WOODSIDE RIDGE
PRELIMINARY
STORMWATER DRAINAGE STUDY

PREPARED FOR

CLAYTON PROPERTIES GROUP, INC. dba SUMMIT HOMES
120 SE 30TH STREET
LEE'S SUMMIT, MO 64082

PREPARED BY

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Olsson Associates Project No. 018-1140

OLSSON ASSOCIATES

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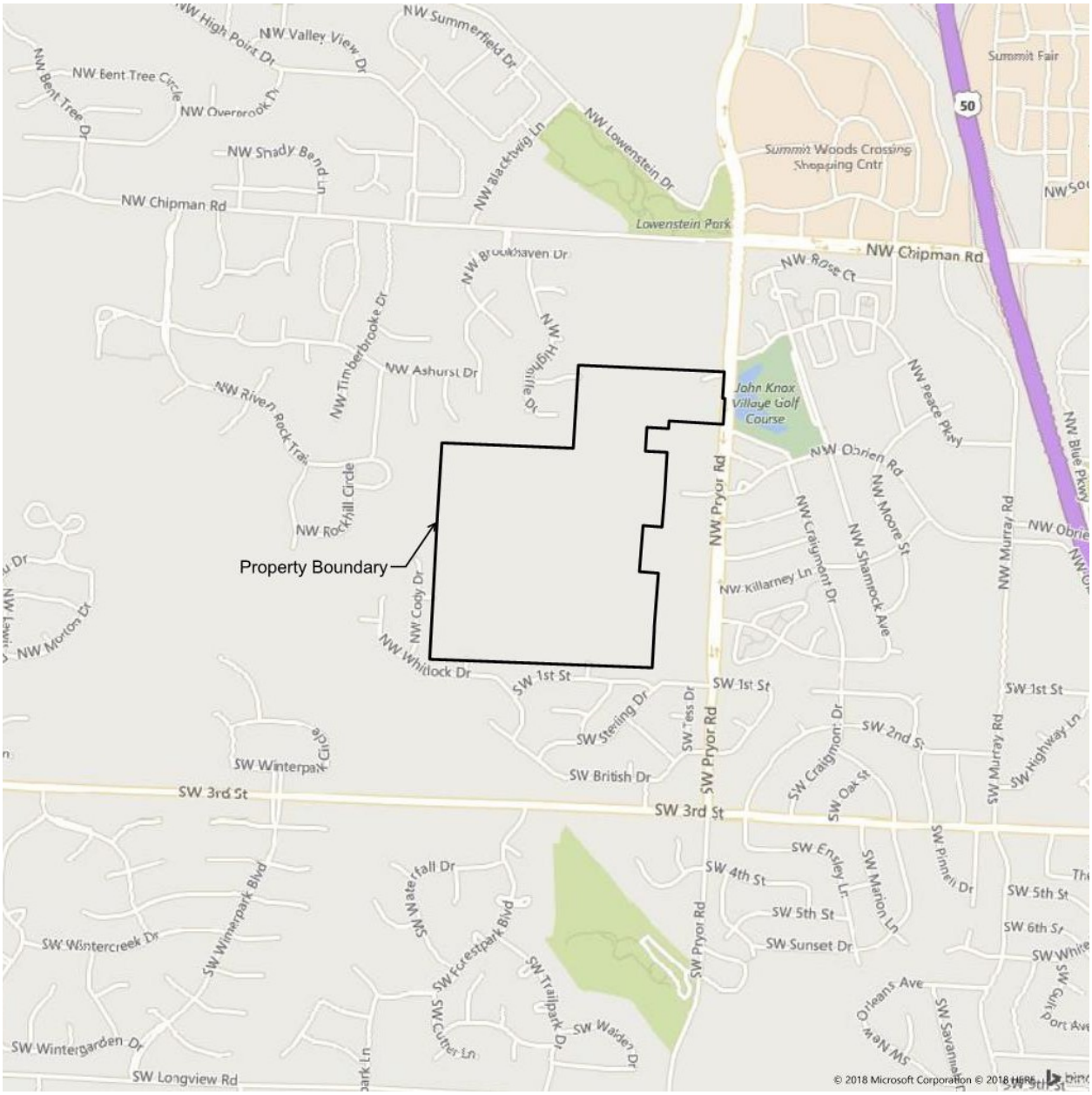
1.0 GENERAL INFORMATION

Woodside Ridge is a proposed 206-lot single family residential development on approximately 112 acres, including a pool and amenity tract and approximately 23 acres which will be reserved for open space and detention. The project is located west of and adjacent to Pryor Road, between Ashurst Drive and SW 1st Street, which lies in the east half of Section 2, Township 47N, Range 32W, Lee's Summit, Jackson County, Missouri.

Stormwater from Woodside Ridge is conveyed into the Cedar Creek Watershed, primarily via two unnamed tributaries which flow east to west through the property.

Figure 1. Location Map



1.1 FEMA Floodplain Classification

FEMA Flood Boundary and Floodway Map Community Panel Number 29095C0416G classifies the Woodside Ridge property as unshaded "Zone X" Area. See Exhibit 1 in Appendix A for location of site in relation to FEMA flood boundaries.

1.2 Soil Classifications

Soil Maps published on the NRCS Web Soil Survey categorize soils on the Woodside Ridge property as shown in Table 1. See Exhibit 2 in Appendix A for a map of soils on the property.

Table 1. Soil Classifications

Symbol	Name	Slopes	HSG
10128	Sharpsburg Urban land complex	2-5%	D
10141	Snead Rock outcrop complex	14-30%	D
10142	Snead Rock outcrop complex	5-14%	D
10143	Snead Urban land complex	9-30%	D

2.0 METHODOLOGY

This drainage study has been prepared to evaluate the hydrologic impact generated by development of Woodside Ridge. The base data for the models prepared for this report has been obtained from available online maps and aerial imagery. Stormwater quantity management is based upon methods and objectives defined in "Kansas City Metropolitan Chapter American Public Works Association (KC-APWA) Section 5600 Storm Drainage Systems & Facilities" (2011).

The following methods were used in this study to model Existing and Future Conditions for stormwater runoff:

- Haestad Methods, Inc. "PondPack" v8i
  - TR55 Unit Hydrograph Method
    - 2-year, 10-year and 100-year Return Frequency Storms
    - AMC II Soil Moisture Conditions
    - 24-Hour SCS Type II Rainfall Distribution
    - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)
    - SCS TR-55 methods for determination of Time of Concentration and Travel Time. Where specific data pertaining to channel geometry is not available, "Length & Velocity" estimates for channel flow Travel Time is utilized per Section 5600, KC-APWA Standard Specifications and Design Criteria.

Stormwater runoff models were created for the 2-, 10- and 100-year design storm events. The precipitation depths used in the analysis have been interpolated from the "Technical Paper No. 40 Rainfall Frequency Atlas of the United States" (TP-40) isopluvial maps (May 1961). The following table summarizes the rainfall depths used in this analysis:

Table 2. Precipitation Depths

Return Period	24-Hour Precipitation Depth (in.)
2-Year (50% Storm)	3.60
10-year (10% Storm)	5.34
100-Year (1% Storm)	7.90

3.0 EXISTING CONDITIONS

To quantify the effects of development of this project, the following areas and points of interest have been used for Existing and Future Conditions analysis. See Exhibit 3, Existing Conditions Drainage Area Map.

Watershed A discharges to the west to an unnamed tributary to Cedar Creek. Total area modeled within this watershed is approximately 434 acres, less than 13% of which is within the Woodside Ridge overall property boundary and considered “onsite”. Where development occurs along the ridgeline between this watershed and Watersheds B and C, less than one acre is expected to be redirected toward the adjacent watersheds.

The unnamed tributary into which Watershed A will discharge generally follows the northwest property line, and discharges from the property approximately 350’ south of the NW property corner. **Point A1** is a point approximately 450’ downstream, where all of the onsite property discharging directly to this tributary converges. The majority of Watershed A is offsite and upstream of the property. **Point A3** is a point approximately 250’ upstream of Point A1, within a side tributary which collects only stormwater from an approximately 10-acre portion of Watershed A. This is the only other defined point within Watershed A where stormwater discharges from the property.

As runoff enters the property from the east, it is collected by an existing pond in the northeast corner of the site. The outlet from the pond is a defined spillway in the northwest corner. The spillway is defined in the model as an irregular weir, with a cross section based on the GIS data available at the time of this report. The “bottom” of the modeled pond is defined by the normal pool elevation which is assumed to be equal to the spillway elevation. Modeled flow into and out of the pond is defined below in Table 6. This pond will remain unchanged with development.

Watershed B discharges to the west to an existing underground storm sewer system leading to Cedar Creek. Total area modeled within this watershed is approximately 7 acres, about 90% of which is within the Woodside Ridge overall property boundary and considered “onsite”. Where development occurs along the ridgeline between this watershed and Watershed C, less than one acre is expected to be redirected toward the adjacent watershed to the south.

Watershed B will discharge from the site via **Point B1**, approximately 200’ north of the SW property corner, directly to an existing field inlet. The outfall of the future detention facility for Watershed B will connect directly to this inlet, so only a small portion of the runoff from Watershed B will continue to flow overland to the existing inlet. Precise storm sewer data was unavailable at the time of this report; however, the downstream system should be analyzed for

capacity to ensure the adequacy of the future detention facility installed with Woodside Ridge, to limit the runoff from Watershed B to less than the capacity of the existing system.

Watershed C discharges to the south to an unnamed tributary to Cedar Creek. Total area modeled within this watershed is approximately 71 acres, approximately 80% of which is considered "onsite". A portion of this "onsite" area does not lie within the project boundary. However, it has been considered onsite area for the purposes of this study. The additional area included is a piece of land between Woodside Ridge and Pryor Road, which will discharge to the future detention within Watershed C. To ensure that this detention is appropriately sized, this additional tributary area will be considered "onsite" for the Allowable Release Rate calculations presented below. In this way, the detention designed for this watershed will account not only for Woodside Ridge, but also the future commercial development bounded by Woodside Ridge, Pryor Road, O'Brien Road and Shamrock Avenue.

Watershed C will discharge from the site via **Point C1**, between SW Ambersham Drive and SW Joshua Drive. As a result of development, Watershed C is expected to increase by approximately 6 acres. Ridgeline shifts include those in relation to Watersheds A and B and a shift in areas to the south of Watershed C, not modeled with the Existing Conditions. Some onsite area will be redirected from the south into Watershed C. The remaining area is assumed to decrease in peak flow rate, as no development will occur in those areas, and the drainage area is reduced.

To provide a direct comparison between the Existing and Future Conditions models, efforts have been made to ensure that the points of interest are as consistent as practical throughout the analysis. Although additional points of interest are included in the hydrologic models, these junctions are of secondary interest.

The following tables summarize the results of the Existing Conditions analysis. The Future Conditions data will be compared to these results in Sections 4 and 5 of this report. Refer to Appendix B for output from and a schematic of the Existing Conditions PondPack model.

Curve Numbers were assumed as follows, and remain the same in all models.

Table 3. Curve Numbers

Land Use	HSG	CN
Open Space	D	80
Park	D	85
Single-Family Residential	D	87
Multi-Family Residential	D	92
Commercial	D	95
Crop/Community Gardens	D	89
Open Graded/Rock Rubble	D	94
Water Surface	D	100

Table 4. Existing Conditions Subarea Data

Subarea	Onsite Area (ac.)	Offsite Area (ac.)	Total Area (ac.)	T_C (hr.)	Weighted CN
A1	0.14	12.44	12.58	0.140	86
A2	7.42	1.80	9.22	0.126	80
A3	10.38	0.08	10.46	0.187	81
A4	0.21	177.43	177.64	0.237	87
A5	5.02	0.77	5.79	0.120	80
A6	0.32	3.56	3.88	0.121	87
A7	5.86	0.22	6.08	0.141	81
A8	15.73	4.09	19.82	0.100	84
A9	11.51	176.80	188.31	0.260	91
Total A	56.59	377.19	433.78		
B1	6.70	0.55	7.25	0.119	80
Total B	6.70	0.55	7.25		
C1	56.38	14.44	70.82	0.252	84
Total C	56.38	14.44	70.82		
Total	119.67	392.18	511.85		

Table 5. Existing Conditions Point of Interest Peak Flow Rates

Point of Interest	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	932.86	1582.99	2595.35
A3	24.93	44.87	76.40
B1	18.25	33.51	57.78
C1	172.71	298.47	492.77

Table 6. Existing Conditions Pond Flow and Volume Data

	Peak Q In (cfs)	TP In (hr)	Peak Q Out (cfs)	TP Out (hr)	VR (ac-ft)	Peak W.S.E. (ft)	Stored Volume (ac-ft)
Existing Pond							
2-Year	574.03	12.03	439.52	12.15	41.242	931.69	7.551
10-Year	909.45	12.03	731.12	12.13	66.882	932.89	10.821
100-Year	1415.77	12.03	1183.94	12.12	106.835	934.35	15.210

Per APWA Section 5608.4 and City of Lee's Summit criteria, the performance criteria for comprehensive control is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
- 1% storm peak rate less than or equal to 3.0 cfs per site acre

Allowable release rates were calculated for the points of interest, allowing that offsite peak discharges would be permitted to bypass the detention. Offsite bypass peak flow rates were calculated as a percentage of the existing conditions, relating to the percentage of offsite area flowing to each point. The release rates for the proposed development on the development site were calculated based on the detention criteria. The development release rates were added to the bypass peak flow rates to calculate an allowable peak flow rate for each point of interest as follows.

Table 7. Point of Interest Onsite Area

Point of Interest	Total Area (ac)	Onsite Area (ac)	Percent Onsite
A1	433.78	56.59	13.0%
A3	10.46	10.38	99.2%
B1	7.25	6.70	92.4%
C1	70.82	56.38	79.6%

Table 8. Allowable Peak Flow Rates

Point of Interest	Allowable 2-Year Q (cfs)	Allowable 10-Year Q (cfs)	Allowable 100-Year Q (cfs)
A1	839.45	1489.65	2426.53
A3	5.38	21.11	31.73
B1	4.73	15.94	24.48
C1	63.40	173.60	269.59

3.1 Stream Buffer

The two main channels flowing through the Woodside Ridge property fall within the requirements of APWA Section 5605.3 Stream Preservation and Buffers Zones. This approach to designating the stream buffer width includes defining the Ordinary High Water Mark (OHM) and defining a width of preservation zone from the OHM on either side of the channel. The OHM for each channel was roughly defined using GIS contours and aerial data, and contributing drainage area is defined as follows.

The channel within Watershed A flows into the site on the eastern property boundary with approximately 190 acres of contributing area, and gradually increases to approximately 430 acres. Per APWA Table 5605-1, the stream buffer width for this channel is defined as 100 feet measured from the OHM.

The channel within Watershed C flows into the site on the eastern property boundary with approximately 14 acres of contributing area, and gradually increases to approximately 70 acres. Due to the size of the contributing area at the point where the channel leaves the site, a stream buffer of 60 feet from the OHM has been assigned to this channel.

4.0 FUTURE CONDITIONS

4.1 Effects of Development

The Future Conditions section of analysis assumes completion of the entire Woodside Ridge development. Due to a shift of the ridgelines along the south side of Watershed C, modeled

stormwater drainage area has increased to approximately 516 acres overall, approximately 124 acres of which is considered “onsite”. Approximately 16 acres of this “onsite” area is the future commercial area discussed in Section 3. The modeled subareas and points of interest are similar to, if not exactly the same as, the Existing Conditions model. However, throughout the site, some shifting of ridgelines as occurred accommodating future detention facilities and anticipated grading activities.

The analysis provided in Section 3 established the Pre-development condition of the watershed, and analysis in this section will provide guidance for a possible configuration of detention to meet the objectives established in Section 3.

Runoff Curve Numbers, Times of Concentration, routings, and tributary regions that are outside the property boundary remain the same as in Section 3. The following tables summarize the results of the Future Conditions analysis. Tables 10 and 11 assume no detention is provided, to demonstrate the effects of development in this watershed. Refer to Appendix C for output from and a schematic of the Future Conditions PondPack model.

Table 9. Future Conditions Subarea Data

Subarea	Onsite Area (ac.)	Offsite Area (ac.)	Total Area (ac.)	T_C (hr.)	Weighted CN
A1	0.13	12.44	12.58	0.140	86
A2	6.69	1.80	8.49	0.126	82
A3	9.36	0.00	9.36	0.100	86
A3a	0.97	0.08	1.05	0.120	81
A4	0.12	177.43	177.55	0.237	87
A5	4.42	0.77	5.19	0.120	81
A6	0.25	3.56	3.81	0.121	87
A7	8.52	0.00	8.52	0.140	86
A7a	1.12	0.22	1.34	0.100	81
A8	11.86	4.09	15.95	0.136	87
A9	12.27	176.80	189.07	0.260	91
Total A	55.71	377.19	432.90		
B1	5.84	0.19	6.03	0.100	86
B1a	0.24	0.36	0.60	0.100	87
Total B	6.08	0.55	6.63		
C1	61.74	14.27	76.01	0.252	88
C1a	0.61	0.17	0.78	0.100	82
Total C	62.35	14.44	76.79		
Total	124.14	392.18	516.23		

Table 10. Future (No Detention) Conditions Point of Interest Peak Flow Rates

Point of Interest	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	938.42	1584.51	2589.19
A3	33.70	57.15	93.14
B1	22.03	37.08	60.08
C1	215.30	352.77	563.29

The following table compares the results of the Future Conditions analysis to the Existing Conditions from Section 3, at the Points of interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. Without detention, flow rates will increase at all points of interest, except for the 100-year flow rate at Point A1, which will decrease slightly, due to routing in relation to minor ridgeline shifts.

Table 11. Future (No Detention) vs. Existing Conditions

Point of Interest	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	5.56	1.52	-6.16
A3	8.77	12.28	16.74
B1	3.78	3.57	2.30
C1	42.59	54.30	70.52

4.2 Future Detention Facilities

To mitigate for the increases in peak flow rates shown in the previous table and where possible, decrease further to the allowable release rates established in Section 3, detention will be provided in each watershed. Detention is intended to be provided within the onsite channel in Watershed C via the construction of a dam upstream of Point C1. The facility located within the channel will include a multi-stage outfall structure to meet the requirements outlined in Section 3 of this study, and will drain completely within 24 hours, per Army Corps of Engineers permit requirements to detain within jurisdictional channels. Dry detention basins will be constructed where feasible and most effective within Watersheds A and B, to capture and treat as much of the developed area as possible, including most of the paved areas.

A waiver will be requested for detention requirements within Watershed A, relating specifically to Point A1. In lieu of matching the release rates, as outlined in Section 2, the future peak flow rates will be reduced to less than the Existing Conditions. This waiver is requested due to several challenges in relation to detention design, described below. Due to these limitations, it is not possible to collect and detain as much runoff as would be necessary to reduce the peak flow rates fully to the standard onsite release rates.

- The watershed consists of steep slopes which are heavily vegetated, making detention basins difficult to construct.

- The tributary flowing through Watershed A generally follows the property line, which results in stormwater generally sheet flowing directly to the tributary, instead of channelizing to create points of discharge where detention can be effective.
- For several reasons, detention within the channel is not feasible or advisable.
    - The channel is protected by a stream setback zone, and should therefore not be disturbed without necessity.
    - The onsite area is a small portion of the watershed, so there is a significant amount of offsite bypass contributing to the main tributary.
    - Constructing a dam would capture most of the offsite runoff which would excessively cut back peak flow rates in the channel, possibly resulting in increased erosion in the channel and diminution of the existing natural habitat.
    - The channel straddles the property line in most places, so detention would be partially offsite, on several existing lots.
    - An existing sanitary sewer trunk main follows the channel, and would be located underneath any new detention facility in the channel.

While the “allowable release rates” are not met at Point A1, peak flow rates will be reduced from the Existing Conditions rates in all storm events. Additionally, over 90% of the paved areas within Watershed A are captured and diverted to a detention facility or the existing pond, providing runoff control for most of the newly developed area in the watershed, and water quality treatment for most of the proposed streets.

Table 12 includes a summary of the future detention facilities within all watersheds, and the existing pond in Watershed A.

Table 12. Future Conditions Detention Flow and Volume Data

	Peak Q In (cfs)	TP In (hr)	Peak Q Out (cfs)	TP Out (hr)	VR (ac-ft)	Peak W.S.E. (ft)	Stored Volume (ac-ft)
Basin A3							
2-Year	31.00	11.93	1.23	13.80	1.704	923.73	1.000
10-Year	52.24	11.93	14.18	12.12	2.920	924.88	1.398
100-Year	84.71	11.93	24.64	12.11	4.858	926.87	2.197
Basin A7							
2-Year	26.30	11.96	0.84	14.88	1.550	934.18	0.970
10-Year	44.34	11.95	7.52	12.27	2.657	935.45	1.388
100-Year	72.07	11.95	19.89	12.17	4.420	937.26	2.096
Existing Pond							
2-Year	576.35	12.03	441.47	12.14	41.409	931.70	7.574
10-Year	913.12	12.03	734.30	12.13	67.152	932.90	10.855
100-Year	1421.48	12.03	1189.06	12.12	107.266	934.37	15.257
Basin B1							
2-Year	19.97	11.93	2.62	12.33	1.098	922.76	0.485
10-Year	33.65	11.93	11.43	12.10	1.881	924.08	0.781
100-Year	54.58	11.93	20.26	12.09	3.129	925.58	1.176
Basin C1							
2-Year	213.77	12.05	45.88	12.41	14.903	921.21	4.835
10-Year	350.15	12.05	112.63	12.30	24.978	923.33	8.193
100-Year	557.91	12.02	247.19	12.23	40.877	925.38	12.477

4.3 Effects of Future Detention

The following table compares the results of the Future Conditions analysis with the detention described above to the Existing Conditions from Section 3, at the Points of Interest. Negative values indicate a reduction in peak flow rate, while positive values indicate an increase. As demonstrated, the planned detention facilities will cause flow rates to decrease at Point A1 from the Existing Conditions rates, per the waiver described above. Flow rates will be decreased at all other points of interest to less than the allowable release rates established in Section 3.

Table 13. Future (with Detention) Point of Interest Peak Flow Rates

Point of Interest	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	898.31	1528.00	2519.41
A3	3.70	16.54	31.34
B1	4.12	12.84	24.28
C1	46.15	113.16	248.17

Table 14. Future (with Detention) vs. Allowable Release Rates

Point of Interest	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	58.86	38.35	92.88
A3	-1.68	-4.57	-0.39
B1	-0.61	-3.10	-0.20
C1	-17.25	-60.44	-21.42

Table 15. Future (with Detention) vs. Existing Conditions

Point of Interest	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
A1	-34.55	-54.99	-75.94
A3	-21.23	-28.33	-45.06
B1	-14.13	-20.67	-33.5
C1	-126.56	-185.31	-244.6

In addition to mitigation of peak flow rates, APWA Section 5608.4 also requires 40 hour extended detention of runoff from the local 90% mean annual event (1.37”/24-hour rainfall). The future detention facilities that are not within existing jurisdictional channels will release the water quality event over a period of 40-72 hours.

4.4 Impacts to Stream Buffer

Much of the defined stream buffer is not impacted by development. However, a few encroachments have been made accommodating the proposed layout.

Watershed C

A detention basin will be constructed, as noted above, within this channel. This impact to the channel will be permitted by the USACE at the time of construction, and is therefore not considered a “stream buffer” impact, since the channel will no longer exist where the dam is constructed. Upstream of the dam, there are a few other minor impacts, where grading and lots encroach into the defined buffer, or utilities will be constructed. Where encroachment occurs for lot construction, a minimum of 25’ of the buffer will be preserved, and an equal or greater area of native vegetation adjacent to the stream buffer will be designated as preserved stream buffer, to mitigate for the impacts. Where encroachments occur to install storm and sanitary sewers, the area will be planted with native grasses to restore the vegetation as much as possible.

Watershed A

Impacts to the stream buffer within Watershed A will be larger in scope, but similar in the type of impact and mitigation. Due to the location of the stream and existing pond on the site, lots north of the pond will only be possible with some impact to the stream buffer. As within Watershed C, a minimum of 25’ width of the stream buffer will remain undisturbed, and an equal or greater area of native vegetation adjacent to the stream buffer will be designated as preserved stream

buffer, to mitigate for the impacts. Small encroachments for installation of storm and sanitary sewers will be planted with native grasses to restore the vegetation as much as possible.

5.0 SUMMARY

This Stormwater Drainage Study was prepared to evaluate the hydrologic impact generated by the development of Woodside Ridge and to provide recommendations for a comprehensive stormwater management plan. The project is a 206-lot single family residential development on approximately 112 acres, including a pool and amenity tract and approximately 23 acres which will be reserved for open space and detention.

Increases in peak flow rates caused by development will be mitigated using dry detention facilities including one within an existing channel. An existing pond will remain as-is, and is essentially unaffected by development.

Stream buffers will be designated based on watershed size, per APWA standards. Where encroachments are necessary, the impacts will be mitigated with preservation of adjacent native vegetation elsewhere on the site, and within the same watershed.

6.0 CONCLUSIONS AND RECOMMENDATIONS

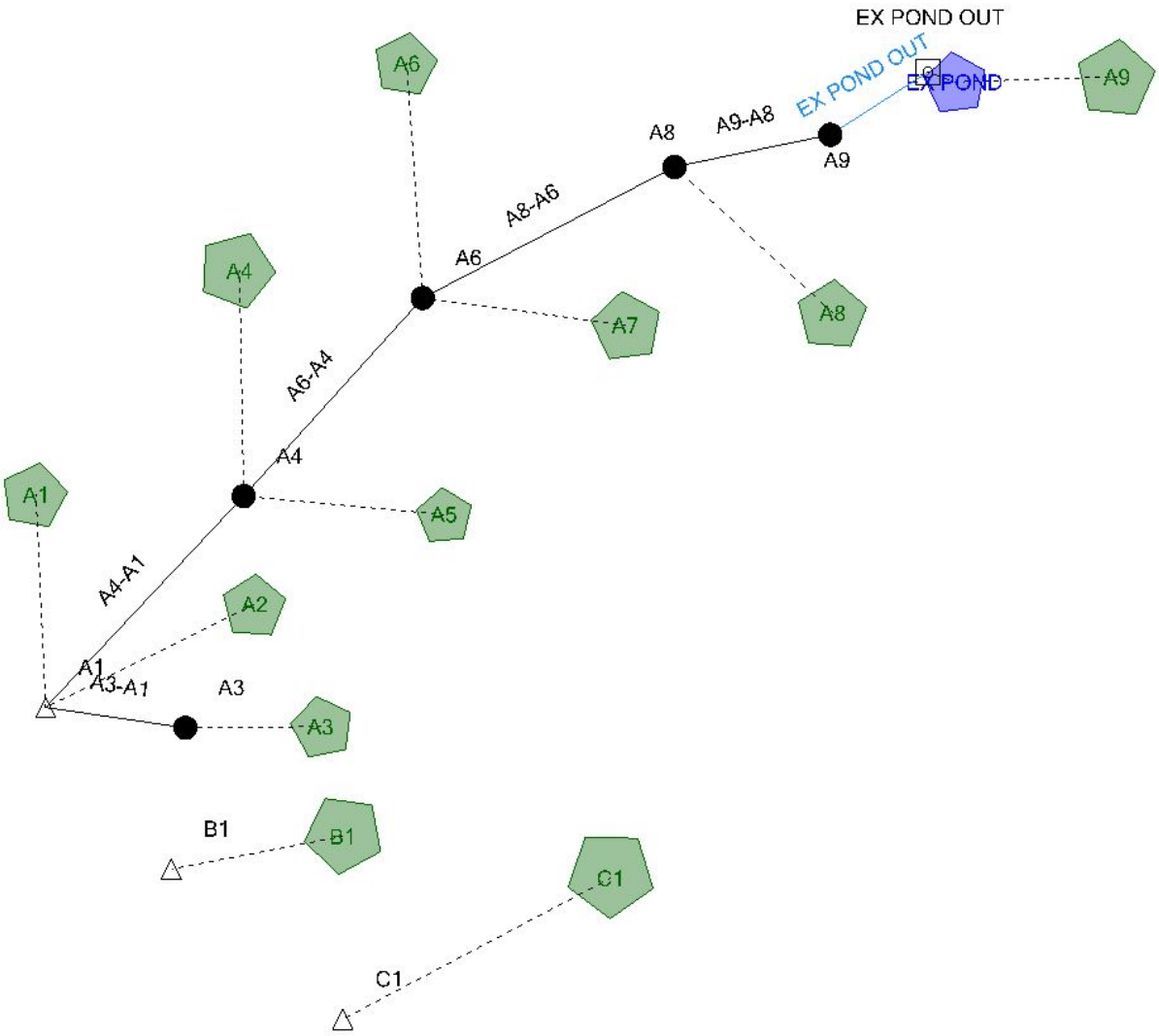
This proposed stormwater management plan was designed to achieve compliance with current design criteria in effect for the City of Lee's Summit, Missouri; however, a waiver is requested for one Point of Interest. A final Macro and First Plat Micro Stormwater Drainage Study will be required with submittal of the First Plat of this development.

The results of the analysis demonstrate that the future stormwater management plan for the project achieves compliance with design criteria or the requested waiver. We therefore request approval of this Woodside Ridge Preliminary Stormwater Drainage Study. This approval is conditional and should be substantiated with each future plat of Woodside Ridge.

APPENDIX A
SITE MAPS

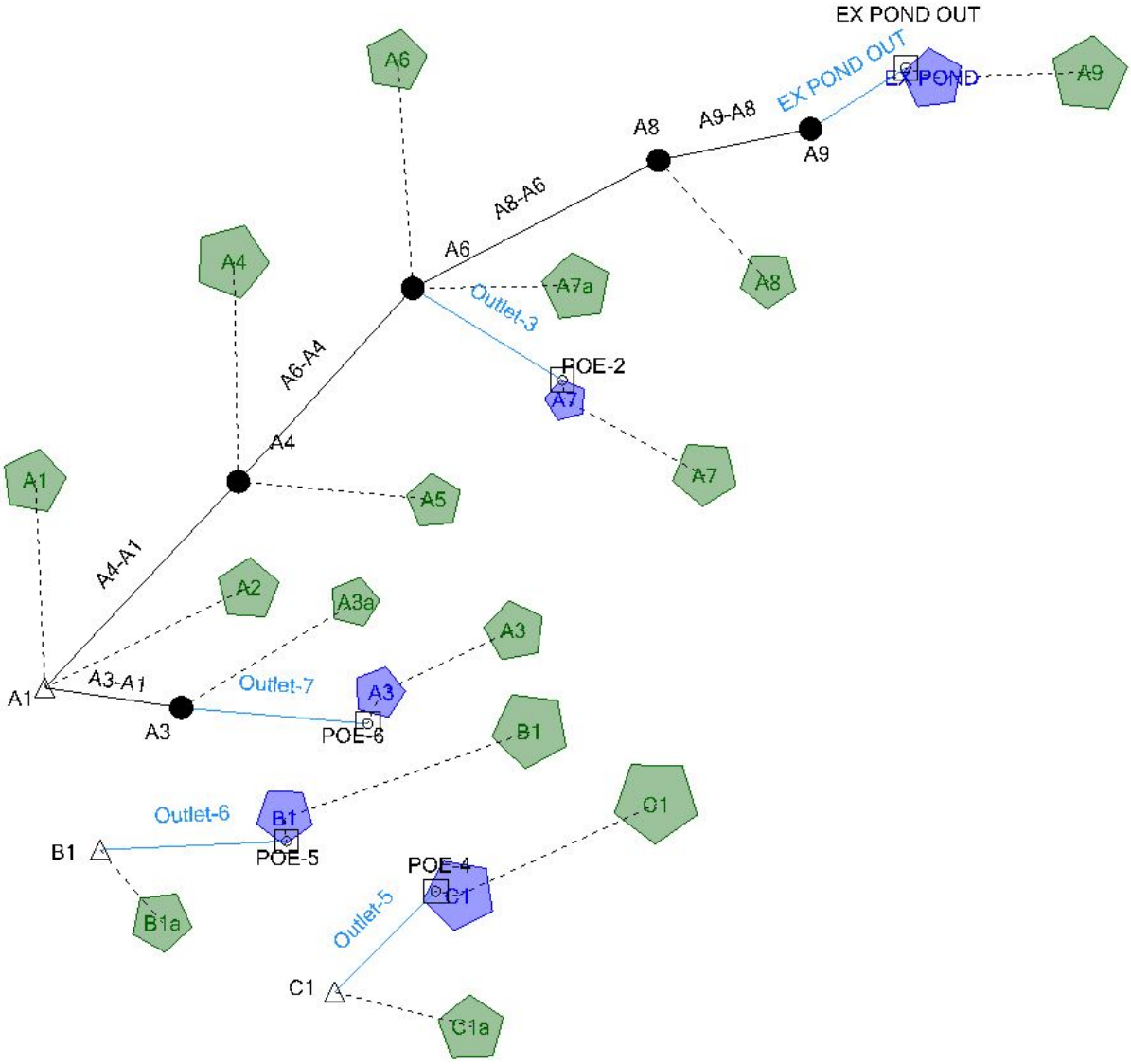
APPENDIX B
EXISTING CONDITIONS PONDPACK MODEL INPUT AND RESULTS

Existing Conditions PondPack Model Schematic



APPENDIX C
FUTURE CONDITIONS PONDPACK MODEL INPUT AND RESULTS

Future Conditions PondPack Model Schematic



APPENDIX D
POINT A1 RELEASE RATE WAIVER REQUEST

APPENDIX A
SITE MAPS

WOODSIDE RIDGE

FLOODPLAIN MAP
EXHIBIT 1

LEGEND

- PROPERTY BOUNDARY
- ZONE AE - 100-YEAR FLOODPLAIN
- FLOODWAY

Source:
FEMA Flood Boundary & Floodway Map
29095C0416G

Effective Date: 01/20/2017

N

0 400 800 Feet

1 ' = 400 "

Drawn: jwitzke 6/20/2018

OLSSON ASSOCIATES

Location: I:\WorkingFolder\Missouri\Woodside Ridge 018-1140\SDS\018-1140 Floodplain Map.mxd

WOODSIDE RIDGE

SOIL MAP

EXHIBIT 2

LEGEND

PROPERTY BOUNDARY

10128
SHARPSBURG-URBAN LAND COMPLEX
2 to 5% SLOPES

10141
SNEAD-ROCK OUTCROP COMPLEX
14 to 30% SLOPES

10142
SNEAD-ROCK OUTCROP COMPLEX
5 to 14% SLOPES

10143
SNEAD-URBAN LAND COMPLEX
9 to 30% SLOPES

Source:
Soil Survey of Jackson County, Missouri

N

0 400 800 Feet

1 ' = 400 "

Drawn: jwitzke 6/20/2018

OLSSON ASSOCIATES

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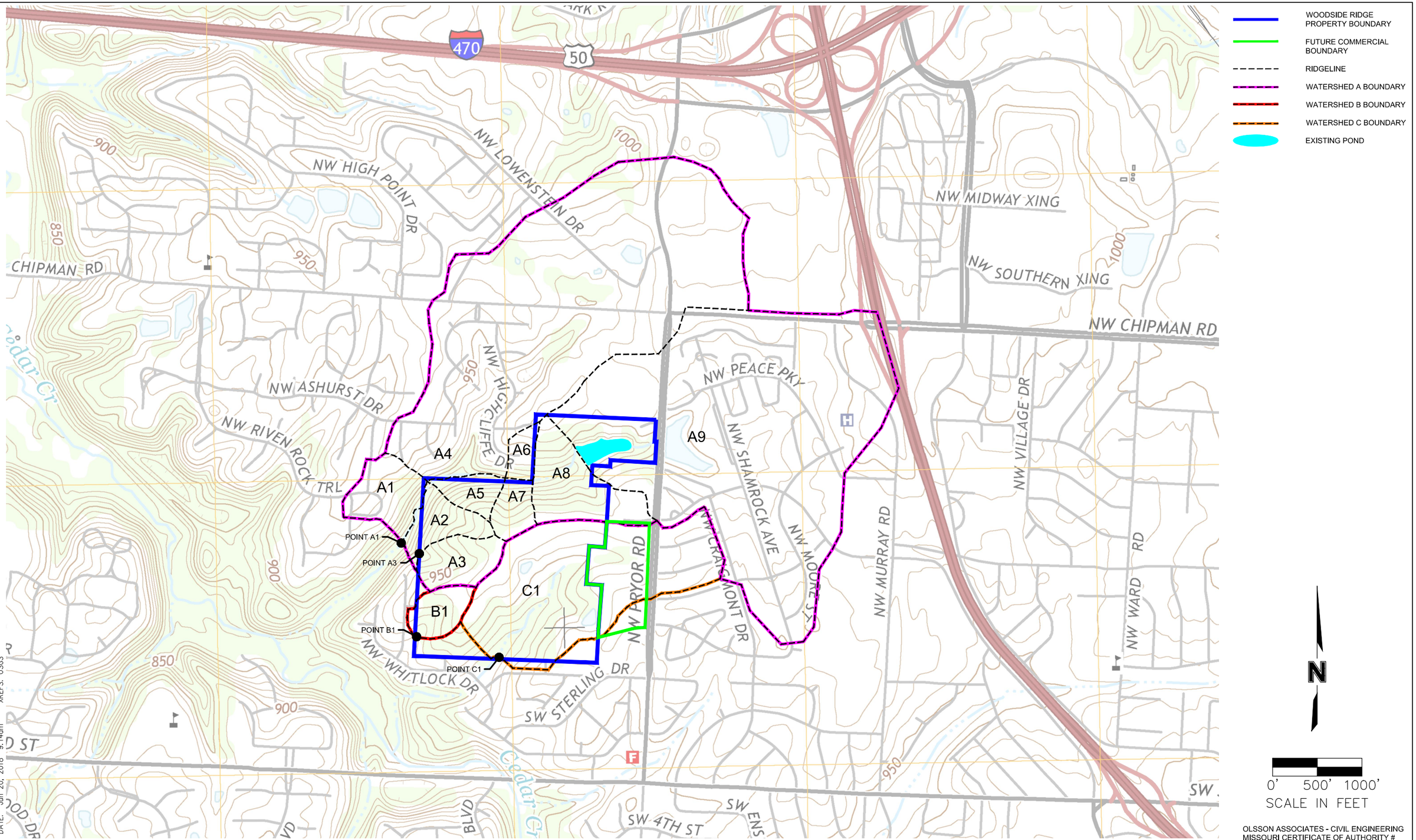
Location: I:\WorkingFolder\Missouri\Woodside Ridge 018-1140\SDS\018-1140 Soils Map.mxd



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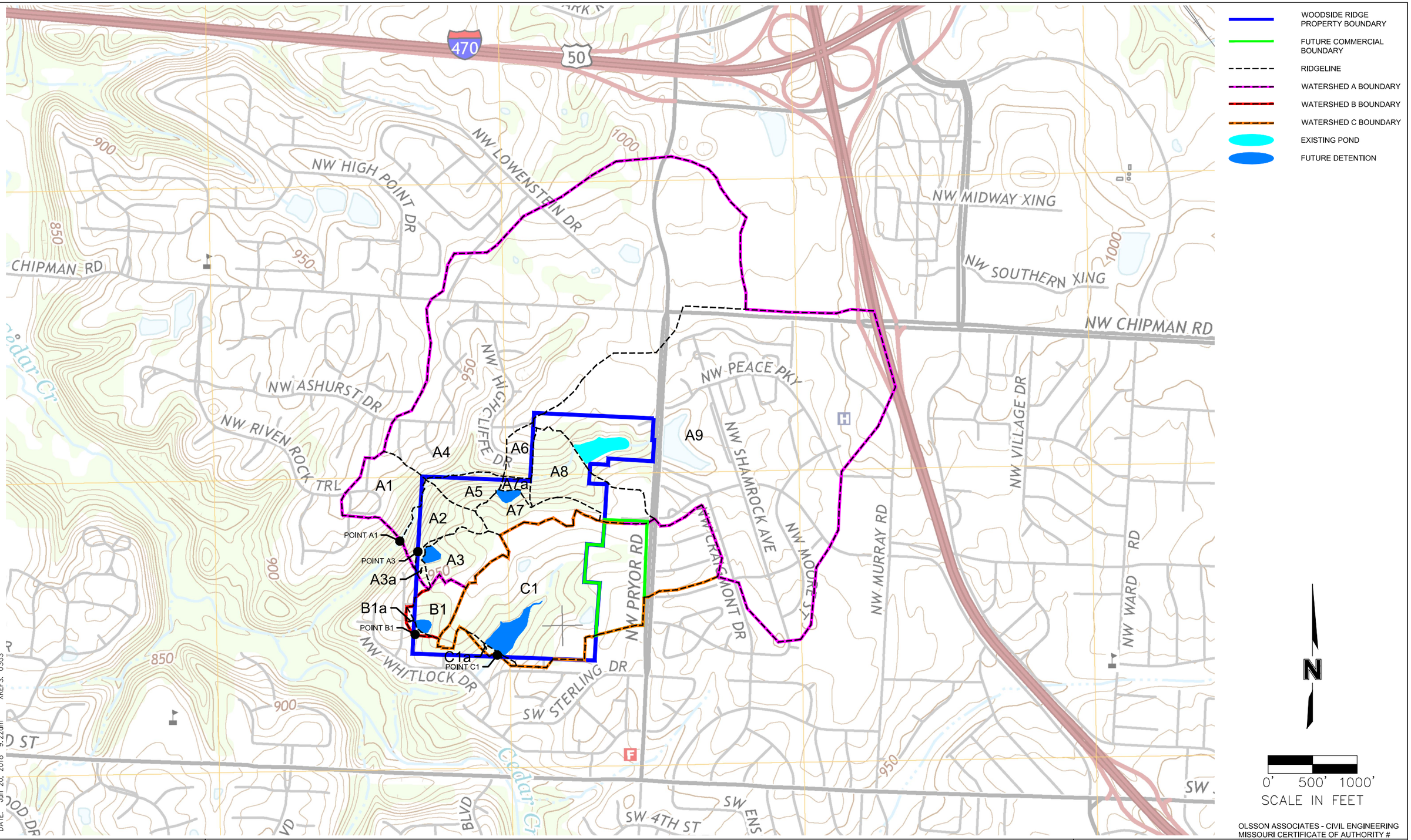
DATE: Jun 20, 2018 9:14am
XREFS: USGS
USER: mdegonia

PROJECT NO: 018-1140	EXISTING CONDITIONS DRAINAGE AREA MAP	OLSSON ASSOCIATES	EXHIBIT
DRAWN BY: MGD		1301 Burlington Street North Kansas City, MO 64116 TEL 816.587.4320 FAX 816.587.1393	3
DATE: 06/20/2018			

OLSSON ASSOCIATES - CIVIL ENGINEERING
MISSOURI CERTIFICATE OF AUTHORITY #



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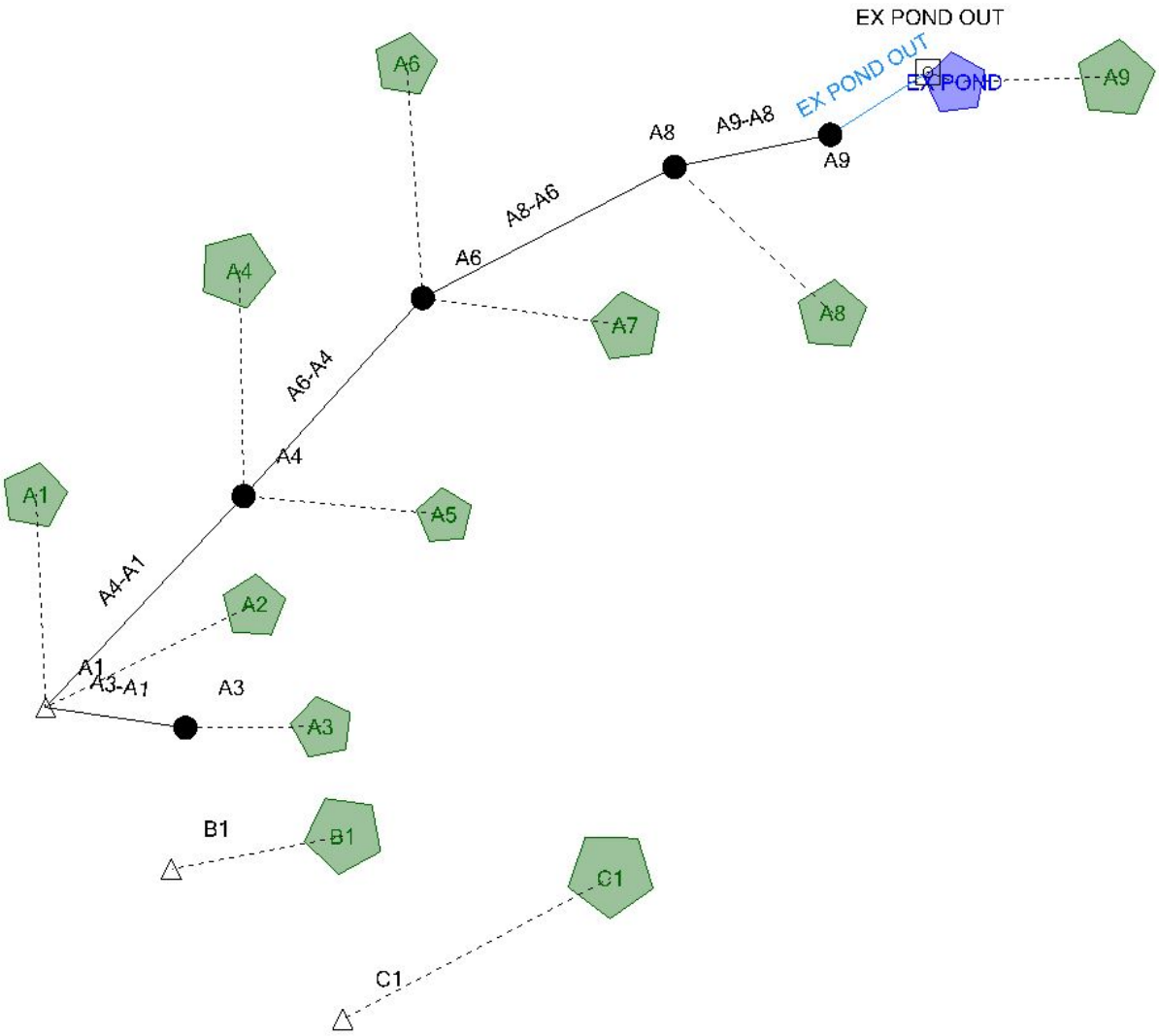
DATE: Jun 20, 2018 9:22am XREFS: USGS

PROJECT NO: 018-1140	FUTURE CONDITIONS DRAINAGE AREA MAP	OLSSON ASSOCIATES - CIVIL ENGINEERING MISSOURI CERTIFICATE OF AUTHORITY #	EXHIBIT
DRAWN BY: MGD		1301 Burlington Street North Kansas City, MO 64116 TEL 816.587.4320 FAX 816.587.1393	4
DATE: 06/20/2018			

APPENDIX B
EXISTING CONDITIONS PONDPACK MODEL INPUT AND RESULTS

Existing Conditions PondPack Model Schematic



Existing Conditions Curve Number Calculations

	Offsite					Onsite								
	80 Open Space (ac.)	85 Park (ac.)	87 SFR (ac.)	92 MFR (ac.)	95 Commercial (ac.)	80 Open Space (ac.)	95 Commercial (ac.)	89 Crop (ac.)	94 Open Graded (ac.)	100 Pond (ac.)	Total Offsite (ac.)	Total Onsite (ac.)	Total (ac.)	Total CN
A1	2.47	0.00	9.97	0.00	0.00	0.13	0.00	0.00	0.00	0.00	12.44	0.135	12.58	86
A2	1.80	0.00	0.00	0.00	0.00	7.42	0.00	0.00	0.00	0.00	1.80	7.420	9.22	80
A3	0.08	0.00	0.00	0.00	0.00	9.70	0.00	0.68	0.00	0.00	0.08	10.382	10.46	81
A4	18.65	25.96	88.37	35.84	8.61	0.05	0.16	0.00	0.00	0.00	177.43	0.216	177.64	87
A5	0.77	0.00	0.00	0.00	0.00	5.02	0.00	0.00	0.00	0.00	0.77	5.021	5.79	80
A6	0.00	0.00	3.55	0.00	0.00	0.27	0.05	0.00	0.00	0.00	3.55	0.324	3.88	87
A7	0.22	0.00	0.00	0.00	0.00	5.00	0.00	0.85	0.00	0.00	0.22	5.854	6.08	81
A8	0.34	0.00	0.00	0.04	3.72	14.11	0.36	1.26	0.00	0.00	4.09	15.728	19.82	84
A9	4.44	0.00	33.55	88.06	50.75	8.08	1.86	0.00	0.00	1.57	176.80	11.508	188.31	91
TOTAL A	28.76	25.96	135.45	123.93	63.08	49.80	2.43	2.79	0.00	1.57	377.18	56.590	433.77	88
B1	0.55	0.00	0.00	0.00	0.00	6.70	0.00	0.00	0.00	0.00	0.55	6.70	7.25	80
TOTAL B	0.55	0.00	0.00	0.00	0.00	6.70	0.00	0.00	0.00	0.00	0.55	6.70	7.25	80
C1	0.00	0.00	14.41	0.02	0.00	40.42	0.00	8.35	7.61	0.00	14.44	56.38	70.82	84
TOTAL C	0.00	0.00	14.41	0.02	0.00	40.42	0.00	8.35	7.61	0.00	14.44	56.38	70.82	84

Existing Conditions

Project Summary	
Title	WOODSIDE RIDGE
Engineer	MGD
Company	Olsson Associates
Date	6/19/2018

Notes

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Existing Conditions

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
A3	2-Year	2	1.556	12.010	24.93
A3	10-Year	10	2.828	12.010	44.87
A3	100-Year	100	4.913	11.990	76.40
B1	2-Year	2	1.035	11.950	18.25
B1	10-Year	10	1.904	11.950	33.51
B1	100-Year	100	3.337	11.940	57.78
C1	2-Year	2	11.895	12.050	172.71
C1	10-Year	10	20.863	12.050	298.47
C1	100-Year	100	35.307	12.050	492.77
A1	2-Year	2	2.289	11.960	38.93
A1	10-Year	10	3.923	11.960	65.59
A1	100-Year	100	6.526	11.960	106.37
A2	2-Year	2	1.316	11.960	22.93
A2	10-Year	10	2.421	11.950	42.16
A2	100-Year	100	4.244	11.950	72.67
A4	2-Year	2	33.541	12.040	493.42
A4	10-Year	10	56.848	12.020	821.84
A4	100-Year	100	93.800	12.020	1,322.87
A5	2-Year	2	0.827	11.950	14.52
A5	10-Year	10	1.520	11.950	26.67
A5	100-Year	100	2.665	11.940	46.04
A6	2-Year	2	0.734	11.950	12.85
A6	10-Year	10	1.243	11.950	21.33
A6	100-Year	100	2.051	11.940	34.29
A7	2-Year	2	0.905	11.970	15.40
A7	10-Year	10	1.645	11.960	27.89
A7	100-Year	100	2.857	11.960	47.57
A8	2-Year	2	3.336	11.930	60.89
A8	10-Year	10	5.850	11.930	105.52
A8	100-Year	100	9.898	11.930	174.45
A9	2-Year	2	41.242	12.030	574.03
A9	10-Year	10	66.882	12.030	909.45
A9	100-Year	100	106.835	12.030	1,415.77

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
A1	2-Year	2	85.316	12.070	932.86
A1	10-Year	10	142.510	12.070	1,582.99
A1	100-Year	100	232.835	12.070	2,595.35
B1	2-Year	2	1.035	11.950	18.25
B1	10-Year	10	1.904	11.950	33.51

Existing Conditions

Subsection: Master Network Summary

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
B1	100-Year	100	3.337	11.940	57.78
C1	2-Year	2	11.895	12.050	172.71
C1	10-Year	10	20.863	12.050	298.47
C1	100-Year	100	35.307	12.050	492.77
A3	2-Year	2	1.556	12.010	24.93
A3	10-Year	10	2.828	12.010	44.87
A3	100-Year	100	4.913	11.990	76.40
A4	2-Year	2	80.180	12.080	872.87
A4	10-Year	10	133.377	12.070	1,475.65
A4	100-Year	100	217.211	12.070	2,411.90
A6	2-Year	2	45.834	12.170	459.50
A6	10-Year	10	75.041	12.150	767.71
A6	100-Year	100	120.794	12.140	1,248.72
A8	2-Year	2	44.202	12.160	451.90
A8	10-Year	10	72.163	12.150	752.98
A8	100-Year	100	115.901	12.130	1,222.28
A9	2-Year	2	40.878	12.150	439.52
A9	10-Year	10	66.332	12.130	731.12
A9	100-Year	100	106.031	12.120	1,183.94

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
EX POND (IN)	2-Year	2	41.242	12.030	574.03	(N/A)	(N/A)
EX POND (OUT)	2-Year	2	40.878	12.150	439.52	931.69	7.551
EX POND (IN)	10-Year	10	66.882	12.030	909.45	(N/A)	(N/A)
EX POND (OUT)	10-Year	10	66.332	12.130	731.12	932.89	10.821
EX POND (IN)	100-Year	100	106.835	12.030	1,415.77	(N/A)	(N/A)
EX POND (OUT)	100-Year	100	106.031	12.120	1,183.94	934.35	15.210

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.050 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.26 ft/s
Segment Time of Concentration	0.107 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.070 ft/ft
Average Velocity	4.27 ft/s
Segment Time of Concentration	0.020 hours

Segment #3: Length and Velocity	
Hydraulic Length	740.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.014 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.140 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.080 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.31 ft/s
Segment Time of Concentration	0.088 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.070 ft/ft
Average Velocity	4.27 ft/s
Segment Time of Concentration	0.020 hours

Segment #3: Length and Velocity	
Hydraulic Length	970.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.018 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.126 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.18 ft/s
Segment Time of Concentration	0.154 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.060 ft/ft
Average Velocity	3.95 ft/s
Segment Time of Concentration	0.021 hours

Segment #3: Length and Velocity	
Hydraulic Length	640.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.012 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.187 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.011
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	1.46 ft/s
Segment Time of Concentration	0.019 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	True
Slope	0.020 ft/ft
Average Velocity	2.87 ft/s
Segment Time of Concentration	0.029 hours

Segment #3: Length and Velocity	
Hydraulic Length	4,750.00 ft
Velocity	7.00 ft/s
Segment Time of Concentration	0.188 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.237 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.080 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.31 ft/s
Segment Time of Concentration	0.088 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.080 ft/ft
Average Velocity	4.56 ft/s
Segment Time of Concentration	0.018 hours

Segment #3: Length and Velocity	
Hydraulic Length	740.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.014 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.120 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.070 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.30 ft/s
Segment Time of Concentration	0.093 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.070 ft/ft
Average Velocity	4.27 ft/s
Segment Time of Concentration	0.020 hours

Segment #3: Length and Velocity	
Hydraulic Length	440.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.008 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.121 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.040 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.24 ft/s
Segment Time of Concentration	0.117 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.080 ft/ft
Average Velocity	4.56 ft/s
Segment Time of Concentration	0.018 hours

Segment #3: Length and Velocity	
Hydraulic Length	330.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.006 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.141 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.011
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	1.46 ft/s
Segment Time of Concentration	0.019 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	260.00 ft
Is Paved?	True
Slope	0.030 ft/ft
Average Velocity	3.52 ft/s
Segment Time of Concentration	0.021 hours

Segment #3: Length and Velocity	
Hydraulic Length	1,010.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.028 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.100 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.030 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.21 ft/s
Segment Time of Concentration	0.131 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.030 ft/ft
Average Velocity	2.79 ft/s
Segment Time of Concentration	0.030 hours

Segment #3: Length and Velocity	
Hydraulic Length	3,570.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.099 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.260 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	50.00 ft
Manning's n	0.150
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.16 ft/s
Segment Time of Concentration	0.088 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.060 ft/ft
Average Velocity	3.95 ft/s
Segment Time of Concentration	0.021 hours

Segment #3: Length and Velocity	
Hydraulic Length	520.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.010 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.119 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.18 ft/s
Segment Time of Concentration	0.154 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	120.00 ft
Is Paved?	False
Slope	0.020 ft/ft
Average Velocity	2.28 ft/s
Segment Time of Concentration	0.015 hours

Segment #3: Length and Velocity	
Hydraulic Length	3,020.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.084 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.252 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Existing Conditions

Subsection: Elevation-Area Volume Curve
Label: EX POND

Return Event: 2 years
Storm Event: 2-YEAR

Elevation (ft)	Planimeter (ft^2)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
928.00	0.0	1.491	0.000	0.000	0.000
930.00	0.0	2.114	5.380	3.587	3.587
932.00	0.0	2.670	7.160	4.773	8.360
934.00	0.0	3.080	8.618	5.745	14.105
936.00	0.0	3.544	9.928	6.619	20.724

Requested Pond Water Surface Elevations	
Minimum (Headwater)	928.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	936.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Irregular Weir	Weir - 1	Forward	TW	928.00	936.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: Weir - 1
Structure Type: Irregular Weir

Station (ft)	Elevation (ft)
0.00	936.00
4.10	934.00
7.70	932.00
12.70	930.00
19.70	928.00
36.00	928.00
39.80	930.00
42.70	932.00
46.30	934.00
50.20	936.00

Lowest Elevation	928.00 ft
Weir Coefficient	2.60 (ft^0.5)/s

Structure ID: TW
Structure Type: TW Setup, DS Channel

Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

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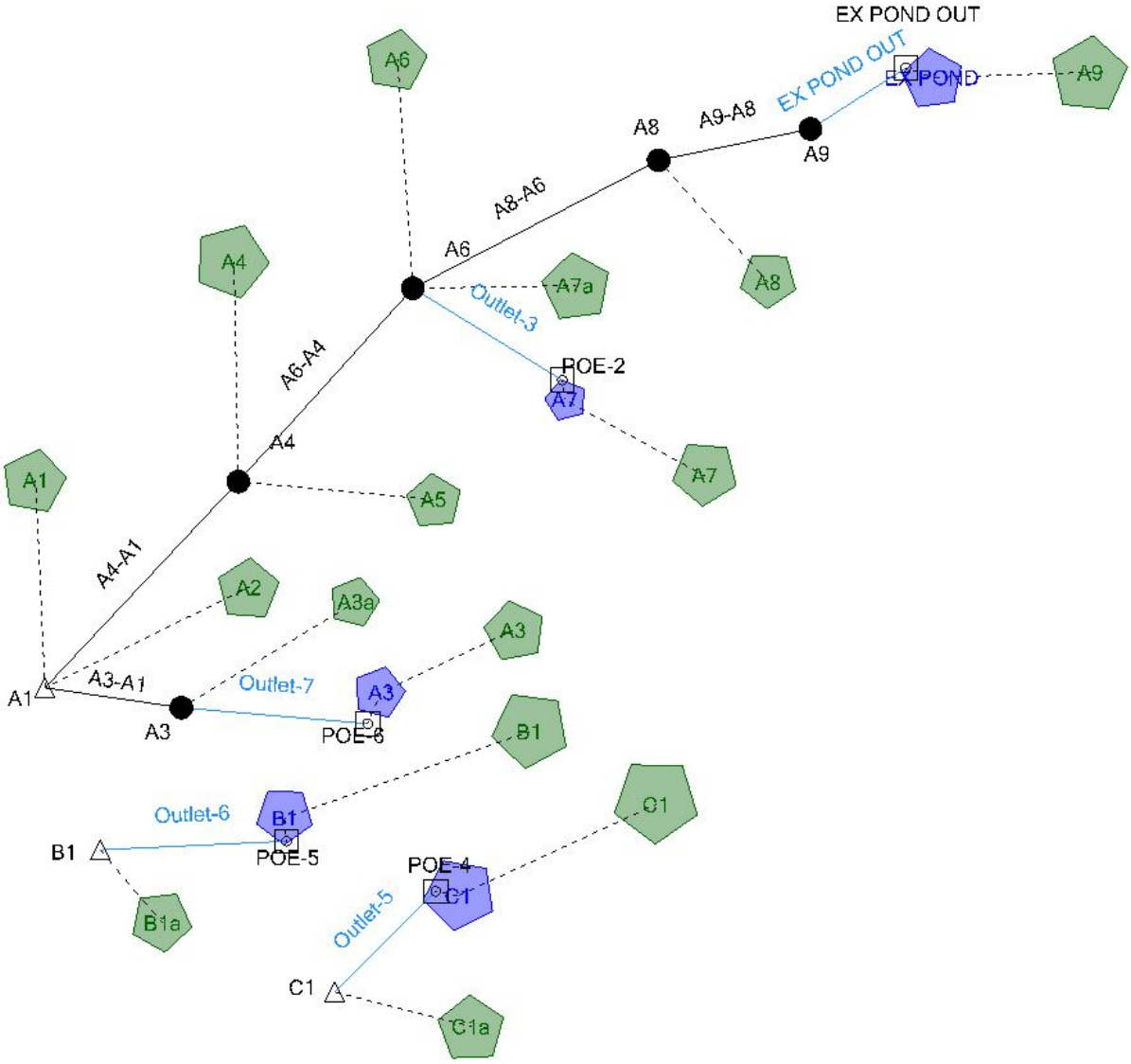
APPENDIX C
FUTURE CONDITIONS PONDPACK MODEL INPUT AND RESULTS

Future Conditions PondPack Model Schematic



Future Conditions Curve Number Calculations

	Offsite					Onsite									
	80 Open Space (ac.)	85 Park (ac.)	87 SFR (ac.)	92 MFR (ac.)	95 Commercial (ac.)	80 Open Space (ac.)	95 Commercial (ac.)	87 SFR (ac.)	89 Crop (ac.)	94 Open Graded (ac.)	100 Pond (ac.)	Total Offsite (ac.)	Total Onsite (ac.)	Total (ac.)	Weighted CN
A1	2.47	0.00	9.97	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	12.44	0.13	12.58	86
A2	1.80	0.00	0.00	0.00	0.00	4.74	0.00	1.96	0.00	0.00	0.00	1.80	6.69	8.49	82
A3	0.00	0.00	0.00	0.00	0.00	1.95	0.00	7.41	0.00	0.00	0.00	0.00	9.36	9.36	86
A3a	0.08	0.00	0.00	0.00	0.00	0.77	0.00	0.20	0.00	0.00	0.00	0.08	0.97	1.05	81
A4	18.65	25.96	88.37	35.84	8.61	0.05	0.00	0.07	0.00	0.00	0.00	177.43	0.12	177.55	87
A5	0.77	0.00	0.00	0.00	0.00	3.56	0.00	0.86	0.00	0.00	0.00	0.77	4.42	5.19	81
A6	0.00	0.00	3.55	0.00	0.00	0.07	0.00	0.18	0.00	0.00	0.00	3.55	0.25	3.80	87
A7	0.00	0.00	0.00	0.00	0.00	1.01	0.00	7.50	0.00	0.00	0.00	0.00	8.52	8.52	86
A7a	0.22	0.00	0.00	0.00	0.00	0.96	0.00	0.15	0.00	0.00	0.00	0.22	1.12	1.34	81
A8	0.34	0.00	0.00	0.04	3.72	5.28	0.34	6.24	0.00	0.00	0.00	4.09	11.86	15.95	87
A9	4.44	0.00	33.55	88.06	50.76	4.55	0.00	6.15	0.00	0.00	1.57	176.80	12.27	189.07	91
TOTAL A	28.76	25.96	135.45	123.93	63.08	23.09	0.34	30.72	0.00	0.00	1.57	377.18	55.71	432.89	89
B1	0.00	0.00	0.19	0.00	0.00	1.26	0.00	4.58	0.00	0.00	0.00	0.19	5.84	6.03	86
B1a	0.00	0.00	0.36	0.00	0.00	0.01	0.00	0.22	0.00	0.00	0.00	0.36	0.24	0.60	87
TOTAL B	0.00	0.00	0.55	0.00	0.00	1.27	0.00	4.81	0.00	0.00	0.00	0.55	6.08	6.63	86
C1	0.00	0.00	14.24	0.02	0.00	10.90	16.29	34.55	0.00	0.00	0.00	14.27	61.74	76.01	88
C1a	0.00	0.00	0.17	0.00	0.00	0.58	0.00	0.02	0.00	0.00	0.00	0.17	0.60	0.78	82
TOTAL C	0.00	0.00	14.41	0.02	0.00	11.49	16.29	34.57	0.00	0.00	0.00	14.44	62.35	76.78	88

Future Conditions

Project Summary	
Title	WOODSIDE RIDGE
Engineer	MGD
Company	Olsson Associates
Date	6/19/2018

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Future Conditions

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)
A3	2-Year	2	1.704	11.930	31.00
A3	10-Year	10	2.920	11.930	52.24
A3	100-Year	100	4.858	11.930	84.71
B1	2-Year	2	1.098	11.930	19.97
B1	10-Year	10	1.881	11.930	33.65
B1	100-Year	100	3.129	11.930	54.58
C1	2-Year	2	14.903	12.050	213.77
C1	10-Year	10	24.978	12.050	350.15
C1	100-Year	100	40.877	12.020	557.91
A1	2-Year	2	2.289	11.960	38.93
A1	10-Year	10	3.923	11.960	65.59
A1	100-Year	100	6.526	11.960	106.37
A2	2-Year	2	1.318	11.950	22.99
A2	10-Year	10	2.366	11.950	41.02
A2	100-Year	100	4.073	11.950	69.21
A4	2-Year	2	33.524	12.040	493.17
A4	10-Year	10	56.819	12.020	821.42
A4	100-Year	100	93.753	12.020	1,322.20
A5	2-Year	2	0.773	11.950	13.59
A5	10-Year	10	1.404	11.940	24.58
A5	100-Year	100	2.439	11.940	42.00
A6	2-Year	2	0.719	11.950	12.58
A6	10-Year	10	1.218	11.950	20.89
A6	100-Year	100	2.009	11.940	33.59
A7a	2-Year	2	0.200	11.940	3.64
A7a	10-Year	10	0.363	11.930	6.60
A7a	100-Year	100	0.630	11.930	11.25
A9	2-Year	2	41.409	12.030	576.35
A9	10-Year	10	67.152	12.030	913.12
A9	100-Year	100	107.266	12.030	1,421.48
A7	2-Year	2	1.550	11.960	26.30
A7	10-Year	10	2.657	11.950	44.34
A7	100-Year	100	4.420	11.950	72.07
A8	2-Year	2	3.015	11.960	51.45
A8	10-Year	10	5.110	11.960	85.44
A8	100-Year	100	8.431	11.950	137.36
C1a	2-Year	2	0.121	11.930	2.21
C1a	10-Year	10	0.217	11.930	3.94
C1a	100-Year	100	0.374	11.930	6.66
B1a	2-Year	2	0.113	11.930	2.06
B1a	10-Year	10	0.192	11.930	3.42
B1a	100-Year	100	0.317	11.930	5.50
A3a	2-Year	2	0.156	11.950	2.75

Future Conditions

Subsection: Master Network Summary

Catchments Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
A3a	10-Year	10	0.284	11.940	4.98
A3a	100-Year	100	0.494	11.940	8.51

Node Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)
A1	2-Year	2	84.979	12.090	898.31
A1	10-Year	10	141.743	12.080	1,528.00
A1	100-Year	100	231.808	12.070	2,519.41
B1	2-Year	2	1.180	11.960	4.12
B1	10-Year	10	2.025	12.070	12.84
B1	100-Year	100	3.374	12.010	24.28
C1	2-Year	2	15.019	12.390	46.15
C1	10-Year	10	25.188	12.300	113.16
C1	100-Year	100	41.238	12.230	248.17
A3	2-Year	2	1.326	11.960	3.70
A3	10-Year	10	2.445	12.080	16.54
A3	100-Year	100	4.408	12.020	31.34
A4	2-Year	2	80.074	12.080	861.39
A4	10-Year	10	133.050	12.080	1,450.58
A4	100-Year	100	216.861	12.070	2,384.20
A6	2-Year	2	45.799	12.160	460.95
A6	10-Year	10	74.859	12.150	774.34
A6	100-Year	100	120.717	12.140	1,268.14
A8	2-Year	2	44.046	12.160	456.47
A8	10-Year	10	71.691	12.140	761.16
A8	100-Year	100	114.863	12.130	1,236.52
A9	2-Year	2	41.043	12.140	441.47
A9	10-Year	10	66.599	12.130	734.30
A9	100-Year	100	106.460	12.120	1,189.06

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft³/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
EX POND (IN)	2-Year	2	41.409	12.030	576.35	(N/A)	(N/A)
EX POND (OUT)	2-Year	2	41.043	12.140	441.47	931.70	7.574

Future Conditions

Subsection: Master Network Summary

Pond Summary

Label	Scenario	Return Event (years)	Hydrograph Volume (ac-ft)	Time to Peak (hours)	Peak Flow (ft^3/s)	Maximum Water Surface Elevation (ft)	Maximum Pond Storage (ac-ft)
EX POND (IN)	10-Year	10	67.152	12.030	913.12	(N/A)	(N/A)
EX POND (OUT)	10-Year	10	66.599	12.130	734.30	932.90	10.855
EX POND (IN)	100-Year	100	107.266	12.030	1,421.48	(N/A)	(N/A)
EX POND (OUT)	100-Year	100	106.460	12.120	1,189.06	934.37	15.257
A7 (IN)	2-Year	2	1.550	11.960	26.30	(N/A)	(N/A)
A7 (OUT)	2-Year	2	0.841	14.880	0.84	934.18	0.970
A7 (IN)	10-Year	10	2.657	11.950	44.34	(N/A)	(N/A)
A7 (OUT)	10-Year	10	1.598	12.270	7.52	935.45	1.388
A7 (IN)	100-Year	100	4.420	11.950	72.07	(N/A)	(N/A)
A7 (OUT)	100-Year	100	3.230	12.170	19.89	937.26	2.096
C1 (IN)	2-Year	2	14.903	12.050	213.77	(N/A)	(N/A)
C1 (OUT)	2-Year	2	14.898	12.410	45.88	921.21	4.835
C1 (IN)	10-Year	10	24.978	12.050	350.15	(N/A)	(N/A)
C1 (OUT)	10-Year	10	24.970	12.300	112.63	923.33	8.193
C1 (IN)	100-Year	100	40.877	12.020	557.91	(N/A)	(N/A)
C1 (OUT)	100-Year	100	40.864	12.230	247.19	925.38	12.477
B1 (IN)	2-Year	2	1.098	11.930	19.97	(N/A)	(N/A)
B1 (OUT)	2-Year	2	1.067	12.330	2.62	922.76	0.485
B1 (IN)	10-Year	10	1.881	11.930	33.65	(N/A)	(N/A)
B1 (OUT)	10-Year	10	1.833	12.100	11.43	924.08	0.781
B1 (IN)	100-Year	100	3.129	11.930	54.58	(N/A)	(N/A)
B1 (OUT)	100-Year	100	3.057	12.090	20.26	925.58	1.176
A3 (IN)	2-Year	2	1.704	11.930	31.00	(N/A)	(N/A)
A3 (OUT)	2-Year	2	1.169	13.800	1.23	923.73	1.000
A3 (IN)	10-Year	10	2.920	11.930	52.24	(N/A)	(N/A)
A3 (OUT)	10-Year	10	2.161	12.120	14.18	924.88	1.398
A3 (IN)	100-Year	100	4.858	11.930	84.71	(N/A)	(N/A)
A3 (OUT)	100-Year	100	3.915	12.110	24.64	926.87	2.197

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.050 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.26 ft/s
Segment Time of Concentration	0.107 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.070 ft/ft
Average Velocity	4.27 ft/s
Segment Time of Concentration	0.020 hours

Segment #3: Length and Velocity	
Hydraulic Length	740.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.014 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.140 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: A2

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.080 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.31 ft/s
Segment Time of Concentration	0.088 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.070 ft/ft
Average Velocity	4.27 ft/s
Segment Time of Concentration	0.020 hours

Segment #3: Length and Velocity	
Hydraulic Length	970.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.018 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.126 hours

Future Conditions

Subsection: Time of Concentration Calculations
Label: A2

Return Event: 2 years
Storm Event: 2-YEAR

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: A3

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	25.00 ft
Manning's n	0.150
Slope	0.030 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.16 ft/s
Segment Time of Concentration	0.043 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	90.00 ft
Is Paved?	True
Slope	0.020 ft/ft
Average Velocity	2.87 ft/s
Segment Time of Concentration	0.009 hours

Segment #3: Length and Velocity	
Hydraulic Length	880.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.016 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.100 hours

Future Conditions

Subsection: Time of Concentration Calculations | Return Event: 2 years
Label: A3 | Storm Event: 2-YEAR

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.050 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.26 ft/s
Segment Time of Concentration	0.107 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.150 ft/ft
Average Velocity	6.25 ft/s
Segment Time of Concentration	0.013 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.120 hours

==== SCS Channel Flow

Tc =

R = Qa / Wp
V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

(Lf / V) / 3600

Where:

R= Hydraulic radius
Aq= Flow area, square feet
Wp= Wetted perimeter, feet
V= Velocity, ft/sec
Sf= Slope, ft/ft
n= Manning's n
Tc= Time of concentration, hours
Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =

Unpaved surface:
V = 16.1345 * (Sf**0.5)

Paved Surface:
V = 20.3282 * (Sf**0.5)

(Lf / V) / 3600

Where:

V= Velocity, ft/sec
Sf= Slope, ft/ft
Tc= Time of concentration, hours
Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.011
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	1.46 ft/s
Segment Time of Concentration	0.019 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	True
Slope	0.020 ft/ft
Average Velocity	2.87 ft/s
Segment Time of Concentration	0.029 hours

Segment #3: Length and Velocity	
Hydraulic Length	4,750.00 ft
Velocity	7.00 ft/s
Segment Time of Concentration	0.188 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.237 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.080 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.31 ft/s
Segment Time of Concentration	0.088 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.080 ft/ft
Average Velocity	4.56 ft/s
Segment Time of Concentration	0.018 hours

Segment #3: Length and Velocity	
Hydraulic Length	740.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.014 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.120 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: A6

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.070 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.30 ft/s
Segment Time of Concentration	0.093 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.070 ft/ft
Average Velocity	4.27 ft/s
Segment Time of Concentration	0.020 hours

Segment #3: Length and Velocity	
Hydraulic Length	440.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.008 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.121 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	65.00 ft
Manning's n	0.150
Slope	0.030 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.19 ft/s
Segment Time of Concentration	0.093 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	True
Slope	0.030 ft/ft
Average Velocity	3.52 ft/s
Segment Time of Concentration	0.024 hours

Segment #3: Length and Velocity	
Hydraulic Length	850.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.024 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.140 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: A7a

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.120 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.37 ft/s
Segment Time of Concentration	0.075 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	220.00 ft
Is Paved?	False
Slope	0.180 ft/ft
Average Velocity	6.85 ft/s
Segment Time of Concentration	0.009 hours

Segment #3: Length and Velocity	
Hydraulic Length	220.00 ft
Velocity	7.00 ft/s
Segment Time of Concentration	0.009 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.100 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.060 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.28 ft/s
Segment Time of Concentration	0.099 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	220.00 ft
Is Paved?	True
Slope	0.080 ft/ft
Average Velocity	5.75 ft/s
Segment Time of Concentration	0.011 hours

Segment #3: Length and Velocity	
Hydraulic Length	930.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.026 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.136 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: A9

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.030 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.21 ft/s
Segment Time of Concentration	0.131 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.030 ft/ft
Average Velocity	2.79 ft/s
Segment Time of Concentration	0.030 hours

Segment #3: Length and Velocity	
Hydraulic Length	3,570.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.099 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.260 hours

Future Conditions

Subsection: Time of Concentration Calculations | Return Event: 2 years
Label: A9 | Storm Event: 2-YEAR

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.120 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.37 ft/s
Segment Time of Concentration	0.075 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	90.00 ft
Is Paved?	False
Slope	0.080 ft/ft
Average Velocity	4.56 ft/s
Segment Time of Concentration	0.005 hours

Segment #3: Length and Velocity	
Hydraulic Length	550.00 ft
Velocity	15.00 ft/s
Segment Time of Concentration	0.010 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.100 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: B1a

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.120 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.37 ft/s
Segment Time of Concentration	0.075 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	190.00 ft
Is Paved?	False
Slope	0.120 ft/ft
Average Velocity	5.59 ft/s
Segment Time of Concentration	0.009 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.100 hours

==== SCS Channel Flow

Tc = R = Qa / Wp
V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

(Lf / V) / 3600

Where:
R= Hydraulic radius
Aq= Flow area, square feet
Wp= Wetted perimeter, feet
V= Velocity, ft/sec
Sf= Slope, ft/ft
n= Manning's n
Tc= Time of concentration, hours
Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc = Unpaved surface:
V = 16.1345 * (Sf**0.5)

Paved Surface:
V = 20.3282 * (Sf**0.5)

(Lf / V) / 3600

Where:
V= Velocity, ft/sec
Sf= Slope, ft/ft
Tc= Time of concentration, hours
Lf= Flow length, feet

Future Conditions

Subsection: Time of Concentration Calculations
Label: C1

Return Event: 2 years
Storm Event: 2-YEAR

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.020 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.18 ft/s
Segment Time of Concentration	0.154 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	120.00 ft
Is Paved?	False
Slope	0.020 ft/ft
Average Velocity	2.28 ft/s
Segment Time of Concentration	0.015 hours

Segment #3: Length and Velocity	
Hydraulic Length	3,020.00 ft
Velocity	10.00 ft/s
Segment Time of Concentration	0.084 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.252 hours

==== User Defined Length & Velocity

Tc =	(Lf / V) / 3600
Where:	Tc= Time of concentration, hours Lf= Flow length, feet V= Velocity, ft/sec

==== SCS Channel Flow

Tc =	R = Qa / Wp V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n (Lf / V) / 3600
Where:	R= Hydraulic radius Aq= Flow area, square feet Wp= Wetted perimeter, feet V= Velocity, ft/sec Sf= Slope, ft/ft n= Manning's n Tc= Time of concentration, hours Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =	Unpaved surface: V = 16.1345 * (Sf**0.5) Paved Surface: V = 20.3282 * (Sf**0.5) (Lf / V) / 3600
Where:	V= Velocity, ft/sec Sf= Slope, ft/ft Tc= Time of concentration, hours Lf= Flow length, feet

Time of Concentration Results

Segment #1: TR-55 Sheet Flow	
Hydraulic Length	100.00 ft
Manning's n	0.150
Slope	0.120 ft/ft
2 Year 24 Hour Depth	3.6 in
Average Velocity	0.37 ft/s
Segment Time of Concentration	0.075 hours

Segment #2: TR-55 Shallow Concentrated Flow	
Hydraulic Length	300.00 ft
Is Paved?	False
Slope	0.120 ft/ft
Average Velocity	5.59 ft/s
Segment Time of Concentration	0.015 hours

Time of Concentration (Composite)	
Time of Concentration (Composite)	0.100 hours

==== SCS Channel Flow

Tc =

R = Qa / Wp
V = (1.49 * (R**(2/3)) * (Sf**-0.5)) / n

(Lf / V) / 3600

Where:

R= Hydraulic radius
Aq= Flow area, square feet
Wp= Wetted perimeter, feet
V= Velocity, ft/sec
Sf= Slope, ft/ft
n= Manning's n
Tc= Time of concentration, hours
Lf= Flow length, feet

==== SCS TR-55 Shallow Concentration Flow

Tc =

Unpaved surface:
V = 16.1345 * (Sf**0.5)

Paved Surface:
V = 20.3282 * (Sf**0.5)

(Lf / V) / 3600

Where:

V= Velocity, ft/sec
Sf= Slope, ft/ft
Tc= Time of concentration, hours
Lf= Flow length, feet

Future Conditions

Subsection: Elevation-Area Volume Curve
Label: A3

Return Event: 2 years
Storm Event: 2-YEAR

Elevation (ft)	Planimeter (ft^2)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
920.00	0.0	0.213	0.000	0.000	0.000
930.00	0.0	0.571	1.133	3.776	3.776

Future Conditions

Subsection: Elevation-Area Volume Curve
Label: A7

Return Event: 2 years
Storm Event: 2-YEAR

Elevation (ft)	Planimeter (ft^2)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
930.00	0.0	0.167	0.000	0.000	0.000
940.00	0.0	0.562	1.035	3.451	3.451

Future Conditions

Subsection: Elevation-Area Volume Curve
Label: B1

Return Event: 2 years
Storm Event: 2-YEAR

Elevation (ft)	Planimeter (ft^2)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
920.00	0.0	0.145	0.000	0.000	0.000
930.00	0.0	0.427	0.821	2.736	2.736

Future Conditions

Subsection: Elevation-Area Volume Curve
Label: C1

Return Event: 2 years
Storm Event: 2-YEAR

Elevation (ft)	Planimeter (ft^2)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
910.00	0.0	0.002	0.000	0.000	0.000
912.00	0.0	0.043	0.054	0.036	0.036
914.00	0.0	0.157	0.282	0.188	0.224
916.00	0.0	0.367	0.764	0.509	0.734
918.00	0.0	0.647	1.501	1.001	1.735
920.00	0.0	1.044	2.513	1.675	3.410
922.00	0.0	1.520	3.824	2.549	5.959
924.00	0.0	1.999	5.262	3.508	9.467
926.00	0.0	2.536	6.787	4.524	13.991

Future Conditions

Subsection: Elevation-Area Volume Curve
Label: EX POND

Return Event: 2 years
Storm Event: 2-YEAR

Elevation (ft)	Planimeter (ft^2)	Area (acres)	A1+A2+sqr(A1*A2) (acres)	Volume (ac-ft)	Volume (Total) (ac-ft)
928.00	0.0	1.491	0.000	0.000	0.000
930.00	0.0	2.114	5.380	3.587	3.587
932.00	0.0	2.670	7.160	4.773	8.360
934.00	0.0	3.080	8.618	5.745	14.105
936.00	0.0	3.544	9.928	6.619	20.724

Requested Pond Water Surface Elevations	
Minimum (Headwater)	920.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	930.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Orifice-Circular	Orifice - 1	Forward	Culvert - 1	920.00	930.00
Orifice-Area	Orifice - 2	Forward	Culvert - 1	924.00	930.00
Culvert-Circular	Culvert - 1	Forward	TW	914.00	930.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	18.0 in
Length	110.00 ft
Length (Computed Barrel)	110.02 ft
Slope (Computed)	0.018 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.500
Kb	0.018
Kr	1.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0078
M	2.0000
C	0.0379
Y	0.6900
T1 ratio (HW/D)	1.127
T2 ratio (HW/D)	1.287
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	915.69 ft	T1 Flow	7.58 ft³/s
T2 Elevation	915.93 ft	T2 Flow	8.66 ft³/s

Structure ID: Orifice - 1 Structure Type: Orifice-Circular	
Number of Openings	1
Elevation	920.00 ft
Orifice Diameter	5.0 in
Orifice Coefficient	0.600

Structure ID: Orifice - 2 Structure Type: Orifice-Area	
Number of Openings	1
Elevation	924.00 ft
Orifice Area	3.0 ft²
Top Elevation	925.00 ft
Datum Elevation	924.00 ft
Orifice Coefficient	0.600

Structure ID: TW Structure Type: TW Setup, DS Channel	
Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

Future Conditions

Subsection: Outlet Input Data
Label: Basin A7

Return Event: 2 years
Storm Event: 2-YEAR

Requested Pond Water Surface Elevations	
Minimum (Headwater)	930.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	940.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Orifice-Circular	Orifice - 1	Forward	Culvert - 1	930.00	940.00
Orifice-Area	Orifice - 2	Forward	Culvert - 1	935.00	940.00
Culvert-Circular	Culvert - 1	Forward	TW	928.00	940.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Future Conditions

Subsection: Outlet Input Data
Label: Basin A7

Return Event: 2 years
Storm Event: 2-YEAR

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	18.0 in
Length	140.00 ft
Length (Computed Barrel)	140.01 ft
Slope (Computed)	0.014 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.500
Kb	0.018
Kr	0.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0078
M	2.0000
C	0.0379
Y	0.6900
T1 ratio (HW/D)	1.129
T2 ratio (HW/D)	1.289
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	929.69 ft	T1 Flow	7.58 ft³/s
T2 Elevation	929.93 ft	T2 Flow	8.66 ft³/s

Structure ID: Orifice - 1 Structure Type: Orifice-Circular	
Number of Openings	1
Elevation	930.00 ft
Orifice Diameter	4.0 in
Orifice Coefficient	0.600

Structure ID: Orifice - 2 Structure Type: Orifice-Area	
Number of Openings	1
Elevation	935.00 ft
Orifice Area	3.0 ft²
Top Elevation	936.00 ft
Datum Elevation	935.00 ft
Orifice Coefficient	0.600

Structure ID: TW Structure Type: TW Setup, DS Channel	
Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

Requested Pond Water Surface Elevations	
Minimum (Headwater)	920.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	930.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Orifice-Circular	Orifice - 1	Forward	Culvert - 1	920.00	930.00
Orifice-Area	Orifice - 2	Forward	Culvert - 1	923.50	930.00
Culvert-Circular	Culvert - 1	Forward	TW	918.00	930.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Future Conditions

Subsection: Outlet Input Data
Label: Basin B1

Return Event: 2 years
Storm Event: 2-YEAR

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	18.0 in
Length	85.00 ft
Length (Computed Barrel)	85.02 ft
Slope (Computed)	0.024 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.500
Kb	0.018
Kr	1.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0078
M	2.0000
C	0.0379
Y	0.6900
T1 ratio (HW/D)	1.124
T2 ratio (HW/D)	1.285
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	919.69 ft	T1 Flow	7.58 ft³/s
T2 Elevation	919.93 ft	T2 Flow	8.66 ft³/s

Structure ID: Orifice - 1 Structure Type: Orifice-Circular	
Number of Openings	1
Elevation	920.00 ft
Orifice Diameter	8.0 in
Orifice Coefficient	0.600

Structure ID: Orifice - 2 Structure Type: Orifice-Area	
Number of Openings	1
Elevation	923.50 ft
Orifice Area	3.0 ft²
Top Elevation	924.50 ft
Datum Elevation	923.50 ft
Orifice Coefficient	0.600

Structure ID: TW Structure Type: TW Setup, DS Channel	
Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

Requested Pond Water Surface Elevations	
Minimum (Headwater)	910.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	926.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Orifice-Area	Orifice - 3	Forward	Culvert - 1	922.25	926.00
Inlet Box	Riser - 1	Forward	Culvert - 1	924.00	926.00
Orifice-Circular	Orifice - 1	Forward	Culvert - 1	910.00	926.00
Culvert-Circular	Culvert - 1	Forward	TW	909.00	926.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	48.0 in
Length	110.00 ft
Length (Computed Barrel)	110.00 ft
Slope (Computed)	0.009 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.200
Kb	0.005
Kr	1.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0045
M	2.0000
C	0.0317
Y	0.6900
T1 ratio (HW/D)	1.091
T2 ratio (HW/D)	1.193
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	913.36 ft	T1 Flow	87.96 ft³/s
T2 Elevation	913.77 ft	T2 Flow	100.53 ft³/s

Structure ID: Orifice - 1 Structure Type: Orifice-Circular	
Number of Openings	1
Elevation	910.00 ft
Orifice Diameter	24.0 in
Orifice Coefficient	0.600

Structure ID: Riser - 1 Structure Type: Inlet Box	
Number of Openings	1
Elevation	924.00 ft
Orifice Area	64.0 ft²
Orifice Coefficient	0.600
Weir Length	32.00 ft
Weir Coefficient	3.00 (ft^0.5)/s
K Reverse	1.000
Manning's n	0.000
Kev, Charged Riser	0.000
Weir Submergence	False
Orifice H to crest	False

Structure ID: Orifice - 3 Structure Type: Orifice-Area	
Number of Openings	3
Elevation	922.25 ft
Orifice Area	4.5 ft²
Top Elevation	923.00 ft
Datum Elevation	922.25 ft
Orifice Coefficient	0.600

Structure ID: TW Structure Type: TW Setup, DS Channel	
Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft

Convergence Tolerances	
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

Requested Pond Water Surface Elevations	
Minimum (Headwater)	910.00 ft
Increment (Headwater)	0.50 ft
Maximum (Headwater)	926.00 ft

Outlet Connectivity

Structure Type	Outlet ID	Direction	Outfall	E1 (ft)	E2 (ft)
Orifice-Area	Orifice - 3	Forward	Culvert - 1	922.25	926.00
Inlet Box	Riser - 1	Forward	Culvert - 1	924.00	926.00
Orifice-Circular	Orifice - 1	Forward	Culvert - 1	910.00	926.00
Culvert-Circular	Culvert - 1	Forward	TW	909.00	926.00
Tailwater Settings	Tailwater			(N/A)	(N/A)

Structure ID: Culvert - 1 Structure Type: Culvert-Circular	
Number of Barrels	1
Diameter	48.0 in
Length	110.00 ft
Length (Computed Barrel)	110.00 ft
Slope (Computed)	0.009 ft/ft

Outlet Control Data	
Manning's n	0.013
Ke	0.200
Kb	0.005
Kr	1.000
Convergence Tolerance	0.00 ft

Inlet Control Data	
Equation Form	Form 1
K	0.0045
M	2.0000
C	0.0317
Y	0.6900
T1 ratio (HW/D)	1.091
T2 ratio (HW/D)	1.193
Slope Correction Factor	-0.500

Use unsubmerged inlet control 0 equation below T1 elevation.
Use submerged inlet control 0 equation above T2 elevation

In transition zone between unsubmerged and submerged inlet control,
interpolate between flows at T1 & T2...

T1 Elevation	913.36 ft	T1 Flow	87.96 ft³/s
T2 Elevation	913.77 ft	T2 Flow	100.53 ft³/s

Structure ID: Orifice - 1 Structure Type: Orifice-Circular	
Number of Openings	1
Elevation	910.00 ft
Orifice Diameter	24.0 in
Orifice Coefficient	0.600

Structure ID: Riser - 1 Structure Type: Inlet Box	
Number of Openings	1
Elevation	924.00 ft
Orifice Area	64.0 ft²
Orifice Coefficient	0.600
Weir Length	32.00 ft
Weir Coefficient	3.00 (ft^0.5)/s
K Reverse	1.000
Manning's n	0.000
Kev, Charged Riser	0.000
Weir Submergence	False
Orifice H to crest	False

Structure ID: Orifice - 3 Structure Type: Orifice-Area	
Number of Openings	3
Elevation	922.25 ft
Orifice Area	4.5 ft²
Top Elevation	923.00 ft
Datum Elevation	922.25 ft
Orifice Coefficient	0.600

Structure ID: TW Structure Type: TW Setup, DS Channel	
Tailwater Type	Free Outfall

Convergence Tolerances	
Maximum Iterations	30
Tailwater Tolerance (Minimum)	0.01 ft
Tailwater Tolerance (Maximum)	0.50 ft
Headwater Tolerance (Minimum)	0.01 ft

Convergence Tolerances	
Headwater Tolerance (Maximum)	0.50 ft
Flow Tolerance (Minimum)	0.001 ft³/s
Flow Tolerance (Maximum)	10.000 ft³/s

Future Conditions

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APPENDIX D
POINT A1 RELEASE RATE WAIVER REQUEST

OLSSON ®
ASSOCIATES

MEMO

☐	Overnight
☐	Regular Mail
☐	Hand Delivery
☐	Other: _____

TO:	City of Lee's Summit Development Center
FROM:	Melissa G. DeGonia, PE
RE:	Woodside Ridge Detention Requirements
DATE:	June 22, 2018
OA PROJECT #:	018-1140
PHASE:	400
TASK:	400006

The following is a request for A waiver for detention requirements within Watershed A, relating specifically to Point A1. Refer to attached exhibit for watershed characteristics in relation to the property and proposed improvements.

Per APWA Section 5608.4 and City of Lee's Summit criteria, the performance criteria for detention is to provide detention to limit peak flow rates at downstream points of interest to maximum release rates:

- 50% storm peak rate less than or equal to 0.5 cfs per site acre
- 10% storm peak rate less than or equal to 2.0 cfs per site acre
- 1% storm peak rate less than or equal to 3.0 cfs per site acre

In lieu of matching these "allowable" release rates, the Future Conditions peak flow rates will be reduced to less than the Existing Conditions.

This waiver is requested due to several challenges in relation to detention design, described below. Due to these limitations, it is not possible to collect and detain as much runoff as would be necessary to reduce the peak flow rates fully to the standard onsite release rates.

- The watershed consists of steep slopes which are heavily vegetated, making detention basins difficult to construct.
- The tributary flowing through Watershed A generally follows the property line, which results in stormwater generally sheet flowing directly to the tributary, instead of channelizing to create points of discharge where detention can be effective.

1301 Burlington, Suite 100
North Kansas City, MO 64116
TEL 816.587.4320
FAX 816.587.1393
www.olssonassociates.com

- For several reasons, detention within the channel is not feasible or advisable.
    - The channel is protected by a stream setback zone, and should therefore not be disturbed without necessity.
    - The onsite area is a small portion of the watershed, so there is a significant amount of offsite bypass contributing to the main tributary.
    - Constructing a dam would capture most of the offsite runoff which would excessively cut back peak flow rates in the channel, possibly resulting in increased erosion in the channel and diminution of the existing natural habitat.
    - The channel straddles the property line in most places, so detention would be partially offsite, on several existing lots.
    - An existing sanitary sewer trunk main follows the channel, and would be located underneath any new detention facility in the channel.

While the "allowable" release rates will not be met at Point A1, peak flow rates will be reduced significantly from the Existing Conditions rates in all storm events. Additionally, over 90% of the paved areas within Watershed A are captured and diverted to a detention facility or the existing pond, providing runoff control for most of the new developed area in the watershed, and water quality treatment for most of the proposed streets.

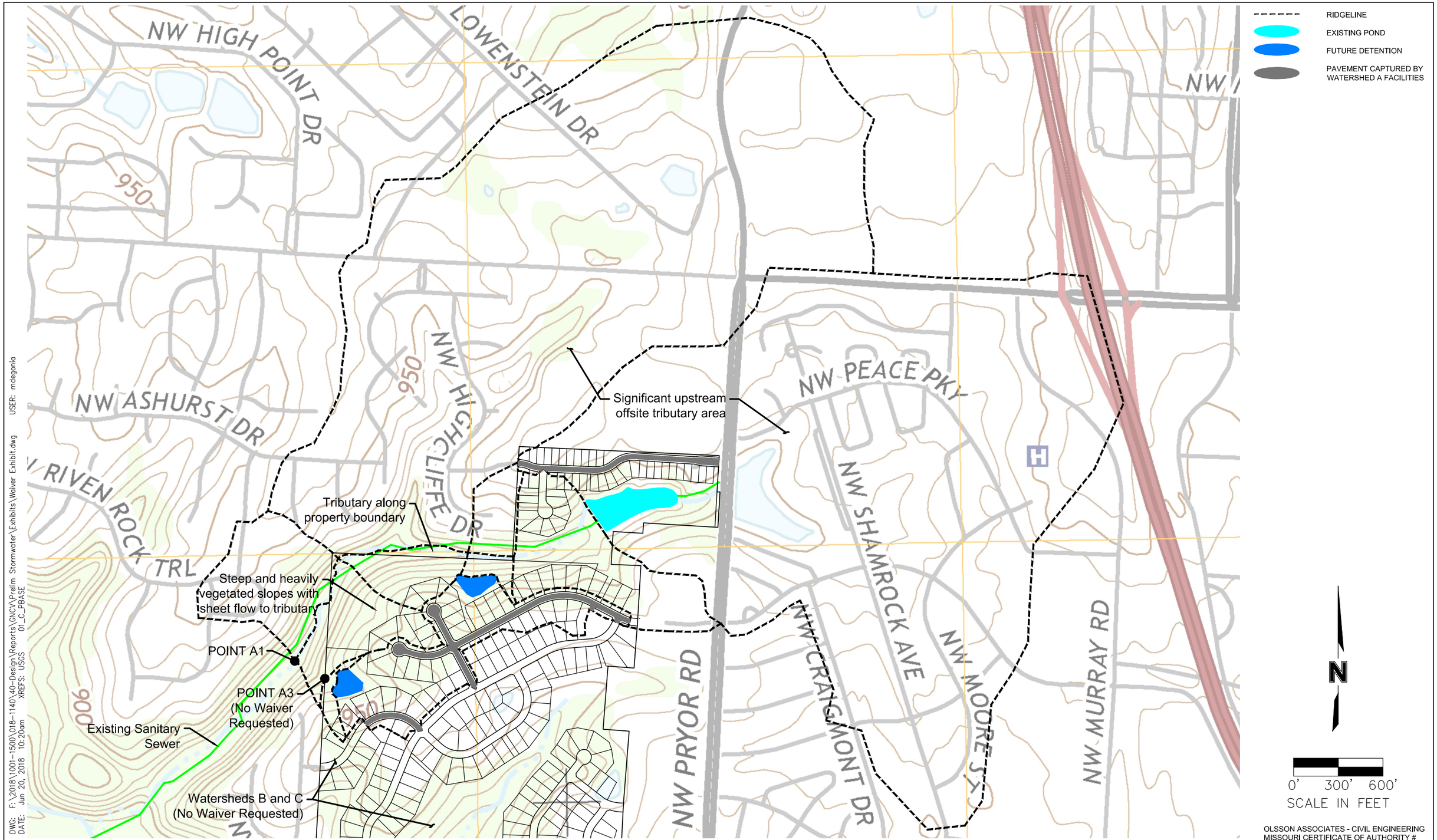
Below is a summary of proposed flow rates in relation to existing and the "allowable" release rates. For more information, reference the Woodside Ridge Preliminary Stormwater Drainage Study.

Table 1. Future vs. Allowable Release Rates

	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Future	898.31	1528.00	2519.41
Allowable	839.45	1489.65	2426.53
Difference	58.86	38.35	92.88

Table 2. Future vs. Existing Release Rates

	Q_1 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Future	898.31	1528.00	2519.41
Existing	932.86	1582.99	2595.35
Difference	-34.55	-54.99	-75.94



DWG: F:\2018\1001-1500\018-1140\40-Design\Reports\GNCV\Prelim Stormwater\Exhibits\Waiver Exhibit.dwg USER: mdegonia
DATE: Jun 20, 2018 10:20am XREFS: USGS 01_C_PBASE

OLSSON ASSOCIATES - CIVIL ENGINEERING
MISSOURI CERTIFICATE OF AUTHORITY #

PROJECT NO: 018-1140 DRAWN BY: MGD DATE: 06/20/2018	POINT A1 WAIVER REQUEST	OLSSON ASSOCIATES 1301 Burlington Street North Kansas City, MO 64116 TEL 816.587.4320 FAX 816.587.1393

EXHIBIT
A