

DESIGN CONCEPTS

Design Concepts Overview

The concept development process is discussed in a summary manner and is followed by a review of the initial concepts developed (at a one-line diagram stage) and then how selected concepts were advanced (to the two-line diagram stage). Next an assessment process seeks to discern differences amongst the concepts through comparisons providing support for choosing a preferred concept. The iterative process continues with further design refinement to include conceptual interchange ramp geometry, including vertical relationships, to develop costs suitable for programming purposes.

Design Criteria

Because the facilities under review are located in a confined urban area, it is acknowledged that a range of design criteria is necessary to allow some flexibility when balancing potential improvements and potential impacts. The range of design criteria is indicated as **desirable** values, **minimum desirable** values and **absolute minimum** values. Obviously, the first value to be met is the desirable value. Only if that value creates significant impact is it worth considering lowering the criteria to other values. Certainly this can be described as engineering judgment. When circumstances arise, the situation is described in more detail.

There are multiple different sets of design criteria for this study. One set of criteria is applied to the I-235 mainline, one to the City facilities, and a different set of criteria is applied to the interchange ramps based upon the type of interchange (system or service). I-235 is a four-lane divided urban freeway section, originally designed to meet a 60 mph design by today's criteria. As a divided freeway, the desirable design speed is 70 mph, but because of the existing urban corridor, a minimum desirable 65 mph design speed (also the posted speed) is also considered. I-235, a KDOT facility, requires 12 foot lanes, including any additional thru or auxiliary lanes. If I-235 is widened to include more than two-lanes in a direction, the shoulders, both inside and outside will be widened to 10 feet.

The horizontal alignment criteria for a 70 mph roadway has a desirable curve radius of 3620 feet at a 6.0% superelevation rate and a minimum desirable curve radius of 2210 feet at the absolute maximum superelevation rate of 8.0%.

The vertical alignment criteria for I-235 also suggests a minimum design speed of 70 mph. The corresponding "K" values for 70 mph vertical curves are 181 for sag curves and 247 for crest curves. The desirable maximum grade for an interstate (70 mph) facility is 3.0%. However, due to the existing urban conditions and desire to minimize impacts, steeper grades may have to be considered, not to exceed 4.0%.

Minimum vertical clearance criteria must also be applied to the vertical alignment for the structures over US-54/400 (Kellogg Ave.), Maple Street, and Central Avenue. The minimum desirable clearance for a bridge over a US route, such as US-54/400 (Kellogg Ave.), is 16'-4". At arterial routes, including Central Avenue (primary arterial) and Maple Street (secondary arterial) the desired vertical clearance is 15'-4".

Vertical clearance must also be established for the nearby Wichita Mid-Continent Airport. Within two miles of the airport all obstructions must be located below an established horizontal surface, in this case at an elevation of 1482.5. The high point on I-235 over Kellogg Avenue is at approximately 1337.2.

The City of Wichita specifies 11 foot lanes for their facilities, therefore that width will be used for any recommended improvements to Central Avenue and any assumed future widening on Maple Street used to determine the I-235 bridge length. It is assumed that no improvements to either City facility's vertical or horizontal alignment will be necessary.

KDOT's minimum width for a single-lane ramp is 14 feet, however 16 feet is more desirable in urban areas. For the system interchange higher speed ramps, wider lane widths may be considered.

For diamond interchange ramps, as ultimately recommended at Central Avenue, there is a maximum grade criteria of 7 to 8% for short upgrades or downgrades, however 5% or less is more desirable. Stopping sight distance on crest vertical curves for downgrade exit ramps are based on a minimum design speed of 50 mph, translating to a stopping sight distance of 425 feet, provided adequate deceleration distance is available.

For a system interchange, I-235 and US-54/400 (Kellogg Ave.), design speed is based on the highway design speed and an associated range of ramp speeds. For a 70 mph highway design speed, the ramp design speed can range from 35 to 60 mph. The higher design speeds should be utilized at the ramp noses as much as possible. For high-speed ramps the maximum grades are also related to the ramp design speed. However, where appropriate for topographic conditions, grades steeper than desirable may be used. The associated curve radii, superelevation, and maximum desirable grades for possible system interchange ramp design speeds are outlined in Exhibit 5.1. Due to the complex decisions drivers are sometime asked to make in a system interchange (i.e. weaving, braided ramps, etc.), decision sight distance and the placement of signing should also be considered as much as practical.

Exhibit 5.1 – System Interchange Ramp Design Criteria

Ramp Design Speed (mph)	Min. Horizontal Radii (feet)	Superelevation Rate	Maximum Grade
40	444	8.0%	4 to 6%
45*	587	8.0%	3 to 5%
50	758	8.0%	3 to 5%

* 45 mph is the desired minimum ramp design speed.

The design criteria relates to physical features. The resulting design must also provide satisfactory traffic operations. Consequently, traffic operations are continuously reviewed as concepts are developed and refined.

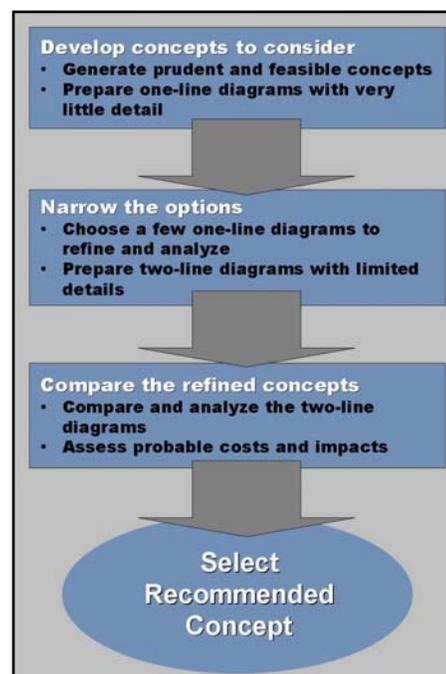
Design Concept Process

In simple terms, the design concept process encompasses the iterative development, assessment and refinement of concepts. The initial stages of concept development include a wide range of potential concepts that are screened down to a manageable level. At each stage the concepts are developed to the same level of detail to allow for equitable comparison. As concepts are advanced to more detail, the assessment also becomes more specific.

It is important to note that the concept stage, while indicating design intent, is NOT a design stage. One must acknowledge the limitations in terms of the degree of accuracy with the available mapping. Yet on the other hand, with a relatively narrow focus along an existing established corridor, it is also necessary to attempt to move beyond general “rules of thumb”, particularly for cost estimating purposes.

Exhibit 5.2 illustrates the design concept process flow chart.

Exhibit 5.2 – Design Concept Process Flow Chart



Design Forms

For interchanges, this was a review of types and potential design forms. Initially, it may start out with “textbook” examples before proceeding to concepts applied to site specific locations. These are shown as “one-line” diagrams. The one-line diagram illustrates basic traffic pathways without detail on width or impacts. Nonetheless, such concepts are suitable for early comparison.

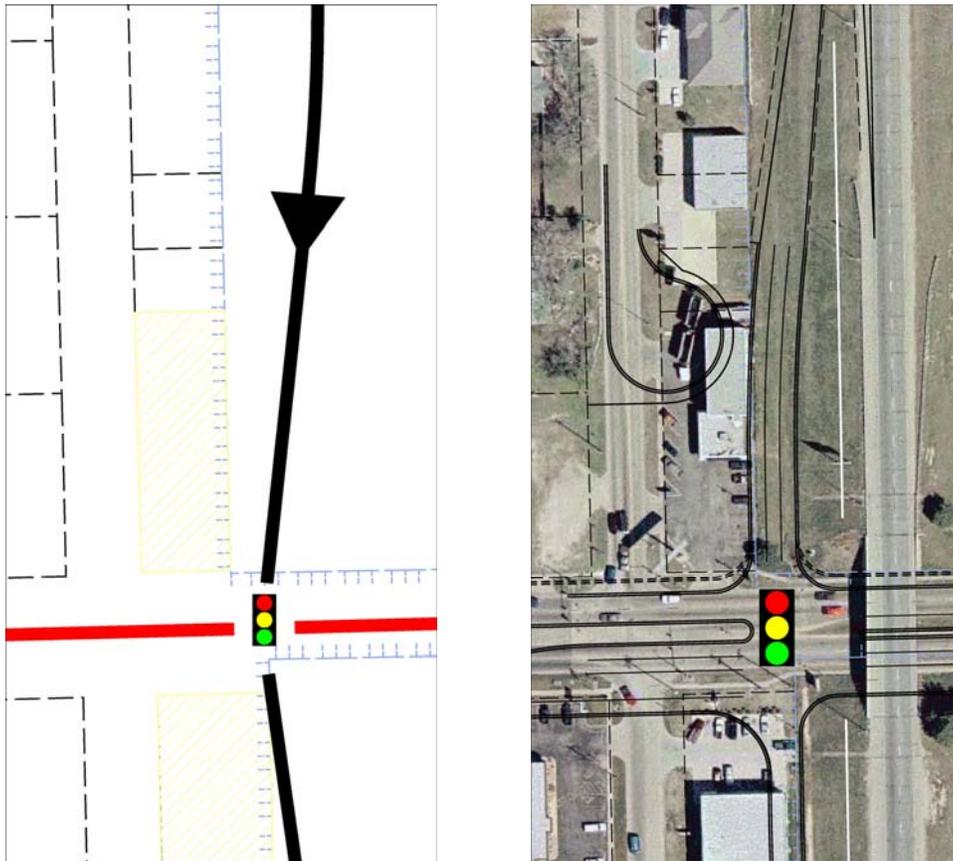
For the mainline, the improvements were initially developed as a series of typical sections. In later stages of development, probable impacts of applying the typical section along the highway were assessed. The assessment acts as a screening of many initial forms to a few that were advanced to design concepts.

Design Concepts

The design concept stage advanced the selected forms to “two-line” diagrams. Here the “two-lines” represent the edges of the roadway improvements. At roadway junctions the number of lanes, particularly at signalized intersections, can be readily shown. However the two-line diagram is only two-dimensional. While the concept intent recognizes the influence and requirements of vertical elements, it does so at a basic level for determining which roadways require grade separation and which roadway is over the other roadway. It has not, however, specifically identified the locations or height of structural elements such as retaining walls or the type and extent of drainage improvements. While the design continues to advance, there are still many details that are not yet answerable which in turn makes the assessment of potential impacts difficult. The two-line diagrams show traffic pathway details and allow for some probable impacts to be estimated. The potential locations of impacts are shown shaded.

Exhibit 5.3 presents an example of the type of information shown at the one-line and two-line diagram stages.

Exhibit 5.3 – One-Line and Two-Line Diagrams



Design Concepts Refinement

The design concept refinement provided further clarification on the issues of vertical control by now developing profiles along the proposed roadway and more importantly along the ramping systems at the interchanges. And while this information may be presented in a format similar to more detailed design information, the basis for such design is only at the conceptual level.

Inclusive Design

While the design focus is upon the highway and its interchanges, other modal aspects are important to include such as transit, bicycle and pedestrian accommodations. These elements have been acknowledged from the start of the study process. The intent here is to identify specific modal elements and their necessary coordination. In certain cases further coordination is needed with other agencies, and continued coordination is likely necessary through future design phases. In any event, the design intent is to provide multimodal accommodations.

The transit interface with this project is confined to the arterial streets of Central Avenue and Maple Street. While several bus stops are signed along both streets only a few have amenities such as benches. Typically a bench will need a wider area and it may be desirable to pave the area surrounding the bench. Such details for type and location of bus stops and any amenities will need to be coordinated with Wichita Transit. It is unlikely that any direct impacts (such as relocation of a stop) would occur along Maple Street. However along Central Avenue, interchange configurations and access management options could affect neighborhood circulation resulting in the rerouting of buses as well as the relocation of bus stops. These potential impacts are readily acknowledged, yet may not be resolved until later in the design stage.

Similar to transit, the bicycle interface with this project is confined to the arterial streets of Central Avenue and Maple Street. While neither street currently has a signed or dedicated bicycle facility, an on-going Pathways study and prior planning efforts indicate the desire for bicycle-friendly accommodations along those corridors that cross the WVCF, including Central Avenue and Maple Street. Review of the existing bridges across the WVCF indicates that both streets provide sidewalks, yet these are not wide enough for two-way trails. Consequently, an on-street network may be necessary to accommodate bicyclists. Unless dedicated bicycle lanes are proposed, wide curb lanes may be a practical and appropriate solution. While the designation of a wide curb lane is typically identified as 14 feet, this is based upon a typical 12 travel lane. Since the City of Wichita's standard for travel lanes is 11 feet, a wide curb lane could be considered 13 feet wide. The issues of the appropriate lane widths to serve bicyclists along both Maple Street and Central Avenue may not be fully resolved until the Pathways study is complete and specific recommendations are made regarding the type and dimensions of such proposed facilities. Such issues will need to be discussed at the design stage.

As with both transit and bicycle accommodations, the pedestrian interface with this project is confined to the arterial streets of Central Avenue and Maple Street, as well as along the north side of Kellogg Drive (serving as an access road to adjacent properties). Central Avenue and Maple Street currently provide sidewalk, although Maple Street only has a sidewalk on the south side. A sidewalk gap occurs on the north side along Maple Street beneath the crossing of I-235. The determination of sidewalk dimensions will be made in coordination with the City of Wichita.

It is recognized that several local residential neighborhoods as well as commercial blocks depend upon the arterial and local streets for access. Access to/from the neighborhoods north/south of Central Avenue, particularly under the existing dual-role of Gilda as a ramp junction and a collector street, become part of the total transportation system under review. The local street network includes the north/south network as well as potential east/west street improvements, as many of these streets are unpaved, if north/south circulation were to change. Other elements for further consideration include transit routing and access to the city maintenance facility (for trucks).

Access to/from Kellogg Drive (an access road along the north side of US-54/400 (Kellogg Ave.)) between Westdale and West Street also requires consideration under the general approach of maintaining access to developments with existing access. A couple of matters further complicating the existing access are

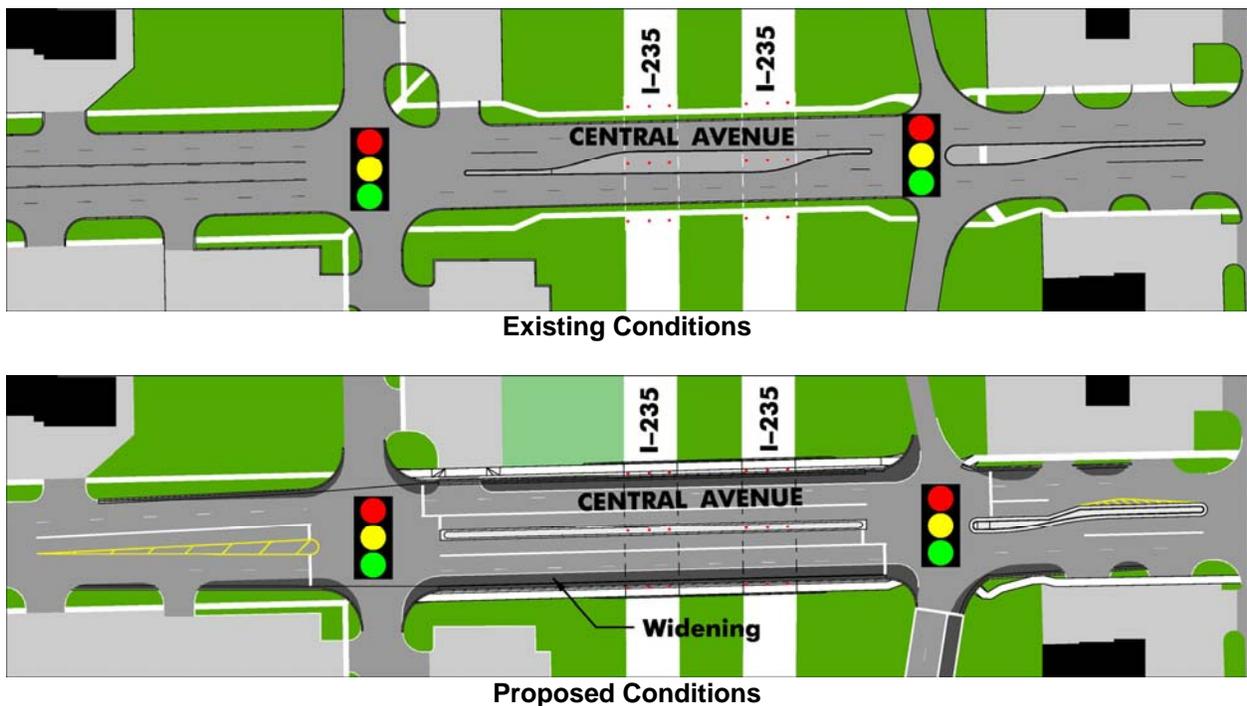
the change from a one-way pattern (from West Street to Tracy) to a two-way travel pattern (from Tracy to Westdale) and the traffic circulation to, from and around Towne West Square.

The City of Wichita has several proposed projects along Central Avenue that will likely have an influence upon the arterial operations. The projects include the widening of the bridges over the Big Ditch to increase from two lanes in each direction to three lanes. This project is on the City's Capital Improvement Plan for funding in 2009. The Long Range Transportation Plan (LRTP) for lane continuity purposes includes widening Central Avenue from 4-lanes to 6-lanes from the above referenced Big Ditch crossing east to the I-235 interchange. This project is not yet funded, though at a certain undefined point, the arterial street is part of the interchange as a total transportation system.

Interim Central Improvements

This City of Wichita construction project is advancing through the design stage. As a design concept, the project includes physical elements such as extending left-turn bays, and through operational analysis suggests signal optimization. However, operational analysis of this configuration under the design year (2030) traffic volumes indicates that it does not operate acceptably; therefore more improvements will be needed. However, the improvements are expected to extend the operational life of the intersections by approximately ten or more years. The interim improvement concept is shown in Exhibit 5.4.

Exhibit 5.4 – Interim Improvement Concept at Central Avenue



Design Concepts - Layouts Developed

The process of developing initial concepts began by responding to the existing and projected traffic operations, while acknowledging and incorporating the existing physical conditions and environmental resources. Each of the interchange locations is considered unique. As such, there is the potential for a varying median width along I-235. With that in mind, it was determined to wait until the interchange selections could be made to develop the two-line diagrams along I-235. However alignment improvements and other design constraints and consideration for I-235 will be discussed within this section as general mainline improvements are considered. The next section will focus upon the process of making comparisons.

Integrated Approach

The process takes a systemic view where all elements from the mainline and interchange ramps to the arterial and local street connections are all a part of the transportation network. A number of concepts were considered, and then screened to concepts suitable for further development.

Operations

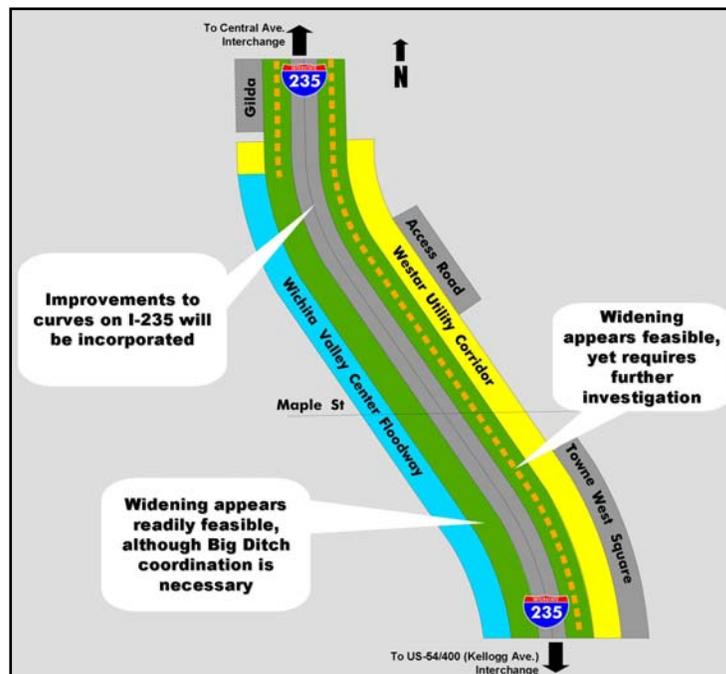
Review of future mainline traffic operations indicate auxiliary lanes along I-235 between the US-54/400 (Kellogg Ave.) and Central Avenue interchanges would provide a sufficient capacity improvement to bring operations to a satisfactory level. Nonetheless, the I-235 southbound off-ramp to US-54/400 (both east and west) would operate best with a decision lane that affords a dual lane off-ramp. The on-ramps from both Central and Kellogg would operate best as a one-lane ramp feeding directly into the auxiliary lane, even if the ramp has two lanes in certain sections prior to entering the I-235 mainline.

Mainline I-235

When considering improvements to the I-235 mainline a number of factors must be considered, including the design constraints associated with the Westar electrical transmission lines, the deficient horizontal and vertical geometry, existing and new bridge lengths, right-of-way needs, as well as general design considerations associated with possible widening options for I-235. These factors are summarized in the following paragraphs.

Exhibit 5.5 illustrates graphically the issues associated with improving I-235.

Exhibit 5.5 – I-235 Mainline



Impacts to the Westar electrical transmission towers that parallel I-235 on the east side can be expected. The impacts are associated with widening along I-235 to provide auxiliary lanes between the US-54/400 (Kellogg Ave.) and Central Avenue interchanges. Relocation of existing towers is also expected to be necessary within the US-54/400 (Kellogg Ave.) interchange itself.

For this study area, the Westar system starts at the south and moves northward. The starting point is considered to be along the east side of I-235 just north of K-42. Here, a series of wooden H towers exit a substation and travel north. The towers are located within the KDOT right-of-way with a level ground maintenance access area beneath the wires. There are 12 poles along this 1.2 mile long stretch at an approximate spacing of 475 feet. As the towers approach the US-54/400 (Kellogg Ave.) interchange they change form and type to metal truss towers. The towers swing slightly to the east, just south of the interchange, crossing over several industrial buildings, and one tower is located directly within the interchange. As the lines continue north out of the interchange, they are adjacent to Westdale Drive (a City street). Eleven (11) metal truss towers continue for 1.1 miles (at an approximate spacing of 575 feet) until reaching the Douglas Avenue substation. Here the towers cross I-235, with two sets of electrical lines from the substation, to a Westar property on the west side of the highway.

The costs of utility relocation may not be a direct KDOT issue since the electrical towers are within state highway right-of-way. Yet, at an approximate cost of \$350,000 per electrical tower, the relocation costs will easily result in several millions of dollars as there are 23 towers (wooden and metal) that could potentially be relocated. Coordination with Westar is obviously necessary through the US-54/400 (Kellogg Ave.) interchange. All of the interchange design concepts require an electrical tower relocation as well as the likelihood of increasing the tower height in order to provide adequate vertical clearance beneath the electrical wires elevated ramps.

Several areas of vertical geometry on I-235 need improvement. These areas were identified as deficient under existing conditions either as a deficient curve assessed at a 70 mph design speed or as related to critical vertical clearance. There is one deficient vertical crest curve over the former railroad. This curve is within the limits of the I-235 and US-54/400 (Kellogg Ave.) interchange and has a design speed of 60 mph based on 2004 AASHTO criteria. All three roadway bridges within the study have deficient vertical clearances. The clearance over US-54/400 (Kellogg Ave.) has a clearance of 15.8 feet (needs 16'-4"). Both Maple Street and Central Avenue require 15'-4" but Maple Street's current clearance is 14.8 feet (posted 14'-0") and Central Avenue's existing critical clearance is 15.0 feet.

At the Maple Street crossing, I-235 improvements must address issues beyond just the vertical clearance. Currently the bridge span is short for the narrow four-lane section in comparison to the five-lane typical cross section on either side of I-235. Pedestrian and bicycle accommodations are also needed. Consequently, an improved cross section for Maple Street should be accommodated.

The Maple Street typical section consists of four 11' travel lanes with a wide center turn lane, 18 feet wide west of I-235 and 20 feet wide east of I-235. However the centerlines of these typical sections do not align; the east side centerline is approximately 9 feet north of the centerline on the west side. Additional right-of-way for widening purposes is available on the south side of Maple Street. Consequently the horizontal alignment geometry of Maple Street will need further investigation to determine the appropriate design which could include a reverse curve or a "kink" in the horizontal alignment. The location of the horizontal alignment centerline under the bridge will affect the vertical profile along I-235. For this planning level study, it is assumed that the centerline of the crossing remains the same as it is today with any widening to be accommodated both to the north and to the south.

The need for a new bridge over Maple Street to accommodate the critical vertical clearance as well as a widened Maple Street typical section translates into profile modifications on I-235. The wider Maple Street means longer bridge spans, which means a deeper structure. Any widening of I-235 on the outside would also work against the critical vertical clearance.

Using the above assumptions and raising I-235 across the bridge by 1'-0" with the minimum length of vertical curve results in a full depth roadway reconstruction limit of approximately 2,000 feet. The

additional vertical clearance allows for design fluctuations as well as accommodating future pavement overlays.

At Central Avenue, as various concepts are being developed to improve the safety and capacity operations of the interchange that result in the need to widen the Central Avenue bridge opening, it is recommended that the interchange design address the issue of vertical clearance. It is worth noting that the existing depth of structure of the Central Avenue bridge appears to be one foot. When planning for a new bridge, a deeper structure will likely be assumed and therefore the impacts to the I-235 profile necessary to provide the critical vertical clearance of 15'-4" may be significant.

Two horizontal curves need to be improved on I-235 to meet the desirable design criteria of 70 mph. One curve has a radius of 2864.93 feet and a superelevation rate of 5.0% translating into a design speed, based on 2004 AASHTO criteria, of 55 mph. This curve is just north of US-54/400 (Kellogg Ave.) near Towne West Mall. The other horizontal curve, located approximately halfway between US-54/400 (Kellogg Ave.) and Central Avenue next to the Westar electrical substation, has a radius of 1910.08 feet and a superelevation rate of 7.0%. The design speed of this curve based on 2004 AASHTO criteria, is 60 mph.

For the curve near Towne West Mall, the radius increase to achieve 70 mph is not significant (2,685 feet to 3,150 feet with a 6.0% superelevation rate) and would require a maximum centerline shift of approximately 10 feet. This shift is towards the Big Ditch drainage channel, but it appears that due to the wider right-of-way associated with the nearby cloverleaf interchange the centerline shift would not result in significant additional right-of-way impacts. It is worth noting that any changes to this curve could be considered within the influence area of the interchange concepts, and they'll likely have greater impacts to the Big Ditch than I-235's horizontal alignment would require.

The curve halfway between US-54/400 (Kellogg Ave.) and Central Avenue, near the Westar substation, would require a more significant realignment (1,910 feet to 3,150 feet). Improving this curve requires a shift to the east of approximately 55 feet. This realignment would have significant impacts to the Westar substation as well as potential impacts to Hoover Road and a number of Westar transmission towers along the highway. At the substation, the current critical distance between the edge of shoulder and the corner of the substation is less than 50 feet. Due to the existing urban condition of this curve, the practical recommendation is to use the existing curve radius and increase the superelevation to 8% to increase the design speed to 70 mph.

There are two basic widening concepts, widening to the inside or outside. Widening to the outside has two basic subsets. The first assumes that the right-of-way can be adequately acquired and widening and grading can be completed as needed. Critical elements of this subset are the detailed issues of side slopes and drainage. The second subset attempts to recognize physical constraints and respond to them by such methods as including retaining walls, enclosing the drainage systems, etc. in an effort to minimize impacts. Because of the additional lanes, it should be noted that per the KDOT Design Manual, shoulder widening to 10 feet would also be necessary to the inside. The concept of widening to the inside assumes no widening to the outside. Therefore, the potential for impacts becomes internalized and issues are focused upon the effects of curve superelevation to median drainage.

Initially three segments along I-235 (a minimum a segment is 1,000 foot long) were reviewed to identify constraints, if any, of widening to the outside.

The first segment reviewed begins at the I-235 and US-54/400 (Kellogg Ave.) interchange and ends to the north at Maple Street. The Wichita Valley Center Floodway (WVCF) runs along the west side of I-235 in this segment. Right-of-way measured from the highway's near edge of the travel way varies from approximately 190 feet near the interchange to only 81 feet closer to the Maple Street crossing. Near Maple Street the WVCF includes a "pump station" and an access road near the highway right-of-way. Cross sections indicate that a drainage ditch is provided within the right-of-way. The only potential constraint in this segment may be the pump station. It is acknowledged that any work adjacent to the WVCF ought not to excavate from the levee's embankment. Considering that the roadway concept is

investigating widening and the existing roadway is higher than the levee, it is unlikely that any excavation would be required. The typical section is a "fill" application.

The east side is abutted by Towne West Square. Right-of-way measured from the near edge of the travel way is typically at 96 feet. As discussed above, within the State right-of-way in this area are the Westar electrical towers and transmission lines. A majority of this length along the east side includes guardrail. This segment mostly consists of a "fill" slope that runs down to a flat area along the 27 foot wide electrical transmission corridor. In the southern portion of this segment is a 40 foot wide gas utility easement that abuts the highway right-of-way. Immediately adjacent to the highway right-of-way is the internal circulation road for Towne West Square. The elevation of the mall's parking lot is approximately 20 feet below the highway. A triangular piece of property (currently paved and used for parking) is identified on the Sedgwick County Assessor's maps as I-235 contingency road dedication.

The electrical towers are a continuous element along the east side of I-235. In whatever manner they are dealt with, they should be dealt with consistently. One possibility would be to construct retaining walls around the towers. Another option would be to relocate the towers to the west side. The mall's circulation road is a physical element that can be shifted. If the circulation road were shifted to the east parking spaces would be lost without the apparent ability to replace them in-kind in an adjacent area. The guardrail is currently provided because of the side slopes and the elevation difference. While the side slopes could be modified, the elevation difference will always remain. However, even with these potential improvements, it is likely that retaining walls will be needed in the northern portion of this segment and will become part of the abutment wall for the Maple Street bridge.

The second segment reviewed begins at Maple Street and ends to the north at the Westar Electrical Substation. The WVCF also runs along the west side of I-235 in this segment. Right-of-way measured from the near edge of the travel way ranges from 60 to 100 feet. The narrowest section is near the Hoover and Douglas Road culvert crossing. Cross sections again indicate that a drainage ditch is provided, though it appears to be outside the highway right-of-way in this segment. The culvert crossing flows towards the WVCF; however topographical relief through the drainage ditches and the crossing is minimal. The only potential constraint on the west side of this segment is the treatment of drainage. It is believed that coordination and cooperation with the WCVF would allow the highway drainage to remain in place and be adequately accommodated.

The east side near Maple Street is abutted by an electrical transmission tower as well as Elder Street. Then, further north, the highway abuts the back of residential properties serviced by public streets such as Flora and Hoover Road. Right-of-way measured from the edge of the travel way is typically 80 to 100 feet. Again, within the State right-of-way are the Westar electrical towers and transmission lines. This segment is again in "fill" slope. Cross sections indicate that a drainage ditch is provided, in this case east of the electrical towers.

The constraints in this segment remain similar to the previous segment and include the electrical towers, adjacent public roads and the drainage ditch. The treatment for the electrical towers (to be determined) is also likely to remain the same.

The public roads are a physical element that can be relocated, but in doing so impacts to numerous residential properties could be expected. In "holding" both the flow line elevation for the drainage ditch as well as its location, the cross slope would need to be increased from 4:1 to 3:1 which is not preferred unless guardrail is provided. Consequently, it is believed that the majority of this segment can accommodate widening to the outside without associated constraints, however some minor sections would likely require the inclusion of retaining walls.

The final segment reviewed begins at the Westar Substation and ends to the north at St. Louis Street. The west side abuts the Westar Electrical property including towers (for approximately 500 feet) and then Gilda Street. Right-of-way measured from the edge of the travel way is consistently 75 feet (approximate). Cross sections indicate that a drainage ditch is provided which is paved for several hundred feet before St. Louis Street.

The largest constraint in this segment is associated with the treatment of drainage. The drainage treatment in relationship to highway widening is compounded by the close proximity of Gilda Street. It is assumed that Gilda Street is to remain in place as is. In “holding” the flow line elevation for the drainage ditch, a low retaining wall would be necessary.

On the east side of this segment is the electrical substation, with its transmission towers very close to the existing edge of pavement (minimum 58 feet). Continuing north to St. Louis Street and the influence area of the Central Avenue interchange, the highway abuts residential properties. Here the right-of-way measured from the edge of the travel way is typically at approximately 70 feet. The highway in this segment is essentially level with the adjacent land, however with the need for drainage ditches this segment is considered to be in a “cut” slope. Cross sections indicate that drainage ditches are currently provided.

The constraints in this segment include the electrical substation and towers, as well as the drainage ditch. However, it is believed that this segment can allow widening to the outside by providing a low wall in critical areas or acquiring right-of-way.

Interchanges with their Arterials

The interchange configurations are treated in an integrated systemic manner with their arterial connections. Each interchange configuration is different and must respond to its specific interchange type, either as a “system” interchange or a “service” interchange.

The two basic forms of system interchanges considered were the all directional and directional with two loops in opposite quadrants. It should be noted that the loops in opposite quadrants do not create weaving conditions. A local example of a directional interchange is the US-54/400 (Kellogg Ave.) and I-135 interchange that incorporates nested ramps. It also utilizes a single exit ramp that then splits by direction on the ramp. The design utilizes varying speeds on the ramps probably associated with serving varying traffic volumes and responding to physical constraints.

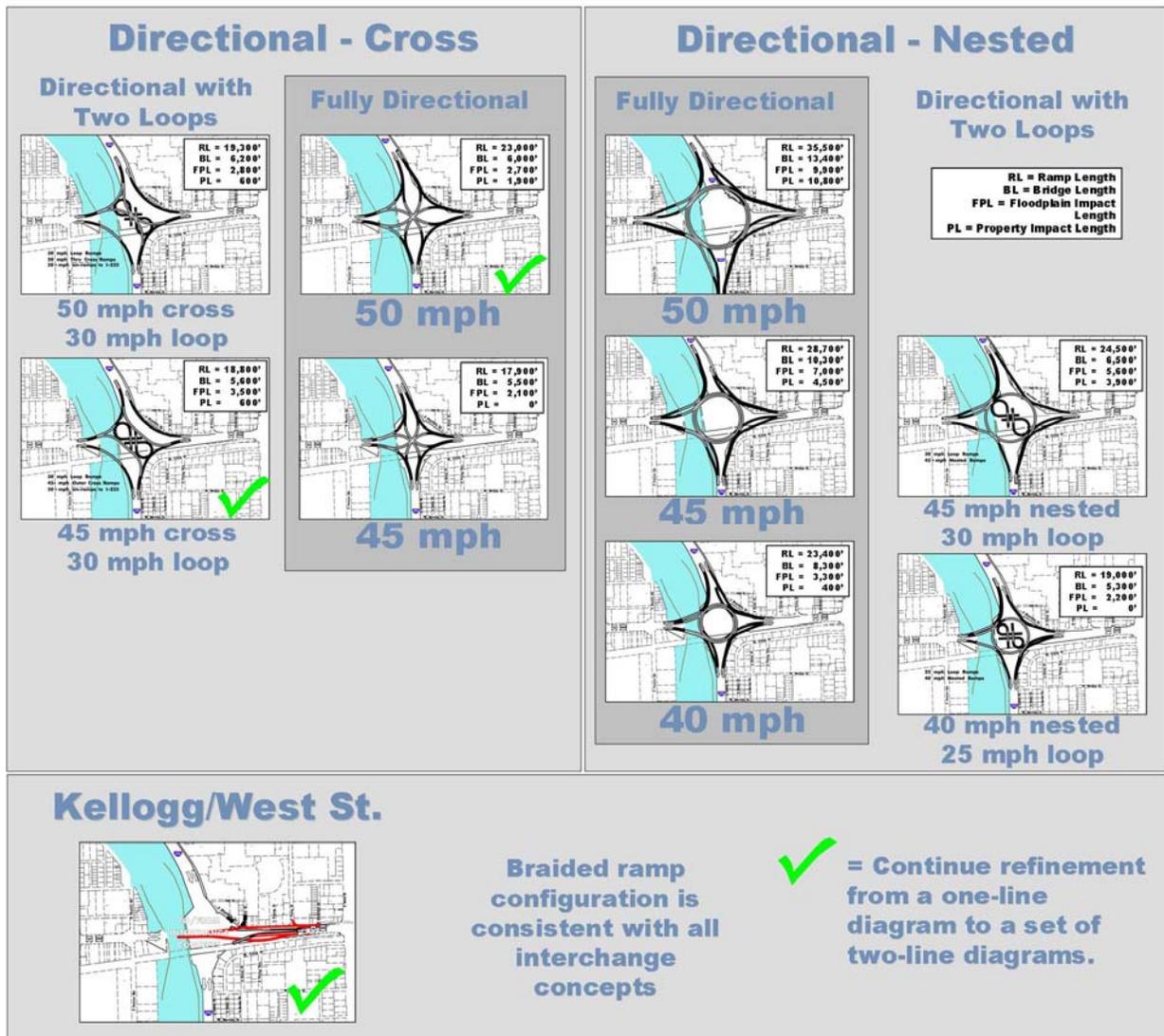
The diamond and partial cloverleaf (PARCLO) interchanges are common forms for service interchanges. There are many types of both forms. For diamond interchanges, the typical distance between ramp termini for a rural diamond is approximately 1,000 feet, while the distance for a compressed diamond is 600 feet, a tight urban diamond is 250 feet and a single point is 200 feet. The first single-point interchange constructed in Kansas was the US-54/400 (Kellogg Ave.) and West Street interchange. The PARCLO design can be found at the I-235 interchanges with K-42 and Zoo Blvd. It was most likely utilized at those locations in response to the adjacent railroad corridors.

I-235 and US-54/400 (Kellogg Ave.) and West Street Access

Because of the system interchange type, only two concept forms (the cross and nested) were developed, yet many variations were considered including a range of speeds on the ramps as well as the inclusion of two loop ramps. See Exhibit 5.6 for “one-line diagram” illustrations of the concepts developed. The concepts show similar geometry for all ramps. However, when the concepts are designed to fit actual conditions, ramp geometry may vary. Each of the interchange configurations requires a multi-level structure that must address the issues of vertical clearance between bridge structures as well as not exceeding the airport horizontal surface elevation. Information has been developed at this stage to assure the concept is feasible, yet detailed design is needed to determine bridge structure types.

The design of the interchange is also complicated by the proximity of the West Street interchange, particularly the distance needed to accommodate traffic volumes through weaving operations. The treatment for this physically constrained area utilizes a braided ramp concept. Other key elements to be given further consideration include crossing the Big Ditch and interfacing with the electrical utility corridor. Another critical issue was constructability and maintaining traffic flow during construction, as well as the potential phasing of improvements.

Exhibit 5.6 – Concepts Developed at I-235 and US-54/400 (Kellogg Ave.) Interchange



Review of the concepts was conducted by comparing several common elements such as the bridge length, ramp length, and potential impacts to floodway and property. This information is shown on Exhibit 5.6 in summary form on each of the concepts developed. The conclusion is that the highest level of design speed connections is the most desirable coupled with the best operations and least impacts. The type which would best accomplish that would have direct connections with 50 mph operations on all the ramps. A form of the two loop configuration was retained for comparative analysis purposes.

With such configurations, the interchange operations are not necessarily assessed within the I-235 and US-54/400 (Kellogg Ave.) interchange but by capacity issues downstream particularly on US-54/400 (Kellogg Ave.) to the east (downtown). Design details associated with the tie-in points are subject to further refinement.

Exhibits 5.7a and b show the two interchange configurations advanced for more detailed review. The material shown here is a CONCEPT ONLY. The design is subject to modifications based upon more detailed information.

Currently an area of potential impact is shown in orange by a shaded band 200 feet or more from the edge of travel way. The extents of probable impacts are subject to change based upon refinements to the concept design. The intent of the concept design is to determine the likely configuration of improvements at a programmatic level for estimating, permitting and scheduling.

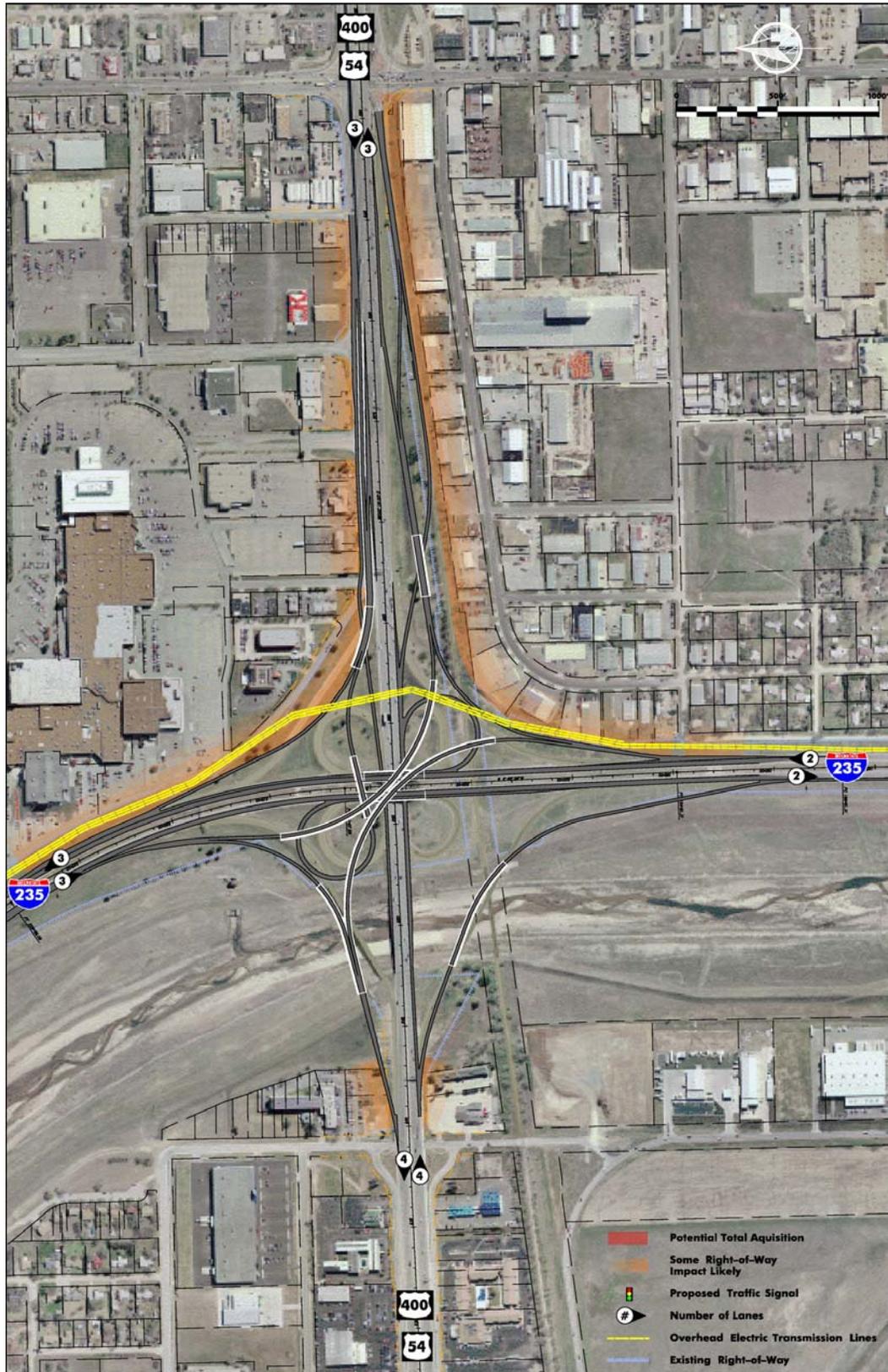
Areas for further refinement include:

- Wichita Valley Center Floodway – requiring coordination and determination of appropriate actions
- Westar Electrical Transmission – requiring coordinate and determination of appropriate actions, both tower location and height are an issue with both interchange concepts
- Operations – continue analyses, included as part of concept design and reviewed throughout permitting and design stages, particularly at ramp merging and weaving areas
- Physical Design and Location of Elements – refine as best as practical, including the spacing of guide signs, tie-in points to the existing highway, improvements to the mainline roadways, access to adjacent public ways and private property, and detailed design such as profiles and depth of bridge structures, though definitive limits of design will not be determined until the permitting and design stages

The first concept, shown in Exhibit 5.7a, is a fully directional cross interchange with flyover ramps serving all four “cross” movements. The similar ramps of all one design speed have been refined for this concept to adapt to physical constraints and to provide the highest speed ramps to the highest traffic demand ramps. The ramp design speeds vary from 40 mph to 50 mph. This interchange requires four levels, with the highest (4th) level ramps crossing offset from each other.

The second concept, shown in Exhibit 5.7b, utilizes loop ramps in the southeast and northwest quadrants. These loop ramps are larger (higher design speed) than the existing loop ramps and because the ramps are in opposing quadrants, weaving is avoided, resulting in acceptable traffic operations.

Exhibit 5.7b – Concepts Carried Forward at I-235 and US-54/400 (Kellogg Ave.) Interchange Fully Directional Interchange with Two Loops



I-235 and Central Avenue

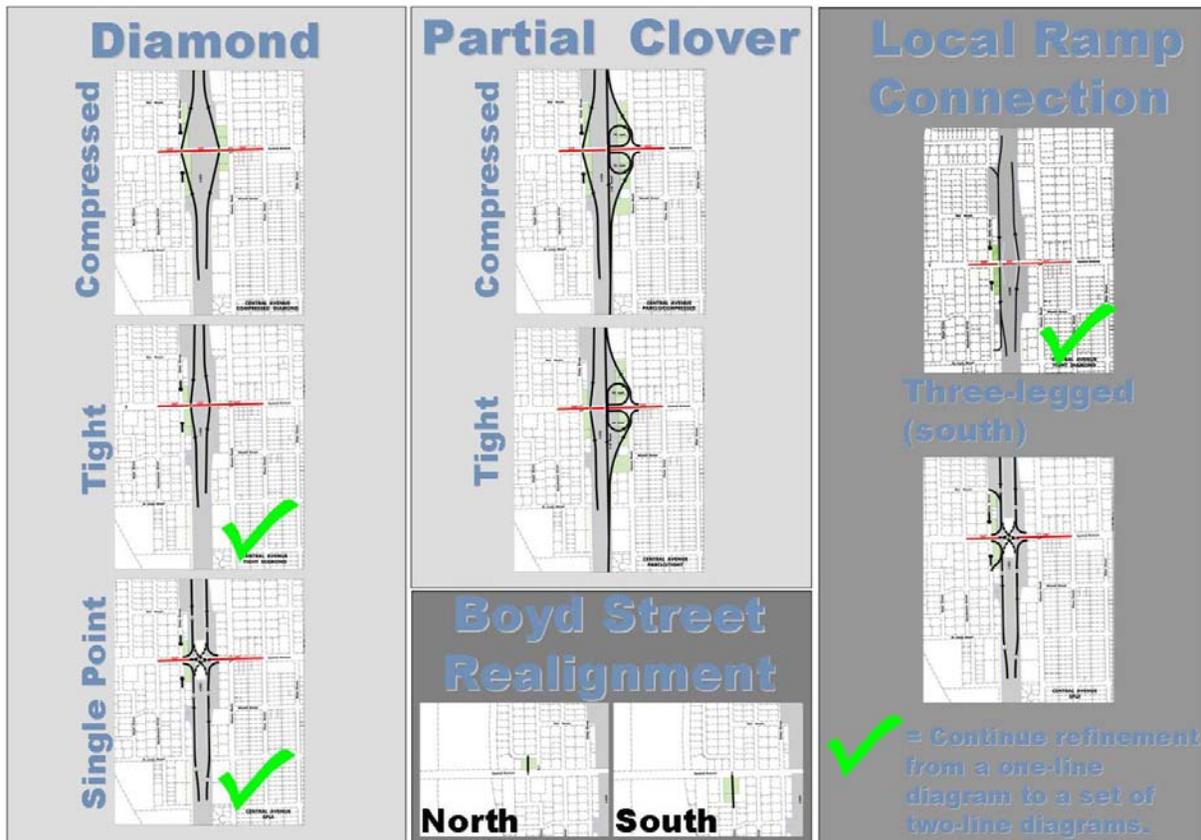
Numerous concepts were developed using forms for a service type interchange. Nonetheless, the issues of access management and neighborhood circulation particularly on the west side of I-235 strongly influenced the development and refinement of the concepts. Concepts with more property impacts and roadway construction were initially eliminated from further review, such as the partial clover interchange configuration.

The Wichita Area Metropolitan Planning Organization's (WAMPO) Long Range Transportation Plan (LRTP) has identified the portion of Central Avenue west of the I-235 interchange to be widened from five to seven lanes. The street widening would be a continuation of widening of the bridges over the Big Ditch, currently on the City of Wichita's Capital Improvement Plan (CIP). The widening would help to serve the traffic along this busy arterial as well as remove a bottleneck from west of the Big Ditch where Central Avenue is already seven lanes.

A potential cross section reviewed indicates that widening to seven lanes could be accommodated within 100 feet of right-of-way. Along much of the length of Central Avenue, 100 feet of right-of-way is available. Continued coordination is necessary to ensure that the proposed improvements along Central Avenue are fully integrated into the I-235 interchange concepts. East of the I-235 interchange, Central Avenue would remain five lanes except as necessary to accommodate turning movements at the ramp junction.

Neighborhood circulation is shown through two basic access management options. One option calls for Gilda Street to be closed with circulation rerouted to Central Avenue via a proposed (4-legged) traffic signal at Boyd Street. The other option includes a connector ramp, serving neighborhood traffic similarly to the Gilda St. operation today, as well as a traffic signal (although 3-legged) at Boyd St. These are shown in Exhibit 5.8.

Exhibit 5.8 – Concepts Developed at I-235 and Central Avenue Interchange



The concepts carried forward are essentially two interchange concepts (SPUI and tight diamond) coupled with two access management options (transfer ramp and no transfer ramp). The concepts have similar lengths of roadway and retaining walls. The SPUI has one traffic signal versus the two signals needed for a tight diamond interchange configuration, but the SPUI bridge is longer and wider.

The transfer ramp concept incorporates:

- The entry of the transfer on-ramp from Gilda is from Murdock.
- The merge of the transfer ramps and the off-ramp are parallel for approximately 360 feet.
- The transfer ramp and the off-ramp are both one-lane.
- The southbound off-ramp lane configuration at Central Avenue is; an exclusive right, a thru-and right lane, and an exclusive left.
- The exit of the transfer ramp to Gilda is close to St. Louis St. While various intersection junction configurations are possible, a T-intersection (three-legged) placed 180 feet north of St. Louis that splits the distance between two private driveways on the west side of Gilda is shown.

This layout for a transfer ramp follows the design elements outlined in *ITE's Freeway and Interchange Geometric Design Handbook*. Sections of Chapter 8 (Frontage Road Systems and Collector-Distributor Road Systems) are dedicated to the design issues of transfer ramps and their operations. An operational review of these interchange configurations was conducted utilizing the Synchro/SimTraffic software and the future traffic volume projections at the intersections along the Central corridor.

At this time for consistency, all of the scenarios included a traffic signal at Boyd. A scenario with just the "interim improvements" (extended left turn lanes under the bridge and a short right turn lane on the northbound off ramp) will not be sufficient to accommodate long term traffic growth. Several other scenarios were tested: A single point (SPUI) both with and without a combined ramp/frontage road on the west side, and variations of a tight-diamond (with varying ramp spacing).

The single point operates at a borderline D/E level of service with a four lane section on Central. With the addition of the transfer ramp/frontage road, the left-turns from the two ramps have to operate exclusively (split phase) and the operation falls significantly to level of service E/F, therefore the SPUI option with a transfer ramp was not carried forward. In addition to causing negative operational impacts, the transfer ramp was eliminated due to safety concerns. Comments at public meetings from residents who live in the neighborhood were supportive of the four-legged signalized intersection at Boyd as an access concept. The tight diamond scenarios all operated acceptably, with LOS C/D at both ramps with and without the frontage road (in this case, the "through" movement on the southbound ramp intersection operates concurrently with the ramps so it has little impact on operation). These analyses are all for PM as AM operation was generally better than PM.

Exhibits 5.9a, b, and c illustrate the interchange concepts carried forward. A raised median is shown from Boyd to the southbound ramps and from the northbound ramps to Flora. The intermediate public streets of Eisenhower and Flora would be restricted to right-in, right-out turning movements. This design at Eisenhower would specifically assist the Wichita Transit bus route which currently utilizes Gilda to serve the Sandpiper Bay community north of Central. At this time no driveway access points are shown. This does NOT mean that the driveways are removed or closed. However, it is suggested that access management be developed and shown later, likely during the design stage.

The concepts show tying into the existing five-lane section on Central west of I-235. The concept is expandable to the seven-lane section (west of I-235) presented in WAMPO's adopted Long Range Transportation Plan. These concepts include a four-legged signalized intersection at Boyd Street and Central Avenue to serve both neighborhoods north and south of Central. Because of the offset alignment of Boyd Street, two concepts have been developed that realign either the north or south leg of Boyd.

Currently an area of potential impact is shown in orange by a shaded band 100 feet or more from the edge of travel way. Where impacts to improvements on properties are more intrusive, the property is shown shaded in red. The extent of probable impacts is subject to change based upon refinements to the

concept. The intent of the concept is to determine the likely configuration of improvements at a programmatic level for estimating, permitting and scheduling.

Exhibit 5.9a shows the “tight” diamond configuration. The heavy eastbound right-turn volume gets an exclusive right-turn lane which is “dropped” before going beneath I-235. This places the lane widening on the south side of Central, essentially between Eisenhower and the southbound on-ramp. Potential future widening to seven lanes is shown dashed. This concept shows a realignment of Boyd Street on the south side of Central Avenue, through Quik Trip, lining up with existing Boyd on the north side. This alignment is interchangeable with a realignment on the north side, as shown in Exhibit 5.9b. However, with the tight diamond configuration, the realignment of Boyd Street on one side or the other will be required in order to maintain local access and the ability to take a left-turn to and from the neighborhoods.

Exhibit 5.9b illustrates the SPUI configuration. As with the tight diamond, the eastbound to southbound right-turn lane requires widening on the south side of Central, and is dropped before going beneath I-235. The exhibit shows a Boyd Street realignment on the north side through a private residential and a commercial property to line up with existing Boyd Street to the south. Again, this Boyd Street realignment is interchangeable with the southern realignment, but is necessary to maintain local access and the ability to make left-turn movements.

Exhibit 5.9c is the “tight” diamond configuration with a transfer ramp. As with the other concepts, the eastbound to southbound right-turn lane requires widening on the south side of Central from Eisenhower to the southbound on-ramp. Because the exiting (especially left-turn) movements from the neighborhood on the north will be possible through the Gilda Street transfer ramp combination, a realignment of Boyd Street is not required for this concept. However, a three-legged signalized intersection would be necessary with the southern alignment of existing Boyd Street to account for the high traffic volumes on Central making left-turns exiting the neighborhood difficult.

Exhibit 5.9a – Concepts Carried Forward at I-235 and Central Avenue Interchange Tight Diamond Interchange



Exhibit 5.9b – Concepts Carried Forward at I-235 and Central Avenue Interchange SPUI



Exhibit 5.9c – Concepts Carried Forward at I-235 and Central Avenue Interchange Tight Diamond Interchange with Transfer Ramp



Design Concepts - Concept Assessment

This section discusses the process utilized to assess the concepts. The intent was to determine discernable differences that allow a comparison among the various concepts and to provide supporting documentation for the selection of a preferred concept. The assessment includes a review of probable impacts, operations and costs before making comparisons.

Probable Impacts

Impacts are directly associated with specific elements of the design concept. At this concept stage, impacts can be divided into three categories:

- Quantifiable impacts – whose elements are often discernibly different between concepts
- Undefined impacts – whose elements are often the same between concepts, and
- Potential impacts requiring further investigation – whose elements are often the same between concepts.

Quantifiable impacts can be measured at this time, such as property impacts but are often subject to the degree of detail currently available. For the element of property impacts, not enough detail is available (nor is it desired at this stage) to determine the area or type of potential impacts (right-of-way acquisition, permanent easement, or temporary construction easement), yet it is possible to quantify the number of properties potentially impacted and the type of property, such as residential, commercial or industrial properties. However based on what is known about property impacts, disproportionate impacts to low income or minority populations are not anticipated. Further, no environmental justice issues were identified during the public engagement activities for this study.

In broad terms, “quantifiable” can also be applied to the categories of operations (such as traffic signal delay) or costs (for such major items as pavement and bridges). Again, at this concept stage each of these quantifiable elements may have certain limitations in expressing their quantities.

Undefined impacts cannot be measured because the information is unavailable, and the appropriate time to determine the extent (if any) of such impacts is later. Such potential impacts could be related to noise or air quality. These and potentially other elements will continue to require review during the environmental permitting stage, which will be the appropriate time to determine such detail.

Potential impacts requiring further investigation elements are similar in some ways to undefined impacts, yet they differ in the sense that the presence of the element is known, but sufficient information is not available to make a determination of appropriate course of action. One of the elements in question for this project is the potential presence of hazardous waste associated with commercial properties (often existing or former gas stations) or industrial properties. Based upon location of these potential sites (the sites cannot be confirmed without additional testing) and commonality of potential impact for all the design concepts, these elements are treated as not being discernibly different amongst the concepts.

Operations

Operational analysis is an important element as it considers the benefits of the proposed improvements and assists in comparing the negative impacts of other elements. While the analysis affords the opportunity to distinguish amongst improved operations, it should also be noted that any degree of improvement above and beyond an acceptable level should be weighed against the increase (if any) of potential impacts or costs. In general, all of the design concepts carried forward for further review at this stage meet the established design and operational criteria.

Similar to previous analyses, VISSIM and HCM capacity analyses were performed for improved conditions with projected future (2030) year traffic volumes. The improvements from the preferred design alternative along I-235, US-54/400 (Kellogg Ave.) and Central Avenue were analyzed in VISSIM network. On I-235, an auxiliary lane in both northbound and southbound directions is provided between US-54/400 (Kellogg Ave.) and Central Avenue ramps.

Highway Segments, Ramp and Weave Sections

US-54/400 (Kellogg Ave.) Eastbound

The AM peak hour analysis in VISSIM indicates that the LOS is improved from no build conditions and is bordering between LOS C and LOS D all along US-54/400 Eastbound. The simulation shows some congestion but long queues are not observed. With reconfiguration of I-235 ramps, weaving is altogether eliminated and the LOS is improved from LOS F to LOS D. During the PM Peak hour, the entire section of the highway from west of Ridge Road to I-235 interchange operates at capacity and with LOS B or LOS C. The simulation shows that uniform travel speeds are maintained.

US-54/400 (Kellogg Ave.) Westbound

Since US-54/400 Westbound is only congested during the PM peak hour, the improved conditions are not very different from the no-build conditions during the AM peak hour. The AM peak hour capacity analysis indicates that all the sections of the highway operate at acceptable LOS. During the PM peak hour, the traffic volumes are three times that of the AM peak hour traffic volumes. Vehicular density on US-54/400 segment between Ridge on ramp and off ramp has decreased with future improved conditions, but the LOS is still at LOS E. The simulation shows that traveling west of I-235 ramps to Dugan Road; vehicles experience LOS E but continue to move at reduced speeds. No spillbacks are observed unlike the analysis with no-build conditions.

I-235 Northbound

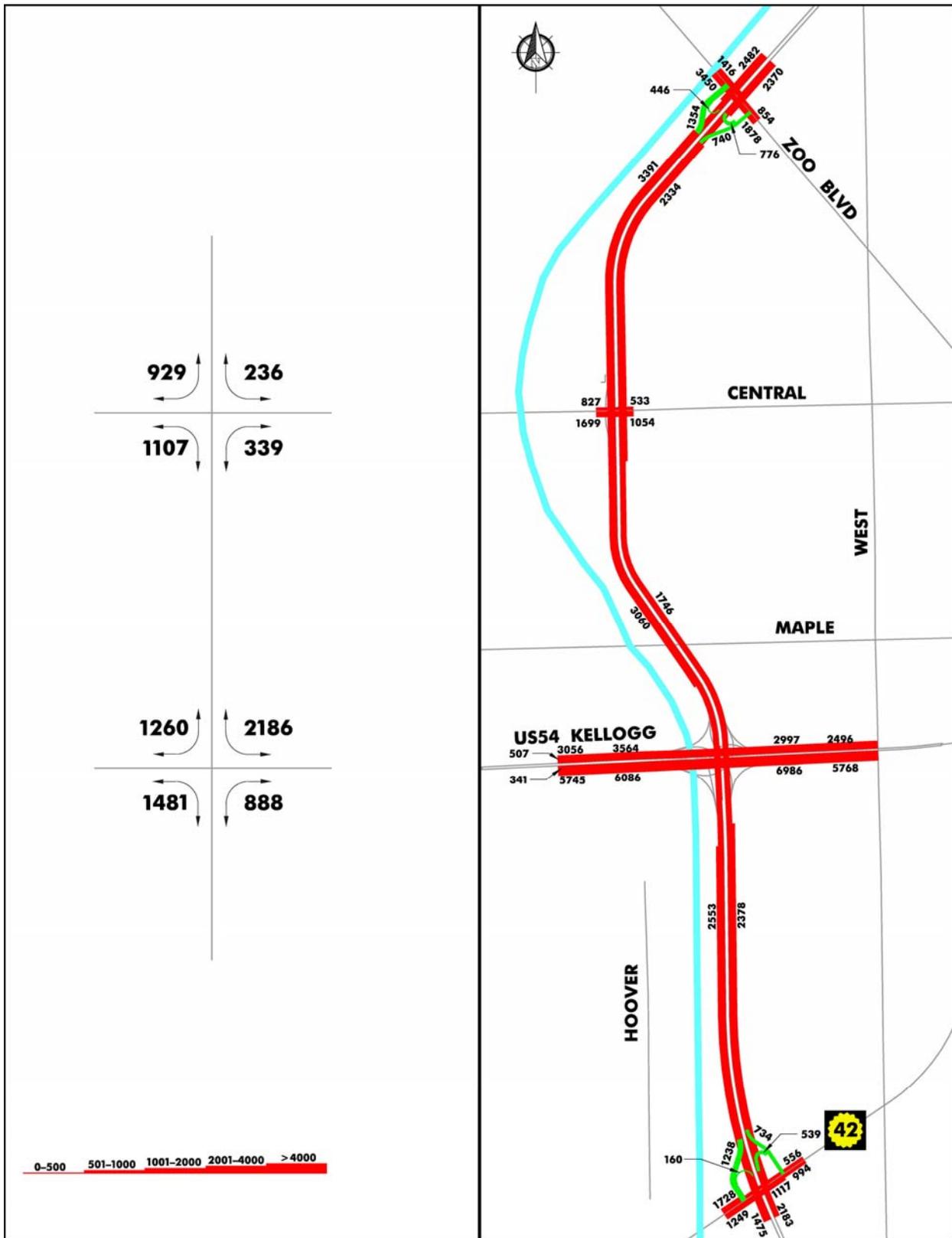
With relatively lower traffic volumes, the future year improved conditions analysis indicates similar LOS during AM peak hour. The only section operating poorly with the no-build conditions is the weaving section near US-54/400, which is eliminated under improved conditions. In general, during the PM peak hour, the northbound direction of I-235 freeway north of Central Avenue is near capacity with only two lanes. The segment from Central Avenue entrance ramp to Zoo Boulevard exit ramp changes from LOS D to LOS E due to lane drop north of Central Avenue ramps. The segment between US-54/400 and Central Avenue ramps improves to LOS D to LOS C with no queuing.

I-235 Southbound

During the AM peak hour, with the addition of a third lane for exiting traffic, the southbound direction of the highway is relieved of congestion. Overall LOS is improved to LOS C. The segment from Zoo Boulevard to Central Avenue operates with LOS C, which is an improvement from LOS F in no-build conditions. The simulation shows uniform travel speeds with little turbulence. South of US-54/400 to K-42, the freeway operates reasonably but a slight increase in vehicular density is observed during the simulation. During the PM peak hour, traffic operations from Zoo Boulevard to Central Avenue are the same as no-build conditions. There is a significant congestion mitigation observed between Central Avenue and US-54/400. LOS improves from LOS F in no-build conditions to LOS B or A under improved conditions. The simulation suggests that the widened freeway could easily sustain more traffic growth beyond 2030. Similar to AM conditions, traffic approaching K-42 ramps experience some delays. In general, the freeway operates at LOS C.

The projected peak hour traffic volumes are shown in Exhibits 5.10a and b. The LOS indicated by the VISSIM analyses for various segments are shown on Exhibit 5.11. The LOS calculated using HCM methodology using basic freeway segments, merge and diverge areas and weaving sections analyses are shown on Exhibit 5.12.a and b. The freeway analysis results from the VISSIM model are included in the Appendix.

**Exhibit 5.10a – Projected 2030 Peak Hour Traffic Volumes – With Proposed Improvements
AM Peak Hour**



**Exhibit 5.10b – Projected 2030 Peak Hour Traffic Volumes – With Proposed Improvements
PM Peak Hour**

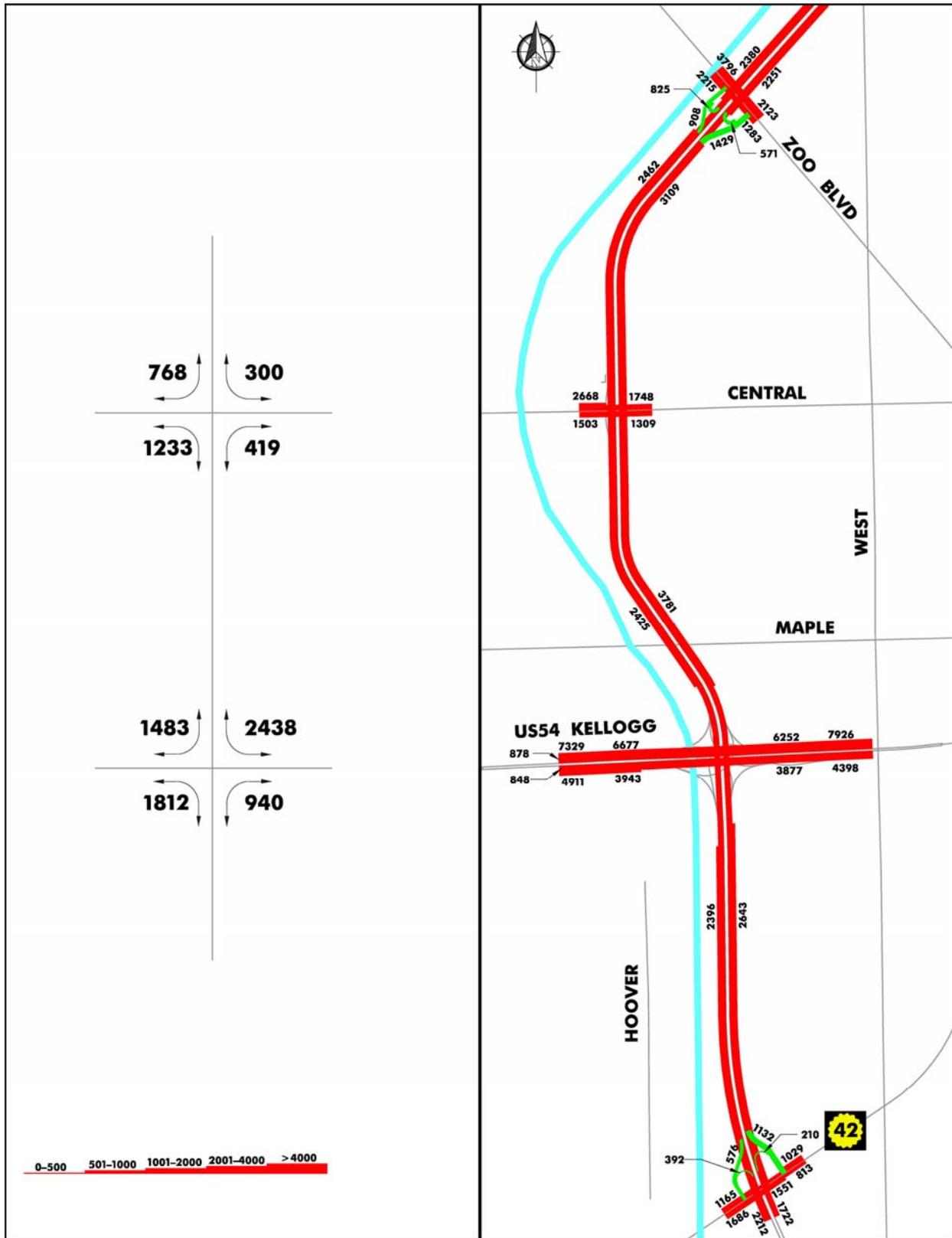


Exhibit 5.11 – Projected 2030 AM and PM Segment Analysis – VISSIM LOS With Proposed Improvements



**Exhibit 5.12 – 2030 AM and PM Segment Analysis – With Proposed Improvements
Interstate 235
US-54/400 (Kellogg Ave.)**

SEGMENT	AM					PM																
	DENSITY		LOS	HCM		DENSITY		LOS	HCM													
	VISSIM	HCM	HCM	VISSIM	HCM	VISSIM	HCM	VISSIM	HCM													
I-235 Southbound																						
Zoo Off Ramp	Approx. 22	26.8	C	Approx. 2	25.8	C																
Merge	18	31.3	D	14	23.3	C																
Zoo On Ramp	35	29.3	D	23	20.1	C																
Basic	28	34.7	D	20	25.6	C																
Central Off Ramp	24	34.7	D	18	22.7	C																
Merge	22	16.5	B	14	10.4	A																
Central On Ramp	28	23.7	C	8	15	B																
Basic	12	11.8	B	18	10.3	B																
US-54 On Ramp	14	20.8	C	25	19.5	C																
Merge	28	27.7	C	18	26.2	C																
US-54 to K-42	10	13.5	B	15	19.9	B																
Basic																						
Merge																						
I-235 Northbound																						
K-42 Off Ramp	19	24.2	C	15	19.7	C																
Diverge	12	22.8	C	11	24.9	C																
Merge	20	20.5	C	22	22.7	C																
US-54 to US-54	14	23	C	15	25.6	C																
Basic	8	8.6	A	20	22	C																
US-54 On Ramp	9	8.9	A	28	15.4	B																
Merge	12	-19.4	A	28	-3.8	A																
Central Off Ramp	14	22.1	C	20	29.2	D																
Merge	27	19	C	38	26	C																
Basic	15	25.2	C	35	32.7	D																
Zoo Off Ramp		20.9	C	15	20	B																
Merge																						
US-54/400 Eastbound																						
Ridge to Dugan	Approx. 31	36.6	E	Approx. 22	23.3	C																
Basic	28	36.5	E	20	32.6	D																
Weave	38	27.5	D	26	17.8	B																
I-235 to West St. Off Ramp	25	29.1	D	24	20.7	C																
Diverge	22	22.4	C	14	11.6	B																
West Street Off	35	33.5	D	22	25.3	C																
Merge		27.8	D		19.8	C																
Basic																						
US-54/400 Westbound																						
K-42 to West Street				14	11.6	B																
Basic	14	14.3	B	36	>70	F																
Diverge	10	10.1	B	40	30.8	D																
Basic	14	8.2	A	50	30.2	D																
Merge	22	18.5	B	48	37.9	F																
West Street On to I-235	15	17.5	B	42	>70	F																
Weave																						
I-235 to Dugan																						
Basic																						
Dugan to Ridge																						

Mainline Operations

Under no-build conditions, the freeway segment on I-235 between the US-54/400 (Kellogg Ave.) interchange and Central Avenue continues to experience congestion in the northbound direction during the PM peak. Sometime between the existing conditions and the 2030 future year, the southbound direction is expected to experience congestion during the AM peak. The logical design element needed to improve operations is to provide additional capacity by adding another lane. The other freeway segments reviewed along I-235, north of the Central Avenue interchange and south of the US-54/400 interchange, are expected to continue to operate at acceptable level with the current four-lane configuration. Consequently, it is concluded that the necessary added capacity is not as a basic travel lane along the freeway, but as an auxiliary lane between the on- and off-ramps of the two interchanges. As an auxiliary lane, the location of the additional lane would be to the outside of the existing roadway.

Under no-build conditions, the freeway segments on US-54/400 (Kellogg Ave.) east of I-235 continue to experience congestion in the eastbound direction during the AM peak and in the westbound direction during the PM peak. This congestion is directly related to the volume of traffic and the on- and off-ramp spacing between I-235 and the West Street interchange. Because of the existing physical limitations, a potential design solution is to use braided ramps, which physically separate the off-ramp and the on-ramp through the use of a bridge.

West of I-235, segment operations deteriorate because of increased traffic volumes yet the current provision of an auxiliary lane and increased on-ramp to off-ramp spacing indicate acceptable conditions. However, because interchange configurations may alter the spacing between the ramps, continued review of this traffic operation is necessary.

Interchange Operations

The existing US-54/400 (Kellogg Ave.) interchange is a cloverleaf design which is technically not classified as a system configuration because of its weaving condition. The combination of the loop ramp configuration, specific geometry of the loop ramps and the traffic volumes cause unacceptable operations. As a system interchange it is necessary to remove the loop ramps that create weaving conditions. While some design options such as a Collector-Distributor (CD) configuration could channel traffic to a slower moving facility, the majority of system interchange forms include direct flyovers. Because the ramp volume exchanges are not equally balanced at the US-54/400 and I-235 interchange, it may be possible to serve the heaviest traffic volumes with directional ramps and possibly accommodate lesser traffic volumes through loop ramps without weaving conditions.

The operation of the I-235 and Central Avenue interchange is essentially governed by the off-ramp operations which become an arterial issue regarding traffic signals and their spacing. A potential negative effect of traffic signal operations at the off-ramp is the significant queue lengths beyond the nose of the off-ramp and in turn, storing vehicles on the mainline. Consequently it is important that the treatment of the mainline, interchange and arterials be viewed as a total transportation system.

Probable Financial Elements

A major component of any transportation improvement project is associated with probable costs. For many, probable cost is viewed as the critical element in making comparisons and in selecting a preferred concept. While the general intent is to be efficient and effective, another purpose of cost estimating is to develop a programmatic cost for the project. A program cost identifies a total cost and then allows a funding strategy to be defined that may utilize a variety of funding sources to reach the total amount needed. At this concept stage, probable costs are not always necessary to determine since all items are not yet defined or quantifiable. Nonetheless, a handful of major quantifiable items can provide an opinion of probable costs. The major items are divided into three categories, construction quantities and utilities, right-of-way parcels, and contingencies, which are discussed below.

Construction Quantities and Utilities

As discussed above, it is proposed to treat quantities of basic construction items as a surrogate for actual cost. This also assists in avoiding, at this stage, the potential fixation on a total cost amount based on today's dollars which will need to be adjusted to account for inflation to an as yet unknown time period. The basic construction items include pavement area as well as bridge area (travel lanes and shoulder). Retaining walls could also be a major cost item, yet typically to more accurately estimate the area of wall, a profile or some specific knowledge of the exposed height is necessary. Since that detail is not yet determined an assumed average height is used, although in later design development stages the actual area is likely to be different. A discussion of other construction items is included under the heading of contingencies.

Another major cost item can involve utility relocation. Again the issue of determining an accurate probable cost estimate appears. Consequently for comparative purposes, the assessment acknowledges that a major electrical utility runs parallel and adjacent to the I-235 corridor and utilizes the number of towers potentially impacted as the degree of difference without the need for specific unit costs.

Right-of-Way Parcels

With the element of right-of-way, it is difficult to determine the potential limits of impact let alone to determine probable costs. Therefore it is suggested that if a monetary approach is used, it is best to provide a range of probable costs. The approach taken at this concept stage is to identify the number of properties by type (commercial, industrial, residential) irrespective of varying costs and other site specific influences. As noted previously, the intent is to determine the level of programming costs and to differentiate (if at all) between the various concepts.

Contingencies

The estimate reflects that a dozen or so items can represent a significant percentage of the total construction cost. Yet with the design only at a concept stage, it is also recognized that the estimated quantities are still very vague and may also need a contingency to cover increased quantities due to increased limits. Other major cost items that are difficult to estimate at this stage include traffic control and drainage. These items are included as a line item but are expressed as a percentage of overall construction costs. Careful review of costs is needed because such an approach includes a percentage of contingencies.

Comparison

A comparison of the design concepts utilizing the above described approach was conducted for the three concepts at the I-235 and Central Avenue interchange and for the two concepts at the I-235 and US-54/400 (Kellogg Ave.) interchange. The mainline segment of I-235 between the two interchanges has only one design concept. While the elements can be assembled for this mainline segment it is unnecessary to include for making a selection, yet the elements are worthwhile to note relative comparative purposes.

The raw quantities provide information for comparison within a specific category. Nonetheless for an overall comparison the different units of the elements make it impossible to add the number of properties, seconds of delay and square yards of pavement area together. Consequently, the values of the categories are converted to a simple albeit subjective scale. The scale utilizes a five-point system

ranging from very poor (0) to very good (4). This approach allows for an overall combined rating assuming that all elements are rated equally. For graphical representation purposes (and practical purposes as well since any concept with a very poor rating should not have progressed to this stage) a circle with four quadrants is used to present the subjective rating. Both the raw quantities and the rating charts for the assessment are shown in Exhibit 5.13.

I-235 and Central Avenue Interchange

Property impacts are shown in two categories, those properties assumed to be taken (shown previously in red) and those properties with some potential impact but whose degree cannot yet be fully defined (shown previously in orange). The SPUI has the least direct amount of property impacts and is rated good. While the other concepts have more impacts they are rated as fair. Operations, both in terms of capacity and safety, would suggest that the tight diamond concept would operate best at a good rating. The other concepts are rated fair. In terms of probable costs, the tight diamond is rated best as the cost of the SPUI's bridge adds extensive costs and the transfer ramp concept includes several more properties and pavement than the other concepts, as well as having worse operations. This assessment elevates the tight diamond concept to the highest overall rating.

I-235 and US-54/400 (Kellogg Ave.) Interchange

Both concepts have essentially the same footprint and consequently the same property impacts. Both are rated good. Safety operations suggest that both would operate at a good rating. Capacity operations suggest that the fully direct concept would operate best at a very good rating. The two loop concept is rated good. In terms of probable costs, the fully direct concept is the most expensive and is rated fair, while the two loop concept is rated good. The overall assessment would suggest that both concepts are rated equally. This assessment assumes that the elements are rated equally. Upon further evaluation, the two different elements are capacity operations and probable costs. If capacity is rated more important than cost, then the fully direct concept should be selected. If cost is rated more important than capacity, then the two loop concept should be selected. Public opinion in Wichita is opposed to the loop design.

Another perspective, which is also possible, is that depending upon financial availability the two loop concept could be constructed initially as an interim improvement and eventually the design could evolve to the fully directional concept by constructing the fly over ramps to replace the two loop ramps. It should also be noted that both concepts have an overall rating of good.

Exhibit 5.13 – Matrix Assessment

Data by Segments								
						AM/PM		
CENTRAL 	SPUI 2 21	3 17	0 0	 Further investigation required	29 78	274K	54K	
	TIGHT 3 18	4 18	0 0	 Further investigation required	39 49	226K	23K	
	TRANSFER 6 18	4 20	0 0	 Further investigation required	42 74	269K	24K	
I-235 	AUXILIARY	TO BE DETERMINED			Further investigation required	WIP	TO BE DETERMINED	
KELLOGG 	FULL 0 3	0 14	0 15	 Further investigation required	WIP	647K	181K	
	2 LOOP 0 3	0 14	0 15	 Further investigation required	WIP	693K	164K	

Conventional underground utility coordination, including gas, water and sewer, as well as the electrical transmission lines of Westar and the Wichita Valley Center Floodway require coordination and are considered to be the same throughout each concept.

		Operations				
CENTRAL	SPUI					
	TIGHT					
	TRANSFER					
I-235 MAIN LINE	AUXILIARY					
KELLOGG	FULL					
	2 LOOP					

Very Good Poor
 Good Fair

4 1
 3 2

Concept Refinement Process

This section documents that even after comparison and selection of a preferred design concept, further refinement needed to occur. In particular, the selection of interchange concepts at both I-235 and US-54/400 (Kellogg Ave.) and I-235 and Central Avenue allows the mainline configuration of I-235 to be depicted. At the I-235 and Central Avenue interchange, continued operational analysis suggested that a refinement that increases the spacing between the ramp junctions (from a tight configuration to a compressed configuration) was appropriate. However, it must be noted that the material shown here is a “concept” only, which means that the design is subject to modifications based upon more detailed information. Nonetheless the concepts are suitable for developing probable costs in order to seek funds and determining the appropriate environmental documentation process. Currently, an area of potential impact is shown in orange by a shaded band (ranging from 100 to 200 feet) from the edge of travel way. Where impacts to improvements on properties are direct, the property is shown shaded in red. Again, the extents of probable impacts are subject to change based upon refinements to the concept. In general, areas for further refinement include:

- Continuing the operational analysis and review, throughout permitting and design stages as well as monitoring of traffic volumes
- Refining the physical design and location as best as practical, though definitive limits cannot be determined until the permitting and design stages
- Coordinating and then determining the appropriate actions with adjacent facility agencies including the Wichita Valley Center Floodway and Westar with their electrical transmission towers

I-235 and US-54/400 (Kellogg Ave.)

The intent was to continue advancing the concept through design refinement as well as reviewing potential impacts in order to ascertain the appropriate process for environmental documentation. This included creating a three-dimensional representation of the I-235 and US-54/400 (Kellogg Ave.) interchange. The three-dimensional representation allows the viewer to understand better the relationships amongst the crisscrossing ramps, while not having to prepare specific profiles for each ramp. Nonetheless the representation utilizes critical design criteria such as vertical clearance, maximum ramp grades and an assumed depth of bridge structure. It also assists in determining where critical areas exist that may benefit from further exploration of the concept and continued refinement if necessary. Exhibit 5.14a shows an overview of the preferred US-54/400 (Kellogg Ave.) interchange while Exhibit 5.14a.i presents various views generated from the 3-D model.

Interstate 235

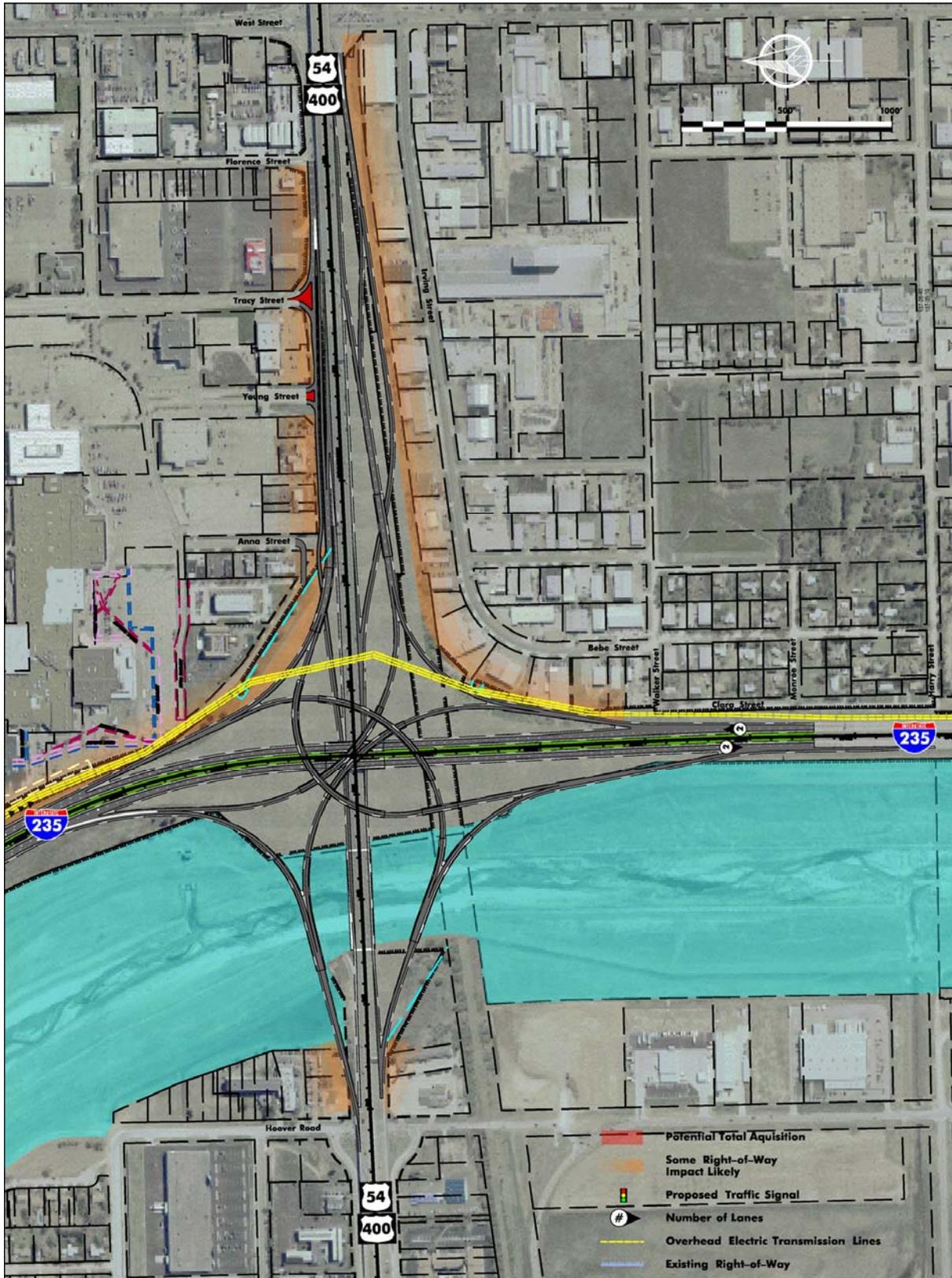
Along I-235 certain design issues will continue to need review and refinement. These issues range from the potential need for retaining walls and/or guardrail in order to minimize the impacts to adjacent structures, drainage flow patterns (while maintaining minimum flow slopes) to further coordination with Westar about relocation of utility structures and the Wichita Valley Center Floodway. The bridges on I-235 over Maple Street will be lengthened to accommodate the expansion of Maple Street to a five-lane section. Exhibit 5.14b shows an overview of the preferred segment of Interstate 235.

I-235 and Central Avenue

At the I-235 and Central Avenue interchange, plans have been refined to reflect the calculated storage lengths needed for turn bay lengths. The concept shows tying into the existing five-lane section on Central, however it is expandable to the seven-lane section (west of I-235) as presented in WAMPO's adopted Long Range Transportation Plan. The concept includes a four-legged, signalized intersection at Boyd Street and Central Avenue to serve both neighborhoods to the south and north. Because of the offset alignment of Boyd Street, realignment is recommended that holds the existing south leg. Further refinement includes coordination with local entities and input from neighborhoods and businesses to refine the access and access management concepts. Exhibit 5.14c shows an overview of the preferred Central Avenue interchange.

A closer plan view of the concepts is presented through a series of exhibits in the Appendix.

Exhibit 5.14a – Preferred Concept Plan Overview I-235 and US-54/400 (Kellogg Ave.) Interchange



**Exhibit 5.14a.i – Visualization
3-D views of the Preferred I-235 and US-54/400 (Kellogg Ave.) Interchange**

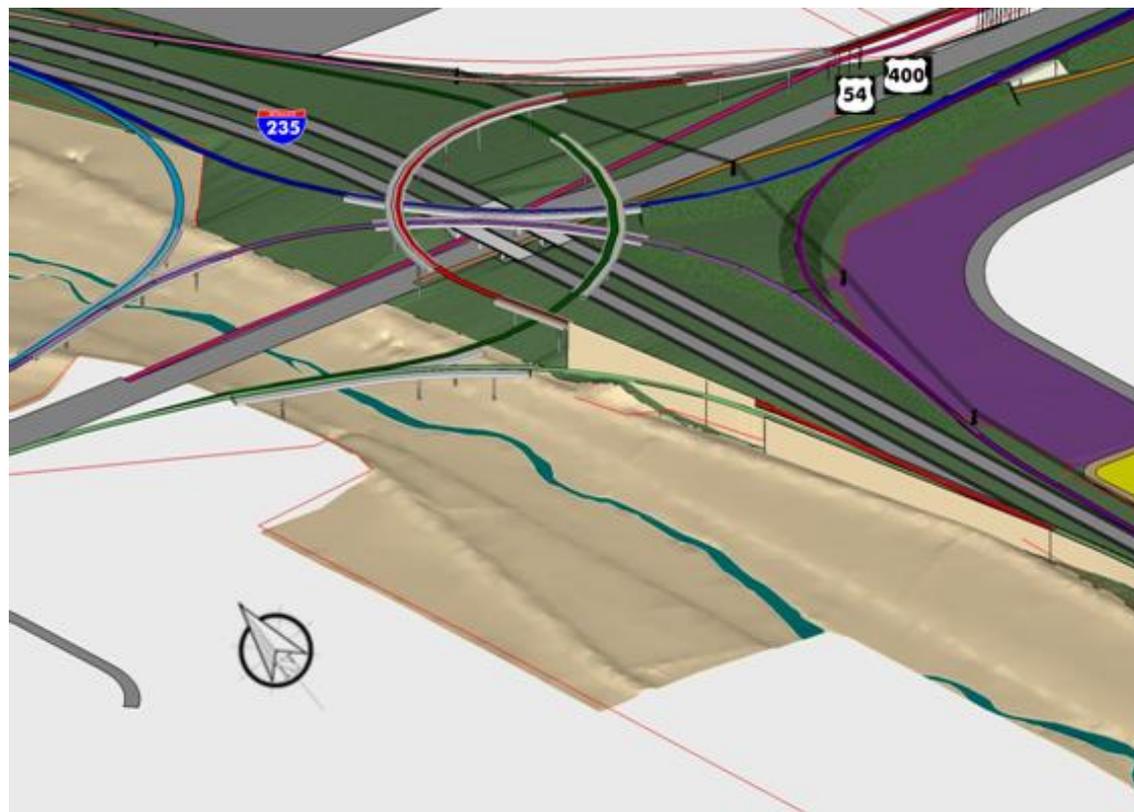
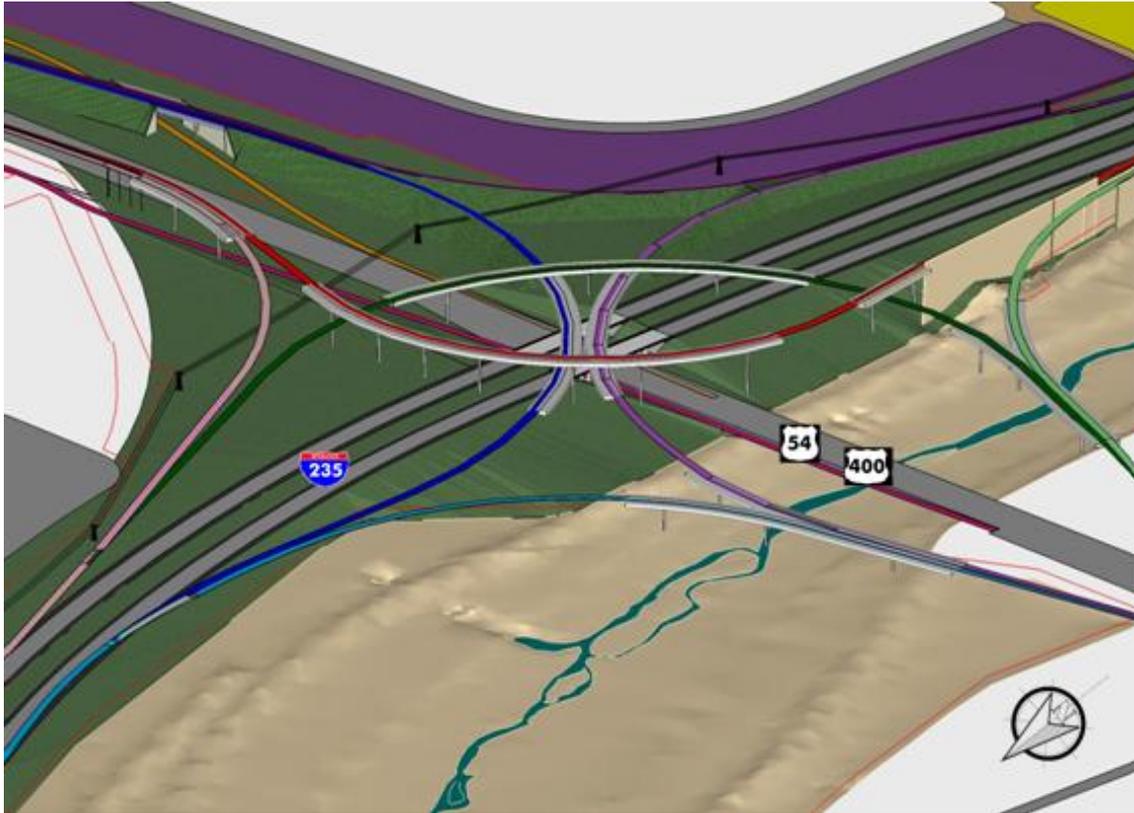


Exhibit 5.14b – Preferred Concept Plan Overview Interstate 235

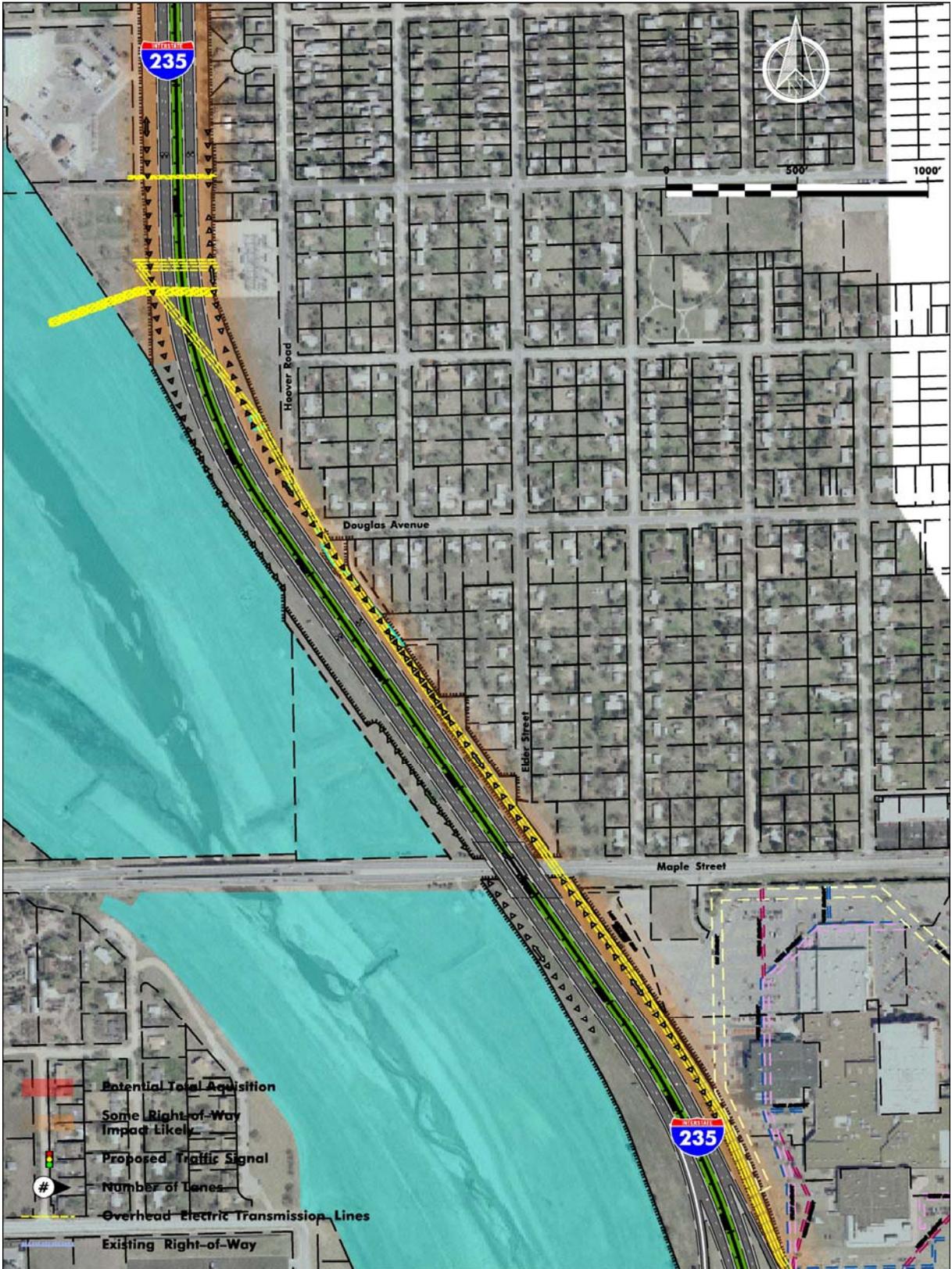
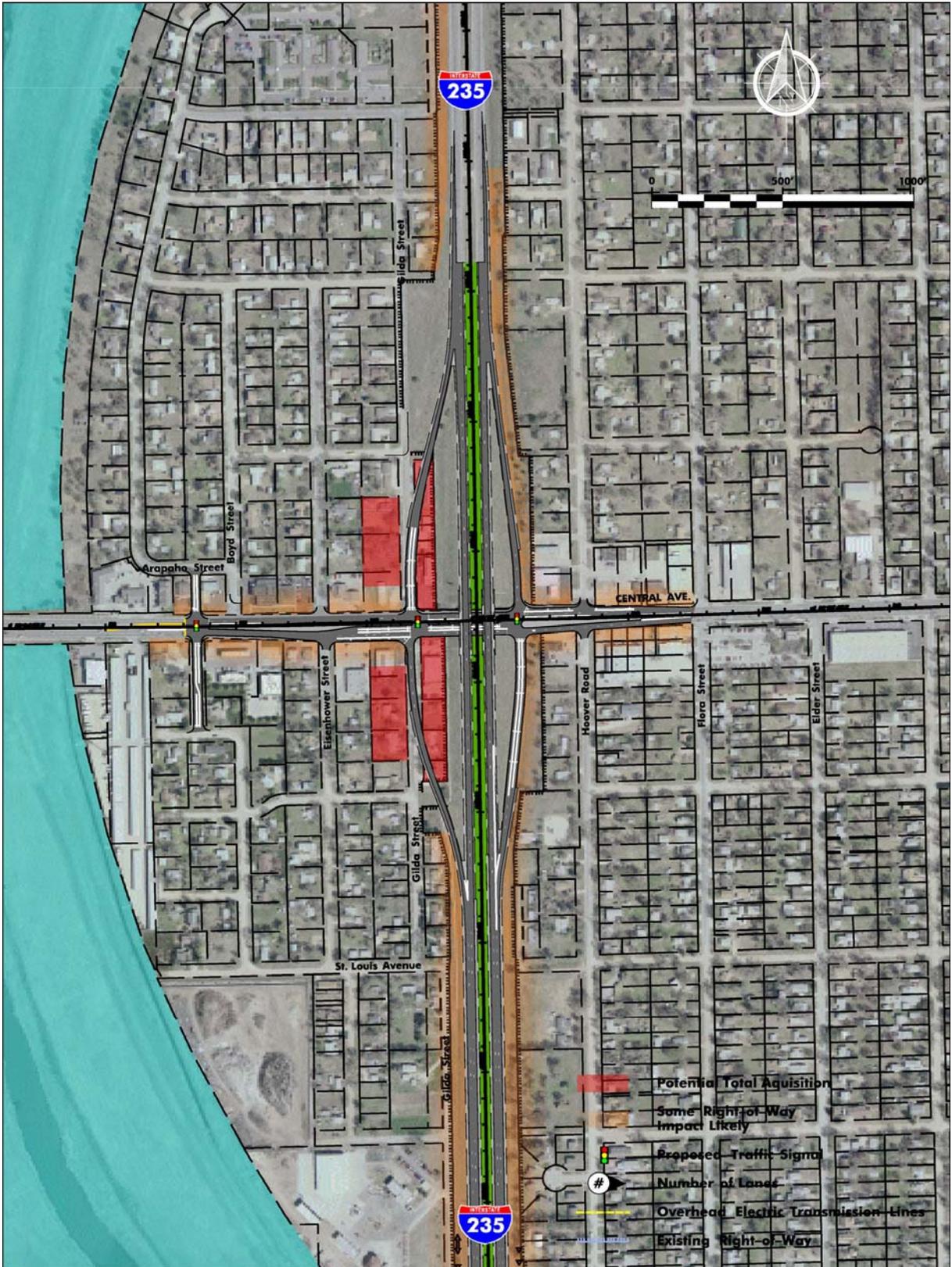


Exhibit 5.14c – Preferred Concept Plan Overview I-235 and Central Avenue Interchange



Probable Costs

With more detailed information comes the ability to generate more specific probable cost. Because the design level at this stage is very preliminary, a 30% contingency is included to allow for unknown design elements. It is worth noting that while some major items are quantifiable at the planning level (pavement, traffic signals, etc.), other items, such as earthwork are very difficult to quantify at a high-degree of accuracy without design-level survey and design. The cost for bridge structures uses a consistent unit price dependant upon what level of bridge it is (within the system interchange), but independent of potentially varying bridge types. While it is acknowledged that bridge costs are also dependent upon soil conditions as well as constructability issues, the information to incorporate that level of detail at this concept stage is unavailable, yet it is attempted to be accounted for with a high contingency percentage. Structures (including drainage structures, bridges, and retaining walls) account for more than half of the overall construction costs for the entire project.

It is also noted that for the Central Avenue interchange construction costs, the project limits and extent along Central Avenue include matching into existing conditions (a five-lane section) at the Boyd Avenue junction. The study acknowledges the widening of the Central Avenue bridge over the Floodway and the subsequent need to widen Central Avenue to seven-lanes from the Floodway to the I-235 interchange so as not to create a bottleneck. Since the widening of Central Avenue west of Boyd Avenue is not fundamentally part of the interchange improvements, costs for such improvements are not included. Nonetheless it is suggested that such improvements be implemented in conjunction with the interchange and if funding permits potentially with the bridge widening over the Floodway as well.

Costs for right-of-way have been identified, however it is acknowledged through previous experiences in the Wichita area and specifically recent construction along US-54/400 (Kellogg Ave.), that it is difficult to determine what properties might actually cost as the prices are a result of a negotiation process. No official property appraisals were done. Probable costs are provided for budgeting purposes, but must be considered as subject to revision based upon actual appraised values.

The same applies to utilities, specifically the Westar transmission lines. At this time it is unknown whether the entire series of transmission towers will be relocated or if only specific towers will need to be adjusted or protected due to grading changes. Probable costs include a worst-case scenario of a relocation of the electrical transmission line. For the Central Avenue interchange project, a utility allowance has been provided.

Preliminary and Construction Engineering have also been included and incorporate survey, engineering design, construction inspections and any other necessary services. These are developed based upon a percentage of the construction cost.

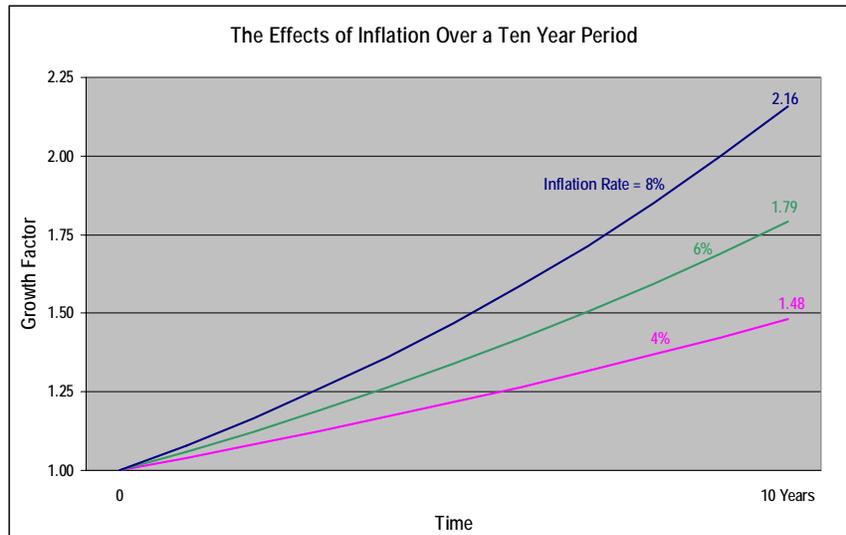
Exhibit 5.15 identifies probable costs by three potential projects, although no additional cost for construction overlap is included. It should also be noted that while the total programming cost estimate is \$170.3 million in today's dollars, inflation (be it an average consumer inflation rate of 4% or the higher construction inflation rate closer to 8%) over a ten year period could have programming costs approaching or exceeding a total of \$225 million. The effects of inflation chart in Exhibit 5.15 shows the growth factor for varying compounded inflation rates.

It is unlikely that the entire project would be built at one time, so assumptions were made to allow showing the effects of inflation at an average 6% rate to each project piece. It is anticipated that because of the interim project at Central Avenue, the interchange will not need to be reconstructed for at least ten years (assume 2017). Construction could begin on part of the US-54/400 (Kellogg Ave.) interchange within three to five years (assume 2011). The auxiliary lanes on I-235 could be constructed between the two interchanges in approximately seven to eight years (assume 2014). Note that these estimated project letting years are based on broad assumptions and are dependant on funding availability.

Exhibit 5.15 – Probable Costs

	US-54/400 (Kellogg Ave.) Interchange		I-235 Widening		Central Avenue Interchange	
	FY 2007	FY 2011	FY 2007	FY 2014	FY 2007	FY 2017
Construction	\$73,000,000	\$92,200,000	\$10,200,000	\$15,400,000	\$9,700,000	\$17,400,000
Constr. Contingency	\$21,900,000	\$27,700,000	\$3,100,000	\$4,700,000	\$3,000,000	\$5,400,000
Utilities	\$2,800,000	\$3,600,000	\$2,400,000	\$3,700,000	\$1,000,000	\$1,800,000
Right-of-Way	\$3,100,000	\$4,000,000	\$1,000,000	\$1,600,000	\$6,500,000	\$11,700,000
Preliminary Engineering	\$11,400,000	\$11,400,000	\$1,600,000	\$1,600,000	\$1,500,000	\$1,500,000
Construction Engineering	\$14,200,000	\$18,000,000	\$2,000,000	\$3,100,000	\$1,900,000	\$3,500,000
Total	\$126,400,000	\$156,900,000	\$20,300,000	\$30,100,000	\$23,600,000	\$41,300,000

GRAND TOTAL (FY 2007) \$170,300,000



Notes:

1. Information describing the material included in this probable cost exhibit can be found on page 5-36.
2. Project costs are subject to revision during the design phase.
3. Project costs do not include construction overlap costs per phase.
4. Estimated project letting years are subject to funding availability. Funds have not been identified at this time.
5. The inflation rate in the table above utilizes a 6% per year compounded rate. Inflation rates may vary, especially right-of-way costs.
6. The cost for preliminary engineering is not inflated.

Recommendations

Key partners in the design process include KDOT, the City of Wichita, Sedgwick County, the Wichita Area Metropolitan Planning Organization (WAMPO) and the Federal Highway Administration (FHWA). The partners are attempting to develop a framework to move the concepts to reality. Before any construction begins, permits must be obtained from various agencies and designs must be completed. While federally earmarked funds are available (and have been used to fund this study), there is not enough money to complete the entire project. This means the project will probably be built in phases, rather than all at once. More funds have been requested although there is no guarantee they will be received.

A design project must pass three tests of feasibility to become a construction project.

1. Is it technically sound?
Yes. The preferred alternatives are the same types of improvements that have decreased congestion and increased safety in other locations with similar challenges.
2. Does it have community support?
Yes. The opinion surveys confirm the community's support for these improvements.
3. Is it financially realistic?
Yes. Some funds are currently available although more is needed to complete the project.

The ideal solution is that implementation is phased over time. That's efficient and effective, but not always possible. For example, the Central Avenue turn bay project is a good interim improvement. It should work well to improve traffic flow for the next ten or more years without greatly changing the current intersections. However, it isn't sufficient to handle projected traffic volumes in the "design year" 2030. The intersection's capacity and traffic flow would improve significantly if it was completely rebuilt with the preferred concept interchange.

Other potential interim improvements throughout the study area were also considered. However there are many factors that suggest building the "design year" solutions in phases over time. Also, US-54/400 (Kellogg) is physically limited to six-lanes and future peak-hour traffic is expected to flow at undesirable levels.

At Central, the bridge needs to be raised and widened. Improvements need to be coordinated with other Central Avenue improvements west of the interchange, including the widening the bridges over the Big Ditch (City CIP Year 2011) and widening Central Avenue to seven lanes (as identified in the WAMPO Long Range Transportation Plan). Concept improvements shown extend to Boyd, coinciding with the limits of access management from the I-235 interchange.

Along I-235, adding auxiliary lanes may sound simple, yet the bridges over Maple need to be widened and raised to accommodate a wider Maple Street. All this lengthens and widens the limits of construction. Improvements to the curves north and south of Maple also affect the mainline alignment enough to require replacement of all the highway lanes, even though the pavement condition is in reasonable shape.

At Kellogg, some seemingly simple solutions of increasing the size of the loops, or providing a collector-distributor system are neither simple nor adequately address the safety or congestion issues. Another issue at this location is that the existing bridge conditions may require replacement soon. When the bridges need to be replaced, they should to be replaced in the "design year" location for future use.

The purpose of the Concept Report has been to document the issues and reasons for various decisions as they occurred throughout the process. And while this brings an end to the concept study stage, it also hints at the beginnings of the next stages. Exhibit 5.16 presents a suggested five-step implementation plan which is described in more detail on the following page.

The plan begins with the implementation of the City's Central Avenue turn bay project and is followed by the design phase along the entire study corridor. Congressional earmarks are available to fund these activities, yet financial partnerships are necessary to complete the overall implementation. At the July En Banc meeting, the partners acknowledged this with a basic understanding to continue moving forward towards the design stage. It is recommended that the implementation plan be a coordinated effort among KDOT, Sedgwick County, the City of Wichita and WAMPO. It is essential that a funding partnership be developed to implement the concepts for the I-235 corridor, between and at the US-54/400 (Kellogg Ave.) interchange and the Central Avenue interchange. The details and scheduling of such activities will continue to evolve as progress is made.

The recommended concepts will generally conform to the configurations shown in Exhibit 5.14. The concepts provide for:

- A cross-form fully-directional system interchange at the I-235 and US-54/400 (Kellogg Ave.) junction
 - In conjunction with this concept, a braided-ramp configuration is recommended for access to the West Street interchange (west of West Street).
 - In response to traffic volumes and physical constraints, the design speeds for the ramps vary. Further information on each ramp is provided in an earlier section of this report.
 - Removal of the former railroad corridor and its grade separations including the
 - Crossing of the Wichita Valley Center Floodway and
 - The I-235 mainline and northbound off-ramp bridges over the former railroad corridor.

- A continuous auxiliary lane in each direction along I-235 between the US-54/400 (Kellogg Ave.) interchange and the Central Avenue interchange
 - Including coordination of adjustments (as necessary) to utilities, specifically the Westar electrical transmission towers
 - Including coordination with the Wichita Valley Center Floodway regarding its adjacent levee system
 - Maintaining neighborhood circulation and property access via Gilda Street south of St. Louis Avenue

- A compressed diamond service interchange with ramp spacing of approximately 250 feet at the I-235 and Central Avenue junction
 - In conjunction with this concept, Central Avenue will be widened to a six-lane section beneath I-235
 - City of Wichita improvements will allow for a continuous seven lane section from the I-235 southbound ramps west to and across the Wichita Valley Center Floodway
 - A series of interconnected and coordinated traffic signals will be installed at the I-235 northbound and southbound ramps, as well as at the intersection of Central Avenue and Boyd Street
 - The recommended intersection configuration at Boyd Street is to shift the north leg west to align with the existing south leg.
 - Access management will be implemented for public streets in the configuration as shown
 - Access management to private properties abutting Central Avenue including access via side streets is to be determined