get RID of rhetoric...

REAL INTERSECTION DESIGN

leaving theory behind for design

a Professional Development Workshop for the
Metropolitan Washington Council of Governments
Riverdale MD
21 November 2003

Intersection of Kenilworth Avenue and Riverdale Road, view from the southwest

OVERVIEW AND OBJECTIVES

The Real Intersection Design (RID) concept was born out of frustration with the usual conference fare. Often, presentations and sessions deal with only the theoretical, and many in the audience never emerge from their rhetorical shells (witness the post-session talk at controversial sessions). While plans and guidelines play an important role in the formulation and development of our transportation system, discussions of the application of that knowledge are often scant.

An example is the case of the free turn lane. Is the convenience for drivers and cyclists worth the inconvenience to walkers, especially those with limited vision? Do the additional crossings help or hinder pedestrian flow? How does one weigh the impacts to land use and access? Yet no intersection is an island, and each design is site specific. In fact, most streets and intersections in the built environment are site specific, and it takes actual design – not abstract rhetoric to make each work.

The RID concept has three objectives:

1. To get participants – often people with vast amounts of knowledge – out into the field where they can give something back to the community.

2. To foster intense interaction between experts and lay people.

3. To test the theory that site conditions often permit just a few alternatives, *a priori* solutions, and each can usually be made to work for most users. The question is balance and understanding the requirements of each user group.

To accomplish these, an intersection is chosen, base maps and data are gathered, a team of experts is assembled, and workshop attendees are randomly divided into teams. The teams represent six primary user groups: cycling, driving, transit, walking, walking with limited mobility, and walking with limited vision. [For the Riverdale workshop a seventh group focusing on signal operations was added.] These users often seem at cross-purposes with one another. In general a cycling advocate wants cycle lanes, which inherently means wider streets. Pedestrian safety experts often call for the narrowest street possible to limit exposure risk. Wheelchair users need perpendicular ramps while those using canes need to know where the sidewalk ends and street begins. Drivers want fewer “flow interrupters” and bus riders want priority at traffic signals.

After dividing into teams, each group travels to the intersection with the tools of their trade: measuring wheels, wheelchairs, transit maps, etc. The journey to the site is an important element of the workshop as walking with a person in a wheelchair, or taking the bus when we would normally just drive is often an eye-opening experience. At the site notes and photographs are taken, specific observations are made (street width, timing patterns) and a redesign is brainstormed.

To facilitate the discussion, design rules of thumb are assembled for each user group, see below. These also allow participants in one group to learn from the other experts.

Back in the workroom, each team has access to data including volume, level of service, speed, crash, and parking information. Working independently, the teams redesign the intersection to prioritize their user group. In general, the redesigns are to be realistic given the existing conditions. For example, turning a road into a transit mall or banning cyclists are not options.

Afterwards, the plans are presented to all the groups and common elements are identified. Likewise, elements that benefit one group but seriously detract from another are debated. In the end, compromises are made so that a unified design may be reached. Figures 1-7 document the workshop.

This report documents the workshop, presents each team's findings and offers a synthesis of the ideas presented. It is not meant to be a complete intersection analysis report, an effort which would require more extensive data collection, field visits, research, calculations and discussion. Nevertheless it is hoped that this report facilitates further discussions for the intersection of Kenilworth Avenue and Riverdale Road.

Figure 1:Explaining Limited Mobility Concepts

Figure 2: Explaining Limited Vision Concepts

Figure 3: Measuring Vehicular Speed

Figure 4: Experiencing Walking Sans Sight

Figure 6: Discussing Ideas in the Workshop

Figure 5: Investigating the Gutter Pan

Figure 7: Presenting Plans to the Group

SITE CONTEXT AND DESCRIPTION

The Metropolitan Washington Council of Governments (MWCOG) Real Intersection Design workshop was held at the intersection of Kenilworth Avenue and Riverdale Road in Riverdale MD outside Washington DC. The intersection is a basic 4-way intersection with free turn lanes and medians (Figures 8 and 18). It is complicated by the fact that all the street segments curve as they approach the intersection. The intersection was reconstructed in about 1999.

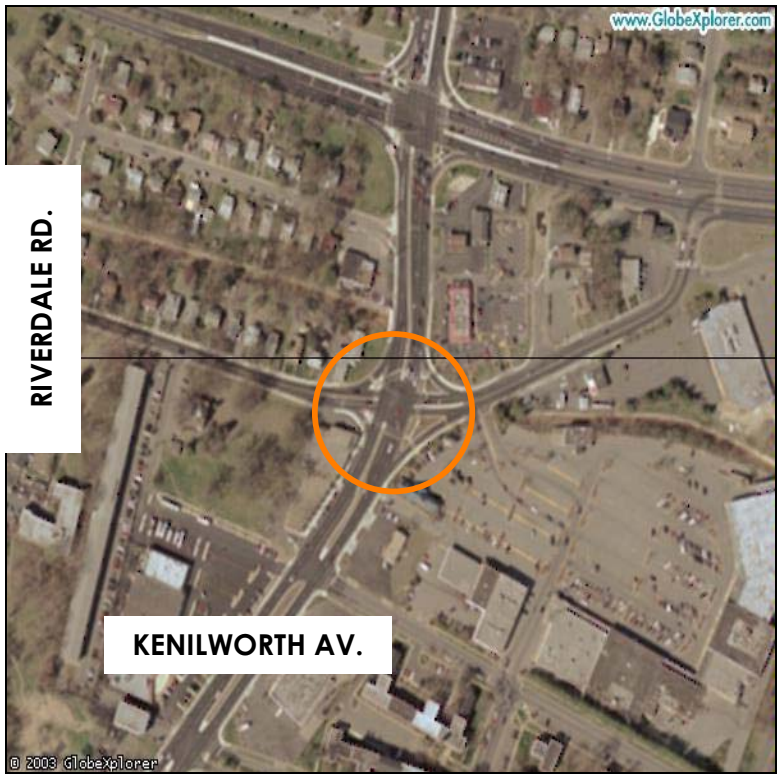

Figure 8: Aerial View

Intersection

Kenilworth Avenue is 70 feet wide with a raised median that varies in width from four to eight feet wide (Figure 9). Traveling southbound there are two 11-foot wide lanes plus a left turn bay. Northbound there are three 11-foot wide lanes plus a left turn bay. The cycle length is 150 seconds.

Riverdale Road is 50 feet wide with a three to four-foot wide raised median at the intersection. To the west there are two 12-foot lanes, one in each direction. At the intersection a left turn lane is added. To the east there are four 12-foot lanes, two in each direction. One block to the east, Riverdale Road is essentially subsumed by the larger East-West Highway. To the west Riverdale Road becomes a rather narrow residential and commercial street.

The southwest corner of the intersection has storefront retail which requires on-street parking. The other three quadrants have suburban type shopping centers with large parking lots.

Figure 9: Median on Kenilworth Avenue

Pedestrians

Pedestrian activity is light during the day, but is said to pick up during the AM and PM peak periods (there was no pedestrian or bicycle data available at the time of the workshop). The blocks towards the west (with the Riverdale municipal buildings, park, schools and residential area) are all quite walkable. In the other directions the pedestrian environment is less friendly.

During the workshop the pedestrian clearance intervals were evaluated, see Table 1. Those crossing Riverdale Road were found to be sufficient at walking speeds of 3.5 fps and faster. The Kenilworth Avenue clearance intervals are timed at 5.5 fps. The standard is 3.0 to 4.0 fps.

Clearance Interval at…	East leg	West leg	North leg	South leg
3 ft/sec	16	16	31	28
3.5 ft/sec	13	13	27	24
4 ft/sec	12	12	24	21
In Field	15	15	18	16

Table 1: Pedestrian Clearance Intervals

The maximum pedestrian delay was calculated for those waiting to cross Kenilworth Avenue. With the push buttons a person has to wait 2 minutes and 10 seconds to legally cross the street if he or she arrives just as the red hand begins to flash. Pedestrians will not generally wait longer than 60 seconds before they cross the street, regardless of the signal.

Crossing the intersection is complicated by the non-linear crosswalk alignment and driver disregard of walkers (Figures 10-11).

Figure 10: Typical Crosswalk Alignment

Figure 11: Vehicle Blocking Crosswalk

Bicycles

The intersection is not on an existing or proposed bicycle route, yet there are striped edge lines which provide space for cycle traffic (Figure 13). Two blocks to the west there is a bike path in the Northeast Branch Anacostia River Park. West of the park, Riverdale Road is a recommended cycling street (shown in blue in Figure 12).

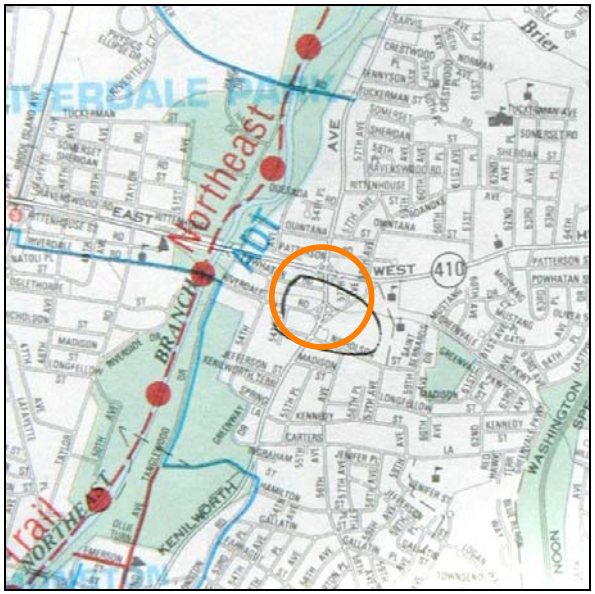

Figure 12: Bike Map

Figure 13: De-facto Bike Lanes at Intersection

Transit

As shown on Figure 14, the R12 bus plys Kenilworth Avenue between Greenbelt and the Deanwood Metro station. The F4 bus travels on Riverdale Road between Silver Spring and New Carrollton. The 84 and 85 busses travel south on Kenilworth Avenue and east on Riverdale Road connecting New Carrolton with the Rhode Island Avenue Metro station. The 14 bus runs on Riverdale Road in and around the town of Riverdale. Suffice to say that transit connections in the area are surprisingly good. The bus stops are located on Kenilworth Avenue, south of East-West Highway and on Riverdale Road east and west of Kenilworth Avenue, slightly away from the intersection.

About a mile to the west on Riverdale Road is downtown Riverdale and the MARC station where there is an effort to create a 'walkable' shopping village. About two miles to the west is the Prince Georges Metro station and regional mall.

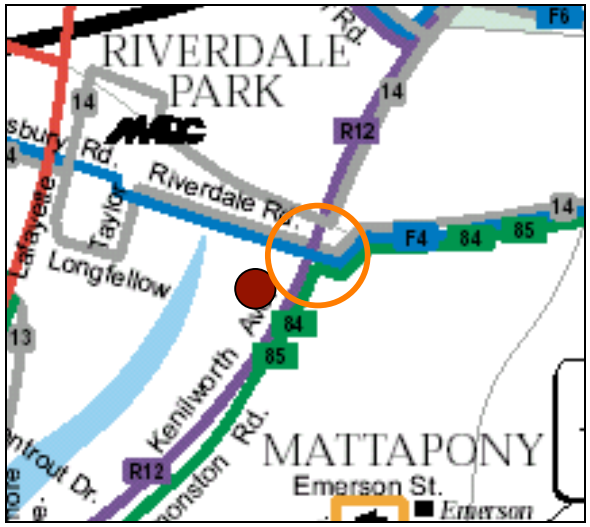

Figure 14: Transit Map

Vehicles

Kenilworth Av. is clearly the more important of the two streets in terms of traffic function. Traffic volumes are "unbalanced,"; northbound and southbound movements on Kenilworth Avenue outnumber eastbound and westbound by at least 4:1 in the AM and PM peaks, see Tables 2 and 3. Accommodating southbound vehicle travel demand is a key challenge at this intersection, as volumes exceed capacity in both the AM and PM peak periods. The southbound PM peak period rates only an E level of service. Vehicle LOS of D or better is widely considered acceptable for peak periods in comparable urban settings.

A spot speed survey was performed during the workshop, see Table 4. Free-flow 85th percentile speeds on Kenilworth Avenue (32-33 mph) were well within the range for a suburban arterial. Speeds on Riverdale Road, while only 30 mph, may be considered high for this type of street. Most interesting were the speeds (25 mph) recorded on the slip lane between northbound Kenilworth Avenue and eastbound Riverdale Road. Here there is a crosswalk, stop sign and driveway access, yet the geometry clearly allows this pace (Figure 15).

		Left Turn	Straight	Right Turn (slip lane)
Kenilworth Av				
NB	AM	88	1232	184
	PM	44	1540	208
SB	AM	48	2268	108
	PM	84	1260	84
	ADT		41950	
Riverdale Rd				
EB	AM	52	264	16
	PM	132	156	140
WB	AM	168	192	16
	PM	188	216	112
	ADT		10520	

Table 2: Vehicle Volumes

		Left Turn	Straight	Right Turn (slip lane)
Kenilworth Av				
NB	AM	88	410	184
	PM	44	513	208
SB	AM	48	1134	108
	PM	84	630	84
	ADT		8390	
Riverdale Rd				
EB	AM	52	264	16
	PM	132	156	140
WB	AM	168	192	16
	PM	188	216	112
	ADT		5260	

Table 3: Vehicle Volumes per Lane

		Straight	Right Turn (slip lane)
Kenilworth Av	NB	33	25
	SB	32	17
Riverdale Rd	EB	30	--
	WB	--	--

Table 4: 85th Percentile Speeds, mph

Figure 15: Slip Lane with Crosswalk ahead of Stop Sign

Crashes

Thirty-two vehicular crashes were recorded in the three years since the reconstruction (Jan 00 – Dec 02). The highest percentage of accidents occurred during off-peak hours, followed by the PM peak period. Almost forty percent of the crashes were rear-end collisions, usually caused by lack of attention by the driver and/or excessive speed. Over fifteen percent of the crashes were sideswipes. Over twenty percent of the crashes were left-turn collisions, while twenty-five percent were angle crashes. General disregard for signals can be the cause of angle crashes. Over the two-year period these thirty-two crashes resulted in eighteen injuries and one fatality. The one fatality was an angle crash, between a SB vehicle going straight and a NB vehicle turning left. Just before the workshop a vehicle(s) turning left from SB Kenilworth Avenue onto EB Riverdale Road ran over a sign in the median and left tracks in the triangle (Figure 16).

Figure 16: Recent Crash Remnants

Trucks

Kenilworth Avenue (shown in blue on Figure 17) is a presumed truck route, although neither the town or county make a formal distinction. Riverdale Road to the west (shown in green on Figure 17) would be considered a truck route for local deliveries only, as East-West Highway is just to the north. The status of Riverdale Road to the east (shown in purple on Figure 17) is questionable as the shopping centers may be accessed from Kenilworth Avenue. It seems that from a traffic function this segment serves as a right turn lane between NB Kenilworth Avenue and EB East-West Highway.

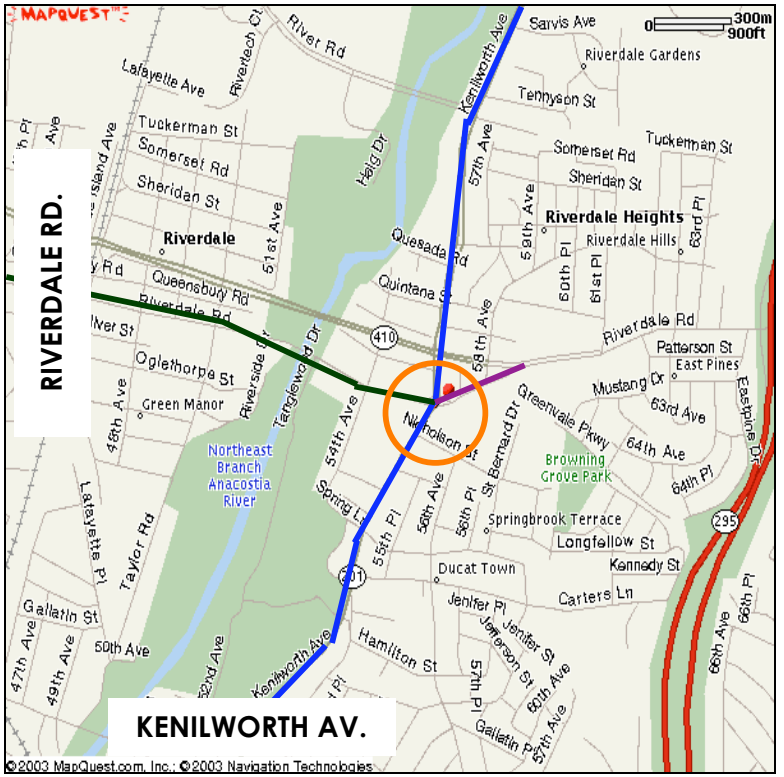

Figure 17: Site Map

RESULTS

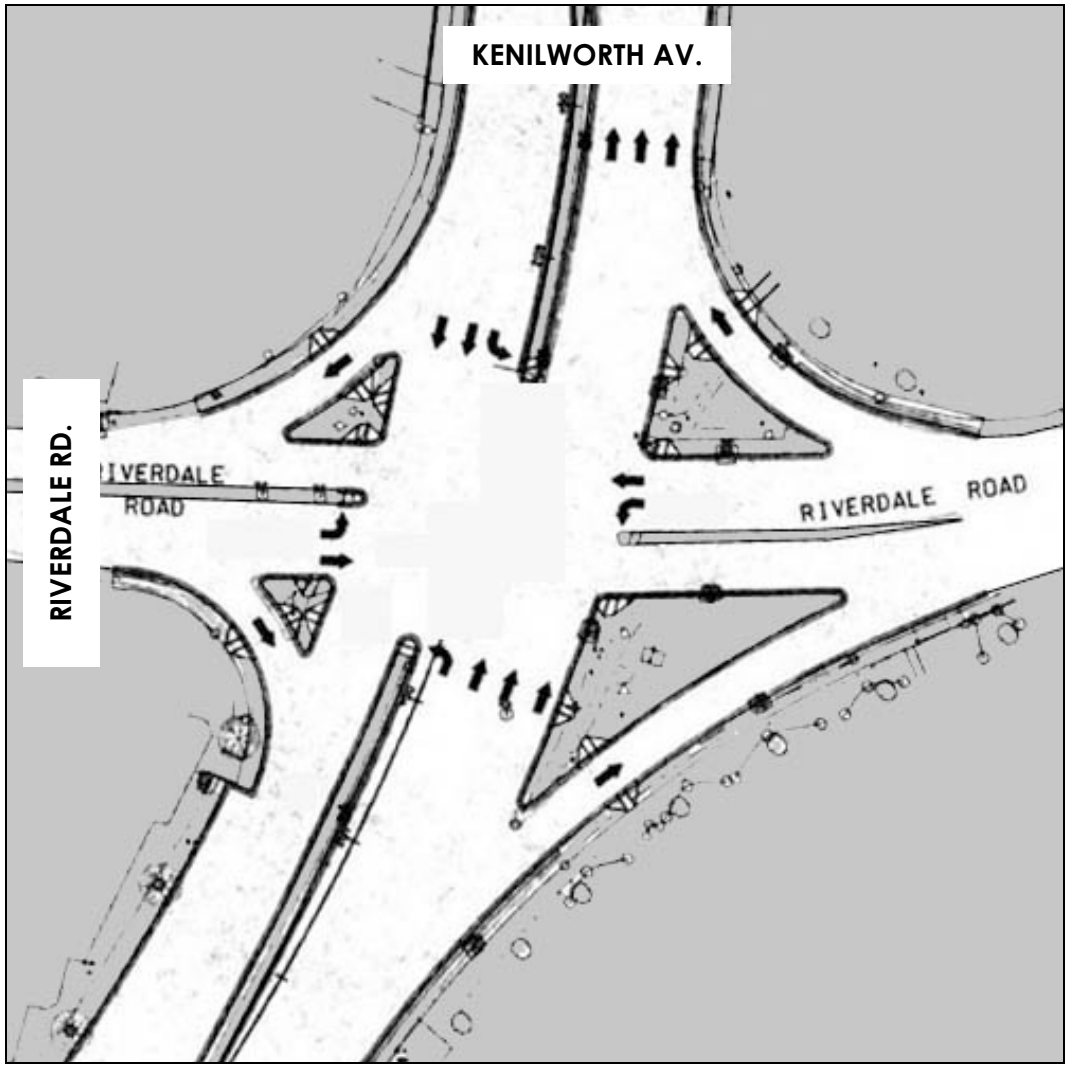

Figure 18: Site Plan

CYCLING

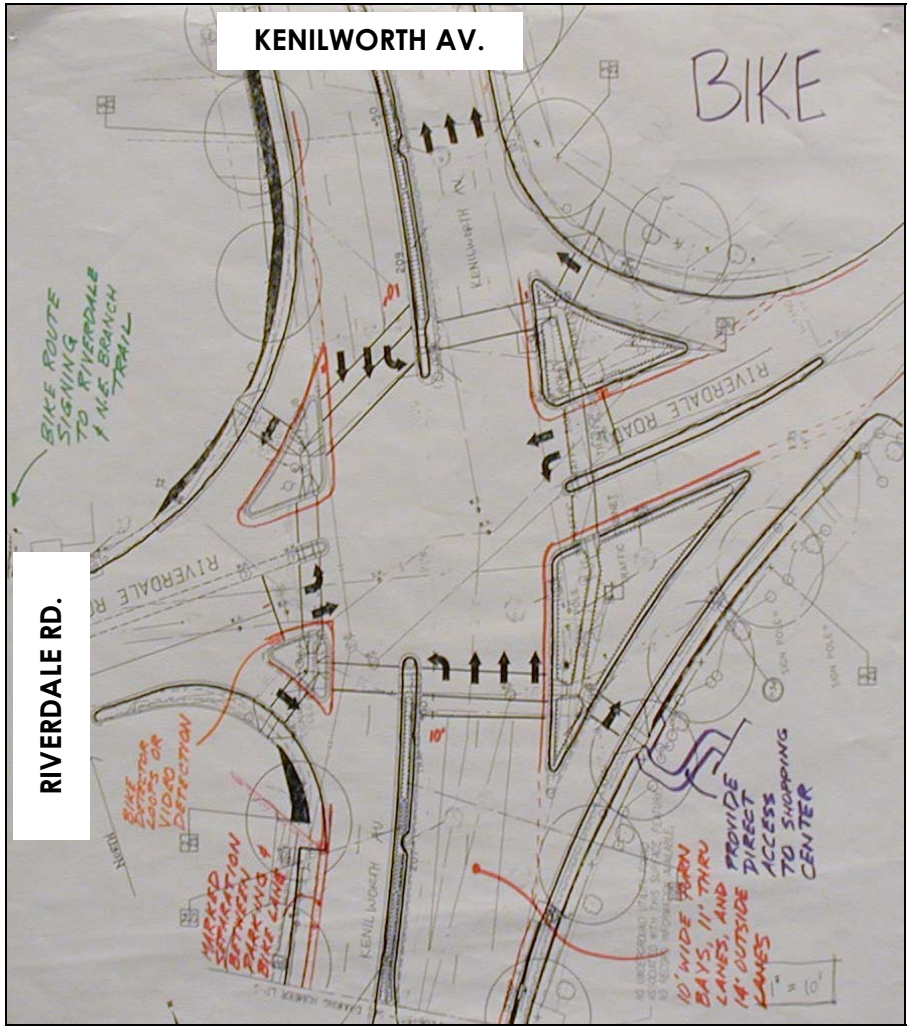

Figure 19: Cycling Team Ideas

Cyclists may be the most difficult user group to accommodate at this intersection given the significantly higher relative volumes of both pedestrians and motorized vehicles. The Northeast Branch Trail, located west of the intersection on Riverdale Road, provides an excellent off-road, paved facilities for pedestrians and cyclists.

Site Analysis

+ Good channelization of vehicular traffic.
+ Split phase on Riverdale Road.
+ Signal timing is good; relatively short cycles.
+ Signal heads are easy to read.
+ Storm grates well installed and bicycle-friendly.

– Travel lanes are tight, especially on the left-turn from Riverdale Road to SB Kenilworth Avenue.
– Slip ramps for right turns can be dangerous.
– Lack of signage to and from trail west of intersection off of Riverdale Road.
– Access to local businesses is tricky.

Recommendations

- Add bike lanes on Kenilworth Avenue and Riverdale Road with skip lines across slip ramps.
- Add loop detectors on Riverdale Road.
- Add bike boxes on Riverdale Road.
- Add signs directing cyclists to the Northeast Branch Trail on Riverdale Road west of the intersection.
- Widen islands, decreasing excess roadbed width.
- Add striped separation between the parking and bike lane on SB Kenilworth Avenue.
- Add bike signal heads.
- Add stairs and a sidewalk to connect to the shopping center on the SE side of the intersection.

DRIVING

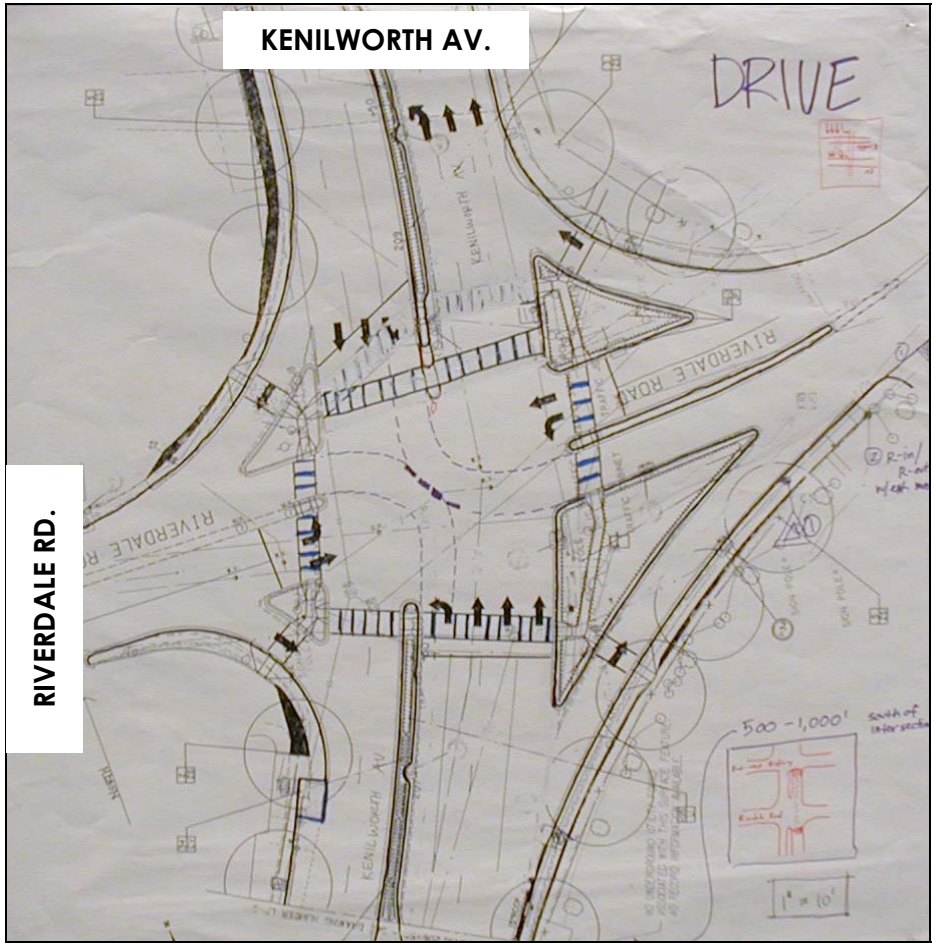

Figure 20: Driving Team Ideas

The intersection's "unbalanced" volumes lead to long queues for some movements and unused capacity. The high amount of asphalt, crosswalk and median placement, free right-turn slip ramps and irregular geometry make the roles of certain lanes unclear as vehicles approach the intersection.

Site Analysis

+ Good signage for pedestrians.
+ Slip right-turn lanes.
+ Unobstructed signal heads.
+ Split phase operation for Riverdale Road.
+ Overall signage.

– Driveway access is too close to intersection.
– Sight distance is limited by bridge rail for drivers traveling southbound on Kenilworth Avenue.

Recommendations

- Add high visibility markings to crosswalks.
- Replace 8-inch with 12-inch signals heads.
- Add sign for NB approach on Kenilworth Avenue to eliminate driver confusion with exclusive left-turn lane at the approach to East-West Highway.
- Add pavement markings to channel left turns from Kenilworth Avenue.
- Extend concrete median noses through crosswalks.
- Add skip lines for left turns from Kenilworth Avenue.
- Consider eliminating right turn slip lanes in the future.

DRIVING – SIGNAL OPERATIONS

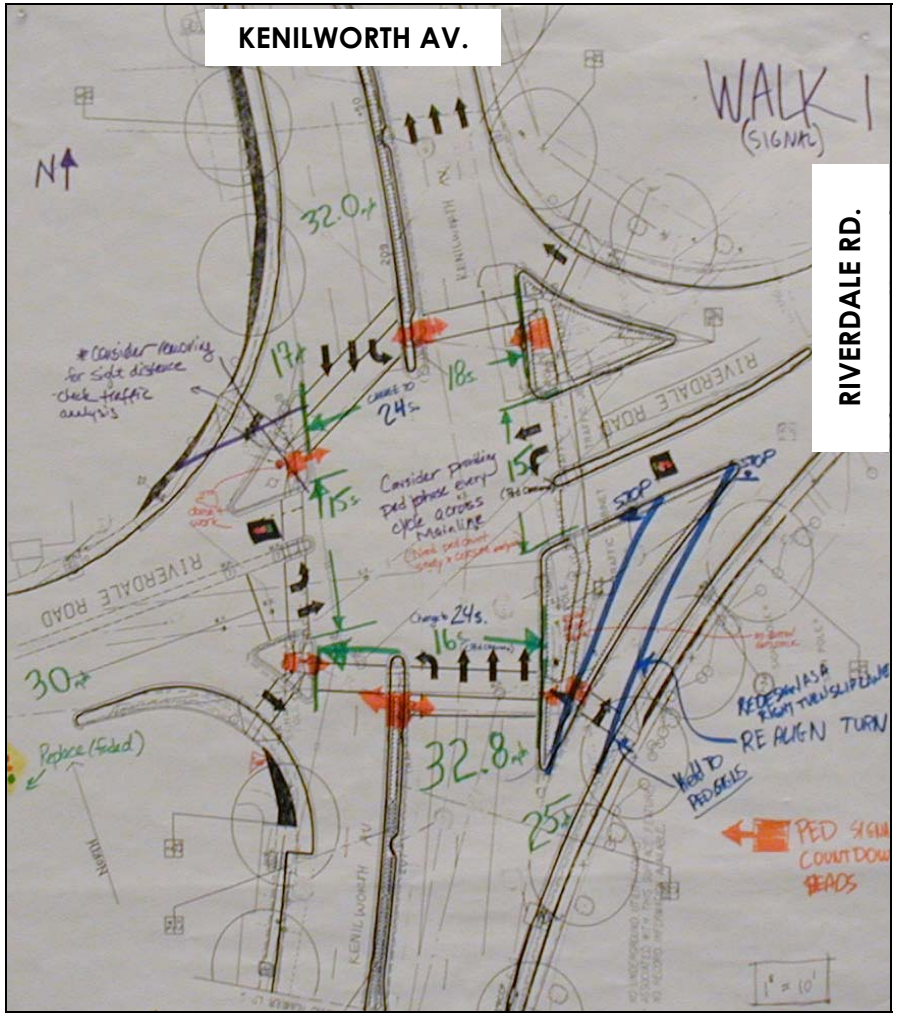

Figure 21: Driving – Signal Operations Team Ideas

Kenilworth Avenue is a wide street to cross, with some pedestrians becoming stranded on the medians because of lack of time or confusion. Adding pedestrian signals in the medians could help guide people across the intersection.

Site Analysis

+ Pedestrian signals at all four intersections; pedestrian call buttons on Kenilworth Av. Push buttons worked well.
+ Sight distance from Kenilworth Av. signals heads is good. Signal heads were 12 inches.
+ Intersection relatively flat.
+ Crosswalks on all legs and free rights.
+ Signal timing good for cars. All red and yellow intervals good.

– Delay too long for pedestrian signal. Cycle length too long.
– NW don't walk signal didn't flash.
– Sight distance (of pedestrians) for SB drivers on north leg is limited.
– Walk phase is too short for crossing Riverdale Road.
– Crosswalks on a angle.
– Too many poles clutter intersection. Utility pole in middle of pedestrian ramp.

Recommendations

- Fix broken pedestrian signal head on NW island.
- Add sign for pedestrian call button in SE island.
- Replace faded SIGNAL AHEAD sign on EB Riverdale Rd.
- Increase pedestrian clearance interval across Kenilworth Av. to 24 seconds.
- Add pedestrian signals in median.
- Realign slip lane on SE corner to decrease speeds; replace stop with yield sign.
- Realign approach angles to improve sight distance.
- Widen median on Kenilworth Avenue to provide a larger refuge area.
- Analyze the intersection with a shorter signal cycle.

TRANSIT

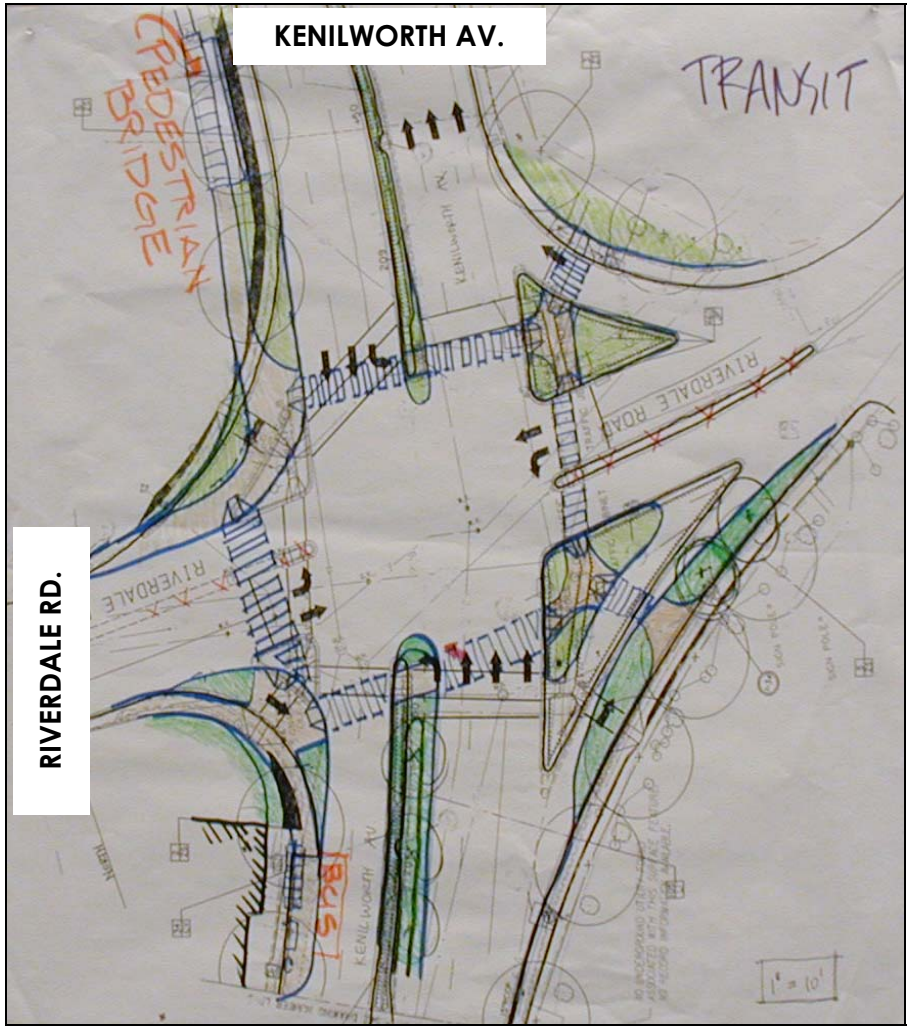

Figure 22: Transit Team Ideas

This intersection suffers from significant vehicle-pedestrian conflict, overabundance of signage, poles, and a confusing mix of medians, islands crosswalks that don't line up or represent desired pedestrian routes.

Site Analysis

+ Bus stops located near intersection.

– Excess pavement and wide turning radii allow vehicles to make turns quickly through intersection.
– Difficult intersection for pedestrians because of irregular crosswalks and left-turning vehicles.
– Lacks landscaping that could slow down traffic.

Recommendations

- Straighten all crosswalks and add high visibility markings.
- Modify islands to create more space for pedestrians and ADA-compliant ramps.
- Add pedestrian activated buttons at all crosswalks.
- Remove excess signage or place signs higher on poles to make intersection easier to navigate for pedestrians.
- Realign slip ramp on SE corner to decrease speeds.
- Add bus stop (removing some parking spaces) and shelter on Kenilworth Avenue south of Riverdale Road.
- Enhance intersection with landscaping.
- Remove left-turn lane from NB Kenilworth Avenue.
- Close SW and NW right turn slip lanes.

WALKING

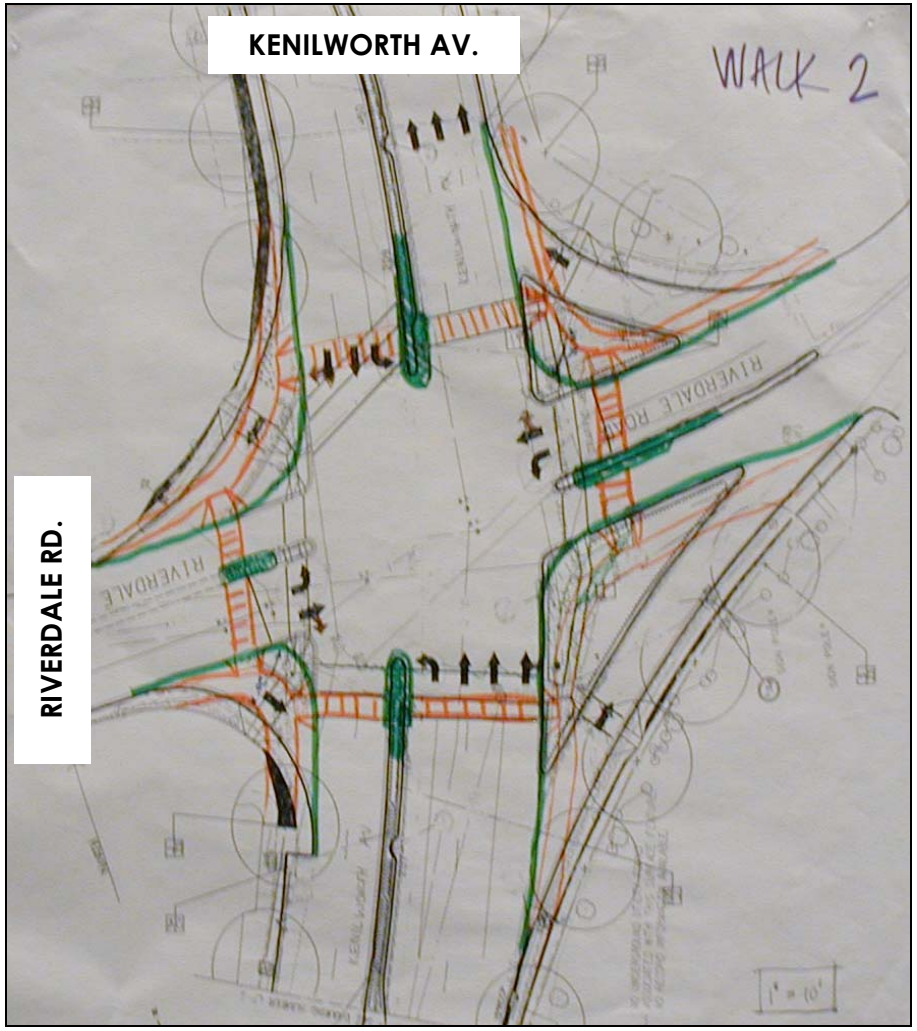

Figure 23: Walking Team Ideas

The sidewalks in most areas of the intersection were adequate in width and in generally good shape. While pedestrian activated crossing buttons are installed throughout the intersection some pedestrians cross at mid-block, waiting on the medians.

Site Analysis

+ Split phasing.
+ Where present, good pedestrian buttons. Presence of pedestrian signals.
+ Good markings, appeared to be good lighting.
+ Storage for one car outside of crosswalk in turns.
+ Adequate sidewalk width in 3 quadrants of the intersection.
+ Sidewalks on all approaches.
+ Some well aligned curb ramps.
+ Use of median refuges.

– Channelization design.
– Excessive delay for pedestrians.
– Inadequate width for median refuges.
– Inconsistent placement of pedestrian buttons.
– Some signs not visible; sight distance problems due to landscaping.
– People not crossing at crosswalks.
– Difficult left turns from SB Kenilworth Av. to EB Riverdale Rd.

Recommendations

- Fix broken pedestrian signal head on NW island.
- Expand and widen median refuges on Kenilworth Av.
- Landscaping improvements for better sight lines.
- Straighten all crosswalks and add high visibility markings.
- Add ADA-compliant pedestrian ramps.
- Remove excess signage or place signs higher on poles to make intersection easier to navigate for pedestrians.
- Close all right turn slip lanes.
- Straighten and align crosswalks, sidewalks, medians and ramps along pedestrian desire lines.

WALKING – LIMITED MOBILITY

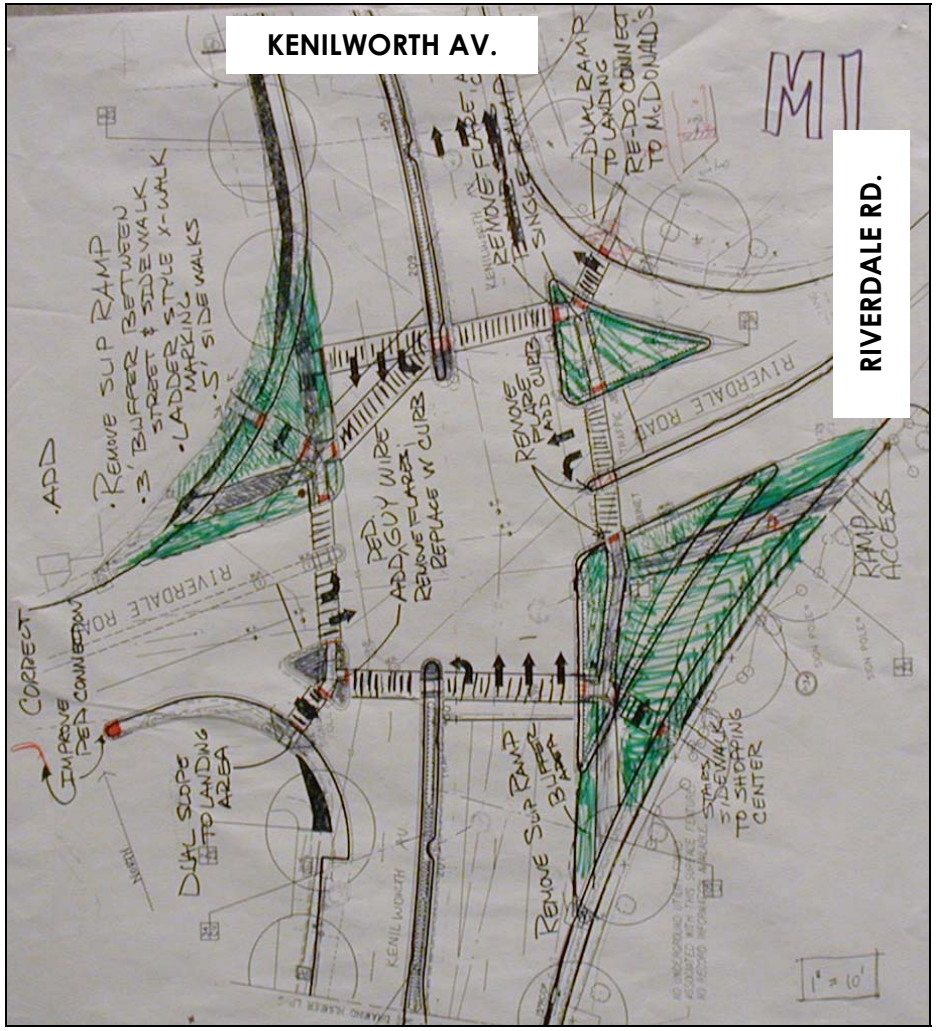

Figure 24: Walking - Limited Mobility Team Ideas

People using wheel chairs are difficult to see at some of the right turn slip lane crossings. The design of the slip lanes and placement of traffic control devices allow drivers to maneuver these turns quickly. In the SE corner the stop sign is placed 40 feet after the crosswalk and is not visible as the driver begins the eastbound turn.

Site Analysis

- Fire hydrant at intersection.
- Pedestrian activated buttons are high pressure and hard to get to. Difficult access to pedestrian button on northbound side.
- Pedestrian crossing signal buttons are poorly located.
- Refuge island on Kenilworth Avenue is too small.

Recommendations

- Add high visibility markings to crosswalks.
- Convert signals to fixed-timed.
- Add pedestrian signals in medians.
- Close SE and NW right turn slip lanes.
- Straighten and align crosswalks, sidewalks, medians and ramps along pedestrian desire lines.
- Widen sidewalks to 5-6 feet throughout intersection.
- Replace sloped with vertical curbs.
- Install 3-foot buffer between street and sidewalks.
- Widen medians to provide a larger refuge area.
- Redo the connection to McDonald's, creating a dual ramp to the landing.
- Add stairs and a sidewalk to connect to the shopping center on the SE side of the intersection.
- Complete sidewalk on SW corner.

WALKING – LIMITED VISION

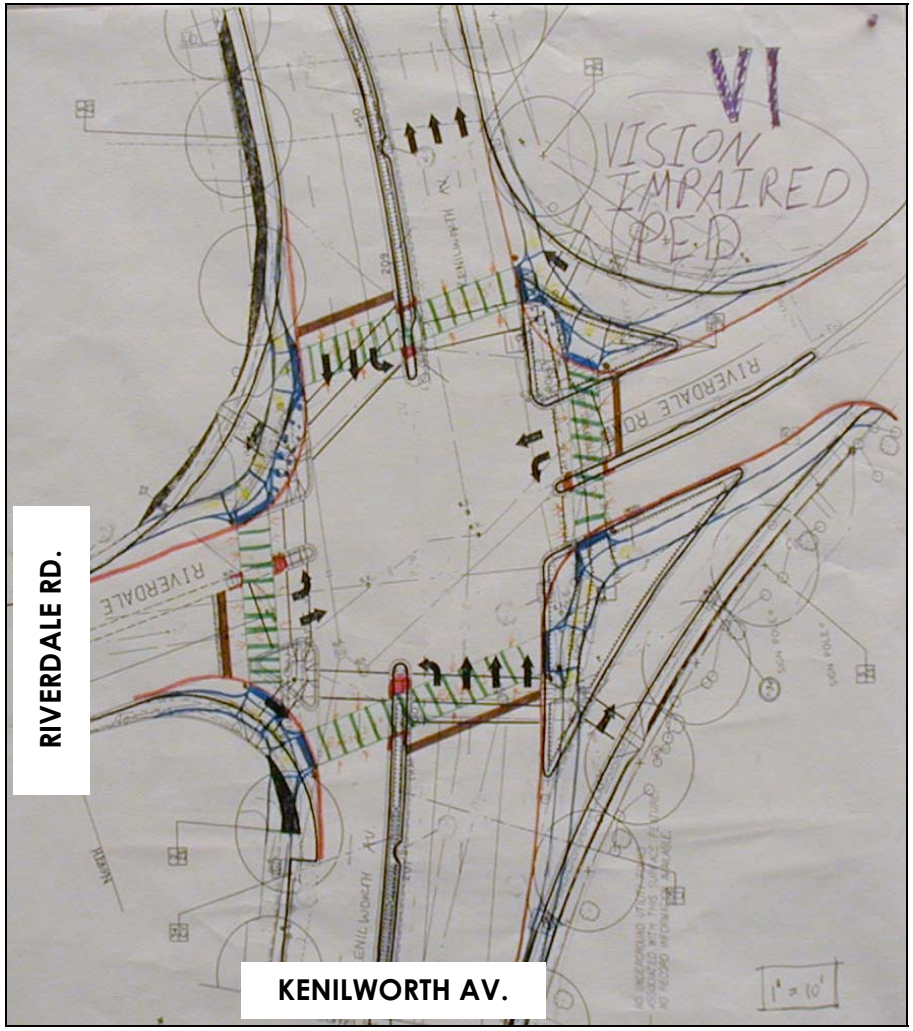

Figure 25: Walking - Limited Vision Team Ideas

The crosswalks and curb ramps are aligned at different angles to the travel lanes at each corner of the intersection, making crossing less predictable for people with limited vision. The design of the curb ramps and lack of warnings make finding the street edge and where to stand tricky.

Site Analysis

+ Some pedestrian activated buttons that functioned.

– Crosswalks at different angles to the street.
– Guy wires hang too low over sidewalk and are not detectable with a cane.
– Lack of detectable warnings on curb ramps to orient pedestrians.
– Inconsistent placement of pedestrian activated crossing buttons.
– Constant noise of intersection makes it almost impossible to detect gaps in traffic at slip lanes.

Recommendations

- Close all right turn slip lanes.
- Straighten and align all crosswalks.
- Realign all curb ramps to meet crosswalks.
- Add detectable warnings at all pedestrian ramps.
- Relocate guy wires away from sidewalks.
- Add accessible pedestrian signals.
- Add a leading pedestrian interval (LPI) for all crossings.
- Re-landscape around each curb ramp to make it easier to locate.
- Install raised crosswalks throughout intersection.

SYNTHESIS

Comparing and contrasting the measures proposed by each team, numerous changes to the intersection can be made without adverse impacts - the workshop discussion was notable for a lack of clearly contradictory recommendations. At a minimum, realigning and re-striping the crosswalks, installing and maintaining pedestrian activated buttons at all crossings, re-landscaping the islands, and removing excess signage and poles would go far to improve the intersection for all users.

Regardless of the mode assigned to each group, workshop participants noted similar issues for improvement at this intersection, even in some cases where it would seemingly disadvantage their group. Noteworthy issues included:

- **Right Turn Slip Lanes** – The slip lanes were the biggest issue discussed at the workshop. Clearly they were installed to facilitate vehicular flow, yet they present operational problems for walkers and drivers alike. Operationally, three or four vehicles stopped at the signal block the lanes, rendering them unusable. Most group recommended altering the slip lanes, even the driving and transit group thought it would make the intersection safer and easier to use. The degree to which these areas should then be redesigned differed slightly.

- **Widening the Traffic Islands –** Most groups wanted to see less asphalt dedicated to moving vehicles. Widening the islands and reconfiguring the slip lanes would also help alleviate sight lines concern. The teams representing pedestrians with limited vision and mobility saw these two issues as critical.

- **Location/function of Pedestrian Activated Buttons/signals –** Many groups found the lack of consistent placement, or improper placement, of pedestrian activated buttons a major issue when crossing the intersection. Some noted malfunctioning and nonfunctioning signals that made crossing times hard to understand.

- **Pedestrian Ramps** – Curb ramps are an issue due to the irregular geometry of the intersection. Many ramps are improperly aligned with crosswalks, making it difficult for people with limited vision and mobility to gauge vehicular speed and position themselves safely for crossing. No ramps had tactile warnings installed to help people navigate the end of the curb and the beginning of the street.

- **Realigning and Installing Ladder Crosswalks** – Most groups noted the difficulties to pedestrians caused by the number of crosswalks installed at obscure angles, making crossing in a straight line impossible. High visibility crosswalks were recommended by almost all groups.

However, it is interesting to note the subtle differences in user groups that were supposedly focusing on similar modes. The Walking team declared the push buttons and sidewalks good, but the Limited Mobility team called the buttons hard to push and sidewalks too narrow. The Signal Operations team requested a sign for a pedestrian call button, while the Limited Vision team wanted Accessible Pedestrian Signals. There is much to be learned from this type of exercise even within a particular discipline.

COMPOSITE LIST

Following is composite list of 45 measures proposed during the workshop. They are grouped according to impact – from 'no negative' to 'needing real discussion'. This list forms the basis for a composite redesign of the intersection of Kenilworth Avenue and Riverdale Road.

First are measures which can be implemented without negative impacts to other modes.

1. Add accessible pedestrian signals.
2. Add ADA-compliant pedestrian ramps.
3. Add detectable warnings at all pedestrian ramps.
4. Add high visibility markings to crosswalks.
5. Add sign for NB approach on Kenilworth Avenue to eliminate driver confusion with exclusive left-turn lane at the approach to East-West Highway.
6. Add signs directing cyclists to the Northeast Branch Trail on Riverdale Road west of the intersection.
7. Add skip lines for left turns from Kenilworth Avenue.
8. Add stairs and a sidewalk to connect to the shopping center on the SE side of the intersection.
9. Complete sidewalk on SW corner.
10. Re-landscape to improve sight lines and make curb ramps easier to locate.
11. Realign crosswalks to decrease crossing time/distance and better reflect desire lines.
12. Realign curb ramps to meet crosswalks.
13. Redesign the connection to the shopping center on the NE side of the intersection.
14. Relocate guy wires away from sidewalks.
15. Remove excess signage or place signs higher on poles to make intersection easier to navigate for pedestrians.
16. Replace 8-inch with 12-inch signals heads.
17. Replace SIGNAL AHEAD sign on EB Riverdale Rd.
18. Replace sloped with vertical curbs.
19. Replace stop with yield sign on SE slip lane.

Second are measures which probably will have minimal impact, but a study should be made nevertheless. The seconds for signal timing changes will have to come from somewhere, likewise for geometric changes and inches.

20. Add bike boxes on Riverdale Road.
21. Add bike signal heads.
22. Add leading pedestrian intervals (LPI) for all crossings.
23. Add striped separation between the parking and bike lane on SB Kenilworth Avenue.
24. Convert signals to fixed-timed.
25. Extend concrete median noses through crosswalks.
26. Increase pedestrian clearance interval across Kenilworth Av to 24 seconds.
27. Install 3-foot buffer between street and sidewalks.
28. Modify islands to create more space for pedestrians and ADA-compliant ramps.
29. Widen medians to provide a larger refuge area.
30. Widen sidewalks to 5-6 feet throughout intersection.

Third are measures which will have greater impact and should be studied in depth.

31. **Add bike lanes on Kenilworth Avenue and Riverdale Road with skip lines across slip ramps.** Is there enough space or would lanes need to be narrowed/removed? Bike lanes on Riverdale Road seem to fit. Do we want to encourage cycling on Kenilworth Avenue, or are there already cyclists there? Are bike lanes called for in the cycling master plan?

32. **Add bus stop and shelter on Kenilworth Avenue south of Riverdale Road.** Some parking spaces would have to be removed, does the benefit or not the businesses? Where is the bus stop now? Would this be advantageous for transfers?

33. **Analyze the intersection with a shorter signal cycle.** At 150 seconds the average delay for drivers, cyclists and pedestrians is 75 seconds, too long for most. A shorter cycle will decrease delay and maybe throughput, but will increase compliance. The net effect on the LOS for all modes would have to be calculated. The signal should be coordinated with the signal at East-West Highway.

34. **Close NW right turn slip lane.** The transit and all three walking teams recommended closing this lane. Speeds on the NW slip lane were recorded at 17 mph. Volumes were 108 and 84 in the AM and PM peak hours. The NW and SW slip lanes access a narrow residential/commercial street and the discussion centered around if slip lanes were appropriate for this type of street. The suggestion of a raised crosswalks imply a dramatic civic gateway.

35. **Close NE right turn slip lane.** The walking and walking – limited vision teams recommended closing this lane. As with the SE slip lane, the need for this maneuver was questioned, given that one can accomplish the same via East-West Highway. In terms of design, the terrain creates sight line issues for drivers and access issues for pedestrians to the shopping center. Symbiotically one could realign the slip lane to better accommodate both these modes. However the skew of the intersection requires a fairly large radius for turning trucks, so the slip lane may be the best alternative. Also the angle is such that vehicles must turn fairly slowly (and safely).

36. **Close or realign SE right turn slip lane.** The signal operations and transit teams recommended realigning this lane. All three walking teams recommended closing it. Speeds on the SE slip lane were recorded at 25 mph. The AASHTO design stopping sight distance at 25 mph is 155 feet, and there was concern whether this is available ahead of the crosswalk. In addition, the stop sign is some 100 feet past the crosswalk, which seems backwards. There were other safety concerns with the terrain, stop v. yield sign, driveway access, and landscaping. One interesting point was that this route (from Kenilworth via Riverdale to East-West Highway) essentially bypasses the right turn at the intersection of Kenilworth and East-West, bringing into question the need for the slip lane at all. If the slip lanes were closed the corner radii would have to be fairly large to accommodate the 84 and 85 busses (or they would need to be given alternate routes); given the intersection angle, this would be fairly simple.

37. **Close SW right turn slip lane.** The walking, walking – limited vision and transit teams recommended closing this lane. As with the NE slip lane the angle of the intersection requires a large radius but keeps turns slow, so the slip lane ultimately might be the best solution.

38. **Install raised crosswalks throughout intersection.** This is not going to happen given the nature of Kenilworth Avenue. But if one were to consider Riverdale Road to the west as the gateway to the Riverdale Park, then a raised crosswalk would certainly reinforce that.

39. **Realign approach angles to improve sight distance.** This is more of a long term goal; the aims may also be accomplished by reducing vehicle speeds.

40. **Remove left-turn lane from NB Kenilworth Avenue.** This dovetails nicely with the desire to widen the medians along Kenilworth and is consistent with the notion of a smaller Riverdale Road. How would this affect the vehicle LOS and could it be coordinated with the left turn lanes at East-West Highway? The number of vehicles turning left from Kenilworth is substantially less than those turning left from Riverdale.

41. **Remove medians on Riverdale Road**. They are currently not wide enough to provide a proper refuge, have mountable curbs and without them the triangles could be wider. But they slow turning vehicles and keep drivers in their lanes.

Last are measures which are contradictory or unnecessary given other recommendations.

42. Add bike loop detectors on Riverdale Road. Unnecessary if the signals are on a fixed cycle.
43. Add pedestrian activated buttons at all crosswalks. Unnecessary if the signals are on a fixed cycle or if an APS system is used.
44. Add pedestrian signals in median. Will not be necessary if proper clearance interval is provided.
45. Add sign for pedestrian call button in SE island. Not appropriate for those with limited vision. Unnecessary if the signals are on a fixed cycle or if an APS system is used

RULES OF THUMB

CYCLING

Design Cyclist: a teenage cyclist.

1. Provide designated space for bicycles at and through intersections, preferably with different pavement color and/or texture.
2. At signals - detector loops to detect bicycles.
3. Low speed, low volume roadways – keep facilities simple and have cyclists merge with traffic.
4. High speed, high volume roadways – separate facilities.
5. Cyclists require a longer clearance interval than automobiles.
6. At turns - cyclists navigate intersections with traffic (in the turn lane) or after traffic (turning once the platoon has cleared).
7. Always use skinny-tire friendly grates, catch basins, and trolley crossings.
8. Advanced stop lines allow cyclists to queue ahead of waiting vehicles.
9. Provide equal LOS for cyclists as for vehicles and pedestrians.

DRIVING

Design Vehicle for speed: passenger vehicle.
Design Vehicle for turns: 90th percentile truck.

1. Optimize fluidity, minimize delays.
2. Only install traffic lights if other control mechanisms (Stop, yield, roundabouts) do not do the job. Do not assume that traffic signals are the safest solution for all users.
3. Do not fear bike/pedestrian/vehicle conflicts, as long as they are simple (i.e. the pedestrian does not have to look out for many different vehicle movements) and the speeds are low.
4. Guide drivers clearly: use rational lane design and line marking. Match approach lanes with departure lanes. Do not provide a departure lane to match an exclusive left or right turn lane.
5. Lane width should be appropriate to traffic using it - generally 10-12 feet. Avoid providing road space that has no clearly defined function.
6. Pedestrian crossings should be highly visible and as close as practicable to the intersection to avoid problems of driver inattention.
7. Signal timing - Cycle time, phase splits and progression plans should be appropriate to traffic conditions. Generally, minimum cycle times consistent with safety requirements and demands of all users are best.
8. Signal design - Signal heads should be visible to all drivers and should be visible from the stop line; there should be no ambiguity about which signal head to obey.
9. Combined through and left turn lanes should be avoided unless they always share common signal phases or left turn volumes are low.
10. Lagging left turn phases are generally safer than leading.
11. Recovery lanes and painted islands – eliminate for they are used by skillful drivers to circumvent regulations and pass stopped/slower vehicles.
12. Tight intersections that must be negotiated slowly and carefully are safer for all users than wide open "sea-of-asphalt" intersections.
13. Right angles are better than skewed approaches.

DRIVING – SIGNAL OPERATIONS

1. Ensure signals are visible and not obstructed by glare, power lines, or tree limbs.
2. Ensure signals are conspicuous and are not lost in visual clutter.

3. Yellow interval must provide adequate time for vehicles closer to the signal to safely enter or clear the intersection and adequate time for those further away to stop at a comfortable deceleration.
4. Ensure that all-red interval is adequate for vehicles to clear the intersection and clear the path of pedestrians before pedestrians receive WALK indication.
5. Use signal phases no longer than enough to accommodate corresponding movements and a short cycle length to reduce the delay for pedestrians.
6. Where pedestrian crossing is regular, provide a pedestrian interval in every cycle.
7. Provide a pedestrian clearance interval that is based on a walking speed that is appropriate for pedestrians at intersection.
8. Provide pedestrian signal heads that can be understood by pedestrians or if needed, provide supplementary signs to explain indications.
9. Locate signal hardware where it won't obstruct pedestrians or visibility of motorists or pedestrians.
10. Provide leading pedestrian intervals where turn volume is high.
11. Prohibit right turn on red.
12. Avoid confusing signal phasing.

TRANSIT

Design vehicle: local bus.

1. Low speed zones allow a more amenable sharing of the street by all modes.
2. Redesign intersections to minimize excess roadway and use the space for transit facilities.
3. Dash cycle lanes at transit stops or have them go around.
4. Ensure that drivers do not block transit stops and lanes.
5. Curb extensions at bus stops in low speed, high volume, high transit locations. If no curb extensions, clearly mark bus stopping location.
6. Paved bus access pads must be provided at all bus stops, and bus shelters are very desirable.
7. Roadway pavement within the bus stop should be concrete, not asphalt, to prevent pavement rippling.
8. Provide priority at signals for busses and trolleys.

WALKING

Design walker: a young, able-bodied risk taker; a teacher with a group of 30 students plus four chaperones.

1. Corners & Turns – use minimum curb radius possible, make use of effective turning radius, curb bulbs where parking exists.
2. Crossings – pedestrians' route must be direct, intuitive and as straight as possible.
3. Crosswalks – well marked and placed where pedestrians will use them, where motorists expect pedestrians, and where motorists will see the pedestrian in time to react.
4. Stop Lines – perpendicular to travel lane, coordinate with vertical elements such as poles, planters and curb extensions.
5. Signal Design – focus driver view on pedestrians, preferably near side and aligned with stop line.
6. Signal Timing – minimize delay to pedestrians by using shorter cycle lengths, strive for no more than 30 second delay; use leading pedestrian intervals where appropriate. All-pedestrian phases only in locations with heavy diagonal crossings. Use 3.0-3.5 feet per second walking rate.
7. Medians – to be designed as a pedestrian refuge on wide streets. Raised and landscaped, minimum six feet wide with cut-through for pedestrians.
8. Lighting - illuminate corners to one foot-candle minimum at the ground.
9. Sidewalks – sized to provide acceptable level of service, minimum width five feet, designed so that drivers cannot park on them.

10. Parking Controls – no parking within 20 feet of any crosswalk.
11. Crossing Distance – minimize by using narrower land widths (10-11 feet) and curb bulbs where parking exists.
12. Free Turn Lanes – discouraged; if they must be included, they should be separated from through traffic via refuge islands and designed to simultaneously slow drivers and create eye contact with pedestrians.
13. Turn On Red – do not use.

WALKING – LIMITED MOBILITY

1. Separate curb ramp for each crossing. No single diagonal curb ramps.
2. Level landing at every ramp.
3. Curb ramp aligned with the crosswalk. No forced exposure to traffic lane when entering street.
4. Flush transition landing to curb ramp to gutter.
5. Pedestrian controls/signals within reach (42-48" high) and located in a place that is easy to reach and intuitively in line with the crosswalk to be crossed.
6. Adequate level maneuvering space at controls close to curb ramp landing.
7. Sidewalk and crosswalk cross slope not to exceed 2%.
8. Curb ramp not to exceed 1:12. Apron slope not to exceed 5%.
9. 48-inch minimum accessible width within sidewalk.
10. Walking surface should be smooth and slip resistant. Brick and bumpy textures are not good walking surfaces and should be used for edging and trim only.

WALKING – LIMITED VISION

1. Intersection Alignment - Right angle intersection with turning radius as small as possible.
2. Street Width - No more than 4 lanes without a refuge.
3. Crosswalk Alignment - Ramp, crosswalk and refuge in straight line with sidewalk and aligned with parallel traffic flow.
4. Crosswalk/sidewalk Relationship - Edge of sidewalk, planter edge, or landscaping used to direct traveler to crossing location (particularly at curb extensions, wide radius turns, or roundabouts).
5. Crosswalk Markings - If not possible to keep straight line, install a tactile guide-strip in crosswalks, as well as clearly marked crosswalk lines (good contrast).
6. Accessible Pedestrian Signals (APS) with locator tone, particularly if leading pedestrian interval (LPI) used.
7. Pushbutton positioned in a predictable, easy-to-reach location.
8. Avoid free turns or roundabouts that require pedestrians to judge traffic and cross in gaps.
9. Street Edge - Install truncated detectable warning domes at base of ramp, 24" deep at street edge, at curb ramps, and at median edges (no cut-through medians without detectable warning!), or at raised crosswalks or intersections.
10. Street Edge - leave some slope to curb ramp (no completely blended curb areas).
11. Turn on Red - creates ambiguous cues for those who rely on traffic movement to align and determine onset of WALK interval; as well as increasing blockage of crosswalk and encouraging drivers to cross pedestrians' path without anticipating them from the right.

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