SCANNELL DEVELOPMENT
LEE'S SUMMIT LOGISTICS
NORTHWEST CORNER OF TUDOR ROAD & MAIN STREET

PRELIMINARY STORMWATER DRAINAGE STUDY

Prepared for:

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Olsson Project No. 021-04157
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1. GENERAL INFORMATION

The Scannell Development project (the project) is approximately 83 acres of proposed industrial development including warehouses, loading docks, parking lots, stormwater detention basins, and open space. This project is located northwest of the intersection of NW Tudor Road and NW Sloan Street in Lee's Summit, Missouri. Stormwater from the project is conveyed into the Cedar Creek Watershed, primarily via Little Cedar Creek (which generally flows from east to west through the project boundary) and an unnamed tributary to Little Cedar Creek (which generally flows from south to north along the west side of the project boundary). Figure 1 shows the location and boundary of the project. It should be noted that the project boundary has been slightly modified from the property boundary for analysis purposes. The project boundary has been expanded to include NW Sloan Road, near the southeast corner of the project boundary, as portions of the road may need to be reconfigured or reconstructed as part of this project.

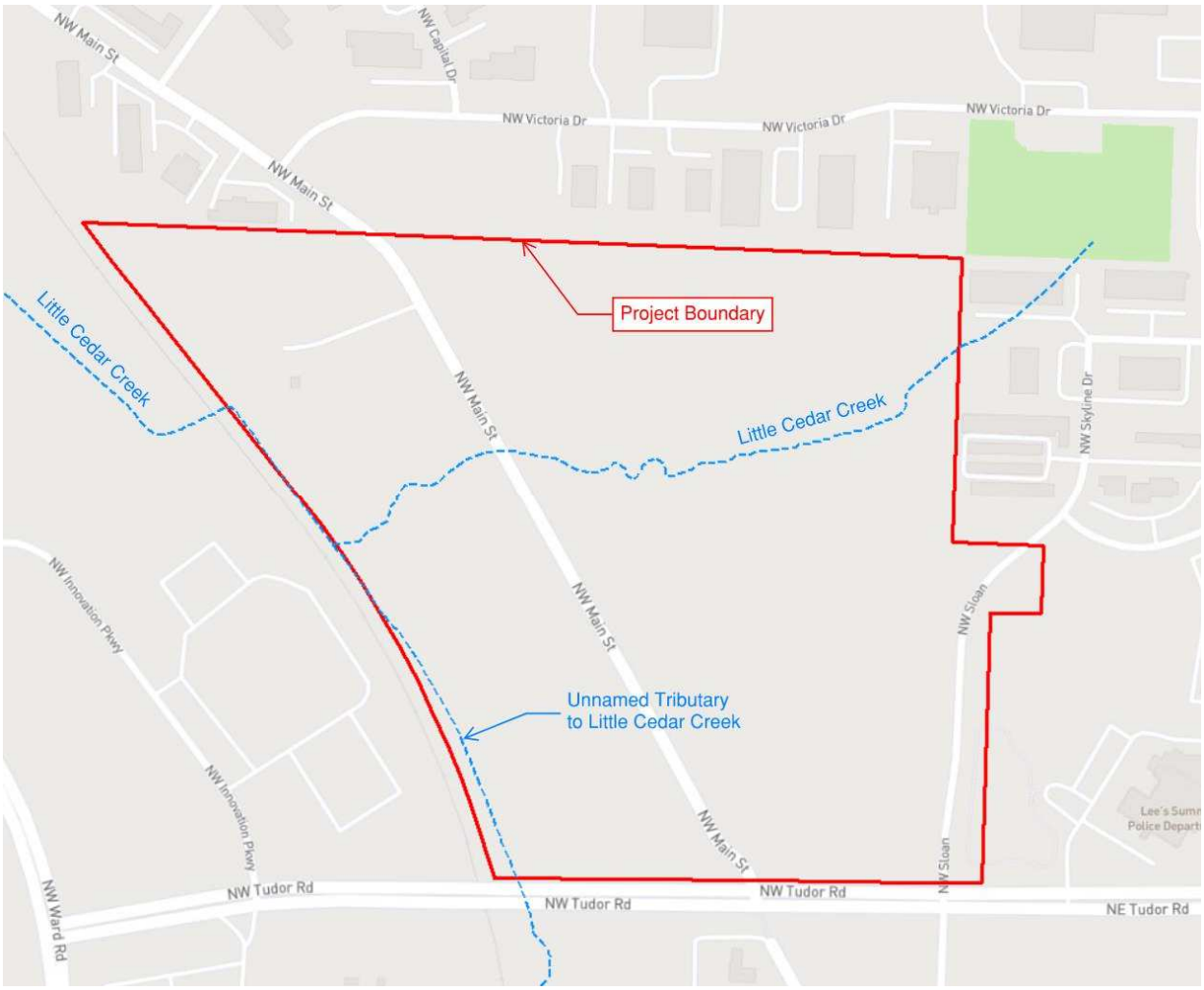

Figure 1. Location Map.

1.1 FEMA Floodplain Classifications

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) Panel Number 29095C0417G classifies portions of the project to be within the special flood hazard area (SFHA). SFHA's located within the project boundary include:

- Zone AE – Areas that are determined through detailed analyses to be subject to inundation from the 100-year (1-percent-annual-chance) flood and for which base flood elevations have been determined.
- Zone A – Areas that are determined through approximate analyses to be subject to inundation from the 100-year (1-percent-annual-chance) flood and for which base flood elevations have not been determined.
- Zone X – Areas that are determined to be moderate flood hazards areas and can be any of the following: areas of the 500-year (0.2-percent-annual-chance) flood; areas of average depths of less than one foot or with drainage areas less than one square mile; areas protected by levees from the 1% annual chance flood.

These SFHA's pertain to Little Cedar Creek and an unnamed tributary to Little Cedar Creek, which flow through the project site as described in Section 1. See Exhibit 1 in Appendix A for the location SFHA boundaries in relation to the project boundary.

1.2 Soil Classifications

Soil maps published on the Natural Resources Conservation Service's (NRCS) Web Soil Survey categorize soils within the project boundary 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	Hydrologic Soil Group
10024	Greenton-Urban land complex	5-9 %	D
10082	Arisburg-Urban land complex	1-5 %	C
10120	Sharpsburg silt loam	2-5 %	C
10128	Sharpsburg-Urban land complex	2-5 %	D
10129	Sharpsburg-Urban land complex	5-9 %	D
10142	Snead-Rock outcrop complex	5-14 %	D
30080	Greenton silt clay loam	5-9 %	C/D

2. METHODOLOGY

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

The following software and methods were used in this study to model existing and proposed conditions for stormwater runoff:

United States Army Corps of Engineers Hydrologic Engineering Center Hydrology Modeling System (HEC-HMS) Version 4.7.1

- Soil Conservation Survey (SCS) Unit Hydrograph Method
  - 2-year, 10-year, and 100-year Return Frequency Storms
  - Antecedent Moisture Conditions II Soil Moisture Conditions
  - 24-Hour SCS Type II Rainfall Distribution
  - SCS Runoff Curve Numbers per SCS TR-55 (Tables 2-2a – 2-2c)

United States Department of Agriculture WinTR-55 Small Watershed Hydrology

- SCS TR-55 methods for determination of time of concentration and travel time. Where specific data pertaining to channel geometry is not available, length and velocity estimates for channel flow travel time is used 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). Table 2 below summarizes the rainfall depths used in this analysis:

Table 2. Precipitation Depths.

Return Period	24-Hour Precipitation Depth (inches)
2-Year (50% Storm)	3.60
10-year (10% Storm)	5.34
50-year (2% Storm)	6.96
100-Year (1% Storm)	7.90

Although not specifically analyzed in this study, the 50-year storm depth is also listed in Table 2 as the peak flow rate was needed for analysis with the corresponding flood study for this project.

3. EXISTING CONDITIONS

The following areas and points of interest have been used for existing and proposed conditions analysis to quantify the effects of developing this project. See Exhibit 3 in Appendix A.

Point 1 is located just downstream of the crossing of Little Cedar Creek at the Union Pacific Railroad and is the primary point-of-interest for this study. Little Cedar Creek and the unnamed tributary to Little Cedar Creek both drain to this common point-of-interest. All of the stormwater runoff from the developed portion of the site eventually drains to Point 1. Therefore, Point 1 was used as the comparison point for calculating allowable peak discharges and comparison to proposed peak discharges. The location of Point 1 was chosen strategically and placed at the upstream limit of FEMA's mapped floodway for Little Cedar Creek. The downstream limit of the hydraulic model that was created for this project is located at Point 1, which is discussed in further detail in the flood study.

Point 2 is located at the confluence of Little Cedar Creek and the unnamed tributary to Little Cedar Creek. All stormwater runoff from Drainage Area B and Drainage Area C eventually drains to this point in existing conditions. This point is used as an intermediate point for calculation purposes.

Drainage Area A discharges to Little Cedar Creek and is located upstream of Point 1. The total area modeled within this drainage area is approximately 20.3 acres in existing conditions, which includes portions of on-site and off-site drainage area. A small amount of on-site area is located at the northwest corner of the project boundary, just outside of Drainage Area A in existing conditions. This area will be further discussed in the proposed conditions analysis (Section 4.1).

Drainage Area B discharges to Little Cedar Creek and encompasses most of the northern portion of the site and off-site area upstream of the site. The total area modeled within this drainage area is approximately 150.9 acres in existing conditions.

Drainage Area C discharges to the unnamed tributary to Little Cedar Creek and encompasses most of the southern portion of the site and off-site area upstream of the site. The total area modeled within this drainage area is approximately 269.3 acres in existing conditions.

3.1 Hydrologic Analysis (Existing Conditions)

To provide a direct comparison between the existing and proposed conditions models, the points of interest have been kept consistent throughout the analysis. Tables 3, 4, and 5 summarize the results of the existing conditions analysis. The proposed conditions data will be compared to these results in Section 4 of this study. Refer to Appendix B for existing conditions curve number and time of concentration calculations. Refer to Appendix C for a schematic of the existing conditions HEC-HMS model.

Curve numbers were determined based on the soil classifications outlined in Section 1.2 and existing land use. Land use was determined from recent aerial imagery. Curve numbers were assumed as shown in Table 3.

Table 3. Curve Numbers.

Land Use	HSG	CN
Fully Developed Urban Areas Good Condition; Grass Cover > 75%	C	74
Fully Developed Urban Areas Good Condition; Grass Cover > 75%	D	80
Impervious Areas Paved parking lots, roofs, driveways	C/D	98
Residential Districts (1/4 acre)	C	83
Residential Districts (1/4 acre)	D	87
Urban Districts Commercial & Business	C	94
Urban Districts Commercial & Business	D	95

*HSG = hydrologic soil group, *CN = curve number

Table 4. Existing Conditions Drainage Area Data.

Drainage Area	On-site Area (acres)	Off-site Area (acres)	Total Area (acres)	T_C (hour)	Weighted CN
A	8.6	11.7	20.3	0.197	86
B	43.3	107.6	150.9	0.355	86
C	27.9	241.4	269.3	0.404	87

*Tc = time of concentration, *CN = curve number

Table 5. Existing Conditions Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Point 1	1,031	1,747	2,802

*Q = flow rate, *cfs = cubic feet per second

3.2 Detention Requirements

Per APWA Section 5608.4 and the 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 percent storm peak rate less than or equal to 0.5 cfs per site acre
- 10 percent storm peak rate less than or equal to 2.0 cfs per site acre
- 1 percent storm peak rate less than or equal to 3.0 cfs per site acre
- Extended detention of the 90-percent mean annual event

Allowable release rates were calculated for the points of interest, allowing that discharges from off-site area and undeveloped portions of on-site area would be permitted to bypass the detention.

Bypass peak flow rates were calculated as the percentage of the existing conditions, relating to the percentage of off-site/undeveloped on-site area flowing to each point. The development release rates for the project were calculated based on City of Lee's Summit 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. Refer to the equation below:

*Allowable Release Rate = (percent off-site area * existing peak flow) + (on-site area * allowable cfs per site acre)*

Tables 6 and 7 below summarize the amount of area on-site and the allowable discharges for each storm event.

Table 6. Point of Interest On-site Area.

Point of Interest	Total Area[1] (acres)	On-site Area[1] (acres)	Percent On-site
Point 1	443.3	65.8	14.9%

*Q = flow rate, *cfs = cubic feet per second
[1]Total area draining to basins A-1, B-1, B-2, B-3, B-4, B-5, B-6 and C-1 in proposed conditions

Table 7. Allowable Peak Flow Rates.

Point of Interest	Allowable 2-Year (cfs)	Allowable 10-Year Q (cfs)	Allowable 100-Year Q (cfs)
Point 1	911	1619	2,583

*Q = flow rate, *cfs = cubic feet per second

3.3 Stream Buffer

Little Cedar Creek and the unnamed tributary to Little Cedar Creek fall within the requirements of KC-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 surveyed contours and aerial data.

Little Cedar Creek flows through the site and is located within Drainage Area B prior to its confluence with the unnamed tributary to Little Cedar Creek, at Point 2. Little Cedar Creek flows into the site on the eastern property boundary with approximately 150 acres of contributing drainage area at Point 2. Per KC-APWA Table 5605-1, the stream buffer width for this channel is defined as 60 feet measured outwards from the OHM in each direction.

The unnamed tributary to Little Cedar Creek flows through the site and is located within Drainage Area C. The tributary flows into the site along the western property boundary with approximately 270 acres of contributing drainage area at Point 2. Per KC-APWA Table 5605-1, the stream buffer width for this channel is defined as 100 feet measured outwards from the OHM in each direction. This same buffer width applies to Little Cedar Creek downstream of Point 2, which has approximately 440 acres of contributing drainage area at Point 1.

3.4 Required Level of Service and Stormwater BMP's

The required level of service (LS) for the project was calculated based off the criteria outlined in the Mid-America Regional Council's (MARC) Manual of Best Management Practices for Stormwater Quality (BMP's). Worksheet 1 of the Marc BMP manual was used to calculate the required LS of 6 for the project by calculating the pre-development (82) and post-development (88) curve numbers. This value was used to design the proposed stormwater BMP's for the project, which are discussed in further detail in Section 4.6. See Appendix D for a copy of Worksheet 1.

4. PROPOSED CONDITIONS

The proposed conditions sections of this analysis assume completion the project. The difference between the existing conditions model and the proposed conditions model is a direct result of the project. Refer to Exhibit 4 in Appendix A for the proposed conditions drainage area map.

4.1 Effects of Development

The modeled drainage areas and points of interest are similar to the existing conditions model. However, throughout the site, some shifting of ridgelines will occur, accommodating proposed detention facilities and anticipated grading activities, which will change the relative areas draining to each point of interest. The following is a summary of the proposed conditions drainage areas.

Drainage Area A in proposed conditions is approximately 22.3 acres overall. Proposed grading activities and construction of buildings on-site will alter ridgelines from existing conditions, shifting area between drainage areas A and B. A portion of the on-site area within this drainage area will be developed and re-graded and has been separated as **Drainage Area A-1**. Runoff from Drainage Area A-1 will be routed to an on-site detention basin and then discharged into Little Cedar Creek, upstream of Point 1. Proposed conditions for Drainage Area A-1 also includes area previously located outside of Drainage Area A, at the northwest corner of the site, which will be re-graded to provide room for the aforementioned detention basin. A small sliver of the on-site area along the western boundary still remains outside of the extents of Drainage Area A-1; this on-site area will not be disturbed as part of this project. The remaining area in Drainage Area A is off-site or will not be developed as part of the project.

Drainage Area B in proposed conditions is approximately 162.4 acres overall. Proposed grading activities and construction of buildings on-site will alter ridgelines from existing conditions, shifting area between drainage areas A, B, and C. The on-site portion of Drainage Area B has been split up into **drainage areas B-1, B-2, B-3, B-4, B-5, and B-6** based off the location of proposed low points. A detention basin will be constructed at the proposed low points for each of the aforementioned on-site drainage areas. Runoff from these drainage areas will be routed to the on-site detention basins and then discharged into Little Cedar Creek, upstream of Point 2. The remaining area in Drainage Area B is off-site or will not be developed as part of the project.

Drainage Area C in proposed conditions is approximately 258.7 acres overall. Proposed grading activities and construction of buildings on-site will alter ridgelines from existing conditions, shifting area between drainage areas B and C. The on-site portion of Drainage Area C has been split out into **Drainage Area C-1**. Runoff from Drainage Area C-1 will be routed to an on-site detention basin and then discharged into the unnamed tributary to Little Cedar Creek, upstream of Point 2. The remaining area in Drainage Area C is off-site or will not be developed as part of the project.

4.2 Hydrologic Analysis (Proposed Conditions)

The analysis provided in Section 3 established existing conditions of the development's drainage areas. The analysis in Section 4 will provide guidance for configuring the detention basin to meet the objectives established in Section 3. Proposed curve numbers for the on-site drainage areas were calculated based off impervious areas for the developed site. Proposed curve numbers for the off-site drainage areas (A, B, and C) were also adjusted accordingly to account for the on-site areas being split out into separate drainage areas. For the purposes of this preliminary stormwater

study, lag times of ranging from 5 minutes to 7 minutes were assumed for each of the on-site drainage areas. This was done for the sake of expediency such that a preliminary study could be submitted alongside the preliminary development plans. Lag time can be estimated as 60-percent of the time of concentration for a watershed; for example, a lag time of 5 minutes corresponds to a time of concentration of 8.33 minutes (0.139 hours). Detailed calculations for lag times will be completed and provided with the final stormwater drainage study and any subsequent submittals. The current lag time estimates for the on-site drainage areas are expected to beat or lower than calculated lag times given the size of the on-site drainage areas. Lower lag times result in higher peak flow rates; therefore, the estimated lag times should be conservative as they are expected to be at or lower than calculated lag times.

The following tables summarize the results of the proposed conditions analysis. Table 8 summarizes the proposed conditions drainage area data. Tables 9 and 10 assume no detention is provided, to demonstrate the effects of development for each drainage area. Refer to Appendix B for proposed conditions curve number calculations. Refer to Appendix C for a schematic of the proposed conditions HEC-HMS model.

Table 8. Proposed Conditions Drainage Area Data.

Drainage Area	On-site Area (acres)	Off-site Area (acres)	Total Area (acres)	T_C[1] (hour)	Weighted CN
A	2.0	11.5	13.5	0.197	89
B	10.6	108.0	118.6	0.355	88
C	4.0	241.4	245.4	0.404	88
A-1	8.8	0.0	8.8	0.194	91
B-1	1.7	0.0	1.7	0.139	87
B-2	9.6	0.0	9.6	0.194	92
B-3	8.3	0.0	8.3	0.194	92
B-4	9.5	0.0	9.5	0.194	92
B-5	12.2	0.0	12.2	0.194	93
B-6	2.4	0.0	2.4	0.139	82
C-1	13.3	0.0	13.3	0.194	87

*Tc = time of concentration, *CN = curve number
[1]Hydrologic model elements are referenced by lag time

Table 9 shows post-development peak discharge values points of interest assuming no detention is provided. Table 10 compares these 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 from existing conditions at Point 1 for the 2-, 10-, and 100-year storms. Proposed conditions peak flow rates without detention are higher than allowable release rates for the 2-year storm, but lower than allowable release rates for the 10- and 100-year storms. Section 4.4 will analyze the effects of detention on proposed conditions

peak flow rates and provide a comparison to peak flow rates without detention to determine if detention is beneficial for this project.

Table 9. Proposed (No Detention) Conditions Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Point 1	1,120	1,855	2,932

*Q = flow rate, *cfs = cubic feet per second

Table 10. Proposed (No Detention) Conditions Point of Interest Peak Flows Comparison.

Point 1	Δ Q_2 (cfs)	Δ Q_{10} (cfs)	Δ Q_{100} (cfs)
Existing Conditions	+89	+108	+130
Allowable Release	+209	+236	+349

*Q = flow rate, *cfs = cubic feet per second, *Δ = difference in value

4.3 Proposed Detention Facilities

To mitigate the increases in peak flows (shown in the previous table) and, where possible, to decrease further to the allowable release rates established in Section 3, detention will be provided for each of the on-site drainage areas. These detention facilities will be constructed as part of the project. The detention facilities are designed to capture most of the site runoff and to mitigate increases in peak discharge from the site. The detention facilities will be located at various locations throughout the site, as shown on Exhibit 4 in Appendix A, and will meet the requirements outlined in Section 3.

Each detention facility will contain a multistage outlet structure with a perforated riser set at the bottom of each outlet structure. These risers will be sized to comply with the KC-AWPA requirement for 40-hour release of the 90-percent mean annual event for proposed conditions. Table 11 summarizes the perforated riser configurations for each of the proposed detention facilities. Trash racks will be installed around the perforated risers to help prevent debris and sediment from clogging the risers. Additional information will be provided for the multistage outlet structures with the final stormwater drainage study.

Each detention facility will also be equipped with and an independent broad-crested weir graded into the berm of the basin to function as the emergency spillway. Proposed emergency spillways have been configured to meet the requirements as outlined in KC-APWA Section 5608.4 F. Table 11 summarizes minimum bottom lengths of the emergency spillways for each of the proposed detention facilities. Each of the proposed spillways are trapezoidal in length, with a 1.5-foot depth and 4:1 (horizontal: vertical) side slopes. Additional detail and exact locations of the emergency spillways will be provided with the final stormwater drainage study.

It should be noted that the perforated riser and emergency spillway configurations shown in Table 11 are design values for the conceptual level of analysis. Final and constructed orifices / emergency spillways may differ from the configurations shown in this preliminary study. As design progresses these configurations will be updated as needed to accommodate for any changes to the site layout that may affect these items. Any changes to detention configurations will be noted in future submittals.

Table 11. Perforated Riser and Emergency Spillway Summary.

Detention Facility	Primary Outlet Pipe Diameter (inches)	Perforation Diameter (inches)	Number of Columns	Number of Rows	Emergency Spillway Length (feet)
A-1	15	1.9	3	2	85
B-1	36	1.6	2	2	15
B-2	30	1.5	1	6	95
B-3	18	1.5	1	5	80
B-4	18	1.5	1	6	95
B-5[1]	36	N/A	N/A	N/A	120
B-6[1]	18	1.2	1	12	95
C-1	21	1.9	1	4	125

[1]Basins B-5 and B-6 are interconnected and were modeled as one basin for extended detention calculations. The multi-stage outlet structure will be constructed in the basin for B-6.

Tables 12-14 includes hydrologic summaries of the proposed detention facilities for the 2-, 10- and 100-year storm events, respectively.

Table 12. Proposed Conditions (2-Year) Detention Flow and Volume Data.

Detention Facility	Peak Q In (cfs)	TP In (hour)	Peak Q Out (cfs)	TP Out (hour)	Peak WSE (feet)	Stored Volume (acre-feet)
A-1	46	12.03	8	12.82	951.3	1.8
B-1	6	11.97	3	12.10	954.8	0.1
B-2	36	12.00	19	12.13	960.3	0.7
B-3	31	12.00	11	12.18	975.8	0.7
B-4	35	12.00	12	12.18	968.1	0.8
B-5	47	12.00	32	12.10	979.8	0.7
B-6	36	12.08	11	12.55	972.8	1.2
C-1	42	12.00	16	12.18	970.0	0.9

*Q = flow rate, *cfs = cubic feet per second, *TP = time of peak, *WSE = water surface elevation

Table 13. Proposed Conditions (10-Year) Detention Flow and Volume Data.

Detention Facility	Peak Q In (cfs)	TP In (hour)	Peak Q Out (cfs)	TP Out (hour)	Peak WSE (feet)	Stored Volume (acre-feet)
A-1	77	12.03	12	12.85	953.8	3.1
B-1	10	11.97	6	12.07	955.2	0.2

Detention Facility	Peak Q In (cfs)	TP In (hour)	Peak Q Out (cfs)	TP Out (hour)	Peak WSE (feet)	Stored Volume (acre-feet)
B-2	56	12.00	33	12.12	961.3	1.0
B-3	49	12.00	15	12.20	977.4	1.1
B-4	55	12.00	16	12.20	970.1	1.2
B-5	73	12.00	52	12.10	980.9	1.0
B-6	60	12.07	16	12.55	974.8	2.0
C-1	71	12.00	23	12.20	972.1	1.5

*Q = flow rate, *cfs = cubic feet per second, *TP = time of peak, *WSE = water surface elevation

Table 14. Proposed Conditions (100-Year) Detention Flow and Volume Data.

Detention Facility	Peak Q In (cfs)	TP In (hour)	Peak Q Out (cfs)	TP Out (hour)	Peak WSE (feet)	Stored Volume (acre-feet)
A-1	116	12.02	15	12.95	957.4	5.0
B-1	16	11.97	11	12.05	955.6	0.2
B-2	86	12.00	45	12.13	962.8	1.5
B-3	74	12.00	20	12.22	979.9	1.7
B-4	85	12.00	21	12.22	973.0	2.0
B-5	110	12.00	73	12.10	982.7	1.4
B-6	86	12.05	21	12.60	977.8	3.3
C-1	113	12.00	31	12.22	975.4	2.5

*Q = flow rate, *cfs = cubic feet per second, *TP = time of peak, *WSE = water surface elevation

4.4 Effects of Proposed Detention

The following tables compare the results of the proposed conditions analysis with the detention described above to the existing conditions from Section 3 at the points of interest. Table 15 shows peak discharge values at the point of interest. Tables 16 compares these discharge values to existing and allowable discharge values. In Table 16, negative values indicate a reduction in peak flows, while positive values indicate an increase.

Table 15. Proposed (with Detention) Point of Interest Peak Flow Rates.

Point of Interest	Q_2 (cfs)	Q_{10} (cfs)	Q_{100} (cfs)
Point 1	978	1,618	2,546

*Q = flow rate, *cfs = cubic feet per second

Table 16. Proposed (with Detention) Conditions Point of Interest Peak Flows Comparison.

Point 1	Δ Q_2 (cfs)	Δ Q_{10} (cfs)	Δ Q_{100} (cfs)
Existing Conditions	-53	-129	-256
Allowable Release	+67	-1	-37
Proposed Conditions (No Detention)	-142	-237	-386

*Q = flow rate, *cfs = cubic feet per second, *Δ = difference in value

As shown in Table 16, with the addition of detention facilities, peak discharges at Point 1 will be at or below the allowable release rates for the 10-year and 100-year storm; however, the proposed conditions peak flow rate for the 2-year storm is above the allowable release rate. The multistage outlet structures described in 4.2 will need to be designed to further restrict peak flows during the 2-year event. Additional details and calculations will be included in the final stormwater to ensure that allowable release rates for the 2-year storm will be met. Proposed conditions peak flow rates (with detention) are lower than the proposed conditions peak flow rates (without detention) and lower than the existing conditions peak flow rates for the 2-, 10- and 100-year storms.

4.5 Impacts to Stream Buffer

Much of the defined stream buffer is not impacted by development; however, a few encroachments have been made to accommodate the proposed layout, which are summarized below:

Little Cedar Creek

Impacts to the stream buffer along Little Cedar Creek will occur at several locations along the site due to proximity of proposed roadway alignments and parking lots. These areas are summarized below and can be seen on Exhibit 5 of Appendix A:

- Toward the middle of the site, just upstream of NW Main St. The proposed alignment for NW Main St encroaches slightly on the 60-foot stream buffer for the south side of the stream. To account for this loss in stream buffer on the south side of the stream, additional width has been provided in this area on the north side.
- Just upstream of Point 2, on the north side of the stream. The 60-foot stream buffer in this area will be encroached upon with construction of the detention facility for Drainage Area B-1. To account for this loss in stream buffer on the north side of the stream, additional width has been provided in this area on the south side.
- Just upstream of the stream's crossing with the Union Pacific Railroad. The proposed loading dock in encroaches on the 100-foot stream buffer in this area on the west side of the stream. The stream in this area has been previously impacted and straightened by the nearby railroad crossing. The existing stream is confined and has little potential for migration due to the proximity of the railroad culvert.

A waiver for the stream buffer requirements is requested for the areas noted above. Additional temporary encroachments on the stream buffer may also take place with proposed grading and

construction activities. These areas will be replanted with native grasses to restore the vegetation as much as possible.

Unnamed Tributary to Little Cedar Creek

Impacts to the stream buffer along the unnamed tributary to Little Cedar Creek will occur at several locations along the site due to proximity of proposed roadway alignments and parking lots. These areas are summarized below and can be seen on Exhibit 5 of Appendix A:

- The proposed roadway on the west side of the building encroaches on the 100-foot stream buffer on the stream's east side, near the northwest corner of drainage area C-1. A waiver for this area is requested. The stream in this area has been previously impacted and straightened by the railroad to the west. The existing stream has little potential for significant migration to the east towards the loading docks due to its orientation, running parallel to the railroad.

A waiver for the stream buffer requirements is requested for the areas noted above. Additional temporary encroachments on the stream buffer may also take place with proposed grading and construction activities. These areas will be replanted with native grasses to restore the vegetation as much as possible.

4.6 Provided Level of Service and Stormwater BMP's

As discussed in Section 3.4, the required LS for the project is 6 based on the pre-development and post-development curve numbers. Stormwater BMP calculations were performed using Worksheet 2 of the MARC BMP manual to design and select appropriate BMP's for the project and meet the required LS. The selected BMP's for the project are summarized below:

- Establishing and preserving native vegetation – This BMP includes the establishment or preservation of native plant types historically present on the existing site. These plant species are well adapted to the climate and natural disturbances in the region.

- Snout system to extended dry detention (treatment train) – Extended dry detention basins are detention facilities designed to detain the water quality volume for 40 hours, which are also vegetated with native plants. A snout system will be placed upstream of each detention basin, which will provide additional treatment and benefits to water quality prior to entering the basin and eventually discharging into the nearby streams. Per the manufacturer's website, "A snout is a vented fiberglass water quality hood that is installed over the outlet pipe in a storm water structure with a sump that skims oils, floatables and trash off of the surface water while letting settleable solids sink to the bottom. The cleaner water exits from beneath the SNOUT, which is lower than the bottom of the pipe, but above the bottom of the structure allowing both floatable material and solids that sink to stay in the structure."

A small portion of the site will be untreated near NW Sloan Road. This area primarily consists of the existing roadway, which may need to be reconfigured or reconstructed as part of the project. The provided LS for the project was calculated to be approximately 7.1, which is above the required LS of 6. See Appendix D for a copy of Worksheet 1.

5. SUMMARY

This stormwater drainage study was prepared to evaluate the hydrologic impact generated by the Scannell Development project and to provide recommendations for a comprehensive stormwater management plan. The project is a proposed industrial development on approximately 83 acres, including warehouses, stormwater detention basins, and open space and vegetation along the existing streams that flow through the site

Increases in peak flow rates for the 2-, 10- and 100-year storms caused by the development will be mitigated for all points of interest through the site through a combination of detention facilities and drainage area changes. Additional detail will be provided in the final stormwater study showing further decrease of the proposed conditions peak flows for the 2-year storm. The detention facilities will also serve as water quality basins and provide detention of the 90-percent mean annual event.

Stream buffers will be designated based on watershed size, per KC-APWA standards. Where encroachments are necessary, the impacts will be mitigated with preservation of adjacent native vegetation and establishment of new native vegetation elsewhere on-site as able.

6. 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 encroachments to stream buffers at several locations. A final macro and first plat micro stormwater drainage study will be required with the submittal of the first plat of this development.

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