MT)
Hydric soil rating: No

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Dwellings and Small Commercial Buildings

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. This table shows the degree and kind of soil limitations that affect dwellings and small commercial buildings.

The ratings in the table 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 building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. 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 the specified use. 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 in the table 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 the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Dwellings are single-family houses of three stories or less. For dwellings without basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. For dwellings with basements, the foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of about 7 feet. The ratings for dwellings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility. Compressibility is inferred from the Unified classification. The properties that affect the ease and amount of excavation include depth to a water table, ponding, flooding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Small commercial buildings are structures that are less than three stories high and do not have basements. The foundation is assumed to consist of spread footings of reinforced concrete built on undisturbed soil at a depth of 2 feet or at the depth of maximum frost penetration, whichever is deeper. The ratings are based on the soil properties that affect the capacity of the soil to support a load without movement and on the properties that affect excavation and construction costs. The properties that affect the load-supporting capacity include depth to a water table, ponding, flooding, subsidence, linear extensibility (shrink-swell potential), and compressibility (which is inferred from the Unified classification). The properties that affect the ease and amount of excavation include flooding, depth to a water table, ponding, slope, depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, and the amount and size of rock fragments.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Report—Dwellings and Small Commercial Buildings

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Dwellings and Small Commercial Buildings–Lewis and Clark County Area, Montana							
Map symbol and soil name	Pct. of map unit	Dwellings without basements		Dwellings with basements		Small commercial buildings	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
137B—Musselshell-Crago complex, 2 to 8 percent slopes							
Musselshell	70	Not limited		Not limited		Somewhat limited	
						Slope	0.14
Crago	25	Not limited		Not limited		Somewhat limited	
						Slope	0.14

Dwellings and Small Commercial Buildings–Lewis and Clark County Area, Montana							
Map symbol and soil name	Pct. of map unit	Dwellings without basements		Dwellings with basements		Small commercial buildings	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
164E—Windham-Lap channery loams, 8 to 45 percent slopes							
Windham	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
Lap	20	Very limited		Very limited		Very limited	
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Slope	1.00
		Slope	1.00	Slope	1.00	Depth to hard bedrock	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50
433E—Crago-Musselshell gravelly loams, 4 to 35 percent slopes							
Crago	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
Musselshell	40	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
664E—Windham-Whitecow-Lap channery loams, 15 to 45 percent slopes							
Windham	45	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
Whitecow	35	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Large stones	0.02	Large stones	0.02	Large stones	0.02
Lap	15	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Depth to hard bedrock	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Shrink-swell	0.50	Shrink-swell	0.50	Shrink-swell	0.50

Data Source Information

Soil Survey Area: Lewis and Clark County Area, Montana
Survey Area Data: Version 15, Jun 4, 2020

Roads and Streets, Shallow Excavations, and Lawns and Landscaping

Soil properties influence the development of building sites, including the selection of the site, the design of the structure, construction, performance after construction, and maintenance. This table shows the degree and kind of soil limitations that affect local roads and streets, shallow excavations, and lawns and landscaping.

The ratings in the table 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 building site development. *Not limited* indicates that the soil has features that are very favorable for the specified use. Good performance and very low maintenance can be expected. *Somewhat limited* indicates that the soil has features that are moderately favorable for the specified use. 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 the specified use. 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 in the table 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 the use (1.00) and the point at which the soil feature is not a limitation (0.00).

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material; a base of gravel, crushed rock, or soil material stabilized by lime or cement; and a surface of flexible material (asphalt), rigid material (concrete), or gravel with a binder. The ratings are based on the soil properties that affect the ease of excavation and grading and the traffic-supporting capacity. The properties that affect the ease of excavation and grading are depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, depth to a water table, ponding, flooding, the amount of large stones, and slope. The properties that affect the traffic-supporting capacity are soil strength (as inferred from the AASHTO group index number), subsidence, linear extensibility (shrink-swell potential), the potential for frost action, depth to a water table, and ponding.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for graves, utility lines, open ditches, or other purposes. The ratings are based on the soil properties that influence the ease of digging and the resistance to sloughing. Depth to bedrock or a cemented pan, hardness of bedrock or a cemented pan, the amount of large stones, and dense layers influence the ease of digging, filling, and compacting. Depth to the seasonal high water table, flooding, and ponding may restrict the period when excavations can be made. Slope influences the ease of using machinery. Soil texture, depth to the water table, and linear extensibility (shrink-swell potential) influence the resistance to sloughing.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. Irrigation is not considered in the ratings. The ratings are based on the soil properties that affect plant growth and trafficability after vegetation is established. The properties that affect plant growth are reaction; depth to a water table; ponding; depth to bedrock or a cemented pan; the available water capacity in the upper 40 inches; the content of salts, sodium, or calcium carbonate; and sulfidic materials. The properties that affect trafficability are flooding, depth to a water table, ponding, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer.

Information in this table is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil between the surface and a depth of 5 to 7 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this table. Local ordinances and regulations should be considered in planning, in site selection, and in design.

Report—Roads and Streets, Shallow Excavations, and Lawns and Landscaping

[Onsite investigation may be needed to validate the interpretations in this table and to confirm the identity of the soil on a given site. The numbers in the value columns range from 0.01 to 1.00. The larger the value, the greater the potential limitation. The table shows only the top five limitations for any given soil. The soil may have additional limitations]

Roads and Streets, Shallow Excavations, and Lawns and Landscaping–Lewis and Clark County Area, Montana							
Map symbol and soil name	Pct. of map unit	Lawns and landscaping		Local roads and streets		Shallow excavations	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
137B—Musselshell-Crago complex, 2 to 8 percent slopes							
Musselshell	70	Very limited		Somewhat limited		Somewhat limited	
		Carbonate content	1.00	Frost action	0.50	Dusty	0.12
		Dusty	0.12			Unstable excavation walls	0.01
Crago	25	Very limited		Somewhat limited		Somewhat limited	
		Carbonate content	1.00	Frost action	0.50	Dusty	0.22
		Droughty	0.50			Unstable excavation walls	0.01
		Gravel content	0.36				
		Dusty	0.22				
164E—Windham-Lap channery loams, 8 to 45 percent slopes							
Windham	75	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Carbonate content	1.00	Frost action	0.50	Dusty	0.08
		Gravel content	0.92			Unstable excavation walls	0.01
		Large stones content	0.08				
		Dusty	0.08				
Lap	20	Very limited		Very limited		Very limited	
		Droughty	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Depth to bedrock	1.00	Slope	1.00	Slope	1.00
		Slope	1.00	Frost action	0.50	Dusty	0.08
		Carbonate content	1.00	Shrink-swell	0.50	Unstable excavation walls	0.03
		Gravel content	0.54	Soluble bedrock	0.15		

Roads and Streets, Shallow Excavations, and Lawns and Landscaping–Lewis and Clark County Area, Montana							
Map symbol and soil name	Pct. of map unit	Lawns and landscaping		Local roads and streets		Shallow excavations	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
433E—Crago-Musselshell gravelly loams, 4 to 35 percent slopes							
Crago	50	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Carbonate content	1.00	Frost action	0.50	Dusty	0.22
		Droughty	0.50			Unstable excavation walls	0.01
		Gravel content	0.36				
		Dusty	0.22				
Musselshell	40	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Carbonate content	1.00	Frost action	0.50	Dusty	0.12
		Dusty	0.12			Unstable excavation walls	0.01
		Large stones content	0.08				
		Gravel content	0.01				

Roads and Streets, Shallow Excavations, and Lawns and Landscaping–Lewis and Clark County Area, Montana							
Map symbol and soil name	Pct. of map unit	Lawns and landscaping		Local roads and streets		Shallow excavations	
		Rating class and limiting features	Value	Rating class and limiting features	Value	Rating class and limiting features	Value
664E—Windham-Whitecow-Lap channery loams, 15 to 45 percent slopes							
Windham	45	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Carbonate content	1.00	Frost action	0.50	Dusty	0.08
		Gravel content	0.92			Unstable excavation walls	0.01
		Large stones content	0.08				
		Dusty	0.08				
Whitecow	35	Very limited		Very limited		Very limited	
		Slope	1.00	Slope	1.00	Slope	1.00
		Carbonate content	1.00	Frost action	0.50	Dusty	0.04
		Droughty	0.50	Large stones	0.02	Large stones	0.02
		Large stones content	0.20			Unstable excavation walls	0.01
		Dusty	0.04				
Lap	15	Very limited		Very limited		Very limited	
		Slope	1.00	Depth to hard bedrock	1.00	Depth to hard bedrock	1.00
		Droughty	1.00	Slope	1.00	Slope	1.00
		Depth to bedrock	1.00	Frost action	0.50	Dusty	0.08
		Carbonate content	1.00	Shrink-swell	0.50	Unstable excavation walls	0.03
		Gravel content	0.54				

Data Source Information

Soil Survey Area: Lewis and Clark County Area, Montana
Survey Area Data: Version 15, Jun 4, 2020