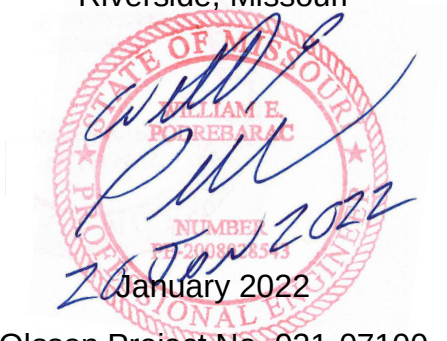
EASTGATE COMMERCE CENTER PRELIMINARY STORMWATER DRAINAGE STUDY

Prepared for:

NorthPoint Development

Riverside, Missouri



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1. GENERAL INFORMATION

This report has been prepared as the Preliminary Stormwater Drainage Study for the EastGate Commerce Center project being undertaken by NorthPoint Development. The project includes several separate parcels situated along the Little Blue River, from north of R.D. Mize Road to the abandoned railroad right-of-way, north of Lake City Road (Highway M-78). Overall, the series of nine separate parcels cover approximately 1,217 acres, extending roughly 4.5 miles along the Little Blue River corridor (Figure 1). This locates the project within portions of Sections: (02, 03, 09, 10, & 16), Twp. 49 N and Sections: (34, 35, & 36), Township 50 N, Range 31 W, within the City of Independence, Jackson County, Missouri.

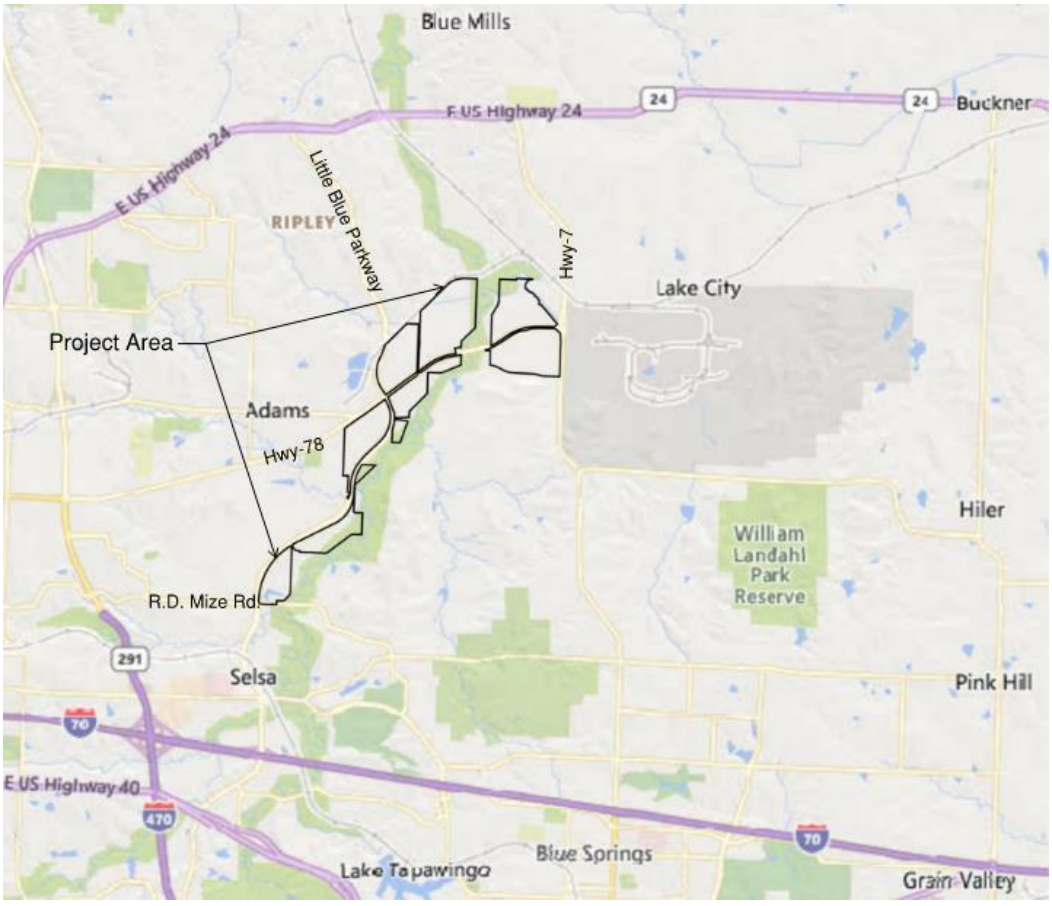

Figure 1. Vicinity Map

The proposed project site is separated into nine defined development areas, each bound by one of the proposed parcels, most of which include a cluster of buildings, as depicted in the current development plan. For the purposes of this report, these areas and the associated buildings are

identified in the following table. The preliminary site layout is depicted in the attached Exhibit B.4. The preliminary Finished Floor Elevation is also provided for reference, although these are based upon a conservative estimate of the potential future floodplain impacts. Ideally, these preliminarily proposed elevations may be lowered somewhat in an effort to optimize the amount of earthwork disturbance required for the project.

Table 1.1 - Project Development Areas and Proposed Buildings

Project Development Area:	Proposed Building ID:	Prop. Finished Floor Elevation (ft; NAVD):
A1	A1	763.5
A2	A2	761.7
A2	A3	760.5
B1	B1	754.3
B1	B2	757.9
B1	B3	758.1
B1	B4	758.2
B2	*n/a*	*n/a*
B3	B5	755.8
B3	B8	754.5
B4	B6	755.5
B4	B7	755.0
B5	B9	753.0
B5	B10	753.0
B5	B11	753.0
B5	B12	752.9
B7	B13	752.9
B7	B14	752.7
B7	B15	752.9
B6	B16	754.5
B6	B17	753.0
B6	B18	753.0
B6	B19	754.5
B6	B20	754.5

1.1 FEMA Floodplain Classification

The FEMA Flood Insurance Rate Map (FIRM) Panels 29095C- 0302G, 0304G, 0306G, 0308G, & 0312G (all effective January 20, 2017) depict the areas proposed for development. Although these effective FIRM Panels do provide the Base Flood Elevations for the majority of the development areas, there is no defined Floodway for the Little Blue River. Refer to the attached FEMA Floodplain Map (Exhibit B.1) for depiction of the established floodplains relative to the project site.

The Little Blue River is the primary flooding source for the overall development site. The effective floodplain modeling for the Little Blue River along this channel segment is dated and not available. An electronic data request was submitted to FEMA requesting the current effective model; FEMA was unable to provide any documentation to support the effective floodplain elevations in this segment of the Little Blue River. The most recent and best available hydraulic modeling for the Little Blue River was obtained from the USACE. Significant differences exist between the FEMA current effective flood elevations and USACE 100-year water surface elevations, with the USACE modeling producing water surface elevations up to three feet higher than the FEMA floodplain elevations. Information provided by the City of Independence and confirmed through the Missouri state emergency management agency (SEMA) informed us that a new floodplain modeling effort is underway and preliminary results will be available later this winter.

Anticipated building elevations provided in Table 1.1 are based on 100-year water surface elevations from the USACE model plus as an allowance of two feet of freeboard. Preliminary modeling results from FEMA will be obtained as the project progresses and the associated building elevations will be updated to reflect new information.

The proposed development consists of multiple phases located along the Little Blue Parkway corridor, and each of these parcels is at least partially located within the FEMA-designated Zone AE 100-year floodplain generated by the adjacent Little Blue River channel. In addition to this primary flooding source, there are several other tributaries, widely varying in drainage area, that convey runoff from lateral regions into the Little Blue River near the proposed development.

Some of these lateral channels cross a proposed development area. The phased project-specific designs will address the approach to managing these lateral channels, whether they're allowed to be integrated into the future stormwater management basins, or re-routed around the developed area is to be determined in the final design for these particular areas.

Three other channels within the proposed project area are currently defined in FEMA documentation as mapped tributaries:

- Spring Branch is a relatively large tributary (drainage area is approx. 9.6 mi^2) that is mapped by FEMA to include a floodway. That floodway designation, however, is not fully extended to the Little Blue River. It is possible that the requisite floodway for this tributary encroaches into the proposed development Area A2. This floodway should be evaluated with the project floodplain analysis.
- Bundschu Creek is another relatively large channel, with a drainage basin of approximately 5.0 mi^2. This channel also has a defined floodway, and while it does extend to the Little Blue River, there exists the possibility that the mapped location for this floodway is offset somewhat from the intended alignment. Detailed review of this floodway, and its potential impact to the proposed development Area B5 should be evaluated with the overall floodplain analysis for the development.
- The West Fire Prairie Creek channel extends along the eastern side of the proposed development Area B7. FEMA had previously designated this channel as a Zone AE floodplain. The current mapping, however, depicts this channel as a Zone A region. Initial review of the tributary region suggests that this re-designation may be the result of the flood control system for Lake City munitions plant. The majority of the drainage area (approx. 8.75 mi of the overall 10.75 mi^2 drainage basin) for West Fire Prairie Creek appears to be diverted at the southern side of Lake City, into a channel that extends to the Little Blue River along the southern side of proposed development Area B6. This diversion channel, though formerly defined as Zone AE, is also currently designated Zone A. It is anticipated that this diversion channel may generate the greater impact to the proposed development than the lower (north) end of the original West Fire Prairie Creek. The latter receives runoff from the remainder of the original watershed from within the Lake City plant perimeter flood control system, where it appears to be regulated with a flood gate at the southeast quadrant of the roundabout near the entrance to Lake City.
- Several other smaller channels affect the proposed development. Most of these will simply be the subject of design for individual building projects within the overall development.

Aside from these particular locations of interest, the overall site design will be required to address the floodplain impacts to the development, and demonstrate compliance with the City's Floodplain Management guidelines. A separate floodplain analysis will be submitted in conjunction with the application for a Floodplain Development Permit. It is anticipated that this permit application will be prepared upon submittal of construction documents for the initial phase of this development.

1.2 Soil Classification

While the proposed post-development conditions for the project will tend toward extensive application of paved or otherwise relatively impervious surfaces, the current land use typically consists of agriculture fields or undeveloped open areas. The site typically exhibits minimal slope, with shallow swales, and few enclosed conveyances. Soils are generally poorly drained in the relatively lower zones which appear to cover the majority of the development, though the portions of the project area that are slightly elevated appear to possess somewhat well drained soil properties. Overall, the soils generally have a deep profile, but tend to exhibit high surface runoff potential. Soil Maps published in the Soil Survey for Jackson County, Missouri categorize soils in this watershed as:

Table 1.2 - NRCS Soil Classifications

Feature ID	Hydrologic Soil Group	Description
12503	Type B	Napier silt loam, 0 to 3 percent slopes (Non-Hydric)
12506	Type C	Wiota silt loam, 0 to 2 percent slopes, rarely flooded (Non-Hydric)
36007	Type C/D	Bremer silt loam, 0 to 2 percent slopes, occasionally flooded (Hydric)
36020	Type C	Kennebec silt loam, 0 to 2 percent slopes, occasionally flooded (Non Hydric)
36046	Type D	Wabash silty clay, 0 to 2 percent slopes, occasionally flooded (Hydric)
36050	Type D	Zook silty clay loam, 0 to 2 percent slopes, occasionally flooded (Hydric)
99033	Type C	Udarents-Urban land complex, 2 to 9 percent slopes (Non-Hydric)

NRCS Runoff Curve Numbers (CN's) in this study have been assigned to development areas based upon these Hydrologic Soil Groups and associated existing land use. Although onsite area within the project site is considered generally undeveloped under Existing Conditions analysis, post-development conditions reflect a fully impervious site, and those Proposed Conditions CN's are assigned accordingly. Refer to the Soils Map (Exhibit B.2) for distribution of soil types throughout the project area.

2. METHODOLOGY

This Preliminary Stormwater Drainage Study has been prepared for the EastGate Commerce Center to establish a proposed stormwater management strategy that achieves compliance with the applicable design requirements of the City of Independence, Missouri. The hydrologic analysis provided in this report is based upon methods prescribed by the currently adopted version of the Kansas City Metropolitan Chapter of the APWA Standard Specifications and Design Criteria, "Storm Drainage Systems and Facilities" Division V, Section 5600 (March

1990). The following sources and methods are used in this report to evaluate the existing and proposed conditions for stormwater runoff.

- Software - Haestad Methods, Inc. “PondPack” V8*i* (08.11.01.56)
- NRCS Curve Number Method
- NRCS TR-55 Unit Hydrograph Method (preliminary estimates for required storage)
- 2-, 10-, and 100-year Return Frequency, 24-hr. Storm Precip. Depths (TP-40)
- AMC Type II Soil Moisture Conditions
- 24-Hour NRCS Type II Rainfall Distribution
- Runoff Curve Numbers per NRCS TR-55 (Tables 2-2a – 2-2c) and APWA Sec.5602.2

Modeling was performed for each of the currently defined development areas. The purpose of this analysis is to establish an estimated total storage volume that would be necessary to meet the allowable release rates (ARR’s) using conventional dry-basin detention, as defined in the City’s Stormwater Management Manual. These rates are 0.5 cfs/ac, 1.0 cfs/ac, and 1.8 cfs/ac for the 2-, 10-, and 100-year design storm events, respectively. This manual also references the general requirements for Stormwater Best Management Practices (BMP’s). The basic requirement is to provide extended detention for the defined Water Quality Volume (WQ_V) storm. This event is defined as a threshold precipitation depth representing the maximum average 24-hour storm for this region, under which the cumulative runoff volume of all annual lesser events generates 90-percent of the average annual stormwater runoff volume.

Stormwater runoff models were created for the 2-, 10-, and 100-year design storm events. The precipitation depths used in the analyses have been interpolated from the “Technical Paper No. 40 Rainfall Frequency Atlas of the United States” (TP-40) isopluvial maps (U.S. Weather Bureau, May 1961). In addition to the three TP-40 design storms based upon return frequency, a fourth event, the WQ_V storm is included to evaluate provisions to improve water quality for site discharge, in accordance with the City’s effective NPDES permit (MO-0130401, Sep. 2018). The following table summarizes the rainfall depths used in this analysis:

Table 2.1 – Precipitation Depths

Return Period:	24-hour Precipitation Depth (in):
Water Quality Storm (WQ_V)	1.37
2-Year (50% Storm)	3.50
10-Year (10% Storm)	5.34
100-Year (1% Storm)	7.71

For the purposes of stormwater runoff analysis in this Preliminary Stormwater Drainage Study, only the 100-year event is relevant with respect to peak discharge rate analysis as defined in

APWA Section 5600. However, these four defined events are referenced in the Stormwater Management Manual. Additional details pertaining to requirements for stormwater management are outlined in the following section.

2.1 Stormwater Detention

Two sources of design guidance define stormwater management requirements for this project. Section 5600 of the APWA Standard Specifications and Design Criteria defines the overall stormwater management requirements for large storm hydrology. The City's Stormwater Management Manual outlines the requirements for compliance with the effective NPDES Permit. Though all four of the defined design storms are referenced, requirements in that document are particularly concerned with small-storm hydrology. The objective of this Preliminary Stormwater Drainage Study is to propose a stormwater management strategy for the EastGate Commerce Center that achieves compliance with both documents that define design standards.

Preliminary review of the current conditions and site constraints for the project area has led to the proposal that this overall development be granted a conditional waiver for the standard requirements for stormwater detention. This request is predominantly based upon the low-lying areas that comprise the development parcels relative to existing enclosed conveyances, channels, and resultant tailwater conditions generated by the contributing watersheds.

Initial justification for this request is defined by the following passage:

APWA 5601.5.C – *"These requirements to provide detention apply to all development except when downstream flooding is entirely confined within the limits of the 100-year flood plain as defined by the Federal Flood Insurance Study current at the time development is proposed."*

While the site conditions clearly satisfy this APWA exemption, additional consideration is warranted with respect to the effective Stormwater Management Manual. The current edition of the City's Stormwater Management Manual includes the provision that:

"Alternative stormwater management techniques may be proposed. It is the responsibility of the design professional to demonstrate the appropriateness and effectiveness of the proposed solution and maintenance plan."

It is in response to this caveat that the following analyses for this Preliminary Stormwater Management Study have been prepared. Specific information related to the justification for this waiver request and for the suggested conditions that would govern future compliance will be provided at the conclusion of this report.

3. CURRENT CONDITIONS ANALYSIS

This section of the Preliminary Stormwater Drainage Study for the EastGate Commerce Center provides an overview of the existing conditions with respect to stormwater runoff for the nine defined areas considered in the current development plan.

This Preliminary Stormwater Drainage Study does not include detailed hydrologic analysis of existing conditions drainage patterns and establishing points of interest to define peak discharge rates from the project area. The rationale for this decision is based upon the somewhat indeterminate drainage patterns that are present for relatively large portions of the parcels. Defining meaningful points of interest that will retain significance throughout the development process is impractical at the time that this preliminary analysis is being prepared. These points are subject to change based upon grading and new drainage pathways that will be established in the design of each development area.

Final design of these various development areas will alter current, and create new drainage paths and conveyances; geometric features within the project will vary throughout the development process. Therefore, an allowable release rates calculation at any discrete series of assigned discharge points would likewise vary, rendering that specific content of this Preliminary Study ineffective.

The design criterion for establishing the prescriptive ARR's does not require the evaluation of pre-project conditions for development areas; only the post-development peak discharge rates are relevant. Offsite flows are considered "allowable bypass" and that aspect of site-specific analysis will be performed in conjunction with detailed design of each of the development areas. This report will provide a hydrologic analysis with the NRCS Curve Number Method. In lieu of computing the existing conditions peak discharge rates, the NRCS Curve Number Method is employed to calculate the cumulative runoff volume for pre-project conditions under the various design storm events.

The following existing conditions analysis is provided to enable comparison between the pre- and post-development conditions, establishing the hydrologic impact generated by the EastGate Commerce Center. The following table provides the acreage and weighted NRCS Curve Number for each defined development area. There is also a column that depicts the "Onsite Development Area." This provides an adjusted acreage for the three development areas that currently appear to incorporate fairly significant portions that will remain undeveloped in the post-project condition.

Table 3.1 Hydrologic Parameters for Existing Conditions Development Areas

Area ID:	Total Area (ac):	Onsite Dev. Area (ac):	Weighted NRCS CN:
Area A1:	91.27	67.49	82
Area A2:	111.67	96.91	80
Area B1:	138.49	138.49	82
Area B2:	18.01	18.01	79
Area B3:	100.15	100.15	81
Area B4:	140.27	140.27	81
Area B5:	252.79	252.79	81
Area B6:	195.40	195.40	81
Area B7:	168.64	139.28	81
Total:	1,216.69	1,148.79	-

Under ordinary circumstances, the computation of existing conditions under a prescriptive release rate design criterion is of value only in establishing the allowable bypass flows- the runoff generated by offsite regions that flows onto the proposed development site or converges at a designated point of interest. Due to the unusual conditions that affect the development areas in this analysis, the existing conditions runoff volume will be utilized to provide some context for the hydrologic impact generated by this project.

The following table provides the results of the NRCS Curve Number Method calculations for each of the defined development areas. Please note that these volumes are based upon the "Onsite Dev. Area" acreage depicted in the preceding table (Table 3.1). This affects the three development Areas A1, A2, and B7 that differ between the anticipated development acreage and the total parcel area. Portions of these three areas are not proposed for future development; they will remain in their current state under post-developed conditions. Therefore, those portions of the site have been omitted from the Existing Conditions calculations so that there is a direct comparison to the Proposed Conditions analysis.

Table 3.2 - Cumulative Runoff Volumes for Existing Conditions Development Areas

	WQ Vol.:		2-Year:		10-Year:		100-Year:	
Area ID:	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):
Area A1:	0.29	1.61	1.78	10.03	3.38	19.04	5.58	31.41
Area A2:	0.23	1.87	1.64	13.22	3.19	25.77	5.35	43.24
Area B1:	0.28	3.20	1.78	20.57	3.38	39.06	5.58	64.45

	WQ Vol.:		2-Year:		10-Year:		100-Year:	
Area B2:	0.21	0.32	1.57	2.35	3.10	4.65	5.24	7.86
Area B3:	0.26	2.18	1.71	14.26	3.29	27.44	5.47	45.64
Area B4:	0.26	3.04	1.71	19.97	3.29	38.43	5.47	63.93
Area B5:	0.24	5.15	1.71	35.99	3.29	69.26	5.47	115.21
Area B6:	0.26	4.25	1.71	27.82	3.29	53.53	5.47	89.06
Area B7:	0.26	3.03	1.71	19.83	3.29	38.16	5.47	63.48

The existing NRCS Curve Numbers are relatively similar for all the development areas, varying only from 79 to 82. Therefore, the computed runoff depth is likewise relatively consistent for each area under a given design storm event.

Please note that, although results from the WQ_V runoff calculations are included in this existing conditions table, they do not have any direct bearing upon the project's BMP requirement, which is solely based upon Proposed Conditions. These have been included strictly for purposes of comparison to post-developed conditions, where the impact of small-storm hydrology will become apparent.

The allowable release rates (ARR's) for the project site are computed in the following section. As this Preliminary Stormwater Drainage Study does not incorporate offsite areas, which generate "Allowable Bypass" these onsite ARR's will be utilized in the effort to compute the estimated storage volume that would be required for new detention basins to meet the general design criteria.

3.1 Allowable Release Rate Calculations

The APWA Standard Specifications and Design Criteria adopted by the City of Independence, Missouri require stormwater management facilities to restrict peak discharge rates from the 100-year design storm to a maximum of 1.8 cfs/ac, for all onsite areas. In addition to this criterion, the City's Stormwater Management Manual includes prescriptive ARR's for the 2- and 10-year design storms (at 0.5 cfs/ac & 1.0 cfs/ac, respectively). Since these are being computed exclusively for proposed development areas, the following rates provided in Table 3.3 are a direct calculation, with no provision for "Allowable Bypass" discharge rates.

Table 3.3 - Allowable Release Rates for Development Areas

Area ID:	Area (ac):	2-Year ARR (cfs):	10-Year ARR (cfs):	100-Year ARR (cfs):
A1	67.49	34	67	121
A2	96.91	48	97	174

Area ID:	Area (ac):	2-Year ARR (cfs):	10-Year ARR (cfs):	100-Year ARR (cfs):
B1	138.49	69	138	249
B2	18.01	9	18	32
B3	100.15	50	100	180
B4	140.27	70	140	252
B5	252.79	126	253	455
B6	195.40	98	195	352
B7	139.28	70	139	251

As noted in Section 2.1, this Preliminary Stormwater Drainage Study includes the request for a waiver from the conventional requirements for stormwater detention. While the conditions for the waiver are readily demonstrated for the APWA Section 5600 compliance, additional analysis is warranted to quantify the hydrologic impact generated by the proposed EastGate Commerce Center in order to justify this request with respect to the City's Stormwater Management Manual. The following section considers the project hydrology in the post-development, proposed condition.

4. PROPOSED CONDITIONS ANALYSIS

Analyses included in this section are provided to evaluate the proposed conditions hydrology for the EastGate Commerce Center. This report has been prepared in conjunction with the Development Plan for the multi-phase EastGate Commerce Center project. It is anticipated that the final configuration of the various phases considered in this report will vary somewhat in response to site constraints and market demand at the time construction of the project proceeds.

Therefore, to provide appropriate flexibility, the proposed conditions for the various development areas utilizes an NRCS Curve Number representing a fully impervious site. It should be noted that this is not an exceedingly conservative assumption, as the proposed land use includes large commercial buildings with extensive parking lots, drive aisles, and storage areas. Beyond the paved site, much of the area surrounding those impervious surfaces will incorporate swales and stormwater storage areas. Therefore, the assumption of CN=98 is likely close to the actual post-project condition and will allow flexibility for the final configuration of the various development areas. Application of this Curve Number also provides a practical estimate of the maximum development within the defined parcels.

The following table provides the proposed conditions hydrologic parameters for the project's development areas, including the anticipated "Onsite Development Area," which will define the areas computed in this report.

Table 4.1 - Hydrologic Parameters for Proposed Conditions Development Areas

Area ID:	Total Area (ac):	Onsite Dev. Area (ac):	Weighted NRCS CN:
Area A1:	91.27	67.49	98
Area A2:	111.67	96.91	98
Area B1:	138.49	138.49	98
Area B2:	18.01	18.01	98
Area B3:	100.15	100.15	98
Area B4:	140.27	140.27	98
Area B5:	252.79	252.79	98
Area B6:	195.40	195.40	98
Area B7:	168.64	139.28	98
Total:	1,216.69	1,148.79	-

Similar to the current conditions considered in Section 3 of this report, the following table provides the results of the NRCS Curve Number Method for Proposed Conditions based upon the hydrologic parameters depicted in Table 4.1.

Table 4.2(a) - Cumulative Runoff Volumes for Proposed Conditions Development Areas

	WQ Vol.:		2-Year:		10-Year:		100-Year:	
Area ID:	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):
Area A1:	1.15	6.48	3.27	18.37	5.10	28.70	7.47	42.01
Area A2:	1.15	9.31	3.27	26.38	5.10	41.21	7.47	60.33
Area B1:	1.15	13.30	3.27	37.70	5.10	58.89	7.47	86.21
Area B2:	1.15	1.73	3.27	4.90	5.10	7.66	7.47	11.21
Area B3:	1.15	9.62	3.27	27.26	5.10	42.59	7.47	62.35
Area B4:	1.15	13.47	3.27	38.18	5.10	59.65	7.47	87.32
Area B5:	1.15	24.27	3.27	68.81	5.10	107.49	7.47	157.37
Area B6:	1.15	18.76	3.27	53.19	5.10	83.09	7.47	121.64
Area B7:	1.15	13.37	3.27	37.91	5.10	59.22	7.47	86.71

Note that the runoff depth is consistent for all the areas under each design storm. This is the result of consistent application of the fully-impervious conditions CN for these development areas: runoff depth is a function of Curve Number and precipitation depth. This aspect of volume computation will also become apparent with review of the results provided in Section 4.1 of this Preliminary Stormwater Drainage Study.

In order to establish the hydrologic impact generated by the proposed EastGate Commerce Center, the following table provides the difference between the Existing- and Proposed Conditions runoff volume calculations. The sign convention used in Table 4.2(b) is "Proposed minus Existing Conditions." Therefore, positive values represent an increase in runoff volume under post-development conditions.

Table 4.2(b) – Comparison of Results:
Cumulative Runoff Volumes for Proposed versus Existing Conditions

	WQ Vol.:		2-Year:		10-Year:		100-Year:	
Area ID:	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):	Runoff (in):	Cum. V_R (ac-ft):
Area A1:	0.87	4.88	1.48	8.35	1.72	9.66	1.89	10.60
Area A2:	0.92	7.44	1.63	13.16	1.91	15.43	2.12	17.09
Area B1:	0.87	10.10	1.48	17.12	1.72	19.82	1.89	21.76
Area B2:	0.94	1.41	1.70	2.55	2.01	3.01	2.23	3.35
Area B3:	0.89	7.44	1.56	13.00	1.82	15.15	2.00	16.70
Area B4:	0.89	10.43	1.56	18.21	1.82	21.22	2.00	23.39
Area B5:	0.91	19.12	1.56	32.82	1.82	38.24	2.00	42.16
Area B6:	0.89	14.52	1.56	25.37	1.82	29.55	2.00	32.59
Area B7:	0.89	10.34	1.56	18.08	1.82	21.07	2.00	23.23
Total:	-	**85.67**	-	**148.67**	-	**173.15**	-	**190.88**

Results provided in the preceding table demonstrate that the proposed development does generate an increase in cumulative runoff volume for the 100-year storm. However, this increase for the nine development areas is actually relatively modest in terms of impact to the overall Little Blue River watershed.

Of more significant hydrologic impact is runoff from the WQ_V event. The average increased runoff depth for the WQ_V event is approximately 0.90 inches, a relative change of roughly 3.5 times the cumulative runoff volume compared to the pre-project conditions.

A compounding factor to the volumetric impact for small-storm hydrology is related to the computation of peak discharge rates. Pre-project conditions for the development exhibit extremely flat, planar drainage areas, and the time of concentration is relatively lengthy for these drainage paths due to shallow ponding and restricted flow velocities. In contrast, the proposed conditions for this site will include design elements to accommodate positive drainage, predominantly across paved surfaces or within efficient swales or enclosed conveyances, resulting in a relatively short time of concentration. Therefore, the total impact of the small-storm hydrology would be further exacerbated by the significant reduction in time of concentration. Significantly increased peak discharge rates coupled with much greater cumulative runoff volumes in these frequent storm events would likely prove to be the greatest hydrologic impact generated by the proposed development.

Therefore, while this report includes the request for a waiver for the provisions for detention under large storm hydrology, it is the acknowledged that this project will need to address post-development impacts to runoff from the Water Quality storm. In order to obtain an estimate for the stormwater detention volumes that would be required for the development areas, construction of runoff hydrographs for each development area is necessary. That analysis, provided in the following section, is based upon the project's proposed conditions hydrologic parameters established in Section 4 of this report.

4.1 Estimated Stormwater Detention Volume Requirements

Based upon preliminary investigation of the project area and general boundary conditions, it is the stated intent of this report to request a waiver for the conventional requirements for detention of the 100-year design storm. While the conditions for an exemption under APWA 5601.5.C are met, further analysis is necessary to evaluate the stormwater runoff and storage calculations in order to warrant a waiver for the City's Stormwater Management Manual allowable release rate criteria. This request is based upon a preliminary site assessment that suggests that conventional stormwater detention basins will be subject to external influence; constructing a basin with adequate depth to receive runoff from the development area will expose the basin's outfall to periodically significant and frequently variable tailwater conditions from the Little Blue River. The entire active storage volume of these conceptual detention basins will be lower than the base flood elevations for the receiving streams. Rather than avoidance of provisions for stormwater management features, this request for a conditional waiver pertains specifically to the established allowable release rates for significant storm events and allowance for an alternative stormwater management technique.

It should be noted that most of these separate development areas would likely incorporate more than a single storage area within the site. The following conceptual analysis considers only a single basin for each area. These volume estimates are somewhat general: multiple basins may

be constructed based upon the total targeted active storage volume. There is some loss of storage efficiency when breaking a total volume requirement into multiple, smaller basins to meet a stated design objective. Provisions for freeboard, overflow spillways, and multi-stage outlets tend to expand the total excavated volume necessary to match the performance of a single, larger basin. However, where they exist, differences in timing of discharge hydrograph peaks from multiple basins is typically a mitigating factor. Regardless, the single calculation convention defining the active-storage volume requirement for each development area is provided in this analysis. Detailed analyses for each of the defined development areas will be the subject of an associated Micro Stormwater Drainage Study.

One other aspect of this analysis is the use of a fixed time of concentration for all the modeled development areas. The rationale behind this decision is that, for conceptual detention volume estimation, a lengthier time of concentration tends to increase the computed volume requirement. Although the hydrograph's computed peak discharge rate trends downward with increases in time of concentration, cumulative runoff volumes remain fixed for a given design storm. A defined time of concentration of 0.250 hours has been applied to each of the proposed development areas in this analysis. That value is based upon the upper limit of preliminary calculations for time of concentration upon the various development areas.

Another aspect of this analysis is the assumption that these conceptual storage areas would be required to utilize multi-stage outlets in order to meet the established ARR's for the three design storms. The "Curvilinear Method" is utilized to estimate storage in this analysis. This method is best suited to estimate the storage requirement for a multi-stage outfall design.

The following tables provide the results of the stormwater detention volume estimates for each of the nine development areas. Information provided in each table includes the computed inflow hydrograph peak discharge rate, the cumulative runoff volume, the development area's ARR, and finally, the two columns at the right end of each table provide the stormwater storage estimates.

The first of these two columns provides the detention volume estimate from the Curvilinear Method. The last column simply provides the sum of that development area's runoff volume from the WQ_V event plus the computed storage volume for each design event. This value will typically over-estimate the actual storage requirement, since runoff generated by the 1.37 inch WQ_V event would also be a component of the other three design storms. However, the true storage requirement would likely be somewhat greater than the basic design storm calculation, since the Stormwater BMP provisions require 40-hour extended detention of runoff from the WQ_V storm. Therefore, the last column provides a conservative estimate of the total volume requirement for the development areas, assuming that each conceptual basin provides the storage for both BMP treatment and conventional dry-basin storage.

Table 4.3(a) – Estimated Required Detention Storage: Area A1 *(67.49 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	238	18.37	34	8.46	14.94
10-Year:	365	28.70	67	12.35	18.83
100-Year:	529	42.02	121	16.99	23.47

Table 4.3(b) – Estimated Required Detention Storage: Area A2 *(96.91 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	342	26.38	48	12.18	21.49
10-Year:	524	41.21	97	17.70	27.01
100-Year:	759	60.33	174	24.39	33.70

Table 4.3(c) – Estimated Required Detention Storage: Area B1 *(138.49 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	488	37.70	69	17.39	30.69
10-Year:	750	58.89	138	25.32	38.62
100-Year:	1,085	86.22	249	34.85	48.14

Table 4.3(d) – Estimated Required Detention Storage: Area B2 *(18.01 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	63	4.90	9	2.26	3.99
10-Year:	97	7.66	18	3.29	5.02
100-Year:	141	11.21	32	4.55	6.27

Note: Development Area B2 is currently intended solely for stormwater storage; there are no proposed buildings depicted on this parcel in the current Site Plan.

Table 4.3(e) – Estimated Required Detention Storage: Area B3 *(100.15 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	353	27.26	50	12.57	22.19
10-Year:	542	42.59	100	18.30	27.92
100-Year:	785	62.35	180	25.20	34.82

Table 4.3(f) – Estimated Required Detention Storage: Area B4 *(140.27 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	494	38.18	70	17.61	31.07
10-Year:	759	59.65	140	25.64	39.11
100-Year:	1,099	87.32	252	35.30	48.77

Note: Significant portions of Development Areas B4 & B5 incorporate proposed stormwater storage units.

Table 4.3(g) – Estimated Required Detention Storage: Area B5 *(252.79 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	891	68.81	126	31.74	56.01
10-Year:	1,368	107.49	253	46.17	70.45
100-Year:	1,981	157.37	455	63.59	87.86

Table 4.3(h) – Estimated Required Detention Storage: Area B6 *(195.40 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	689	53.19	98	24.50	43.26
10-Year:	1,058	83.09	195	35.71	54.48
100-Year:	1,531	121.64	352	49.14	67.90

Table 4.3(i) – Estimated Required Detention Storage: Area B7 *(139.28 ac.)*

Return Event:	Peak Inflow (ft^3/s):	Total V_R (ac-ft):	ARR Target Peak Discharge Rate (ft^3/s):	Est. Detention Storage Req'd (ac-ft):	Max. Estimate [WQv+Det] (ac-ft):
2-Year:	491	37.91	70	17.46	30.83
10-Year:	754	59.23	139	25.46	38.83
100-Year:	1,091	86.71	251	35.03	48.40

Consideration of the preceding values for estimated detention storage indicates that there is underlying consistency in the results for each of the events for these areas under consideration. The use of fixed times of concentration and CN's for proposed conditions upon all the development areas generates identical unit-storage requirements for each of the given areas. The Curvilinear Method used in this analysis provides estimated requirements of 0.13 (ac-ft)/acre for the 2-year event, 0.18 (ac-ft)/acre for the 10-year event, and 0.25 (ac-ft)/acre for the 100-year design storm.

In addition to the estimated storage volumes for these larger return-frequency based design storms, small storm hydrology, defined by the WQ_V event is also of interest. The Stormwater Management Manual requires extended detention for runoff from the WQ_V storm, or equivalent provisions for Stormwater BMP's. Detailed design for water quality treatment systems will be included in each development area's construction documents and associated Micro Stormwater Drainage Study.

For purposes of this Macro-level analysis, the runoff generated by the WQ_V storm is included for total storage volume estimates. While there is not necessarily a direct-sum addition requirement for runoff from the WQ_V storm to the 100-year estimated detention volume, it is not a completely separate element. Runoff computed for the WQ_V storm also represents the first 1.15 inches of runoff from each larger storm under proposed conditions for this site. With the requirement for 40-hour Extended Detention, this nested volume is subject to what constitutes a negligible ARR. Therefore, when utilizing the assumption of a single conceptual detention basin with a multi-stage outlet, the significant volume of runoff from the WQ_V event within each development area in turn creates an inefficiency affecting the initially computed storage volume. Final design analysis would typically find storage requirements that fall somewhere in between the base-volume estimate for the 100-year storm, and the sum of that volume plus the WQ_V.

5. SUMMARY

For reference, the results of this preliminary analysis are summarized in the following table (Table 5.1), which provides the sum of all the separate development areas. Data in this table

demonstrate that the initial detention storage estimates exhibit broad variation in comparison to the relative increases in runoff volume. Total storage required for the 2-year event is slightly lower than the cumulative increase in runoff volume for that event, whereas the 100-year event exhibits an increase of nearly 100 ac-ft of required storage. The additional 110 ac-ft runoff generated by the WQ_V storm represents a significant increase to each of these storage estimates for the project.

Table 5.1 – Total Estimated Detention Storage

Return Event:	Increased Runoff Volume (ac-ft):	Total Est. Detention Storage Req'd (ac-ft):	Total Runoff from WQV Storm (ac-ft):	Total Storage Volume Est. [WQv+Det] (ac-ft):
2-Year:	148.67	144.15	110.31	254.46
10-Year:	173.15	209.94	110.31	320.25
100-Year:	190.88	289.03	110.31	399.34

The nearly 400 ac-ft cumulative volume estimate for the 100-year design storm represents a substantial amount of storage required for this project to meet the prescribed ARR's. However, as stated in Section 2.1 of this report, the EastGate Commerce Center meets the requirement for an exemption from the requirements for providing stormwater detention under APWA 5601.5.C, due to the proximity of the project area and the FEMA floodplain.

The City's Stormwater Management Manual provides additional guidance for design requirements. That document outlines additional stormwater detention criteria, including provisions for stormwater BMP's and allowable release rates. As with the waiver for stormwater detention under APWA Section 5600, the site assessment conducted for this Preliminary Stormwater Management Study indicates that conventional stormwater detention basins are inclined to be subject to external influence based upon the project area's position within the watershed and proximity to floodplains; the excavated areas will all be considerably lower than the established base flood elevation. Therefore, under the Manual's allowance for alternative stormwater management techniques, a conditional waiver is being requested for the provision of stormwater detention designed to meet these prescribed release rates.

The alternative technique recommended for this project includes construction of excavated storage units within each of the proposed development areas in lieu of conventional stormwater detention that is designed to meet a prescribed peak discharge rate for the three larger design storm events. Each excavated storage unit would provide a direct connection to the receiving channel either by an enclosed conveyance that would allow interflow, or as an overbank shelf region. These excavations will be configured in the project's grading plans, as the spoils are proposed for use as onsite fill material required to elevate the building pads safely above the

effective FEMA-designated base flood elevation. Preliminary analysis indicates that the total storage generated by these excavations would exceed the estimated volume computed for the project, as established in Section 4.1 of this report.

This request for a conditional waiver pertains to the established ARR's and detention facilities; the remaining design criterion that the project would be required to meet is the provision for water quality treatment in the form of stormwater BMP's. The intent of these excavated storage areas is not a conventional provision for stormwater detention. Instead, while these areas do compensate for the increased runoff volume generated by the proposed development, they allow the opportunity for use as stormwater BMP's where they can be configured to receive onsite stormwater runoff. Other development areas may be required to construct smaller onsite treatment cells to fully accommodate the water quality treatment. Details for implementation of stormwater BMP's will be the subject of a phase-specific Micro Stormwater Drainage Study.

Information defining the final site plans for all the development areas is unavailable at the time of this analysis and beyond the scope of this Macro-level, Preliminary Stormwater Drainage Study. The objective of this report is to define an overall stormwater management strategy that is compliant with requirements for the City of Independence, and applies to all the project's development areas. As final site plans and construction documents are generated for the various development areas, the proposed conditions are subject to update and revision. Details for addressing provisions for stormwater BMP's will be based upon the findings established by each Micro Study prepared for the phases of the EastGate Commerce Center.