

MEMORANDUM

To: City of Louisville

From: Cassie Slade, PE, PTOE and Scott Kilgore, PE

Date: March 7, 2024

Project: Redtail Ridge – Louisville, Colorado

Subject: Internal Site Intersection Analysis

The Fox Tuttle Transportation Group completed the *Redtail Ridge Traffic Impact Study*¹ (TIS) with a comprehensive analysis of traffic generation and proposed improvements with the Redtail Ridge project. This memorandum provides a specific look at planned intersections internal to the Redtail Ridge site with recommended infrastructure including traffic control type, number of lanes, and lane assignment. Analysis methodology used for this memorandum is consistent with the TIS as described in Section 4.0 and the internal intersections were discussion in Section 9.0.

The proposed cross section for internal streets was designed to provide a high degree of access and comfortable multimodal travel. Internal local roadways are all proposed to have one travel lane per direction, a buffered bicycle lane in each direction, and detached 5-foot sidewalks on both sides of the street separated from the roadway by an 8-foot landscape buffer. Vehicle volumes on internal roadways are expected to be below 2,500 vpd. Turning volumes and opposing through volume, under the full buildout scenario, do not justify the addition of dedicated turn lanes at access points to individual lots.

Proposed Internal Street Grid

The Redtail Ridge site is vacant and currently does not have any through street connections. With the project, a new street grid will be established to provide access to the individual lots within the site as well as improve circulation and redundancy within the area. The proposed internal street grid is shown on **Figure 1** and is comprised of the streets described on the following page.

¹ *Redtail Ridge Traffic Impact Study*. Fox Tuttle Transportation Group. October 2023.



- **Campus Drive** is a primary east-west collector street on the north side of the site. At present, Campus Drive goes from S. 88th Street and dead ends at the east edge of the Monarch School campus. Redtail Ridge will be extending Campus Drive east from the current end point to S. 96th Street, providing a key missing connection in the street grid in the area. The current cross-section east of S. 88th Street will remain, which includes two eastbound lanes and one westbound lane. East of the Monarch campus to the future Sorrel Avenue, Campus Drive is proposed to provide one vehicle travel lane per direction. Between Sorrel Avenue and S. 96th Avenue, it is proposed that Campus Drive provide two vehicle travel lanes per direction. Detached sidewalks and buffered bike lanes in both directions are planned for the entire length of Campus Drive.
- **Rockcress Drive** will be a primary east-west collector street on the south side of the Redtail Ridge property that will utilize the former Tape Drive access points at S. 88th Street and Northwest Parkway. One travel lane in each direction is planned from S. 88th Street to Sorrel Avenue and then widened to two travel lanes per direction from Sorrel Avenue to Northwest Parkway. Detached sidewalks and buffered bike lanes are planned in both directions for the entire length of Rockcress Drive.
- **Sorrel Avenue** will be the primary north-south collector street within Redtail Ridge and connect Rockcress Drive to Campus Drive. One vehicle travel lane in each direction is planned, with buffered bike lanes and detached sidewalks on each side of the street.
- **Internal Private Streets** will include one north-south street between Campus Drive and Rockcress Drive (west of Sorrel Avenue) and two east-west streets extending from Sorrel Avenue to the north-south collector. All internal private streets are planned to have one travel lane per direction with buffered bike lanes and detached sidewalks. These roadways will provide directional access to the driveways, parking lots, loading areas, and circulation through the site.

The roadway classification and lanes per direction are shown on **Figure 1**.

Proposed Internal Intersections

This memorandum focuses on the evaluation of internal intersections within Redtail Ridge to ensure the appropriate traffic control and auxiliary lanes are provided. There are several internal intersections that are proposed to be roundabouts, including Campus Drive at Sorrel Avenue and Rockcress Drive at Sorrel Avenue. These two roundabout intersections were not included in this memorandum (refer to TIS for details on the roundabouts). Analysis methodology, development of future background volumes, and estimation of project-generated volumes are discussed in detail in the TIS and are consistent in this memorandum.



The following intersections were analyzed in this memorandum are shown on **Figure 2** and include:

- **Intersection #101:** Campus Drive & Private Street (north-south)
- **Intersection #103:** Rockcross Drive & Private Street (north-south)
- **Intersection #104:** Rockcross Drive & Private Street (southern east-west)
- **Intersection #106:** Sorrel Avenue & Private Street (southern east-west)
- **Intersection #107:** Sorrel Avenue & Private Street (northern east-west)
- **Intersection #108:** Private Street (northern east-west) & Private Street (north-south)

Internal **intersections #102 and #105** are have been previously identified to use roundabout traffic control and as mentioned previously, are not included in this analysis but are shown on figures and in tables for informational purposes.

Future volumes for the internal intersections to the Redtail Ridge site are shown on **Figure 2** for Year 2025, **Figure 3** for Year 2030, and **Figure 4** for Year 2040. Level of service (LOS) for the internal intersections are shown in **Table 1**. **Figure 5** summarizes the ultimate buildout lane configuration and traffic control for each internal intersection. The following list details the analysis, traffic control,

Intersection #101: Campus Drive & Private Street (north-south)

- *Phasing:* not applicable.
- *Performance:* Estimated to operate overall at LOS A in both the AM and PM peak hours and all individual movements are anticipated to operate at LOS A or LOS B.
- *Traffic Control:* Side-street stop control on Private Street.
- *Roadway Cross-Sections:* Private Street with one lane per direction. Campus Drive with one lane per direction.
- *Auxiliary Lanes:* One westbound left-turn lane (100-foot storage). Auxiliary lane is currently being added to HKS Campus Drive roadway plans.

Intersection #103: Rockcross Drive & Private Street (north-south)

- *Phasing:* T-intersection without a south leg until future development warrants the need.
- *Performance:* Estimated to operate overall at LOS A in both the AM and PM peak hours and all individual movements operating at LOS A or LOS B.
- *Traffic Control:* Side-street stop control on Private Street.
- *Roadway Cross-Sections:* Private Street with one lane per direction. Rockcross Drive with one lane per direction.
- *Auxiliary Lanes:* One eastbound left-turn lane (100-foot storage). Auxiliary lane is currently being added to HKS Rockcross Drive roadway plans.



Intersection #104: Rockcress Drive & Private Street (southern east-west)

- *Phasing:* T-intersection without a south leg until future development warrants the need.
- *Performance:* Estimated to operate overall at LOS A in both the AM and PM peak hours and all individual movements operating at LOS A or LOS B.
- *Traffic Control:* Side-street stop control on Private Street
- *Roadway Cross-Sections:* Private Street with one lane per direction. Rockcress Drive with one lane per direction.
- *Auxiliary Lanes:* One eastbound left-turn lane (100-foot storage). Auxiliary lane is currently being added to HKS Rockcress Drive roadway plans.

Intersection #106: Sorrel Avenue & Private Street (southern east-west)

- *Phasing:* T-intersection without an east leg until future development warrants the need.
- *Performance:*
 - *Initial (3-leg):* Estimated to operate overall at LOS A in both the AM and PM peak hours and all individual movements operating at LOS A or LOS B.
 - *Ultimate (4-leg):* Estimated to operate overall at LOS B in the AM peak hour and LOS C in the PM peak hour with all individual movements operating at LOS C or better.
- *Traffic Control:*
 - *Initial (3-leg):* Side-street stop control on Private Street.
 - *Ultimate (4-leg):* All-way stop control. Warrants were met for minor street delay, minor street volume, and total entering volume. Refer to “All-Way Stop Control Warrants” for details on the performed analysis.
- *Roadway Cross-Sections:* Private Street with one lane per direction. Sorrel Avenue with one lane per direction.
- *Auxiliary lanes:* One continuous two-way left turn lane on Sorrel Avenue.

Intersection #107: Sorrel Avenue & Private Street (northern east-west)

- *Phasing:* T-intersection without an east leg until future development warrants the need.
- *Performance:*
 - *Initial (3-leg):* Estimated to operate overall at LOS A in the AM and PM peak hours with all individual movements operating at LOS A or LOS B.
 - *Ultimate (4-leg):* Estimated to operate overall at LOS A in the AM peak hour and LOS B in the PM peak hour with all individual movements operating at LOS A or LOS B.
- *Traffic Control:*
 - *Initial (3-leg):* Side-street stop control on Private Street.

- *Ultimate (4-leg)*: All-way stop control. Warrants were met for minor street volume and total entering volume. Refer to “All-Way Stop Control Warrants” for details on the performed analysis.
- *Roadway Cross-Sections*: Private Street with one lane per direction. Sorrel Avenue with one lane per direction.
- *Auxiliary Lanes*: One continuous two-way left turn lane on Sorrel Avenue.

Intersection #108: Private Street (northern east-west) & Private Street (north-south)

- *Phasing*: not applicable.
- *Performance*: Estimated to operate overall at LOS A in both the AM and PM peak hours with all individual movements anticipated to operate at LOS A or LOS B.
- *Traffic Control*: Side-street stop control on Private Street.
- *Auxiliary Lanes*: No separate turn lanes.

All -Way Stop Control Warrants

Warrants from the *Manual on Uniform Traffic Control Devices (MUTCD)* were analyzed to support the installation of all-way stop control at intersections #106 and #107 on Sorrel Avenue. Section 2B.07 of the *MUTCD* defines appropriate applications of multi-way stop control. Criteria for multi-way stop control include:

- Where traffic control signals are justified, the multi-way stop is an interim measure that can be installed quickly to control traffic while arrangements are being made for the installation of the traffic control signal.
- Five or more reported crashes in a 12-month period that are susceptible to correction by a multi-way stop installation. Such crashes include right-turn and left-turn collisions as well as right-angle collisions. As the intersections have not yet been built and therefore have no crash history, the consideration of crash occurrence is not applicable to these intersections.
- Minimum volumes:
 - The vehicular volume entering the intersect from the major street approaches (total of both approaches) averages at least 300 vehicles per hour for any 8 hours of an average day; and
 - The combined vehicular, pedestrian, and bicycle volume entering the intersection from the minor street approaches (total of both approaches) averages at least 200 units per hour



for the same 8 hours, with an average delay to minor-street vehicular traffic of at least 30 seconds per vehicle during the highest hour; but

- If the 85th-percentile approach speed of the major-street traffic exceeds 40 mph, the minimum vehicular volume warrants are 70 percent of the values provided in the previous two items.

Traffic Signal Warrants for Consideration

Applicable traffic signal warrants were considered for the first multi-way stop control criterion. Of the eight (8) traffic signal warrants in the MUTCD, Warrant 1 (Eight-Hour Vehicular Volume), Warrant 2 (Four-Hour Vehicular Volume), and Warrant 3 (Peak Hour) are applicable for consideration at these two intersections. Warrant 1 (Eight-Hour Vehicular Volume) and Warrant 2 (Four-Hour Vehicular Volume) are unlikely to be met at intersections #106 and #107 based on projected traffic volume generated by Redtail Ridge land uses and connectivity of Sorrel Avenue. Warrant 3 (Peak Hour) was analyzed in detail.

Traffic Signal Warrant 3, Peak Hour

Section 4C.04 of the *MUTCD* defines the criteria for traffic signal Warrant 3, Peak Hour. Guidance for this warrant states “this signal warrant shall be applied only in unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time.” Given the industrial use of Redtail Ridge, consideration of Warrant 3 is appropriate at intersections #106 and #107. Criteria for this traffic signal warrant are:

- If all three of the following conditions exist for the same 1 hour (any four consecutive 15-minute periods) of an average day:
 - The total stopped time delay experienced by the traffic on one minor-street approach (one direction only) controlled by a STOP sign equals or exceeds: 4 vehicle-hours for a one-lane approach or 5 vehicle-hours for a two-lane approach; and
 - The volume on the same minor-street approach (one direction only) equals or exceeds 100 vehicles per hour for one moving lane of traffic or 150 vehicles per hour for two moving lanes; and
 - The total entering volume serviced during the hour equals or exceeds 650 vehicles per hour for intersections with three approaches or 800 vehicles per hour for intersections with four or more approaches.
- The plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding vehicles per hour on the higher-volume minor-

street approach (one direction only) for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4C-3 for the existing combination of approach lanes.

All-Way Stop Control Warrant Evaluation

Intersections #106 and #107 were evaluated based on the previously defined criteria for multi-way stop control and peak hour traffic signal warrants. Turning movement volumes at both intersections were only developed for the future AM and PM peak hours; therefore, the only volume warrant that can be evaluated is traffic signal Warrant 3, Peak Hour. The results of traffic signal Warrant 3 evaluation are shown in **Table 2**.

Table 2 - Traffic Signal Warrant 3 (Peak Hour) Evaluation

	Criteria	Calculated	Threshold	Criteria Satisfied?
Intersection #106	Maximum minor street delay	8.9 vehicle-hours (PM peak)	4 vehicle-hours	Yes
	Maximum minor street volume	312 vph (PM peak)	100 vph	Yes
	Total entering volume	1076 vph (PM peak)	800 vph	Yes
Intersection #107	Maximum minor street delay	2.3 vehicle-hours (PM peak)	4 vehicle-hours	No
	Maximum minor street volume	246 vph (PM peak)	100 vph	Yes
	Total entering volume	860 vph (PM peak)	800 vph	Yes

Based on the PM peak operations, intersection #106 meets all three criteria to satisfy traffic signal Warrant 3, peak hour. Though one traffic signal warrant is met, it is very unlikely that any others would be met. Considering that the minor street volume is primarily driven by traffic to and from the hospital use, which has more even demand throughout the day than industrial uses, the future 8-hour volume at intersection #106 may satisfy the all-way stop warrant minimum volume. One traffic signal warrant does not require the installation of a traffic signal, and in this case, installing an all-way stop at intersection #106 is a more prudent course of action.

At intersection #107, two of three criteria for the peak hour traffic signal warrant are met. While peak hour delay does not meet the threshold for the peak hour traffic signal warrant, peak hour delay does exceed 30 seconds delay per vehicle for the minor street approach as identified in the multi-way stop

warrant. Peak hour volumes also exceed the peak hour volume thresholds in the multi-way stop warrant in addition to traffic signal Warrant 3. To estimate off-peak volume, projected peak hour volume was extrapolated based on the nearest daily traffic counts on S. 96th Street south of Dillon Road.

Based on the projected volumes at intersection #107, the multi-way stop warrant is met for five (5) hours, as shown in **Table 3**. Three (3) additional hours nearly meet the threshold for the multi-way stop warrant with vehicle traffic only. With the addition of pedestrian and bicycle traffic anticipated based on the multimodal connections through Redtail Ridge it is very likely that the multi-way stop warrant will be met. **An all-way stop is therefore recommended at intersection #107 for operational benefit, as well as improving opportunities for pedestrians and bicyclists to cross Sorrel Avenue.**

Table 3 – Intersection #107 Multi-Way Stop Evaluation

Hour	Sorrel Avenue Volume	Internal Connector/Access Volume	Multi-Way Stop Warrant Met?
5:00 AM	111	18	No
6:00 AM	254	41	No
7:00 AM	541	87	No
8:00 AM	652	105	No
9:00 AM	398	64	No
10:00 AM	339	55	No
11:00 AM	365	211	Yes
12:00 PM	417	239	Yes
1:00 PM	250	223	Almost
2:00 PM	282	251	Almost
3:00 PM	373	332	Yes
4:00 PM	455	405	Yes
5:00 PM	432	385	Yes
6:00 PM	255	227	Almost

Recommendation

The Redtail Ridge team proposes to install all-way stop control at intersection #106 and intersection #107 for improved performance and enhanced safety.

Traffic Calming

Traffic calming is a set of physical and management strategies that aim to reduce vehicle speeds and improve safety for people that walk, bike, and drive along the roadway. Traffic calming can enhance the street environment and promote non-auto use (walking, biking, using transit). The City of Louisville has requested that traffic calming measures be evaluated for the internal roadway. The roadway and intersection designs include many physical elements that are intended to reduce vehicle speeds and provide a safer environment for all road users, as summarized in **Table 4**.

Table 4 – Traffic Calming Strategies

Traffic Calming Strategy	Benefit	Campus Drive Between Monarch Campus and 96 th St.	Sorrel Avenue Between Campus Dr. and Rockcress Dr.	Rockcress Drive	Internal Roadways
Roundabout	Slows drivers to a safe speed to maneuver through the intersection. Removes several conflict points compared to traditional intersections.	✓ At Monarch High School and at Sorrel Ave.	✓ At Campus Dr. and at Rockcress Dr.	✓ At Sorrel Ave.	
All-Way Stop	<i>[Implementing only when warranted for traffic control]</i> . Breaks up the flow of traffic, resulting in slower speeds at the intersection.		✓ At East-West Private Streets		✓ At Private St. (Northern E-W) at Private St. (N-S)
Lower Posted Speed Limit	Sets speed limits that are safe, consistent, and reasonable.	✓ 35 mph	✓ 35 mph	✓ 35 mph	✓ 35 mph
Narrowed Lane Width	Reduces speed and minimizes crashes by reducing the right-of-way and making drivers aware of adjacent users.	✓ 10-foot	✓ 10-foot	✓ 10-foot	
Wide or Buffered Bike Lane	Reduces the stress of riding on roadways.	✓ 4-ft lane w/ 2-ft buffer	✓ 4-ft lane w/ 2-ft buffer	✓ 4-ft lane w/ 2-ft buffer	✓ 4-ft lane w/ 2-ft buffer
Detached Sidewalk or Multi-Use Path	Improves pedestrian and bicyclist safety and comfort.	✓ 10-ft Multi-Use Path (northside) & 8-ft Multi-Use Path (southside)	✓ 6-ft detached Multi-Use Path	✓ 6-ft detached	✓ 5-ft detached

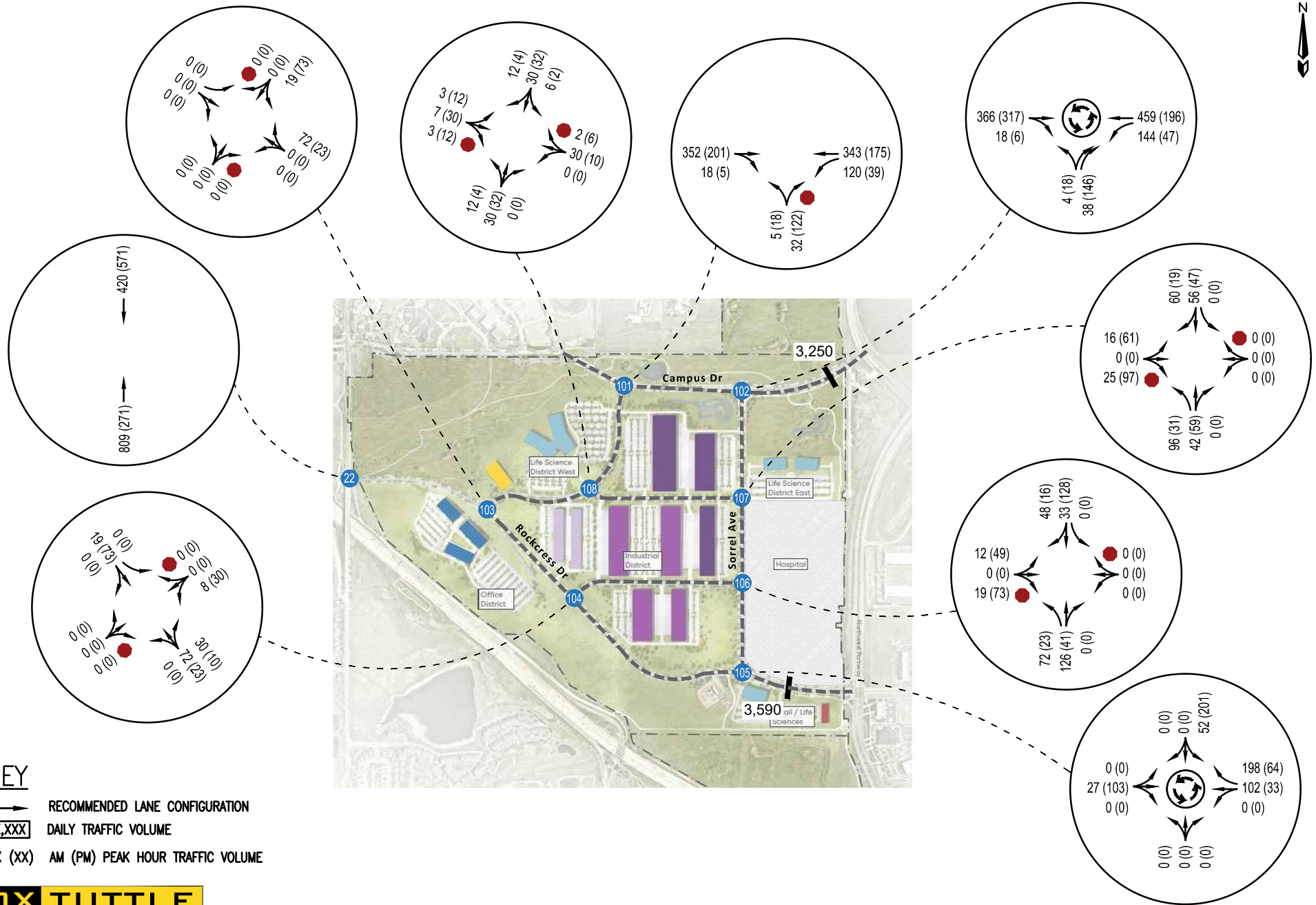


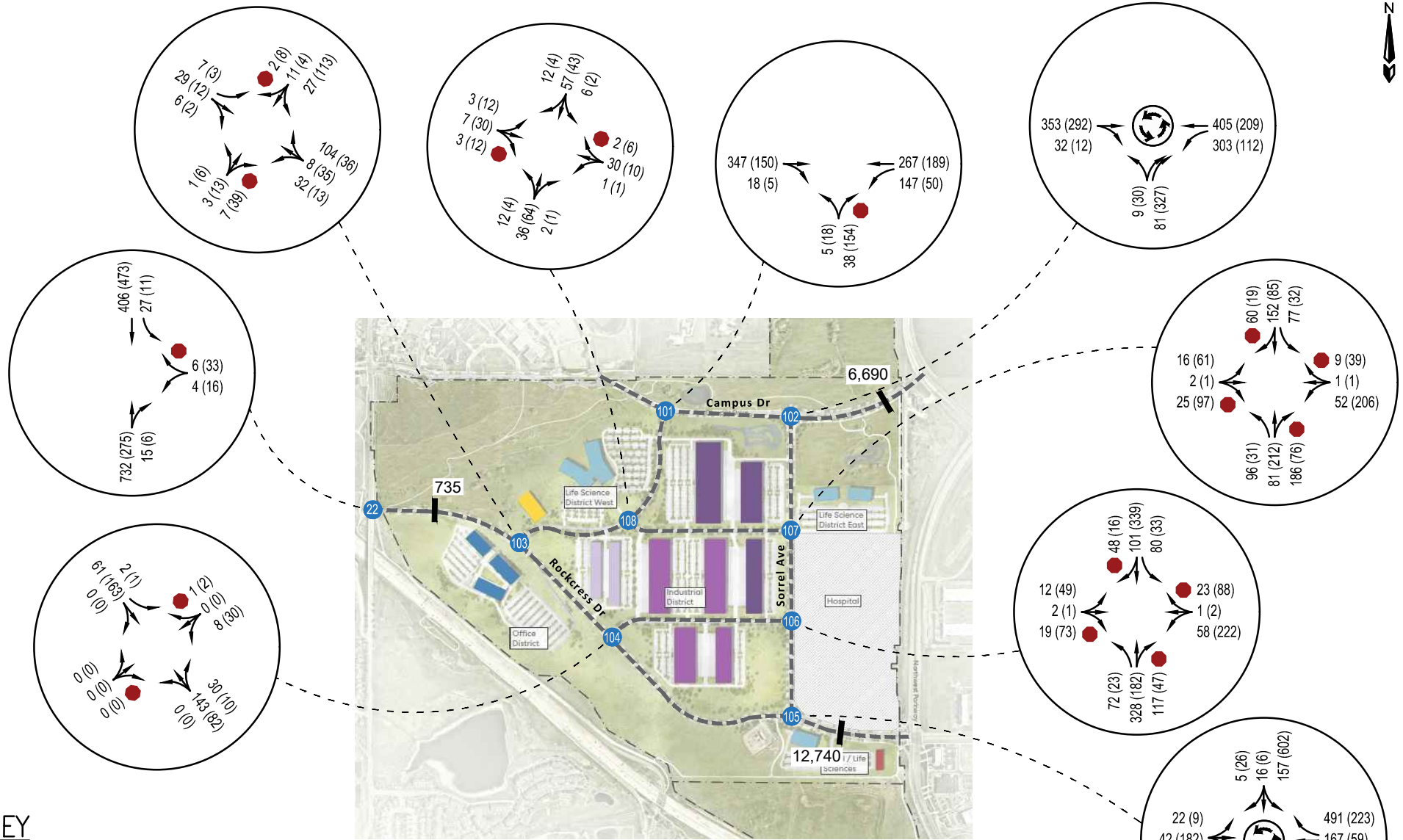
Traffic Calming Strategy	Benefit	Campus Drive Between Monarch Campus and 96 th St.	Sorrel Avenue Between Campus Dr. and Rockcress Dr.	Rockcress Drive	Internal Roadways
Street Trees	Narrows a driver's visual field and effectively reduces speed.	✓	✓	✓	✓
Horizontal Curvature in Roadway	Encourages a driver to slow speed to navigate the horizontal curve.	✓	✓	✓	✓

/CRS

Attachments:

- Table 1: Peak Hour Intersection Level of Service Summary
- Figure 1: Internal Street Network
- Figure 2: 2025 Total Volumes, Lane Configuration, and Traffic Control
- Figure 3: 2030 Total Volumes, Lane Configuration, and Traffic Control
- Figure 4: 2040 Total Volumes, Lane Configuration, and Traffic Control
- Figure 5: Internal Auxiliary Lanes and Traffic Control





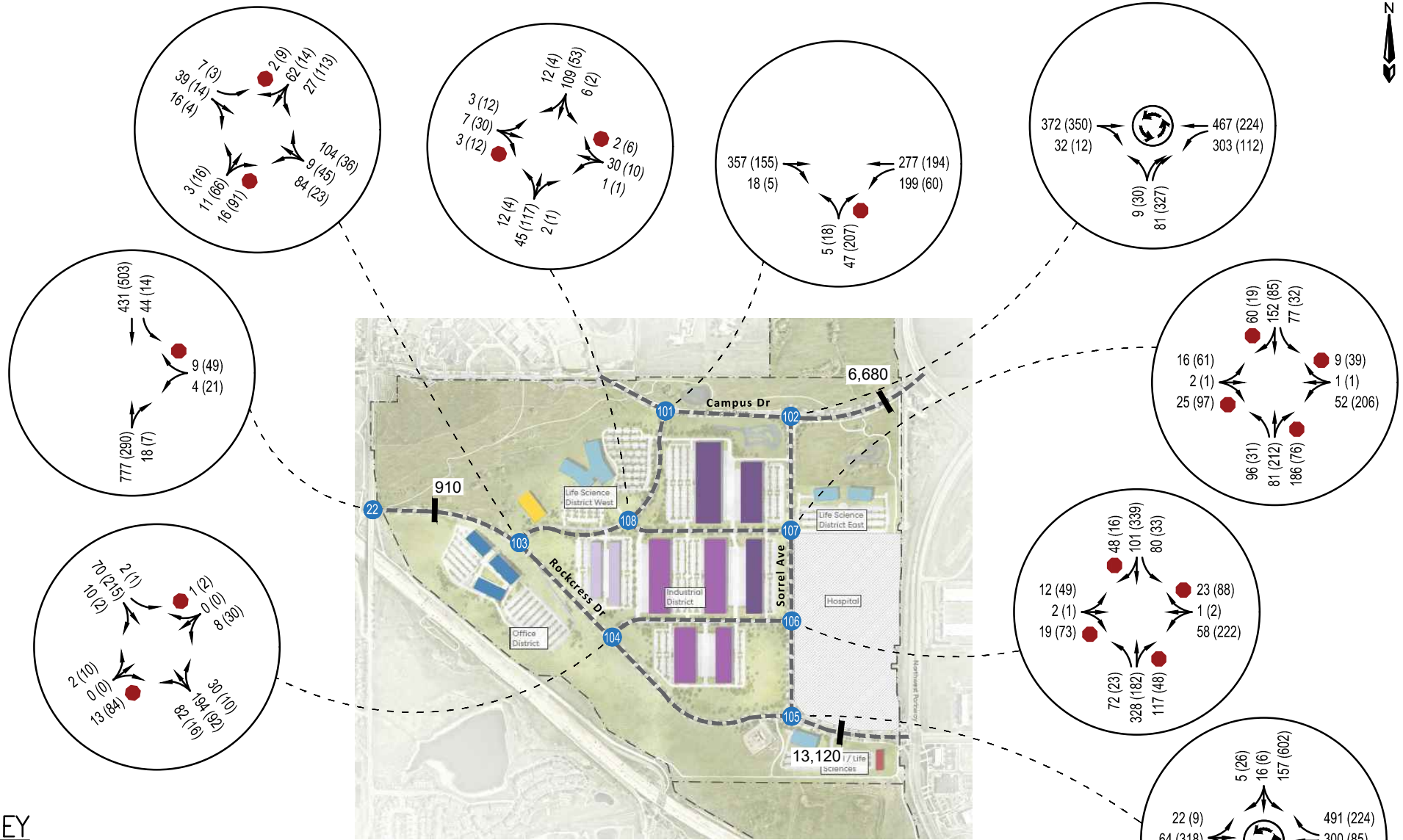
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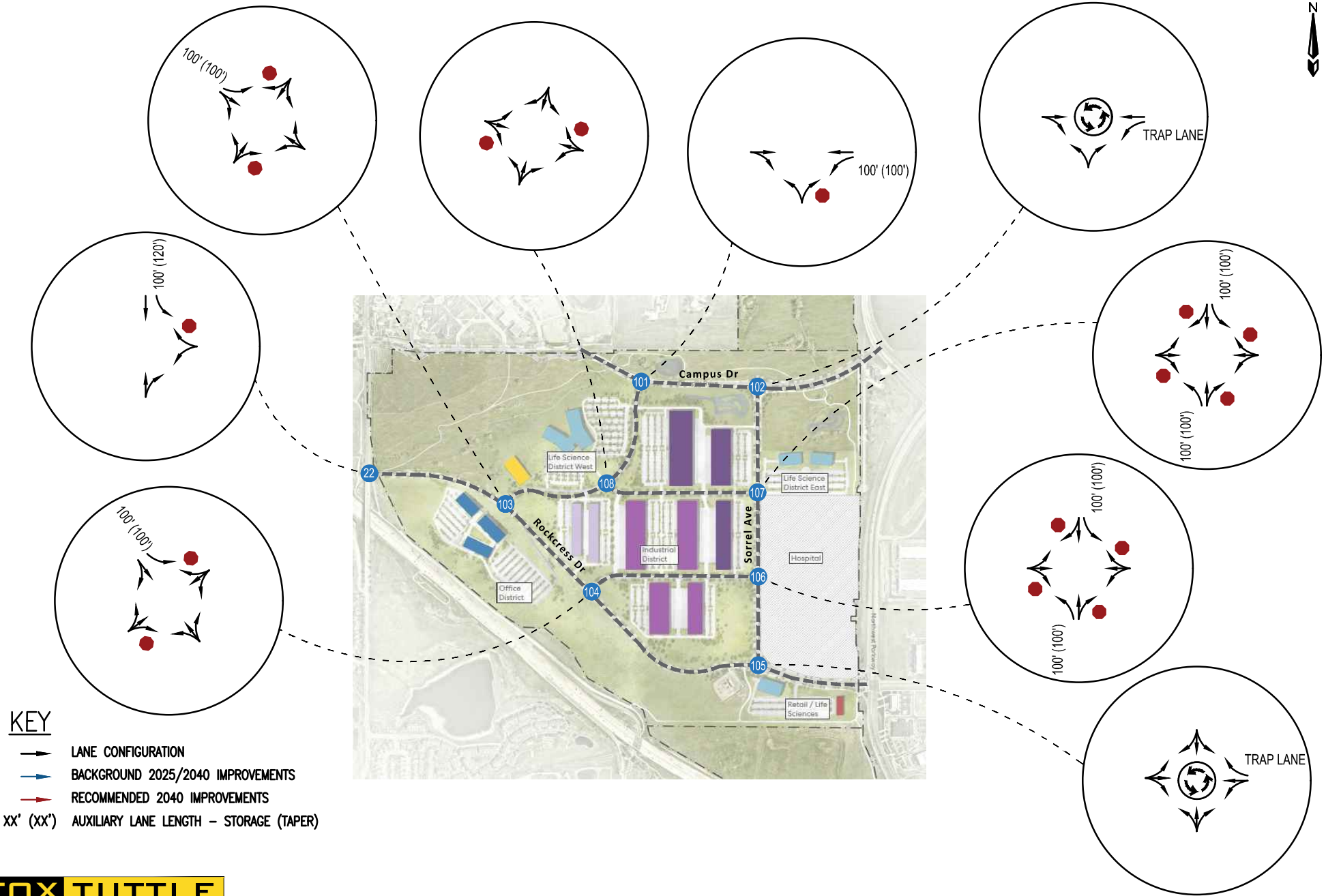
- RECOMMENDED LANE CONFIGURATION
- [X,XXX] DAILY TRAFFIC VOLUME
- XX (XX) AM (PM) PEAK HOUR TRAFFIC VOLUME



REDTAIL RIDGE TRAFFIC AND MOBILITY STUDY
2030 TOTAL VOLUMES, LANE CONFIGURATION AND TRAFFIC CONTROL

FT Project #	19055	Original Scale	NTS	Date	02/29/2024	Drawn by	SKK	Figure #	3
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- KEY**
- LANE CONFIGURATION
 - BACKGROUND 2025/2040 IMPROVEMENTS
 - RECOMMENDED 2040 IMPROVEMENTS
 - XX' (XX') AUXILIARY LANE LENGTH – STORAGE (TAPER)



REDTAIL RIDGE TRAFFIC AND MOBILITY STUDY
INTERNAL AUXILIARY LANES AND TRAFFIC CONTROL

FT Project #	19055	Original Scale	NTS	Date	02/29/2024	Drawn by	SKK	Figure #	5
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