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

PRELIMINARY FLOOD STUDY

Prepared for:

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8801 River Crossing Blvd, Ste 300
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Olsson Project No. 021-04157
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Prepared for:

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olsson

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1. INTRODUCTION

Scannell Properties, LLC has retained Olsson to complete a flood study for the Scannell Development project (the project), generally located northwest of the intersection of NW Tudor Road and NW Sloan Street. The project is a proposed industrial development on approximately 83 acres, including warehouses, loading docks, parking lots, stormwater detention basins, and open space. The project is located within the Cedar Creek watershed and is located adjacent to two existing streams: Little Cedar Creek generally flows from east to west through the project boundary and an unnamed tributary to Little Cedar Creek generally flows from south to north along the west side of the project boundary. Figure 1 shows the location and approximate boundary of the project.

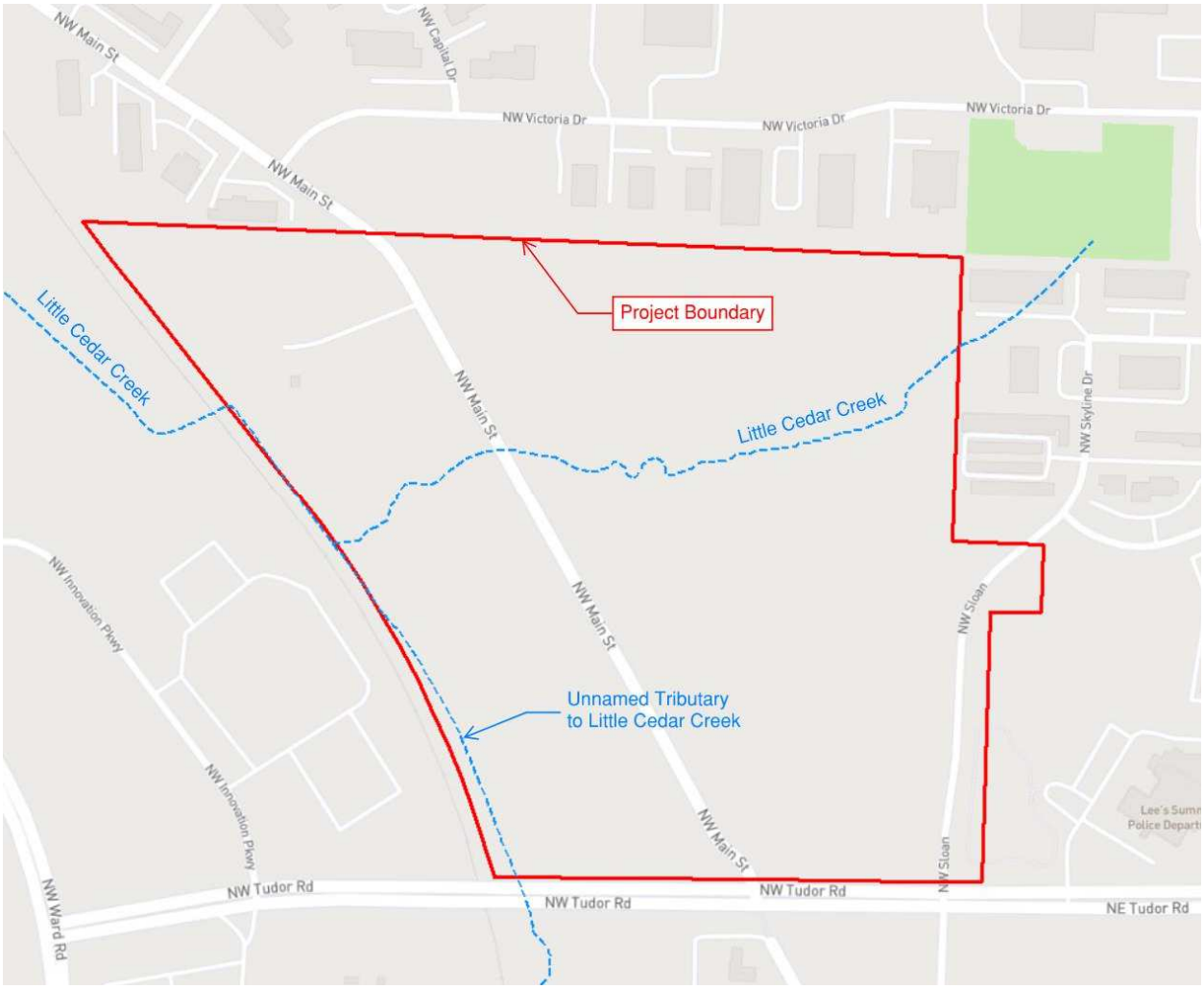

Figure 1. Location Map.

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) for Little Cedar Creek and the unnamed tributary to Little Cedar Creek. 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 (BFE's) 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 BFE's 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.

This flood study will examine the impacts to SFHA's caused by the project. See Exhibit 1 in Appendix A for the location SFHA boundaries in relation to the project boundary.

2. MODEL DEVELOPMENT

Hydrologic and hydraulic analyses were performed using the United States Army Corps of Engineers (USACE) Hydrologic Engineering Center Hydrologic Modeling System (HEC-HMS) version 4.7.1 and River Analysis System (HEC-RAS) version 5.0.7, respectively. Hydrologic flow data derived from HEC-HMS was incorporated into the updated HEC-RAS model for the 2-percent-annual-chance (50-year) and 1-percent-annual-chance (100-year) storm events. These peak flows were used in conjunction with the HEC-RAS model to compare water surface elevations (WSE's) between existing conditions and proposed conditions and ensure conformance with City of Lee's Summit design criteria. The hydrologic and hydraulic models for Little Cedar Creek and its tributaries at the project location were requested from FEMA, the City of Lee's Summit, and other sources. Usable hydrologic and hydraulic models were not available for the project area. A copy of the effective hydraulic model for Cedar Creek downstream of the project site was obtained from a FEMA data request, which was used to set starting WSE's of the hydraulic model that was developed for this project.

2.1. Hydrologic Model Development

Olsson created a hydrologic model for the project using HEC-HMS to determine the peak flows used in this flood study and the corresponding stormwater drainage study. Drainage areas and points of interest for the project are summarized below. See Exhibit 2 in Appendix A for a map indicating the location of these items.

- **Point 1** is located just downstream of the crossing of Little Cedar Creek at the Union Pacific Railroad Little Cedar Creek and the unnamed tributary to Little Cedar Creek both drain to this common point-of-interest. Point 1 is located at the upstream limit of FEMA's mapped floodway for Little Cedar Creek at cross-section AF.
- **Drainage Area A** discharges to Little Cedar Creek and is located upstream of Point 1.
- **Point 2** is located at the confluence of Little Cedar Creek and the unnamed tributary to Little Cedar Creek. This point is used as an intermediate point for calculation purposes.
- **Drainage Area B** discharges to Little Cedar Creek and is located upstream of Point 2.
- **Drainage Area C** discharges to the unnamed tributary to Little Cedar Creek and is located upstream of Point 2.

Hydrologic inputs from the existing conditions HEC-HMS model are summarized in Table 1. Existing conditions peak flow rates were used for purposes of this flood study as on-site detention will be provided that will mitigate increases in peak flow rates. Refer to the stormwater drainage study for a detailed explanation of how inputs were determined.

Table 1. Hydrologic Inputs Summary.

Hydrologic Element	Total Area (acres)	T_C (hour)	Weighted CN	Q_{50} (cfs)	Q_{100} (cfs)
Area A	20.3	0.197	86	146	169
Area B	150.9	0.355	86	866	1,006

Hydrologic Element	Total Area (acres)	T_C (hour)	Weighted CN	Q_{50} (cfs)	Q_{100} (cfs)
Area C	269.3	0.404	87	1,476	1,711
Point 1	-	-	-	2,416	2,802
Point 2	-	-	-	2,335	2,709

*Tc = time of concentration, *CN = curve number, *Q = flow rate, *cfs = cubic feet per second

The Flood Insurance Study (FIS) identifier for this area is 29095C, which has 8 total volumes. It should be noted that the peak flow rates calculated from this model are higher than FEMA peak flow rates from this FIS, which was last revised in January 2017. Although this revision was fairly recent, peak flows along Little Cedar Creek and the unnamed tributary to Little Cedar Creek were not updated with this revision. Peak flow rates for Little Cedar Creek are listed in the summary of discharges table of FIS 29095CV001B. The nearest flooding source location listed in this table is located at approximately 153 feet upstream of I-470, which has a peak flow rate of 1,952 cubic feet per second (cfs) for the 50-year storm and a peak flow rate of 2,254 cfs for the 100-year storm. This location is downstream of Point 1 and listed peak flow rates are lower than the calculated flow rates for Point 1. Therefore, the calculated peak flow rates are conservative and should be acceptable for the modeling purposes of this flood study.

The summary of discharges table from FIS 29095CV001B references the use of a frequency discharge-drainage area curve for determination of peak flow rates for peak flow rates along Little Cedar Creek for points of interest located more than 153 feet upstream of I-470. This curve may be used for determining peak flow rates for the project; however, creation of a hydrologic model was needed for the stormwater drainage study.

2.2. Hydraulic Model Development

Olsson created a hydraulic model for the project using HEC-RAS for determination of peak WSE's. Existing conditions and proposed conditions hydraulic models were created in order to provide a comparison of peak WSE's prior to and after development of the project. All hydraulic models used in the analysis of the project are referenced to the North American Vertical Datum of 1988 (NAVD88). Refer to Figure 3 in Appendix A for a map showing the locations of hydraulic model cross-sections and centerlines.

2.2.1. Hydraulic Model Development - Existing Conditions

The existing conditions geometric data was sourced from a combination of topographic survey, and drone LiDAR survey. Where the cross-section data extended outside of the surveyed area, the overbank geometry data was used from available 2012 County LiDAR data. Cross-sections were placed intermittently and at appropriate locations along Little Cedar Creek. Station-elevation data was then cut for each cross-section using the geometric data mentioned above. Blocked obstructions and ineffective flow areas were set appropriately using engineering judgement and guidance from the HEC-RAS hydraulic reference manual. Manning's "n" values for the cross-sections were determined using recent aerial imagery. Manning's "n" values used in the hydraulic study are summarized in Table 2.

Table 2. Hydraulic Model Manning's "n" values.

Land Cover	Manning's "n" value
Natural Channel	0.045
Open Space	0.040
Manicured Grass	0.030
Wooded / Forested Areas	0.100
Railroad / Industrial	0.180

Little Cedar Creek crosses NW Main Street and the Union Pacific Railroad in the hydraulic model. Elevations and sizes for these culverts were modeled based off of multiple topographic surveys and drone LiDAR. Some discrepancies in regard to culvert sizes and invert elevations exist between these surveys. Culvert configurations were set using engineering judgement based off of the available information for the purposed of this preliminary flood study. Additional survey will be completed prior to the submittal of the final flood study to confirm these culvert related items. Table 3 contains a summary of the culvert configurations in the existing conditions HEC-RAS model.

Table 3. Hydraulic Model Culvert Configurations (Existing Conditions).

Location	Cross-Section	Size	Material
NW Main Street	3540	9-foot by 6-foot elliptical	corrugated metal
Union Pacific Railroad	2232	10-foot by 6-foot elliptical	corrugated metal

The downstream cross-section of the hydraulic model is located at the upstream limit of FEMA's detailed study for Little Cedar Creek at cross-section AF. The starting WSE for the 50-year and 100-year flow profiles of Little Cedar Creek were set equal to the corresponding WSE's at FEMA cross-section AF.

These same modeling procedures were repeated for creation of the hydraulic model for the unnamed tributary to Little Cedar Creek. The starting 100-year WSE for this model was set by first running the existing conditions model for Little Cedar Creek. The 100-year WSE at the confluence of Little Cedar Creek and the unnamed tributary to Little Cedar Creek was then calculated by interpolating between the determined WSE's for nearby cross-sections (2791 and 3207) of Little Cedar Creek. The calculated 100-year WSE for Little Cedar Creek at the confluence was used as the starting WSE for the unnamed tributary to Little Cedar Creek. This process was repeated for the 50-year flow profile.

Flow changes from the hydrologic model were incorporated into the hydraulic model. Table 4 contains a summary of these flow changes.

Table 4. Hydraulic Model Flow Changes.

Hydrologic Element	Q_{50} (cfs)	Q_{100} (cfs)	Reach[1]	Cross-Section
Point 1	2,416	2,709	Main Channel	2791
Area B	866	1,066	Main Channel	5394
Area C	1,476	1,711	Tributary	1192

*Q = flow rate, *cfs = cubic feet per second
[1]Little Cedar Creek = Main Channel, Unnamed Tributary to Little Cedar Creek = Tributary

2.2.2.Hydraulic Model Development - Proposed Conditions

The proposed conditions hydraulic model was created by modifying the existing conditions hydraulic model to match the proposed site layout. Proposed grading was incorporated into the hydraulic model and affected cross-sections were cut using the proposed topographic information. Proposed grading affects the overbank geometries of multiple cross-sections; however, the channelized portions of both streams remain largely unaffected by the project. For this reason, the locations of all cross-sections are the same in both existing and proposed conditions. Manning's n-values and other items were updated appropriately to match the proposed site layout. Peak flow rates remain the same as in existing conditions as detention will be provided for the site to limit peak flow rates for proposed conditions to at or below peak flow rates in existing conditions. Locations of flow changes also remain the same as in existing conditions.

The culvert crossing located under NW Main St was updated to meet City of Lee's Summit design criteria. Per the City of Lee's Summit's Thoroughfare Master Plan, NW Main Street is classified as commercial/industrial collector. City of Lee's Summit's Design criteria states that the minimum design storm capacity for collector streets 50-year design storm. The City of Lee's Summit has also adopted the design criteria of the Kansas City Metropolitan Chapter of the American Public Works Association's (KC-APWA) 2011 design guidance document "Section 5600 Storm Drainage Systems & Facilities". KC-APWA 5600 requires that overflow depths at low points in roadways be limited to 7-inches or less during the 100-year design storms. The proposed culvert configuration was sized in order to meet the design criteria stated above. For the purposes of this preliminary study, proposed roadway widths and profile are assumed to be the same as in existing conditions. These items will be updated as the design progresses and verified prior to submitting the final version of this study. The culvert located under the Union Pacific Railroad remains the same as in existing conditions as it is located outside of the project limits.

3. RESULTS

The following sections summarize the results of hydraulic analysis. The results of the hydrologic analysis have been summarized in Section 2.1 of this study.

3.1. Hydraulic Results

The hydraulic impact of the project along Little Cedar Creek and the unnamed Tributary to Little Cedar Creek can be analyzed by examining water surface elevations of the nearby HEC-RAS cross-sections. The 50-year and 100-year storm WSE's are shown below in Table 5 at representative cross-sections throughout the site for existing conditions and proposed conditions. A summary of outputs from HEC-RAS model can be found in Appendix B.

Table 5. 100-Year Water Surface Elevations.

Reach[1]	Cross Section	Proposed Conditions (feet)	Existing Conditions (feet)	Δ WSE (feet)
Main Channel	5394	980.33	980.39	-0.06
Main Channel	5209	974.91	974.91	0.00
Main Channel	5015	971.19	971.22	-0.03
Main Channel	4787	968.79	968.81	-0.02
Main Channel	4506	965.53	965.65	-0.12
Main Channel	4225	962.67	963.06	-0.39
Main Channel	3909	957.74	959.92	-2.18
Main Channel	3635	957.63	959.89	-2.26
Main Channel	3591	957.47	959.89	-2.42
Main Channel	3540 (Culvert)	-	-	-
Main Channel	3488	949.34	949.34	0.00
Main Channel	3411	948.3	948.3	0.00
Main Channel	3207	947.46	947.42	+0.04
Main Channel	2791	947.32	947.32	0.00
Main Channel	2598	947.25	947.26	-0.01
Main Channel	2272	947.26	947.26	0.00
Main Channel	2232 (Culvert)	-	-	-
Main Channel	2191	937.45	937.45	0.00
Main Channel	2146	934.88	934.88	0.00
Tributary	1192	961.54	961.54	0.00
Tributary	1076	960.05	960.06	-0.01
Tributary	886	956.69	956.68	+0.01

Reach[1]	Cross Section	Proposed Conditions (feet)	Existing Conditions (feet)	Δ WSE (feet)
Tributary	784	954.53	954.62	-0.09
Tributary	612	951.64	951.62	+0.02
Tributary	488	949.94	949.94	0.00
Tributary	300	947.54	947.54	0.00
Tributary	188	947.39	947.39	0.00
Tributary	100	947.32	947.32	0.00

*WSE = water surface elevation, *Δ = difference in value

[1]Little Cedar Creek = Main Channel, Unnamed Tributary to Little Cedar Creek = Tributary

The results of the HEC-RAS model indicate that 100-year water surface elevations are not increased from proposed conditions to existing conditions along a majority of the cross-sections along Little Cedar Creek and the unnamed tributary to Little Cedar Creek. Three cross sections (612, 886, 3207) indicate an increase in 100-year water surface elevations as shown in Table 5. These three sections are all located within the property limits of the project and are relatively minor elevation increases, each being less than 0.05 feet. The proposed grading in these areas may be able to be adjusted to mitigate any increases in 100-year water surface elevations and meet no-rise conditions, which will be explored with the final flood study and future phases of the project.

The configuration for the culvert crossing at NW main street was updated to meet City of Lee's Summit design criteria as described in Section 2.2.2. The configuration for the culvert crossing at the Union Pacific Railroad remains the same as in existing conditions. Culvert configurations for proposed conditions are summarized in Table 6.

Table 6. Hydraulic Model Culvert Configurations (Proposed Conditions).

Location	Cross-Section	Size	Material
NW Main Street	3540	double 8-foot by 6-foot box	reinforced concrete
Union Pacific Railroad	2232	10-foot by 6-foot elliptical	corrugated metal

3.2. Low Adjacent Grade Determination

Per the City of Lee's Summit Unified Development Ordinance (Article 5. – Overlay Districts, Division II. – Floodplain Overlay District, Sec. 5.170) non-residential structures must be elevated to two feet above the BFE. Proposed conditions 100-year WSE's were used to determine the minimum low adjacent grade (LAG) elevations for the proposed buildings. These values were calculated by taking the corresponding proposed 100-year WSE at the most upstream corner of the building and adding two feet. Table 7 contains a comparison of the proposed LAG elevations to the minimum required LAG elevations. Proposed LAG's correspond to the side of the building adjacent to the stream corridor. Refer to Exhibit 3 in Appendix A for locations of proposed buildings.

Table 7. Low Adjacent Grade Comparison.

Lot	Building	Proposed LAG (feet)	100-Year WSE[1] (feet)	Minimum LAG (feet)	Δ LAG (feet)
1	A (SW Corner)	991.5	954.5	956.5	+35.0
1	A (NE Corner)	991.5	968.8	970.8	+20.7
2	B	962.0	948.3	950.3	+11.7
3	C	972.0	971.2	973.2	-1.2

*LAG = low adjacent grade, *Δ = difference in value, *WSE = water surface elevation
[1]Proposed Conditions

The calculated LAG's for buildings A and B exceed the City of Lee's Summit's requirements for minimum elevation above the floodplain. Building C as currently shown in the preliminary plans does not meet these requirements. The proposed grading around building C will be modified in final design so that the building is elevated a minimum of two feet above the corresponding 100-year WSE.

3.3. Floodplain Impacts

As described in Section 3.1, the proposed conditions floodplain elevations are lower than the existing conditions except at three cross-sections, where minor increases may occur. Floodplain widths will be affected as a result of this project as well. An exhibit displaying cross-section locations, the regulatory floodplain, the existing conditions floodplain, and the proposed conditions floodplain can be found in Exhibit 3 of Appendix A. As seen on the exhibit, the proposed buildings are located outside of the limits of the proposed 100-year floodplain.

Future submittals to the City of Lee's Summit and FEMA will be required due to changes occurring from the existing conditions floodplain to the proposed conditions floodplain. These submittals are summarized below:

- Conditional Letter of Map Revision Based on Fill (CLOMR-F) and Letter of Map Revision Based on Fill (LOMR-F) – CLOMR-F and LOMR-F's can be submitted to FEMA to remove a structure from the floodplain that has been elevated by fill. A CLOMR-F is submitted prior to construction to ensure compliance with regulations and a LOMR-F is submitted post-construction to receive official determination of removal from the floodplain. The CLOMR-F and LOMR-F process could be used to remove the proposed buildings from the regulatory floodplain as needed should the City of Lee's Summit elect not to require a CLOMR or LOMR for this project.
- Floodplain Development Permit – A floodplain development permit is required from the City of Lee's Summit for all work within the regulatory floodplain.

The CLOMR-F and LOMR-F process is recommended for this projects should no-rise conditions be achieved in final design. As noted in Section 3.1, the proposed grading will be modified in areas where a rise is currently shown to try to eliminate any increases in 100-year WSE's between existing and proposed conditions. CLOMR-F and LOMR-F submittals typically have a shorter

duration than CLOMR and LOMR submittals as reviews by FEMA are less intensive. Given the current effective Zone AE floodplain and current building layouts, CLOMR-F and LOMR-F submittals be required for Building A. Buildings B and C are outside of the limits of the current effective Zone AE floodplain.

4. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This flood study study was prepared to evaluate the floodplain impacts generated by the Scannell Development project and achieve compliance with current design criteria in effect for the City of Lee's Summit, Missouri. The project is a proposed industrial development on approximately 83 acres, including warehouses, stormwater detention basins, and open space.

The results of the hydrologic and hydraulic analysis show that the project will have little impact on floodplain elevations along Little Cedar Creek and the unnamed tributary to Little Cedar Creek. Proposed conditions 100-year water surface elevations are at or below the existing conditions 100-year water surface elevations except as noted in sections 3.1 and 3.2. Construction of detention basins as part of the project will mitigate increases in and/or reduce peak flows to points of interest as summarized in this study and discussed in detail in the stormwater study. Applications for additional permits through the City of Lee's Summit will also need to be submitted as outlined in Section 3.3.

The results of the analysis demonstrate that the flood study for the project achieves compliance with design criteria. We therefore request approval of this Scannell Development Preliminary Flood Study. This approval is conditional and should be substantiated with each plat / future phase of the project.

5. REFERENCES

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APPENDIX A

Site Maps

Exhibit 1.
FEMA Floodplain Map

Scannell Development Project
Lee's Summit, MO

- Stream Centerlines
- FEMA Floodway
- FEMA Zone AE
- FEMA Zone A
- Project Boundary

0 250 500 Feet

1 Inch = 250 Feet

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