ANALYSIS OF CAMPUS TRAFFIC PROBLEMS

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Because of the large volume of pedestrian and bicycle traffic that occurs on most university campuses, special techniques must be applied to provide for safe and efficient movement of persons traveling through the campus by these modes. Automobile traffic presents potential hazards to pedestrians and cyclists and disrupts the desired park-like atmosphere of the closed campus community. In this report, guidelines that should be followed when a traffic plan is developed for a campus area are discussed. Data collection techniques and sources of useful existing data are suggested. By examining the collected data and following the recommended guidelines, one may develop a comprehensive traffic plan for a campus or similar study area. These techniques are applied in a specific case study of the University of Colorado, Boulder to improve traffic flow on the main campus. Through increased modal separation and establishment of a network of bike routes, modal conflicts are greatly reduced. This is the primary goal that the designers of a campus traffic plan should seek.

•CAMPUS traffic problems require special techniques for solution. Pedestrian and bicycle traffic harmonize with the quiet park-like atmosphere of a campus. Automobiles not only detract from this atmosphere but also are not useful for most intracampus travel. Traffic plans developed for the campus area should provide for safe, efficient movement of persons by limiting automobile-bicycle-pedestrian conflicts and by shortening travel times. The techniques used to solve these problems will become applicable to urban and planned community areas as automobile use is restricted, public transit systems are developed, and bicycle use is encouraged for environmental and energy-use considerations.

GUIDELINES FOR A CAMPUS TRAFFIC PLAN

Providing for modal separation contributes most to the safe and efficient movement of persons. When automobiles, bicycles, and pedestrians move on exclusive rights-of-way, modal conflicts are greatly reduced. Accident rates can be expected to drop significantly because large speed differences no longer exist among modes operating on the same facility and because intermodal conflicts occur only at controlled intersections. Eliminating bicycles on automobile routes and pedestrians on bicycle paths permits higher speeds for the faster modes and increases safety for the slower modes. So, modal separation should be the overall guideline in planning the final system.

Eliminating through traffic, which detracts from the park-like atmosphere of the campus, is also important. Nonessential traffic should be routed around the campus. Shuttle buses may operate on campus on routes shared with delivery and maintenance vehicles. Boarding areas should be clearly signed to encourage their use. Hazardous areas like intersections and crosswalks should be well marked, and precautions like stops or dismounts should be required if they are warranted. At intersections on bicycle routes, curb cuts and radius fillets should be used to lower the number of required stops and dismounts.

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Direct routes with few grades should be designed, especially for bicyclists and pedestrians. Locating bicycle parking areas near heavily traveled pedestrian routes will reduce cycle theft. The implementation of a new plan, construction of a new facility, or redesignation of an existing facility for a new use should be publicized through leaflets and through local and campus newspapers. Provisions should be made for special events like sports activities and concerts. Special enforcement procedures also may be required initially.

If standardized design practices are followed for automobile facilities (1, 2), bicycle routes (3), and pedestrian rights-of-way (4), a comprehensive traffic plan for any campus can be developed.

SOURCES OF EXISTING DATA

It is necessary to research the study area to form an inventory of existing data. These data should be studied and deficiencies noted. Then, other data collected to complete the study will be pertinent.

Existing data that should be researched include:

1. Population projections. If available from transportation studies, data on origin-destination (O-D) and generation and distribution of trips are helpful to predict the number of potential users of a system. These projections give a workable set of values on which to base the design.
2. Traffic volumes and flows. These data are usually available from government highway or traffic engineering departments. They show peak periods of use and give an empirical basis for conclusions.
3. Public transit. Existing public transit facilities and service should be studied for routes, ridership, scheduling, and operating costs.
4. Accident studies. Accident records of the area should be studied for those involving bicycles (bicycle-automobile, bicycle-pedestrian, bicycle only). These records, then, should be checked to determine if the accidents could have been prevented through a bikeway plan.
5. Bicycle facility demand studies. Demand for bicycle facilities can be predicted by studying the number of bicycle registrations and the number of bicycle sales.

VOLUME STUDIES AND COUNTING PROCEDURES

If an area has many bicycles, traffic counts must be done to plan a network of bicycle paths. And, most traffic counts must be done manually. The following types of counts may be conducted to obtain desired data:

1. Cordon counts. The major inbound and outbound flows should be studied to obtain the number of bicycles entering and exiting the area to determine peak periods and traffic volumes over various routes.
2. Automobile and bicycle counts. There should be a turning movement count with conflicting movements noted at a major intersection to determine the number of conflicts between automobiles and bicycles.
3. Bicycle and pedestrian counts. A count should be done at an established bicycle and pedestrian conflict area to show conflicting movements and hours of greatest use.
4. Screen line counts. Screen line counts determine the total traffic crossing into the area and show where new routes or new crossings are required. These counts provide a check of O-D data by comparing hourly volume estimates.
5. Bicycle parking lot occupancy counts. Bicycles should be counted at regular intervals to determine their long- or short-term parking use. Space availability per time period can then be computed to show periods of maximum use. When these data are compared with data from the other counts the effectiveness of parking lot placement can be determined.

The results of these studies should be tabulated and presented in a form that can be easily interpreted. The cordon count should be presented either in graph form to show volume changes by time or by flow maps to indicate totals in or out of the area. Turning movement counts should be tabulated and a traffic flow diagram prepared. Tabulated results will show time fluctuations of the specific movements. Bicycle and pedestrian counts should be conducted concurrently to show conflicts per time period. Graphs, if 5-minute periods are used, will indicate time periods of greatest conflict.

CASE STUDY

The University of Colorado, Boulder is in a beautiful location at the base of the Rocky Mountain Eastern Range. But, several features of the traffic patterns in and around the campus detract from the setting. As shown in Figure 1, the campus is adjacent to a major north-south thoroughfare, Broadway, which brings heavy traffic near the campus. This corridor separates the campus from The Hill, which contains small businesses and privately owned student housing and residences. In addition, the campus is split by a route where through traffic is permitted—18th Street and Colorado Avenue. Traffic counts show that over 8,000 vehicles pass through the campus every day on this route.

Primary residence areas for the approximately 20,000 students are the southeast portion of campus in university-owned halls and west of the campus in private housing on The Hill. Approximately 1,000 students reside in Williams Village, a high-rise university complex 1 mile southeast of the main campus to which the university provides shuttle bus service. Classrooms are, in general, located in the northwest portion of the campus except for the Engineering Center and a few other buildings on the east side. Because most activity is in the northwest classroom area, most attention was given to identifying and correcting traffic problems there. The items identified as particularly acute were

1. No modal separation.
2. Excessive automobile traffic through campus.
3. No designated bicycle paths.
4. Too much bicycle traffic through the main east-west corridor, which is heavily traveled by pedestrians.
5. Need for a separate bicycle access route to the University Memorial Center (UMC) from the north to alleviate pedestrian-bicycle conflicts.
6. Lack of curb cuts and radius fillets.

Existing Data

The following components of existing data went into this design study:

Population Projections—Student enrollment within campus sectors and student O-D patterns were obtained from the university planning office. Commuter destination patterns were analyzed for 1970, and a majority of students were found to have destinations in the west sector of campus, the sector considered in this study. (The campus was divided into 3 sectors in the planning office study—east, central, and west.) The west sector includes the UMC and most of the arts and sciences classes. In 1970, 15,800 students out of a total 20,400 were enrolled in classes in the west sector. Two projections were made for 1980 in this study. The first projection assumed an increase of 400 students in the total campus enrollment; the second projection, an increase of 3,000 students. If there were a 400 student increase, there would be a drop in student commuters in the west sector from 5,400 students per day to 4,400 students per day. If there were a 3,000 student increase, there would be an increase of commuters in the west sector from 5,400 students per day to 6,500 students per day. These projections were done after taking into consideration enrollment patterns, campus construction, and other planning items.

Vehicle accesses to the entire campus were projected to increase from 9,000 vehicles per day to 15,400 vehicles per day over this 10-year period.

Pedestrian Movements—A pedestrian study from the planning office estimated there are now 40,000 person trips per day throughout the campus. (This includes class, supply, and maintenance trips.)

Automobile Study—An automobile traffic study was consulted that stated that there are 30,000 vehicle trips per day to and from the Boulder campus. This study claimed 8,000

Figure 1. University of Colorado, Boulder, west sector.

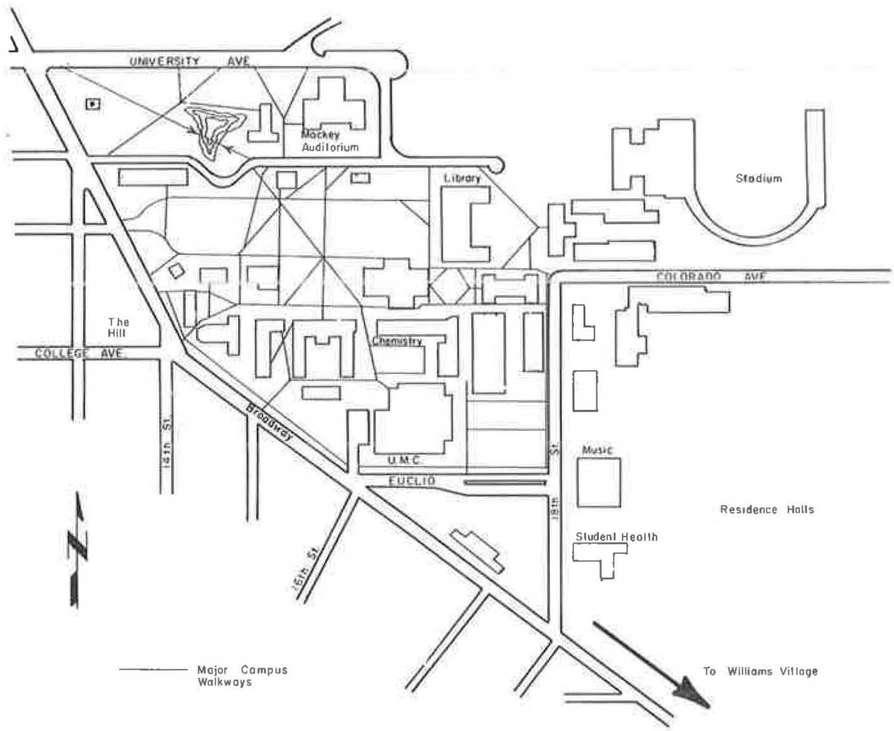
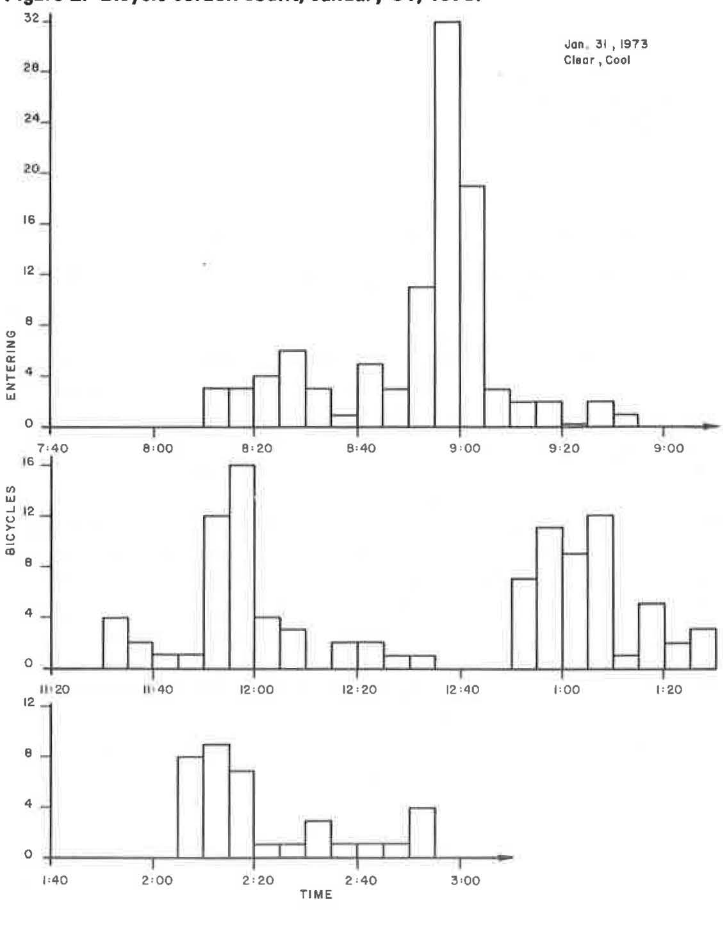


Figure 2. Bicycle cordon count, January 31, 1973.



vehicle accesses per day to the campus—lower than the figure given in the population study of the planning office. It recommended closing the campus streets to through automobile traffic and to allow only service vehicles access.

Bus Service—The university operates a bus service that carries several thousand students per day (4,000 persons per day to and from Williams Village). The bus service is operated through student activity funds; fares are also collected. The 9 buses can transport about 30 riders each. The route is 2.5 miles (4 km) and average travel time is 20 minutes, with a 6.5- to 7-minute headway. The schedule is as follows:

Times	Days	Number of Buses
7:15 a.m. to 5:30 p.m.	Monday through Friday	3
5:30 p.m. to 7:30 p.m.	Monday through Friday	2
7:30 p.m. to midnight	Monday through Friday	1
7:00 a.m. to midnight	Saturday and Sunday	1

Express buses traverse the route in 15 minutes and bypass the UMC. There are 2 express buses in the morning for 2 hours and 1 express bus at noon for 1 hour. Boulder city bus service has a route along Broadway at the west edge of campus but service to the campus community is limited and ridership by campus commuters is low.

Collection of Data

These data did not provide enough information for planning a system, so bicycle and pedestrian traffic counts were made.

The west section of campus was studied and preliminary investigation showed the major entrance and exit points to be

1. University Avenue and Broadway,
2. 14th Street and College Avenue and Broadway,
3. 16th Street and Broadway,
4. 18th Street between Euclid Avenue and Colorado Avenue, and
5. A one-way drive near Macky Auditorium south of University Avenue.

Cordon counts at these locations were conducted on Wednesday, January 31, 1973, and Tuesday, February 6, 1973. These 2 days were chosen for the counts because of the scheduling procedures of the Boulder campus. Courses in the Monday-Wednesday-Friday sequence and courses in the Tuesday-Thursday sequence are conducted at different hours of the day. Different peak periods were expected for the 2 different types of schedules. But, there was no major difference in peak periods. Figures 2 and 3 show the results of the 2 counting days on the one-way drive near Macky Auditorium. Figure 4 shows the results of a morning count at University Avenue and Broadway on Wednesday, May 8. This count was made to show how weather influences use. The 2 earlier count days were conducted in fair winter weather [high temperature about 45 F (280K)]; the May count day had temperatures near 80 F (300K) and the results show much more bicycle use. Although fair winters in Boulder permit bicycle use, much more volume is seen in fall and spring when temperatures are higher.

In all the volume counts, peak periods were from 10 minutes before the hour to 5 minutes after the hour. Because fewer classes are scheduled in late afternoon than in the morning, afternoon volumes were more uniformly distributed. Therefore, afternoon peak hours were studied.

Figure 5 shows the 5 entry points and their 5-minute peak volumes for the winter study days. The greatest inbound morning volume originates northwest of the campus at University Avenue and Broadway. Figure 2, however, shows a greater peak at the one-way drive near Macky Auditorium. Many bicycles that enter at University Avenue and Broadway proceed east down the one-way drive and may have been counted at each location. This would cause the one-way drive to show a higher volume. University Avenue and Broadway is probably the largest entry point.

Figure 3. Bicycle cordon count, February 6, 1973.

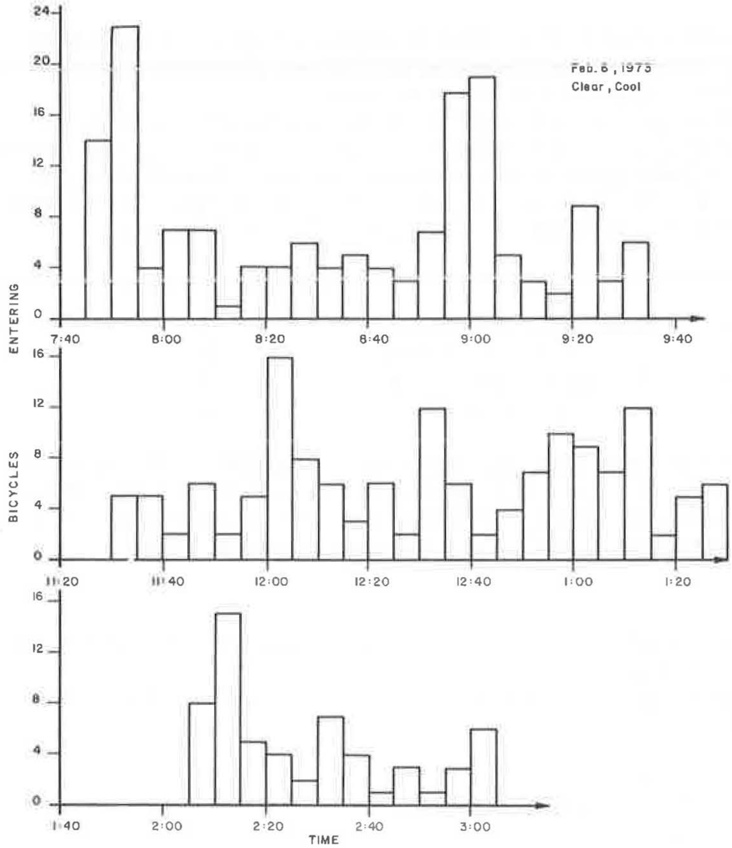


Figure 4. Pedestrian-bicycle cordon count, University Avenue and Broadway.

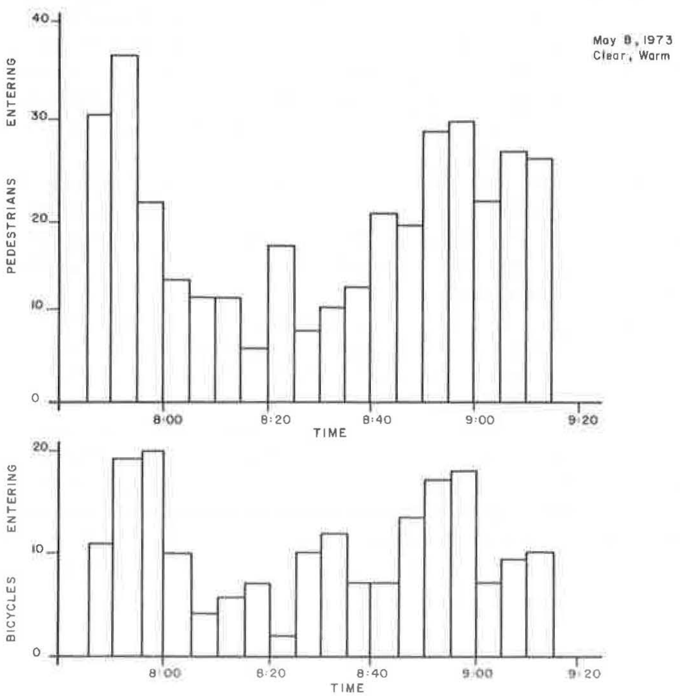


Figure 5. Major entrance locations and peak 5-minute volumes.

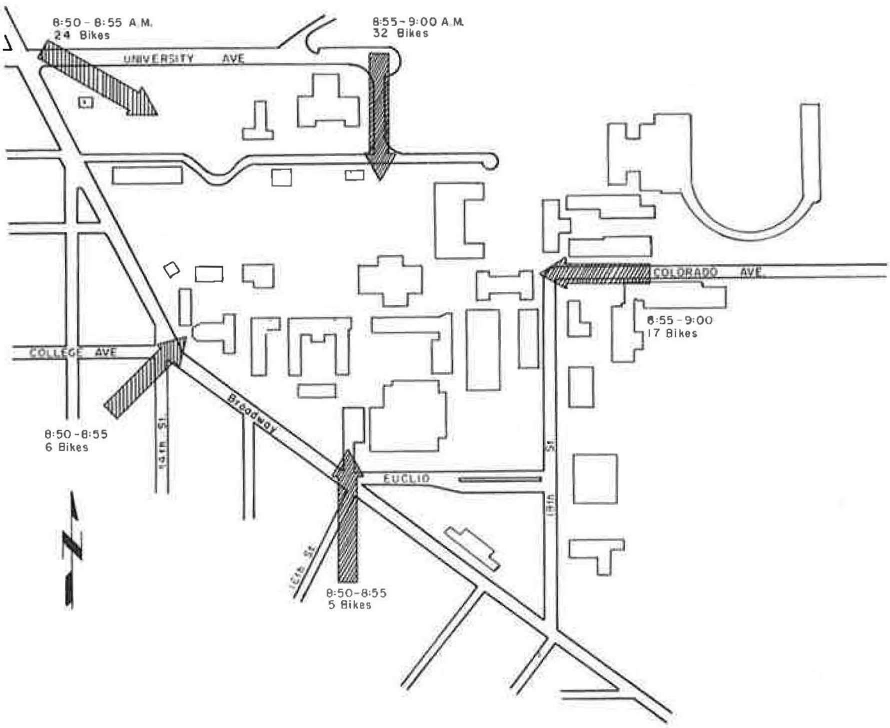


Figure 6. Turning movement count, automobile-bicycle.

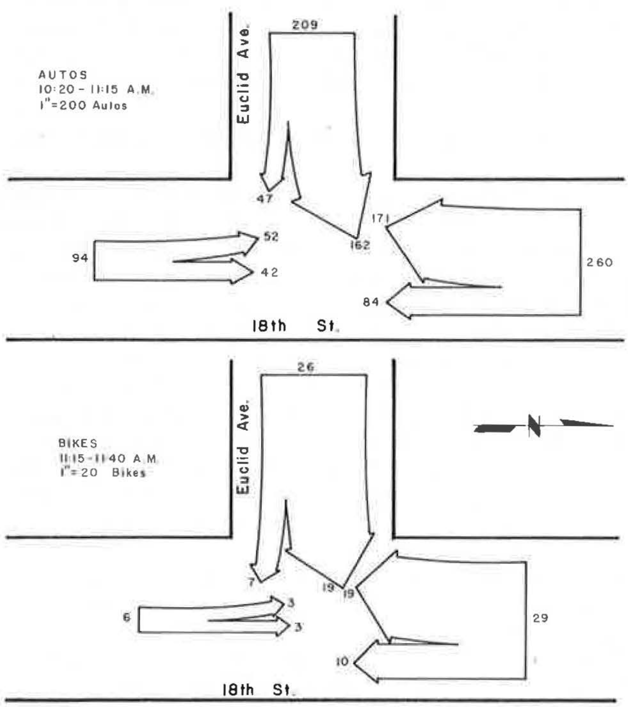


Figure 6 is a flow diagram of automobile and bicycle traffic at Euclid Avenue and 18th Street. Figure 7 is a flow diagram of pedestrian and bicycle traffic north of the UMC near the chemistry building. It is clear from these flow diagrams that conflicts of turning maneuvers exist between the different travel modes. These conflicts are aggravated during peak periods by the crossing of larger numers of pedestrians, bicycles, and autos. The peak periods here were also from 10 minutes before the hour to 5 minutes after the hour.

Recommended Solutions and Improvements

The deficiencies of the existing traffic plan arise from 2 factors: an insufficient network of bicycle paths and disruption caused by through automobile traffic. The plan shown in Figure 8 would provide adequate corridors for bicycle travel and would alleviate the problems of conflicts between bicycles and other modes. The most significant features of the network are

1. Restriction of through traffic on 18th Street and Colorado Avenue and use of this route as a bicycle path, pedestrian mall, and bus lane;
2. Designation of a separate east-west bicycle lane and restriction of bicycles from the other main east-west route;
3. Exclusion of bicycles from the narrow bridge in the northwest corner of campus;
4. Construction of a peripheral bicycle path paralleling Broadway;
5. Construction of a new bicycle access route to the UMC from the north as shown in Figure 9 to reduce pedestrian-bicycle conflicts; and
6. Restriction of automobiles and automobile parking from the one-way drive.

This plan requires installation of radius fillets at intersections to facilitate bicycle turning movements and construction of curb cuts to facilitate bicycle movements from streets to pathways. Areas that need particular attention are the peripheral route along Broadway, the access route at University Avenue, and the corridor just east of the library. The bicycle paths should be constructed to the standards established in Bikeway Planning Criteria and Guidelines (3). These include a 10 mph (16 km/h) design speed, a 3 percent maximum grade, a minimum radius of curvature of 14 ft (4.3 m) at 10 mph(16 km/h), a minimum vertical clearance of 8 ft (2.4 m), and a minimum width of 3.3 ft (1 m) for each lane of travel. Where both pedestrians and bicycles travel in 2 directions, pathway width should be 8 ft (2.4 m). These paths can be laid by most conventional asphalt spreading machines. Asphalt should be 1.5 to 2 in. (3.8 to 5 cm) thick on a 3- to 4-in. (7.6- to 10-cm) aggregate base. Routes should be clearly marked with standard signs.

A major aspect of the recommended traffic plan for the Boulder campus is the closing of the 18th Street and Colorado Avenue route to through traffic. Also, restricting Euclid Avenue to one-way traffic eastbound is suggested as shown in Figure 10. Colorado Avenue at Folson Street should be closed to all but shuttle bus and maintenance traffic by an automated gate. This would allow use of Colorado Avenue and 18th Street as a bicycle route and pedestrian mall. A center lane could be used for limited motorized vehicle use.

If Euclid Avenue were restricted to one-way eastbound traffic, and the right turn from Euclid Avenue to Broadway northbound were eliminated, bicyclists could move across Broadway more easily when Broadway traffic would be stopped at its red light. Euclid Avenue, in front of the UMC, is wide enough—45 ft (13.7 m)—to allow two 10-ft (3-m) eastbound lanes for automobile traffic, one 8-ft (2.4-m) loading lane on the south side, and two 8-ft (2.4-m) bicycle lanes on the north side as shown in Figure 10. A crosswalk from the loading area to the UMC would be required. Separation between the automobile and bicycle lanes should be by double yellow lines.

Euclid Avenue, east of the UMC, is divided by a center planter into eastbound and westbound lanes. This divider should separate the 2 one-way eastbound automobile lanes and the 2 bicycle paths on the north as shown in Figure 10.

As shown in Figure 11, at the intersection of Euclid Avenue and 18th Street, right turns should be the only movement allowed from both eastbound automobile lanes on Euclid Avenue because 18th Street would be one-way southbound. Full stops by both

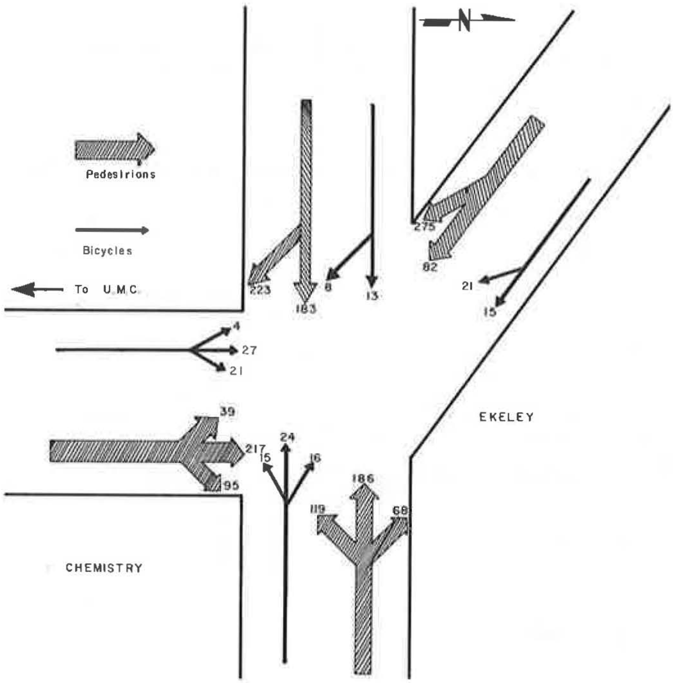


Figure 7. Turning movement count, pedestrian-bicycle.

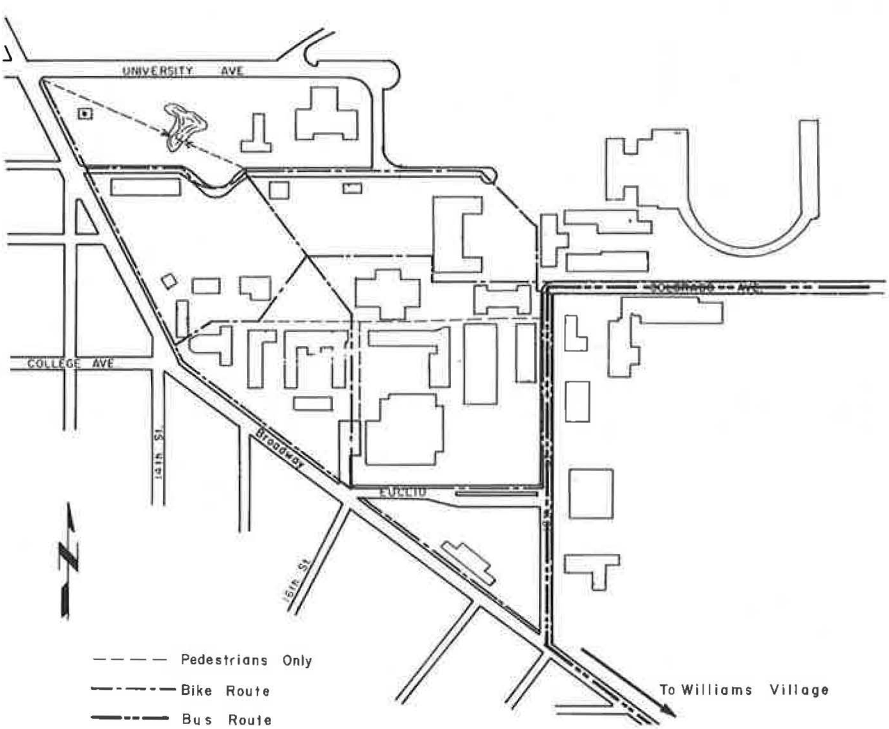


Figure 8. Planned bicycle, pedestrian, and bus routes.

Figure 9. Proposed access to UMC.

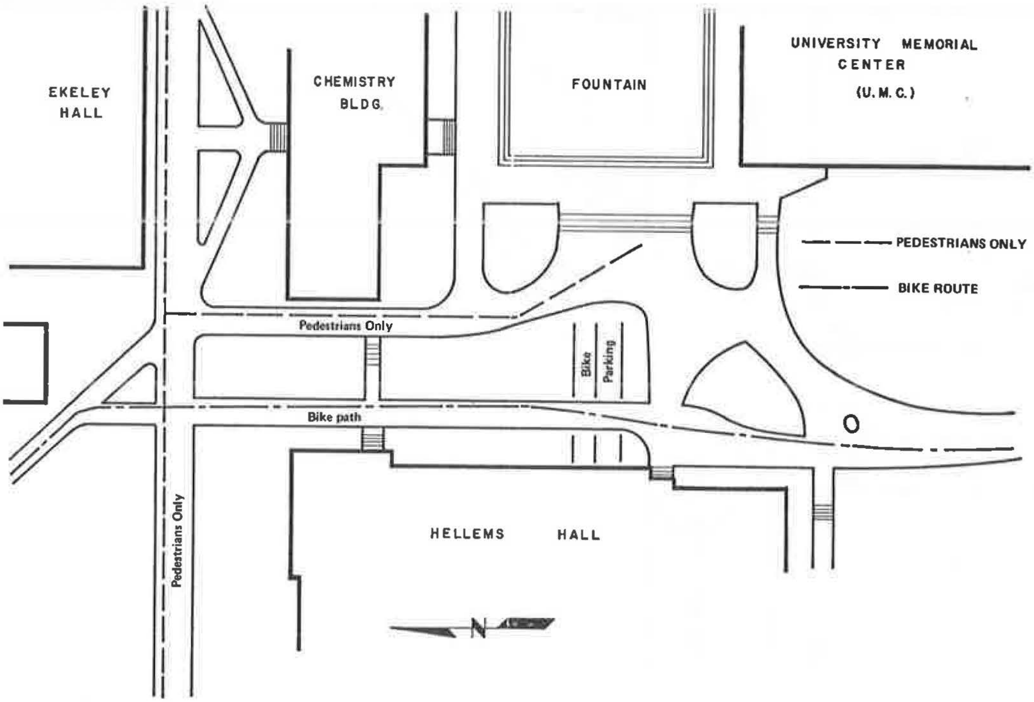


Figure 10. Proposed plan for Euclid Avenue.

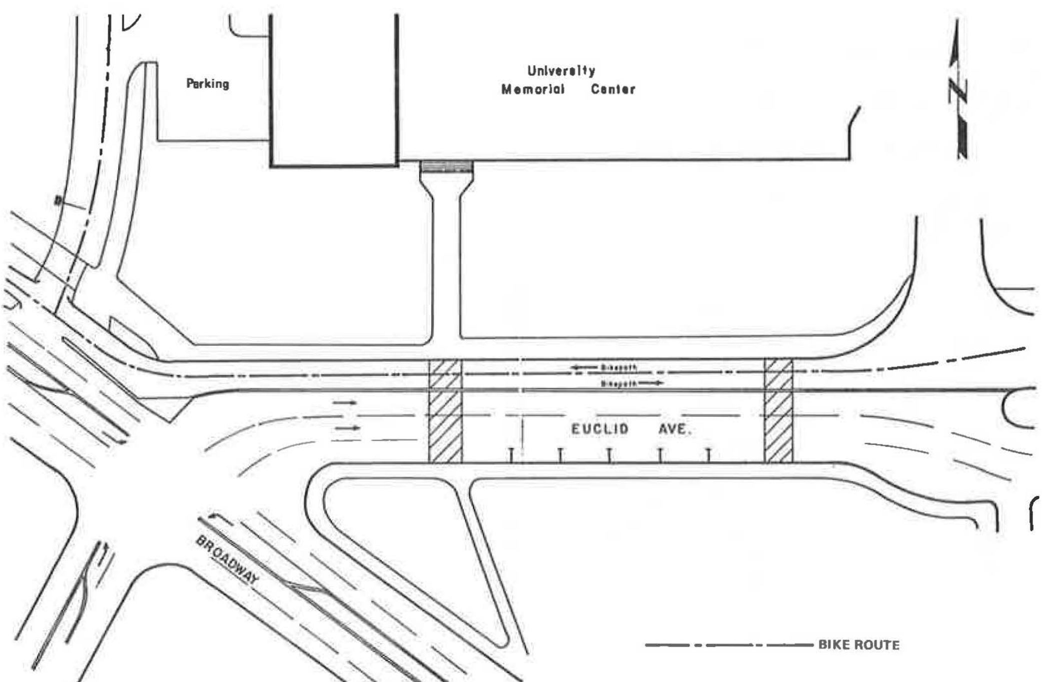
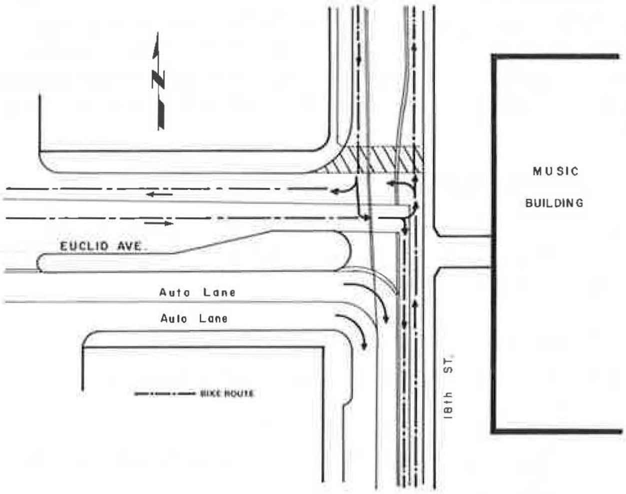


Figure 11. Proposed configuration at Euclid Avenue and 18th Street.



lanes should be required. South of this intersection, 18th Street should be marked for two 12-ft (3.6-m) southbound automobile lanes on the west side and two 6-ft (1.8-m) bicycle lanes on the east side. These bicycle lanes would provide access to the path between the music building and the Wardenburg Student Health Center that leads to several residence halls.

North of the Euclid Avenue and 18th Street intersection, Colorado Avenue should be divided into two 8-ft (2.4-m) bicycle paths on either side of a 20-ft (6.1-m) southbound bus lane. At the intersection, a full stop should be required by motorized vehicles that are southbound on 18th Street. Because traffic would be restricted to buses and delivery and maintenance vehicles on Colorado Avenue, nonbus traffic would be light. A separate bus loading lane would not be necessary. Boarding and unloading should be permitted when the buses stop and a boarding area should be provided for passengers at this location. Crosswalks should be added and all vehicles, including bicycles, should be required to yield to pedestrians.

A cost estimate for the proposed bicycle route installation has been prepared. This cost schedule is for direct costs. No benefit-cost analysis was performed because this project was assumed to be feasible for the area. The prices are estimated rather than exact because they are based on local prices and may vary with contractors and distributors.

Item	Amount (dollars)
Signs	
16—bicycle route, with symbol	68.80
6—no bicycles, with symbol	28.80
2—stop	8.60
1—yield	4.30
21—24-in. by 18-in. sign blanks, octagon and triangle	48.93
3—24-in. by 24-in. sign blanks, octagon and triangle	9.00
24—11-ft channel posts, 3 lb	100.12
Asphalt, 285 yd by 3 yd	5,130.00
Curb cuts, 6—8 ft wide	384.00
Paint striping, 15,000 ft	600.00
Arrow and bicycle symbols	100.00
Labor, 30 hours	112.50
Miscellaneous hardware	25.00
Total	6,625.05

CONCLUSIONS

A traffic plan for any university campus or similar closed community area may be developed by applying the techniques and guidelines used in the University of Colorado case study. The comprehensive traffic plan would facilitate movement of automobiles, bicycles, and pedestrians through the campus. Because of increased modal separation, modal conflicts would be greatly reduced. This is the primary goal that the designers of a campus traffic plan should seek.

ACKNOWLEDGMENTS

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