Bicycle Demand Model Update

Task D of the Multimodal Planning Research Project

Final Report

Prepared for:

City of San Diego

Prepared by:

CHEN RYAN

3900 5th Avenue
Suite 210
San Diego, California 92103

December 11, 2015

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1.0 Background

This report documents an update to the City of San Diego's Bicycle Demand Model (BDM), with a particular focus on recording data inputs, analysis methodology and key outputs. The City is updating the BDM since several of the data inputs are out of date, as it was originally developed in 2010, over five years ago. This report documents BDM data inputs and GIS analysis steps in detail, in order to build capacity among other San Diego consultants and City staff to work fluently with the BDM on a variety of planning efforts.

The BDM was originally developed in 2010 during the Bicycle Master Plan update process to assist with prioritization of bicycle facility improvement corridors across the City. An overview of bicycle planning in the City of San Diego is provided below as a background to the current BDM update.

- The previous Bicycle Master Plan was adopted in May 2002 with a vision to *"lay a more firm foundation for a bicycle-friendly environment to serve commuter or recreational affairs."* The 2002 Bicycle Master Plan identified quality of life factors linked to fostering an attractive cycling environment, as well as safety and health objectives in support of bicycle facility improvements.

  The City of San Diego General Plan (2008) makes reference to the 2002 BMP, describing its key purpose:

  > *"The BMP contains detailed policies, action items, and network maps, and addresses issues such as bikeway planning, community development, facility design, bikeway classifications, multi-modal integration, safety and education, and support facilities… the BMP is intended to provide a citywide perspective that is enhances with more detailed community plan level recommendations and refinements. The BMP also identifies specific bicycling programs and addresses network implementation, maintenance and funding strategies" (ME-36).*

- An update to the 2002 Bicycle Master Plan began in 2009, with plan adoption occurring in 2013. The 2013 Bicycle Master Plan Update was developed consistently with the State of California Bicycle Transportation Account (BTA) requirements, including a discussion of bicycle infrastructure and program funding sources; identification of needed bicycle facilities, bicycle programs, and high priority projects; outlining strategies for bicycle safety enhancements, encouraging cycling, and improving overall quality of life in San Diego. The BDM was an innovative tool developed during this planning process to provide objective measures of the propensity for cycling across the City.

This report is organized into the following chapters:

- ***Chapter 2.0 Modeling Overview:*** This chapter summarizes the overarching methodology utilized to create the BDM, including the intra-community and inter-community submodels.

- ***Chapter 3.0 Data Inputs:*** This chapter documents data inputs by filename and source to aid in replicating the BDM as necessary in the future.

- ***Chapter 4.0 Points and Weighting System:*** This chapter summarizes the point and weight system applied to the data inputs for each submodel of the BDM, as well as provides maps of each of the submodel outputs.

- ***Chapter 5.0 GIS Steps:*** This chapter provides step-by-step guidance for creating the BDM in ArcGIS 10.1.

- ***Chapter 6.0 Data Outputs:*** This chapter presents the final composite BDM.

2.0 Modelling Overview

The BDM was originally developed to identify locations across the City of San Diego with high bicycle demand or places warranting relatively higher consideration for bicycle infrastructure improvements. The BDM analyzes two components of demand: *intra-community travel* and *inter-community travel*. The former consists of shorter trips made within a neighborhood or community area; the latter refers to longer trips made between communities and neighborhoods. Cycling demand was modeled at these two scales because there is variation in the strength of factors believed to attract or generate bicycle trips for shorter (less than five miles) versus longer trips.

The intra-community demand submodel is comprised of bicycle trip attractors and generators, and addresses likely factors at the trip origin and destination contributing to the decision to make a relatively shorter bicycle trip. The inter-community demand submodel utilizes network analysis to map shortest paths along various bicycle networks, including all bikeable roadways and existing/proposed bicycle facilities. Shortest paths between activity centers distributed across the city and region are determined using the Network Analyst extension in ArcGIS 10.1. The inter-community demand model is based on a 'gravity model' theory, whereby higher intensity activity centers are hypothesized to have higher levels of bicycle trips flowing between them, and activity centers located in closer proximity are hypothesized to have higher levels of bicycle trips flowing between them. In other words, bicycle trip flows between two nodes or activity centers is a function of the land use intensity of the nodes and the distance between the nodes.

2.1 Intra-Community Demand

The intra-community demand submodel utilizes suitability analysis techniques to combine bicycle trip attractors and generators across the City of San Diego. Suitability analysis in the classical sense of the term refers to the layering of mapped information across a study area in a manner that allows for the simultaneous consideration of multiple factors to support decision-making processes. The layering of multiple mapped inputs helps to identify the spatial coincidence of these inputs. The analyst may want to locate places where inputs overlap, or where they do not overlap, depending on the decision-making process and the specific inputs assessed. Suitability analysis is well-suited for studying intra-community demand because this type of demand is characterized by relatively short trips occurring in a dispersed manner across a district or zone, rather than concentrated along a linear network over longer distances.

The intra-community demand model was specifically developed as a "weighted suitability model" meaning that each input criteria is categorized and ranked with points, and then weights are assigned to each of the input criteria. This results in the values of each criteria being scaled as "high to low" with points, and in some criteria having more strength in the overall output than others via the assigned weights. In other words, there is a "within" criteria ranking and a "between" criteria ranking.

Table 2.1 displays this concept of "within" and "between" criteria ranking using a simple set of two inputs, population density and household income. In the case of the BDM intra-community submodel, each input was assigned equal weights.

Table 2.1: Example of "Within" and "Between" Suitability Analysis Criteria Ranking

Bicycle Generators	Points	Weighted Multiplier	Final Score
Population Density (people per acre)			
> 40	3 (high)	2 (high)	6
25 - 40	2 (medium)		4
5 - 25	1 (low)		2
<5	0		0
Household Income (affects transportation mode)			
< $34,500	3 (high)	1 (low)	3
$34,500 - $63,400	2 (medium)		2
> $63,400	1 (low)		1

Source: Chen Ryan Associates, December 2015

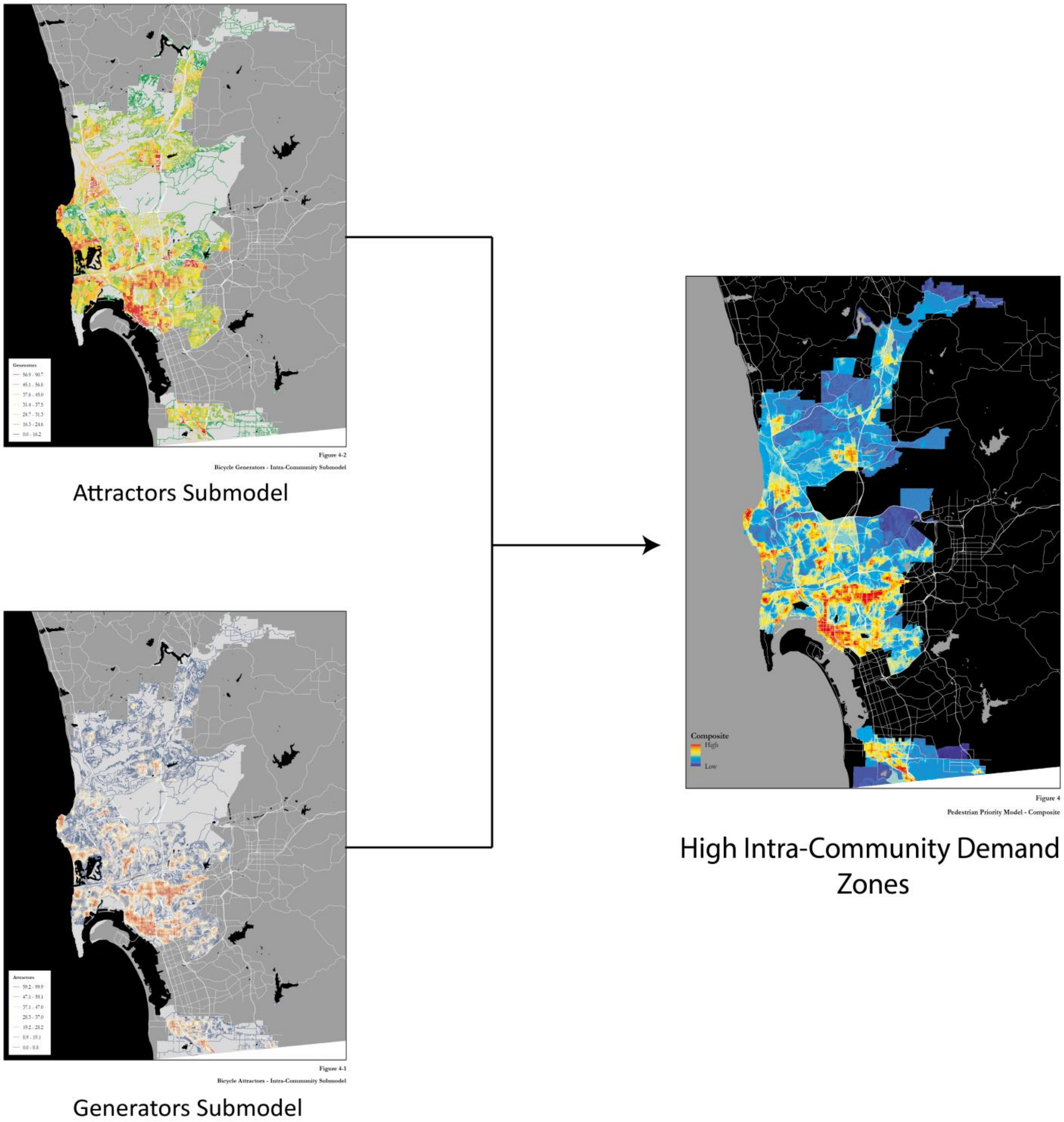
In terms of population density, the data values are categorized into four classes (>40 persons per acre, 25 – 40 persons per acre; 5-25 persons per acre, and <5 persons per acre). Points are then assigned to the four classes to reflect which class has a relatively higher expected contribution to bicycle trip generation. The highest class receives the highest point value (3 points), and the lowest class receives the lowest point value (0 points). The same process is applied to the income data – the data are categorized into three classes and points are assigned to reflect higher to lower expected contribution to bicycle trip generation. This effectively ranks each criteria "within" or relative to itself.

In terms of the "between" criteria ranking in the example above, weights are assigned to each of the criteria reflecting how each one is expected to contribute to bicycle trip generation. In the example presented in Table 2.1, population density is expected to contribute relatively more than household income, thus a higher weight is applied to population density than to household income (2 versus 1). A final score for each criteria's class is calculated by multiplying the points and weights.

Figure 2-1 summarizes the modeling process employed for developing the intra-community bicycle demand submodel.

The final intra-community bicycle demand submodel output is a raster file containing cell scores reflecting relative levels of demand for short cycling trips across San Diego. The cell size chosen for this analysis, 75' by 75', maintains compatibility with the City's Pedestrian Priority Model (PPM), and was chosen to capture the best detail possible in relation to the datasets and the geographic size of the City of San Diego. The raster cells are intersected with the "All_Roads" roadway network in order to attribute each roadway segment with an intra-community bicycle demand score.

Figure 2-1: Intra-Community Bicycle Demand Modeling Process



2.2 Inter-Community Demand

Development of the inter-community bicycle demand submodel requires two processes:

1. ***Defining a Bicycle Planning Network*** – A 'bicycle planning network' was identified by finding the shortest paths along the 'bikeable' City roadways, as well as along the existing and proposed bicycle network, connecting a set of activity centers across the City.

2. ***Developing and Assigning Bicycle Demand Points to the Bicycle Planning Network*** – A gravity model theory was employed to rank the segments of the bicycle planning network. This theory hypothesizes that segments connecting higher intensity activity centers in closer proximity will rank higher than segments connecting lower intensity activity centers farther apart from each other.

Key steps in these inter-community bicycle demand submodel processes are described below.

2.2.1 Defining a Bicycle Planning Network

The first step in the bicycle demand modeling process is to identify a reasonable network for which longer-trip cycling demand can be determined. This network includes a subset of all roadways across the City of San Diego (the bikeable roadway network), since cyclists do not have access to all roadways. The bikeable roadway network was then combined with the existing and planned bicycle networks (the bicycle facilities network), and used to find a set of shortest paths between key activity centers across the City. The activity centers were defined using Smart Growth Opportunity Areas (SGOAs), the two Ports of Entry with Mexico (San Ysidro and Otay Mesa), and three large employment centers that were not included in SANDAG's SGOAs. A total of 90 activity center locations were utilized in the inter-community bicycle demand submodel.

Figure 2-2 displays the bikeable roadway network and the bicycle facilities network. **Figure 2-3** displays the activity centers used for this analysis.

The inclusion of these two networks – a bikeable roadway network and a bicycle facilities network – ensures that a range of cycling preferences is captured. In general terms, cyclists tend to fall into two categories defined by their route preferences: those with a high tolerance for interacting with vehicular traffic, who will use any roadway as long as it provides a direct route; and those with a low tolerance for interacting with vehicular traffic and will travel out of direction to use bicycle facilities.

Finally **Figure 2-4** presents the 'bicycle planning network' which reflects the shortest paths between activity centers along the combined bikeable roadway network and the bicycle facilities network.

2.2.2 Developing and Assigning Demand Points to the Bicycle Planning Network

As mentioned earlier, the bicycle planning network was ranked or assigned points using a gravity model theory whereby,

1. The intensity of the activity centers being connected by the bicycle planning network is positively related to cycling demand, and
2. The distance between activity centers along the bicycle planning network is inversely related to cycling demand.

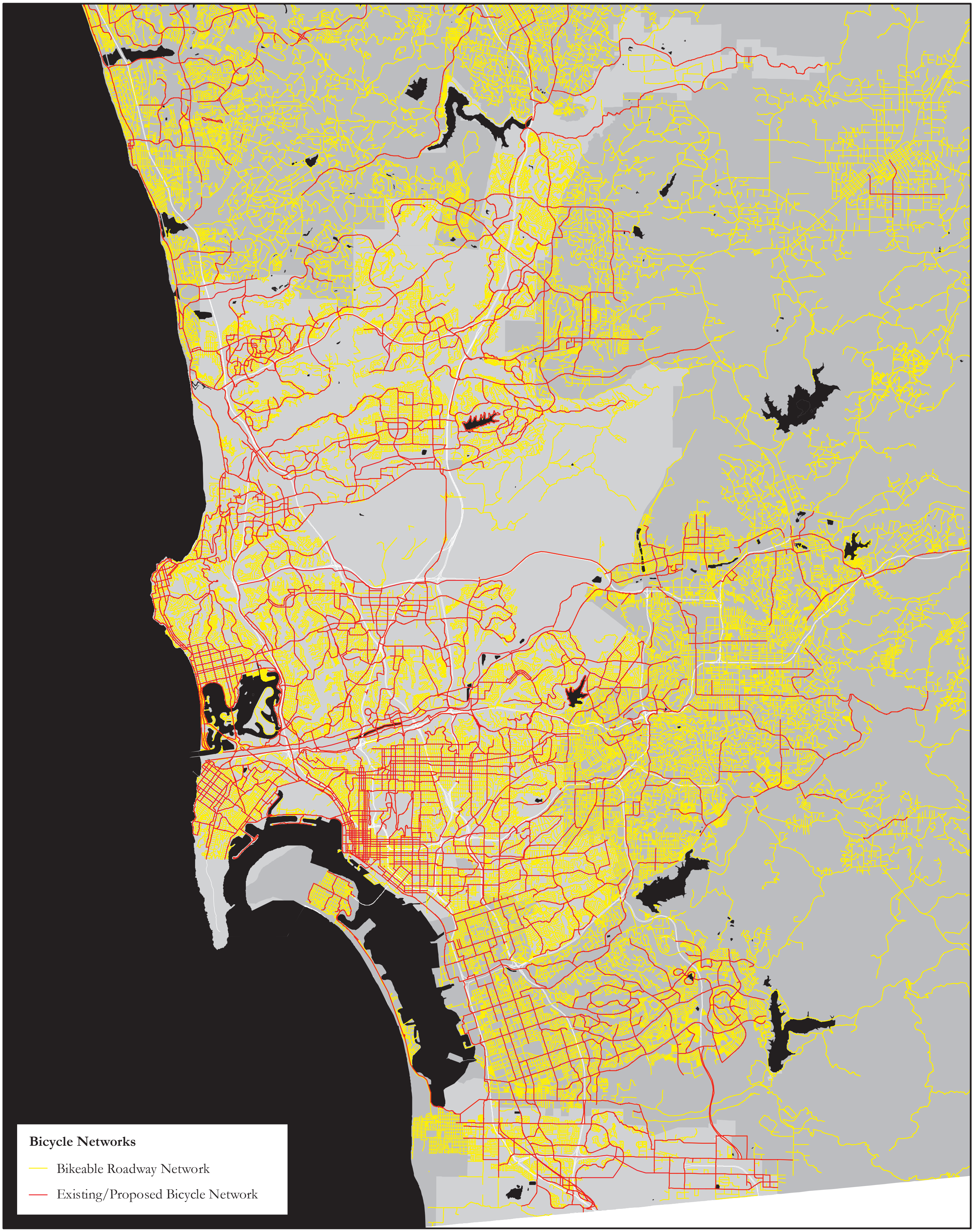


Figure 2-2

Bikeable Roadway Network + Existing/Proposed Bicycle Network

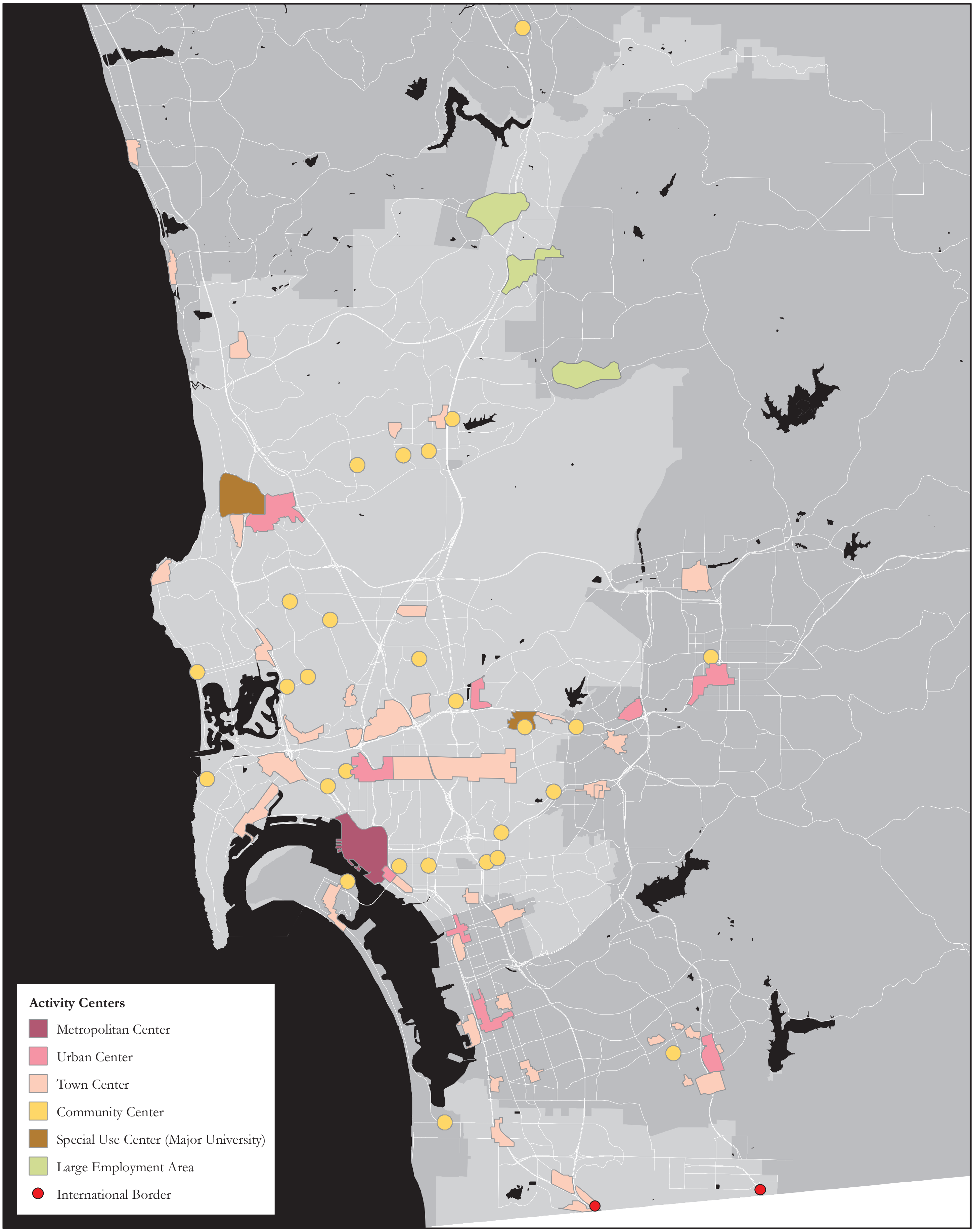


Figure 2-3

Activity Centers

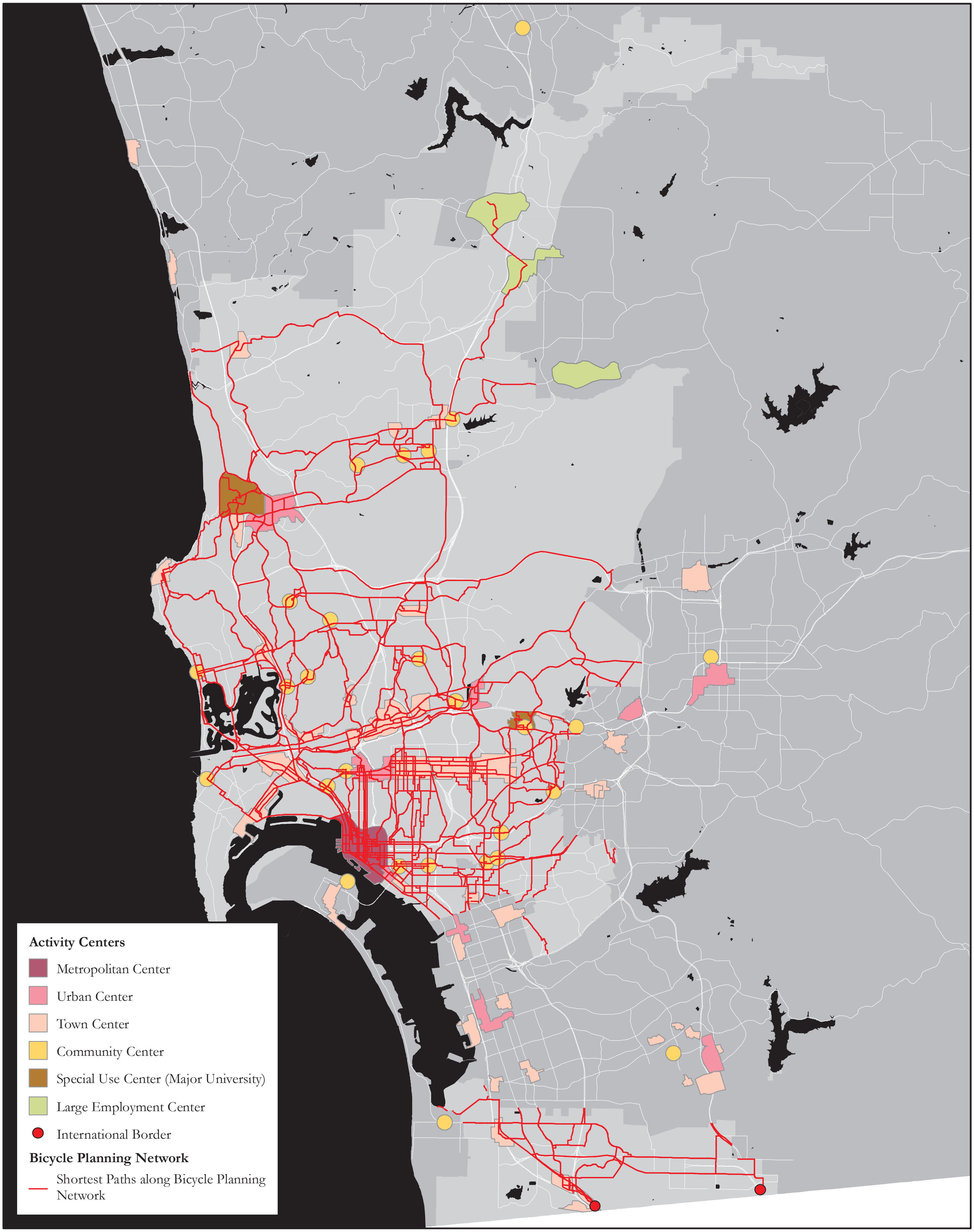


Figure 2-4

Activity Centers and Bicycle Planning Network (Shortest Paths)

Table 2.2 displays the SGOA place types. As shown, place types vary by residential density, employment density, and transit service characteristics, with Metropolitan Centers having the highest intensity and Rural Village having the lowest intensity.

Table 2.2: SANDAG's Smart Growth Opportunity Area (SGOA) Typologies

Smart Growth Place Type	Minimum Residential Target	Minimum Employment Target	Minimum Transit Characteristics	Included in Model as Activity Center	Number of Sites Included in Analysis
Metropolitan Center	75 du/ac	80 emp/ac	Regional Services	Included, plus San Ysidro POE	2
Urban Center	40 du/ac	50 emp/ac	Light Rail, Rapid Bus	Included	9
Town Center	20 du/ac	30 emp/ac	Light Rail, Rapid Bus	Included, plus Otay Mesa POE	44
Community Center	20 du/ac	n/a	High Frequency Local Bus	Included	30
Rural Village	10.9 du/ac	n/a	n/a	Excluded	-
Special Use Center	Optional	45 emp/ac	Light Rail, Rapid Bus	Excluded, except for SDSU and UCSD	2
Mixed-Use Transit Corridor	25 du/ac	n/a	High Frequency Local Bus	Excluded	-

Source: Smart Growth Concept Site Descriptions June 6, 2008 (SANDAG)

According to the gravity theory framework, for example, cycling demand will be higher along segments of the bicycle planning network that connect Metropolitan Centers versus those connecting Community Centers. The point allocation associated with activity center intensity is described in *Chapter 4.0 Points and Weights*.

The second component of cycling demand is related to the distance between activity centers along the bicycle planning network. According to the gravity model framework, as the distance of the network connection between activity centers increases, cycling demand decreases. This is a typical and intuitive assumption in many transportation planning frameworks – travelers do not engage in traveling for travel's sake, rather they are attempting to access opportunities. The trip is necessitated by distances between places and is thought of as a dis-utility or 'cost'. Following this assumptions, places farther apart will have less travel flowing between them; while places in closer proximity will have more travel flowing between them. The point allocation associated with the distance between activity centers is described in *Chapter 4.0 Points and Weights*.

The final inter-community cycling demand submodel includes a summation of the points related to activity center intensity with the points related to distance between activity centers.

Figure 2-5 summarizes the inter-community demand submodel analysis process.

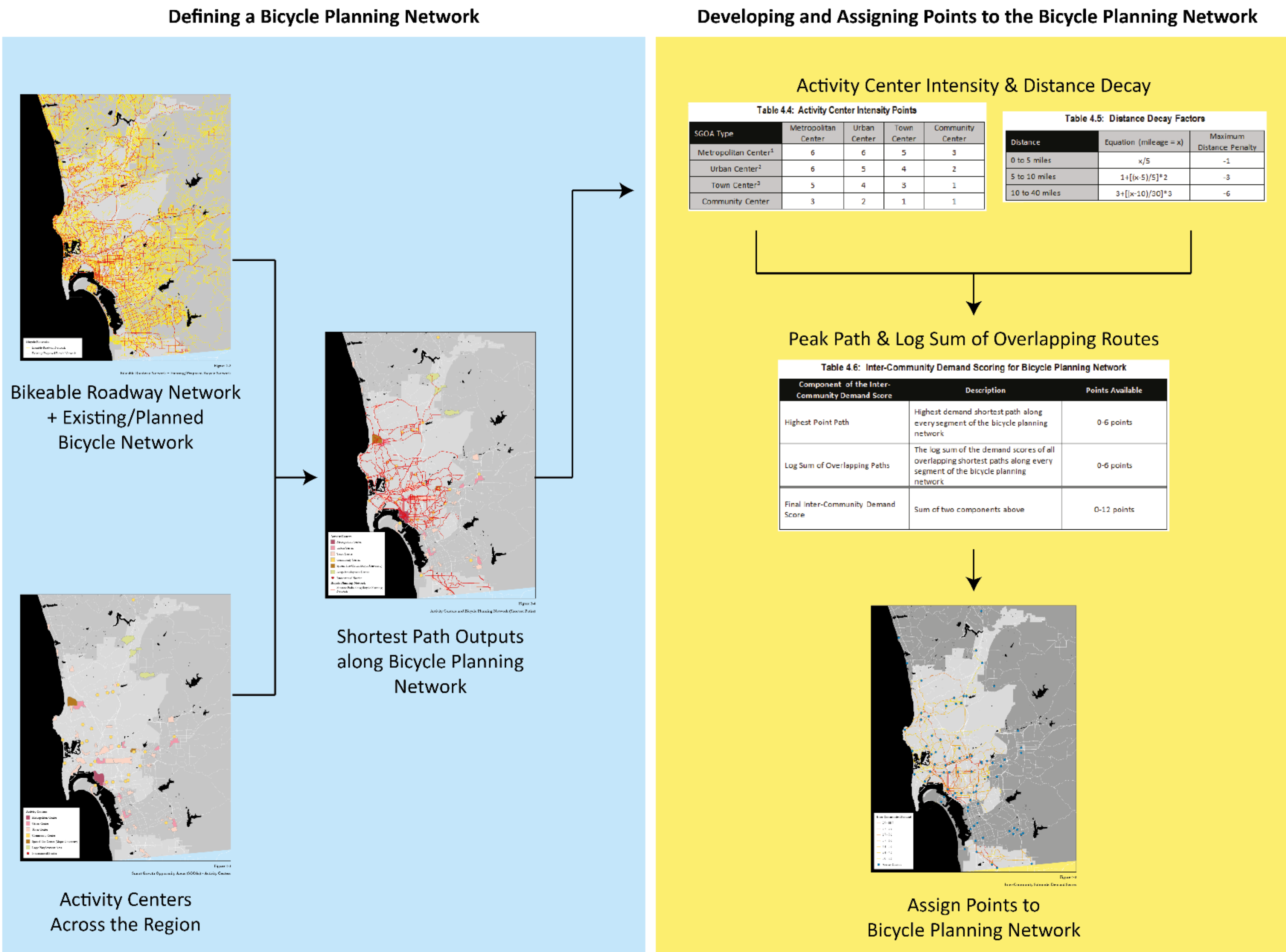


Table 4.4: Activity Center Intensity Points

SGOA Type	Metropolitan Center	Urban Center	Town Center	Community Center
Metropolitan Center[1]	6	6	5	3
Urban Center[2]	6	5	4	2
Town Center[3]	5	4	3	1
Community Center	3	2	1	1

Table 4.5: Distance Decay Factors

Distance	Equation (mileage = x)	Maximum Distance Penalty
0 to 5 miles	x/5	-1
5 to 10 miles	1+[(x-5)/5]*2	-3
10 to 40 miles	3+[(x-10)/30]*3	-6

Table 4.6: Inter-Community Demand Scoring for Bicycle Planning Network

Component of the Inter-Community Demand Score	Description	Points Available
Highest Point Path	Highest demand shortest path along every segment of the bicycle planning network	0-6 points
Log Sum of Overlapping Paths	The log sum of the demand scores of all overlapping shortest paths along every segment of the bicycle planning network	0-6 points
Final Inter-Community Demand Score	Sum of two components above	0-12 points

Figure 2-5: Inter-Community Bicycle Demand Submodel Analysis Process

3.0 Data Inputs

Tables 3-1 and **3-2** display the filenames, field headers, file source, and dates of all data used for developing the BDM's intra-community submodel, including attractors and generators, respectively. **Table 3-3** presents the same information for the BDM's inter-community demand submodel.

The majority of data was obtained from SanGIS, SANDAG, and the U.S. Census Bureau.

Table 3-1: Intra-Community Bicycle Attractor Submodel Inputs

Input #	Model Input	Filenames	Field	Source	Date	Folder
1	Major Universities (SDSU and UCSD)	LANDUSE_CURRENT.shp	SDSU/CSU San Marcos/UCSD, only selected: SDSU and UCSD	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
2	Beaches	LANDUSE_CURRENT.shp	Beach – Active	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
3	Tourist Attractions	LANDUSE_CURRENT.shp	Tourist Attraction	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
4	Transit Ridership (>1,000 boardings and alightings per day)	CityofSanDiegoStops2014.shp	Ridership ("total" is original ridership number but stops adjacent to each were other consolidated and assigned into categories)	Metropolitan Transit System	2015	Intra-Community Demand/Attractors
5	Regional Class I Bicycle Path	Bike.shp	CLASS: 1	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
6	Parks	LANDUSE_CURRENT.shp	Park – Active	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
7	Schools	LANDUSE_CURRENT.shp	Elementary School, Junior High School or Middle School, Senior High School	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
8	Small Colleges and Universities	LANDUSE_CURRENT.shp	Junior College, Other University or College – only selected: USD, PLNU, City College, Mesa College, Grossmont College, Miramar College, Alliant International University	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
9	Smart Growth Opportunity Areas	SmartGrowthAreas2014.shp	SG_TYPE: MC, UC, TC, CC, SU (SD UN-3 and SD CO-2 only) & PROPOSED = 0	SANDAG	2014	Intra-Community Demand/Attractors
10	Retail	LANDUSE_CURRENT.shp	Arterial Commercial, Community Shopping Center, Mixed Use, Neighborhood Shopping Center, Other Retail Trade and Strip Commercial, Regional Shopping Center, Specialty Commercial	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors
11	Civic Facilities	LANDUSE_CURRENT.shp	Government Office/Civic Center, Library, Post Office, Religious Facility	SanGIS/SANDAG	2015	Intra-Community Demand/Attractors

Source: Chen Ryan Associates, December 2015

Table 3-2: Intra-Community Bicycle Generator Submodel Inputs

Input #	Model Input	Filenames	Field	Source	Date	Folder
1	Population Density	Census_Block_Groups.shp	Join and copy data from table below	US Census TIGER/Line shapefiles	2010	Intra-Community Demand/Generators
		ACS_13_5YR_B01003_with_ann [TOTAL POPULATION (Table B01003)]	Total	US Census 2013 American Community Survey 5-year estimates/American Fact Finder Download Center	2013	Intra-Community Demand/Generators/Census Tables
2	2012 Employment Density	Census_Block_Groups.shp	Join and copy data from table below	US Census TIGER/Line shapefiles	2010	Intra-Community Demand/Generators
		points_2012	c000	US Census/Longitudinal Employer-Household Dynamics OnTheMap	2013	Intra-Community Demand/Generators
3	Percentage of Zero-Vehicle Households	Census_Block_Groups.shp	Join and copy data from table below	US Census TIGER/Line shapefiles	2010	Intra-Community Demand/Generators
		ACS_13_5YR_B25044_with_nn [TENURE BY VEHICLES AVAILABLE (Table B25044)]	Total, Owner – No Vehicle Available, Renter – No Vehicle Available	US Census 2013 American Community Survey 5-year estimates/American Fact Finder Download Center	2013	Intra-Community Demand/Generators/Census Tables
4	Census Mobility: People Who Bicycle to Work	Census_Block_Groups.shp	Join and copy data from table below	US Census TIGER/Line shapefiles	2010	Intra-Community Demand/Generators

Table 3-2: Intra-Community Bicycle Generator Submodel Inputs

Input #	Model Input	Filenames	Field	Source	Date	Folder
		ACS_13_5YR_B08301_with_ann [MEANS OF TRANSPORTATION TO WORK (Table B08301)]	Total, Bike	US Census 2013 American Community Survey 5-year estimates/American Fact Finder Download Center	2013	Intra-Community Demand/Generators/Census Tables
5	Census Mobility: People Who Walk and Take Transit to Work	Census_Block_Groups.shp	Join and copy data from table below	US Census TIGER/Line shapefiles	2010	Intra-Community Demand/Generators
		ACS_13_5YR_B08301_with_ann [MEANS OF TRANSPORTATION TO WORK (Table B08301)]	Total, Walked, Public Transit	US Census 2013 American Community Survey 5-year estimates/American Fact Finder Download Center	2013	Intra-Community Demand/Generators/Census Tables

Source: Chen Ryan Associates, December 2015

Table 3-3: Inter-Community Submodel Inputs

Input #	Model Input	Filenames	Field	Source	Date	Folder
1	Roadways traversable by bicycle (bikeable roadways)	Roads_all.shp	Excludes FUNCLASS fields: F, R, E, M, P, A, and 1	SanGIS, with some additional digitizing by Chen Ryan staff	2015	Inter-Community Demand
2	Existing bicycle facilities	Bike.shp	Excludes ROUTE fields: 4 and 5	SanGIS, with some additional digitizing by Chen Ryan staff	2015	Inter-Community Demand
3	Proposed bicycle facilities	BIKE_MASTER_PLAN_SD	-	SanGIS, with some additional digitizing by Chen Ryan staff	2015	Inter-Community Demand
4	Smart Growth Opportunity Areas	SmartGrowthAreas2014.shp	SG_TYPE: mc, uc, tc, cc, and su (SD-CO-2 and SD-UN-3 only)	SANDAG	2014	Inter-Community Demand
5	Large Employment Centers	MajorEmploymentAreas.shp	NAME: Poway Industrial Center, Rancho Bernardo, Sabre Springs	SANDAG	2014	Inter-Community Demand
6	International Ports of Entry	Ports_of_Entry.shp	-	Digitized by Chen Ryan	2015	Inter-Community Demand

Source: Chen Ryan Associates, December 2015

4.0 Intra-Community and Inter-Community Submodel Points and Weights

This chapter summarizes steps taken to analyze the data presented in Chapter 3.0, using the intra-community and inter-community bicycle demand submodels described in Chapter 2.0. In particular, data inputs for each of the BDM submodels are described, along with the point and weight system.

4.1 Intra-Community Submodel Points and Weights

The intra-community bicycle demand model integrates bicycle trip attractors and generators. The intra-community model is intended to identify areas with greater propensity for making short bicycle trips. The inputs used in these submodels are identical to those used in the 2013 Bicycle Master Plan iteration of the intra-community bicycle demand model.

A key difference between the current update to the bicycle attractors and that prepared for the 2013 BMP Update is a reduction in maximum buffer distances from three miles in the 2013 BMP Update to one mile in this current update. The 3-mile buffer was reduced because it resulted in high levels of overlap creating limited variation in the data inputs.

4.1.1 Bicycle Attractors

Bicycle attractors are defined as land uses or features likely to attract cycling trips. **Table 4.1** displays the specific attractors used in the intra-community submodel. As shown, six types of bicycle attractors are represented:

- Schools,
- Transit stations,
- Recreational facilities, such as parks, beaches, regional Class I bicycle paths, and tourist attractions
- Smart Growth Opportunity Areas
- Neighborhood and community retail, and
- Neighborhood and community serving civic facilities (libraries, post offices, and religious facilities).

Table 4.1: Bicycle Attractor Data Inputs and Assigned Points and Weights

Bicycle Attractors	Points	Weighting	Final Score
Major Universities (SDSU and UCSD)	4	1	4
Beaches	4		4
Tourist Attractions	4		4
Transit Stops (Greater than 1,000 boardings and alightings per day)	4		4
Regional Class I Bicycle Paths	4		4
Parks	3		3
Small Universities and Colleges	3		3
Smart Growth Opportunity Areas	2		2
Retail Facilities	1		1
High, Middle and Elementary Schools	1		1
Neighborhood Civic Facilities	1		1

Source: Adapted from City of San Diego Bicycle Master Plan, 2013

Table 4.2 displays the distance-based points and weights applied to bicycle attractors in the intra-community submodel. As shown, higher points are assigned to locations within closer proximity of bicycle-attracting land uses.

Table 4.2: Bicycle Attractor Distance-Based Points and Weights

Weighting Values Based on Distance to Attractor	Points	Weighting	Final Score
1/4 Mile	1.5	1	1.5
1/3 Mile	1		1
1/2 Mile	0.75		0.75
1 Mile	0.5		0.5

Source: Adapted from City of San Diego Bicycle Master Plan, 2013

After the point system is developed, buffers are drawn around each bicycle-attracting land use at increasing distances from their center point. The distance-based weighted values are assigned to each buffer. For example, a 1/4-mile radius buffer is assigned a higher value than a 1/2-mile radius buffer, since there is likely to be a greater convergence of cyclists within 1/4 of a mile of an attraction than within a 1/2 mile.

Figure 4-1 displays the resulting bicycle attractor raster developed for use in the intra-community submodel.

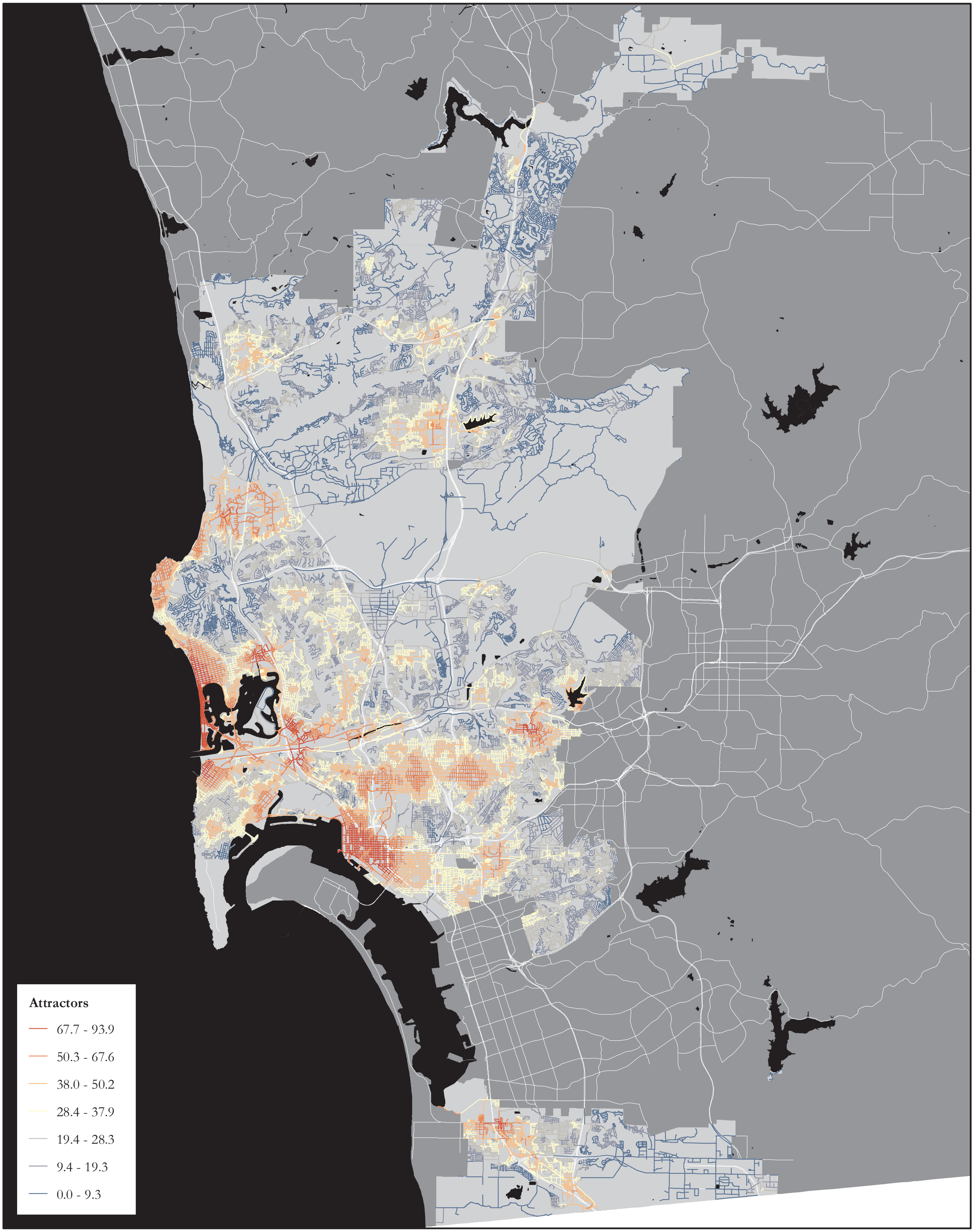


Figure 4-1

Bicycle Attractors - Intra-Community Submodel

4.1.2 Bicycle Generators

Bicycle generators are defined in terms of population sub-groups and employment likely to generate a bicycle trip. **Table 4.3** displays the specific factors used to reflect bicycle trip generation, along with the point and weight system applied to these inputs.

Figure 4-2 displays the resulting bicycle generator raster used for the intra-community bicycle demand submodel.

Table 4.3: Bicycle Generator Data Inputs and Assigned Points and Weights

Pedestrian Generators	Points	Weighting	Final Score
Population Density (people per acre)			
≥ 40	3	2	6
25 – 39.9	2		4
–5-24.9	1		2
< 5	0		0
Employment Density (jobs per acre)			
≥ 15	3	2	6
5 – 14.9	2		4
1 – 4.9	1		2
<1	0		0
Zero-Vehicle Households (percent of households)			
≥ 25%	3	2	6
15% – 24.9%	2		4
5% - 14.9%	1		2
<1%	0		0
Bicycling Commuters (percent of commuters)			
≥4%	3	2	6
2% – 3.9%	2		4
1% – 1.9%	1		2
<1%	0		0
Walking and Transit Commuters (percent of commuters)			
≥ 25%	3	2	6
15% – 24.9%	2		4
5% - 14.9%	1		2
<1%	0		0

Source: Adapted from City of San Diego Bicycle Master Plan, 2013

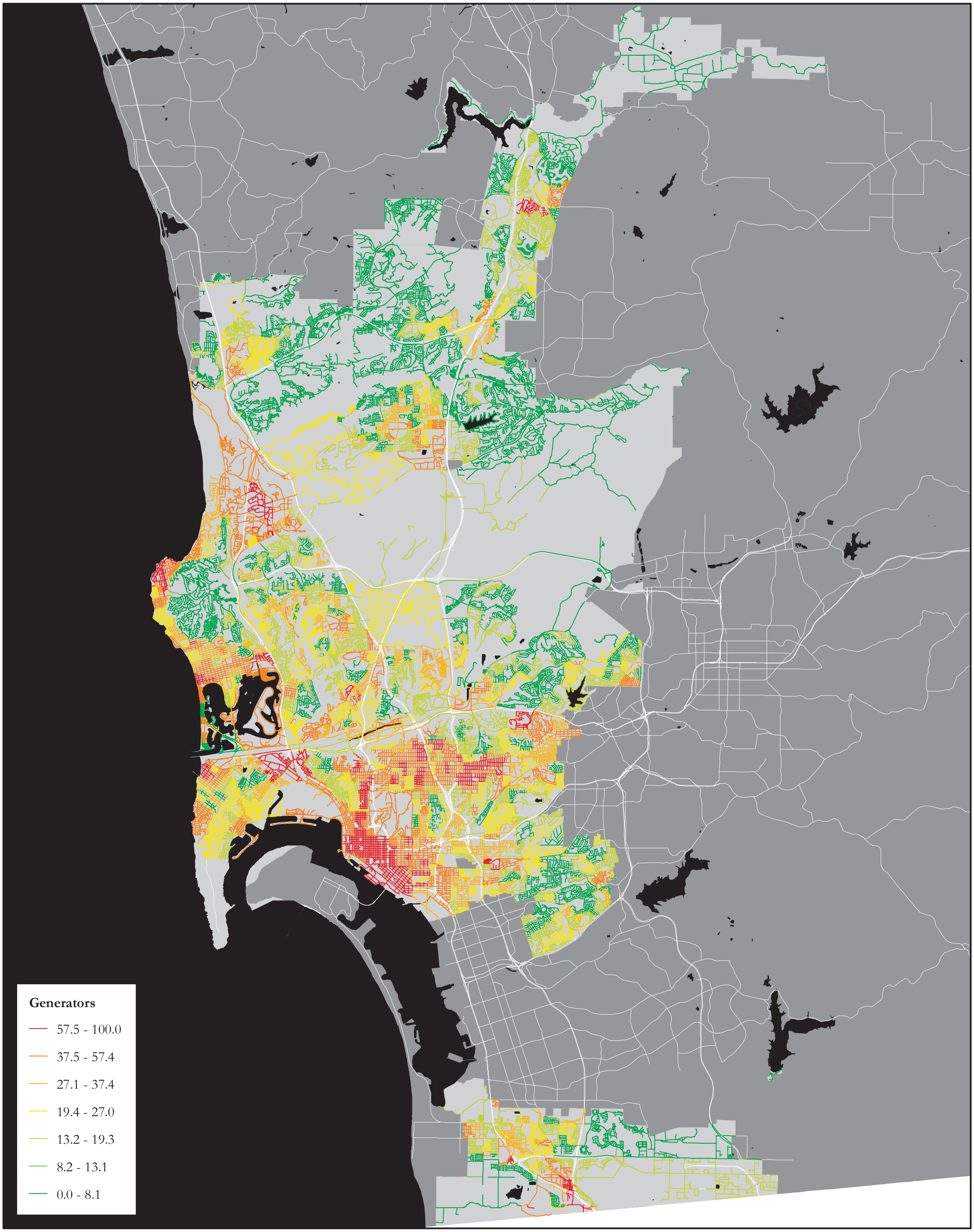


Figure 4-2

Bicycle Generators - Intra-Community Submodel

4.1.3 Defining Intra-Community Bicycle Demand Zones

Bicycle trip attractors and generators were summed to create a final intra-community bicycle demand score. This composite raster (attractors + generators) was then intersected with the bicycle planning network. The segments of the bicycle planning network that scored within the highest 50% were selected and assembled into high cycling demand zones.

Figure 4-3 displays the results of the combined attractor and generator rasters on the bicycle planning network, along with the top 50% scoring segments used to form the high intra-community bicycle demand zones. Key intra-community bicycle demand zones include the University City, La Jolla, Pacific Beach, Ocean Beach, Midway, Downtown, Mid-City, and the College Area communities.

Figure 4-4 displays City of San Diego Circulation Element roadway segments within high intra-community demand zones.

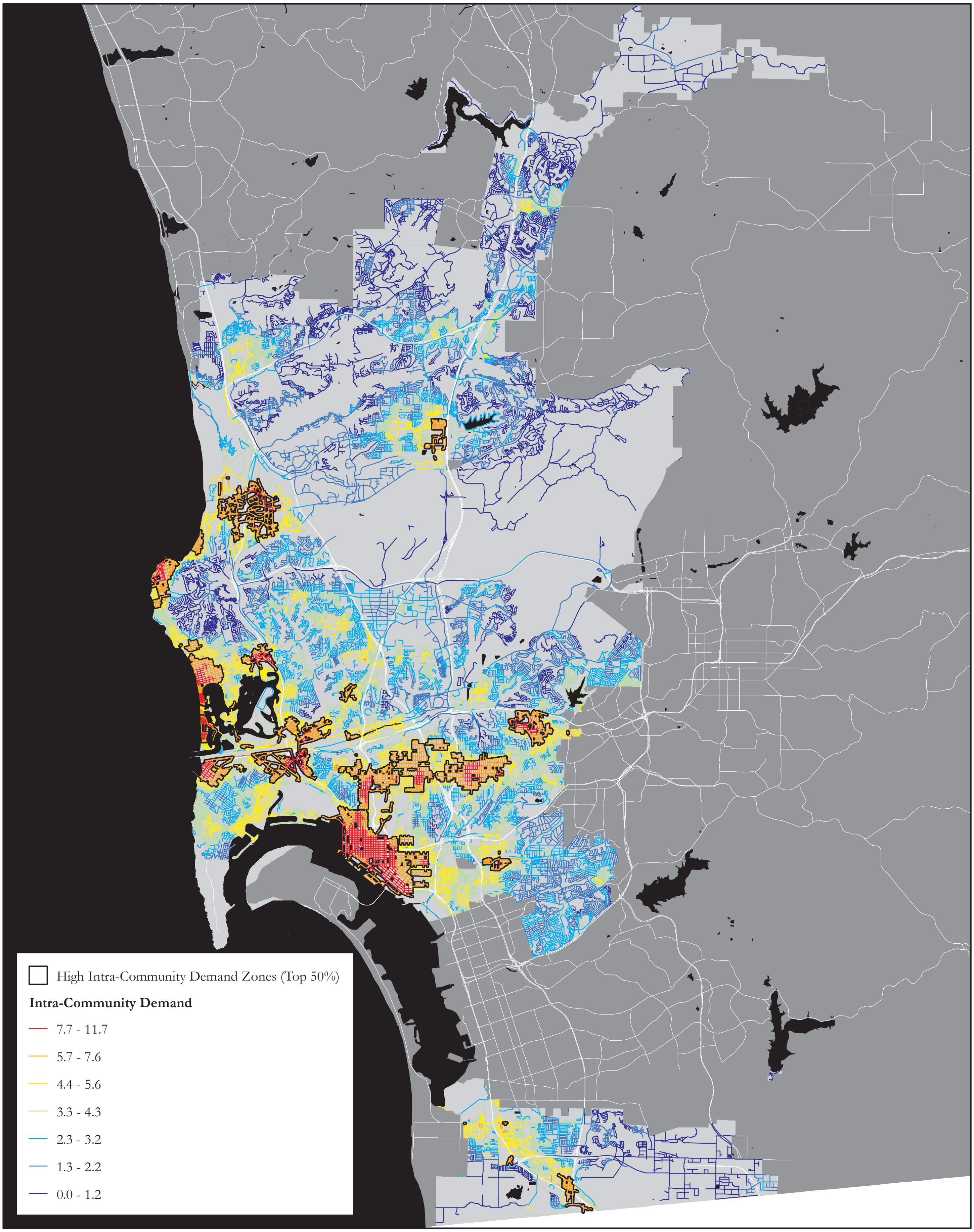


Figure 4-3

High Intra-Community Bicycle Demand Zones

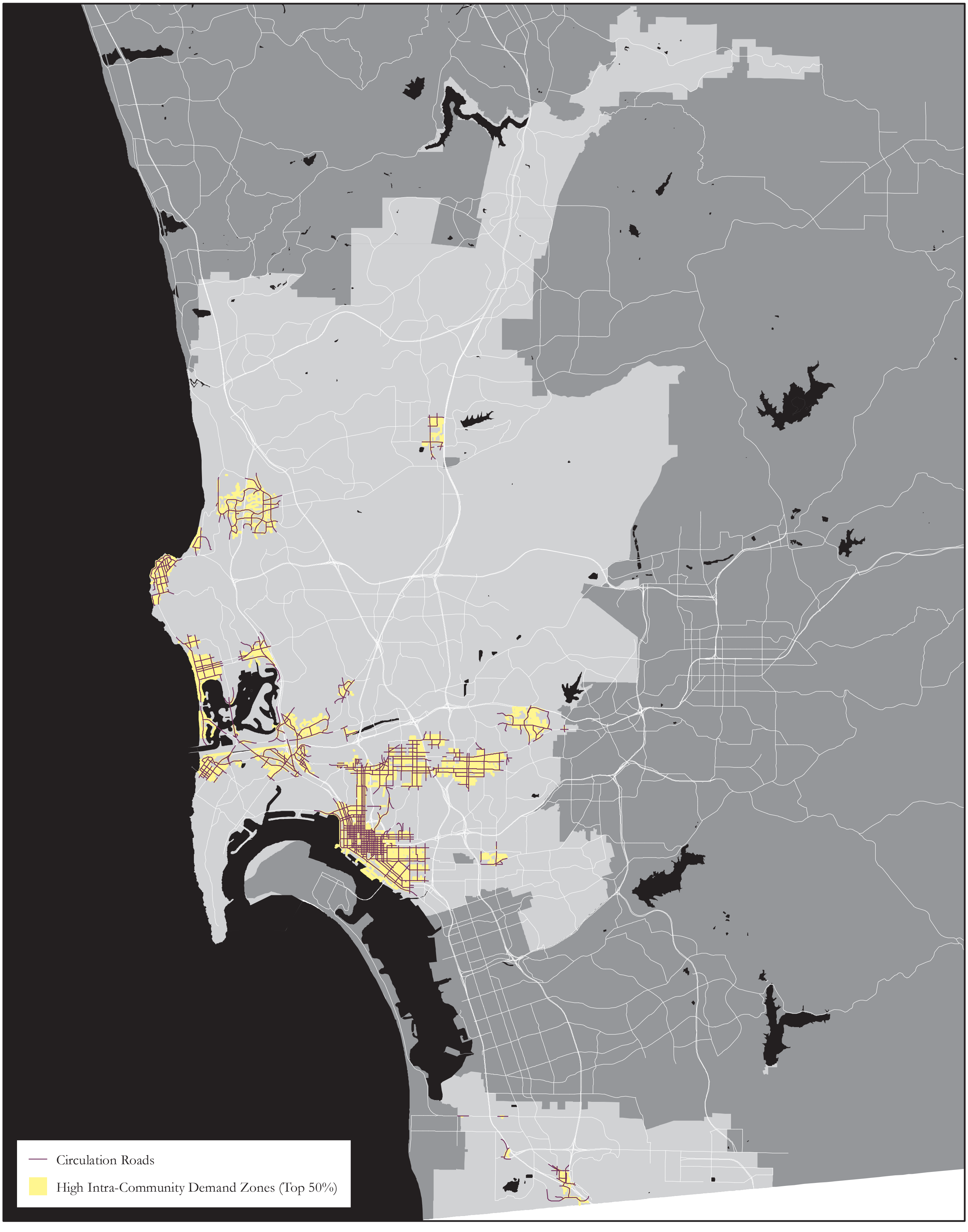


Figure 4-4

Circulation Element Roadways within High Intra-Community Bicycle Demand Zones

4.2 Inter-Community Submodel Points and Weights

The inter-community bicycle demand submodel utilizes a shortest path analysis to generate paths along the bicycle planning network (bikeable roadway network + bicycle facilities network), between activity centers across the City. Each activity center functions as an origin and destination pair in the shortest path analysis. As described in Chapter 2.0, SGOAs, large employment centers and the international borders are used to represent activity center origins and destinations for the purpose of this analysis.

Table 4.4 displays activity center place types used and their respective points based upon the residential and employment intensity of the activity center. As shown, Metropolitan Centers have the highest points since they are the most intense place types in terms of residential and employment densities, while Community Centers have the lowest points. A shortest path between an Urban Center and a Town Center, for example, would be assigned 4 points based on the intensity of the activity centers being connected.

Table 4.4: Activity Center Intensity Points

SGOA Type	Metropolitan Center	Urban Center	Town Center	Large Employment Centers	Community Center
Metropolitan Center[1]	6	6	5	4	3
Urban Center[2]	6	5	4	3	2
Town Center[3]	5	4	3	2	1
Large Employment Centers	4	3	2	1	1
Community Center	3	2	1	1	1

Source: Chen Ryan Associates, December 2015

As described in Chapter 2.0, the second component of the inter-community submodel considers the distance between activity centers. **Table 4.5** shows the points assigned based on distance between activity centers along the shortest connecting route.

Since there is an inverse relationship between cycling demand and travel distances, the point values are negative, with shorter distances, say 0 to 5 miles, having a lower level of 'dis-utility' than longer distances.

Table 4.5: Distance Decay Factors

Distance	Equation (mileage = x)	Maximum Distance Penalty
0 to 5 miles	x/5	-1
5 to 10 miles	1+[(x-5)/5]*2	-3
10 to 40 miles	3+[(x-10)/30]*3	-6

Source: Chen Ryan Associates, December 2015

[1] The San Ysidro Port of Entry is given the same base point value as a Metropolitan Center.

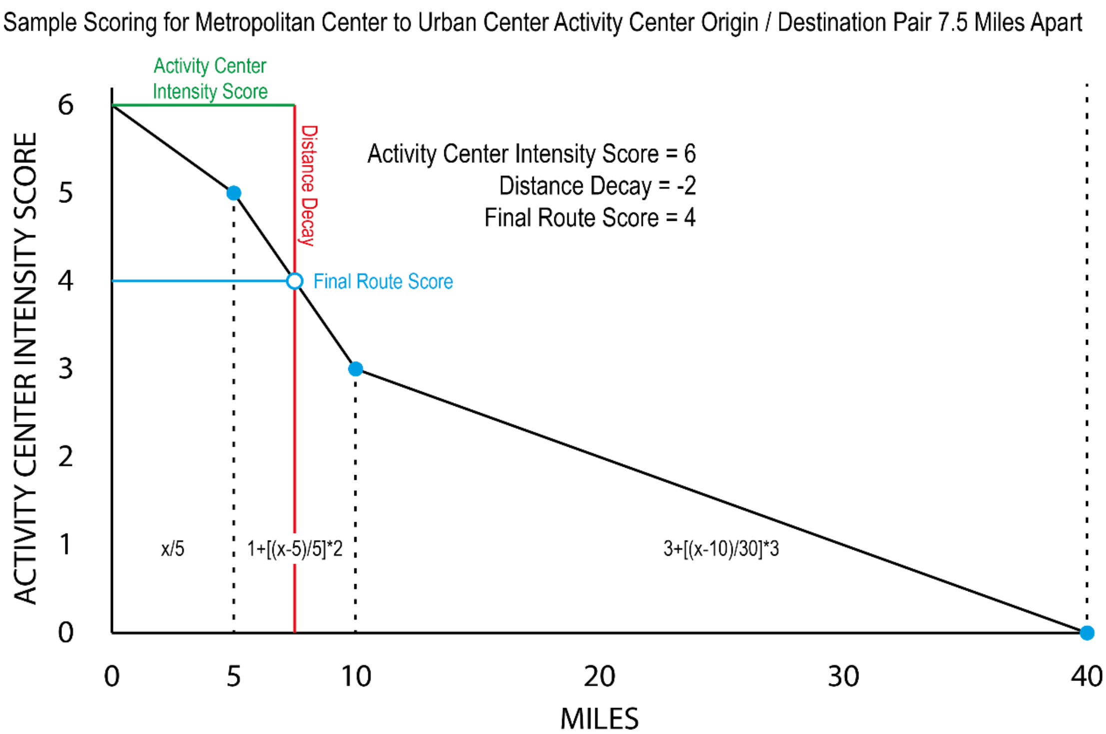
[2] SDSU and UCSD Special Use Centers are given the same base point value as an Urban Center.

[3] The Otay Mesa Port of Entry is given the same base point values as a Town Center.

In this two component scoring system presented in Tables 4.4 and 4.5, the activity center origin-destination pairs will typically score zero or a negative value for trips longer than 10 miles, which is reasonable given that the average bicycle trip length is about 3.5 miles. When the distance penalty or decay exceeds the activity center intensity score, the route receives zero points for inter-community demand and is determined to have no inter-community demand.

Figure 4-5 demonstrates how the activity center intensity score and the distance decay combine to generate a final route score for each activity center pair. Using Table 4.4, we see that the activity center intensity score is 6 based on the ranked interactions between Metropolitan Centers and Urban Centers. Then, using Table 4.5, we see that the distance decay equation is 1+[(x-5)/5]*2. Assuming x = 7.5 miles, and solving the equation, we calculate a distance decay score of -2. The final route score would be 6 – 2 = 4.

Figure 4-5: Activity Center and Distance Decay Calculation



After points associated with activity center intensity and distance decay are assigned to the bicycle planning network, the highest-point path and the log sum of all overlapping paths are calculated for each segment of the bicycle planning network.

Table 4.6 summarizes these components of the inter-community demand score.

Table 4.6: Inter-Community Demand Scoring for Bicycle Planning Network

Component of the Inter-Community Submodel Score	Description	Points Available
Highest-Point Path	Highest demand shortest path along every segment of the bicycle planning network	0-6 points
Log Sum of Overlapping Paths[1]	The log sum of the demand scores of all overlapping shortest paths along every segment of the bicycle planning network. The log sum transforms the points so that they fall along a scale that is in line with	0-6 points
Final Inter-Community Demand Score	Sum of two components above	0-12 points

Source: Chen Ryan Associates, December 2015

Note:

1) The log sum is applied here in order to transform the Overlapping Paths points so that they fall along a similar scale as the Highest-Point Paths, and so that the two inputs will be similarly weighted. If the log sum is not applied the Overlapping Paths points range from 0 to over 100.

As shown, the final inter-community submodel scores range from 0 to 12, and consists of a combination of the highest-point shortest path along the bicycle planning network (maximum cannot exceed 6 points) and the log sum of all overlapping paths (log sums exceeding 6 are awarded 6 full points; negative log sums are awarded 0 points). Including the log sum of points associated with overlapping paths provides network choke points with equal consideration to network connections occurring in high density areas with numerous network options. In other words, this including the log sum of all overlapping paths gives credit to those critical segments of the network where there are few alternative routes for cyclists, such as Pacific Highway over I-5 near Mission Bay, Genesee Avenue through Clairemont, or Bachman Place between Mission Valley and Uptown.

Figure 4-6 shows the highest-point routes generated from the shortest path analysis along the bicycle planning network. As shown, the highest scoring segments occur between Downtown (a Metropolitan Center, the SGOA type contributing to the highest demand base scores In Table 4.4) and the Urban Centers in adjacent neighborhoods, including Hillcrest, Old Town, Mission Hills, Barrio Logan and North Park. The blue symbols in Figure 4-6 represent activity center origins and destinations. The roadways serving the San Ysidro Port of Entry also receive demand scores in the highest category.

Figure 4-7 shows the log sum of overlapping paths along the bicycle planning network. As shown, a large number of paths generated from the shortest path analysis will converge to use paths through places with limited network options. Locations where this occurs include north-south travel through Mission Valley, the SR-56 corridor and Genesee Avenue between University Avenue and Linda Vista.

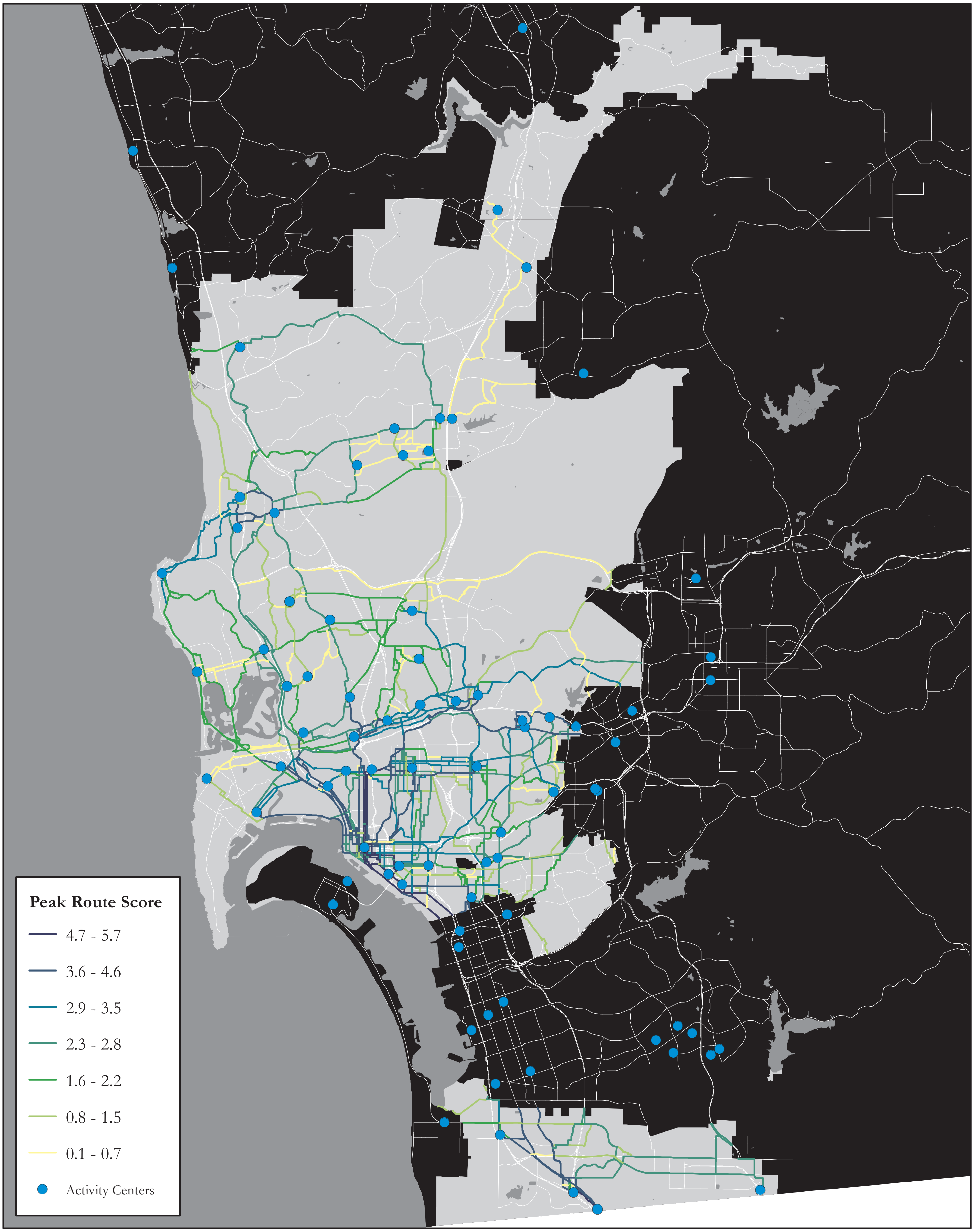


Figure 4-6

Peak Route Score - Inter-Community Submodel

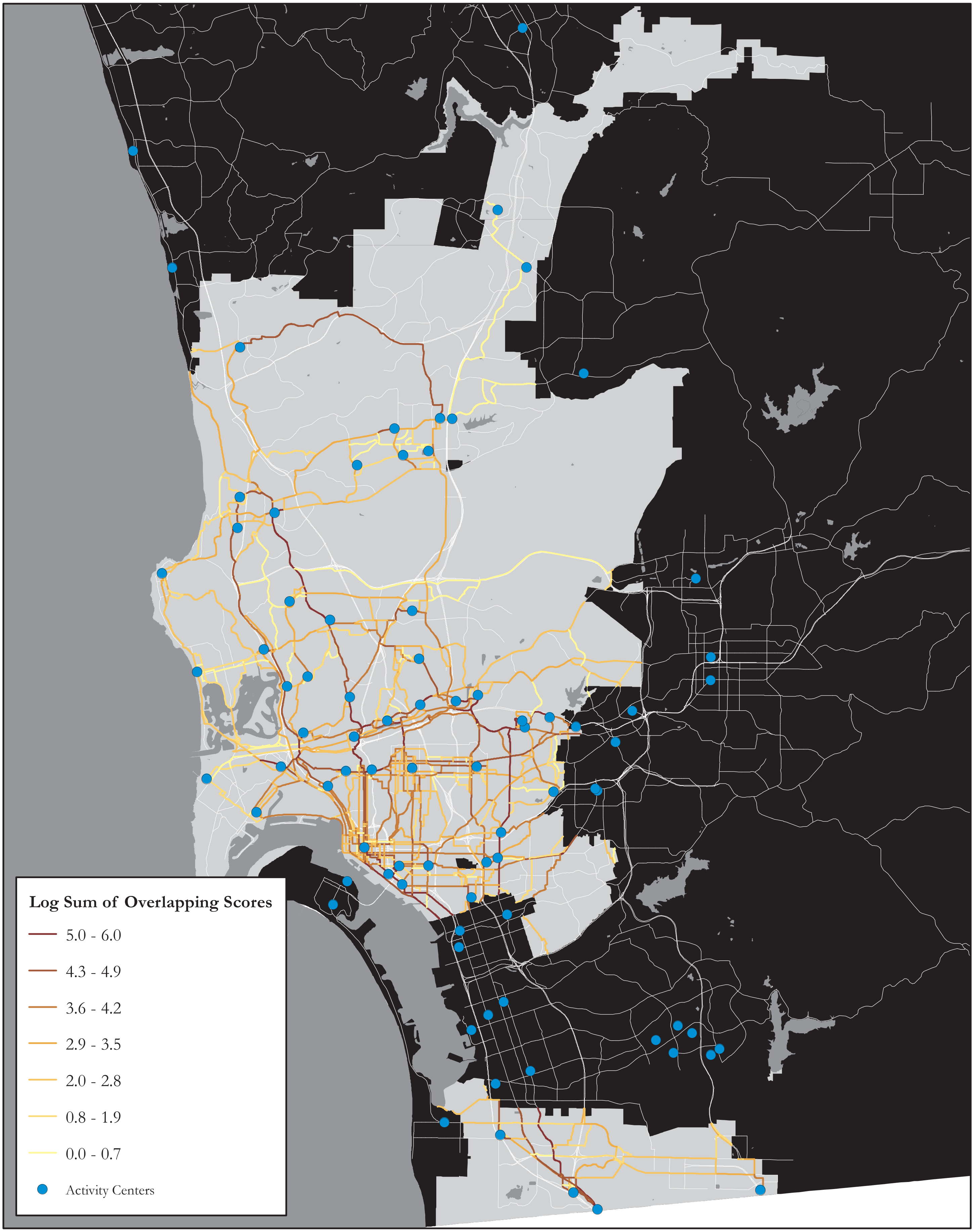


Figure 4-7

Log Sum of Overlapping Route - Inter-Community Submodel

Figure 4-8 presents the results of the inter-community submodel.

As shown, the highest inter-community demand appears along axes feeding into Downtown from the north (Uptown) and south (Barrio Logan and South Bay cities). Genesee Avenue through Clairemont Mesa scores high due to few other alternatives available for inter-community travel. Roadways serving the San Ysidro Port of Entry, San Diego State University and UC San Diego also score in the highest inter-community demand categories.

4.3 Combined Intra- and Inter-Community Demand

The demand scores from both the intra-community and inter-community submodels are combined to create the final BDM score. Each component of demand was weighted evenly on a 12 point scale, thus the maximum possible score is 24 points.

Figure 4-9 displays the final BDM score. As shown, combined intra- and inter-community demand is very high in the central communities surrounding downtown (Uptown, Southeastern San Diego, North Park and City Heights). Mira Mesa, University City, La Jolla, Mission Valley, College Area, Pacific Beach, Ocean Beach, Peninsula and San Ysidro also show high combined demand.

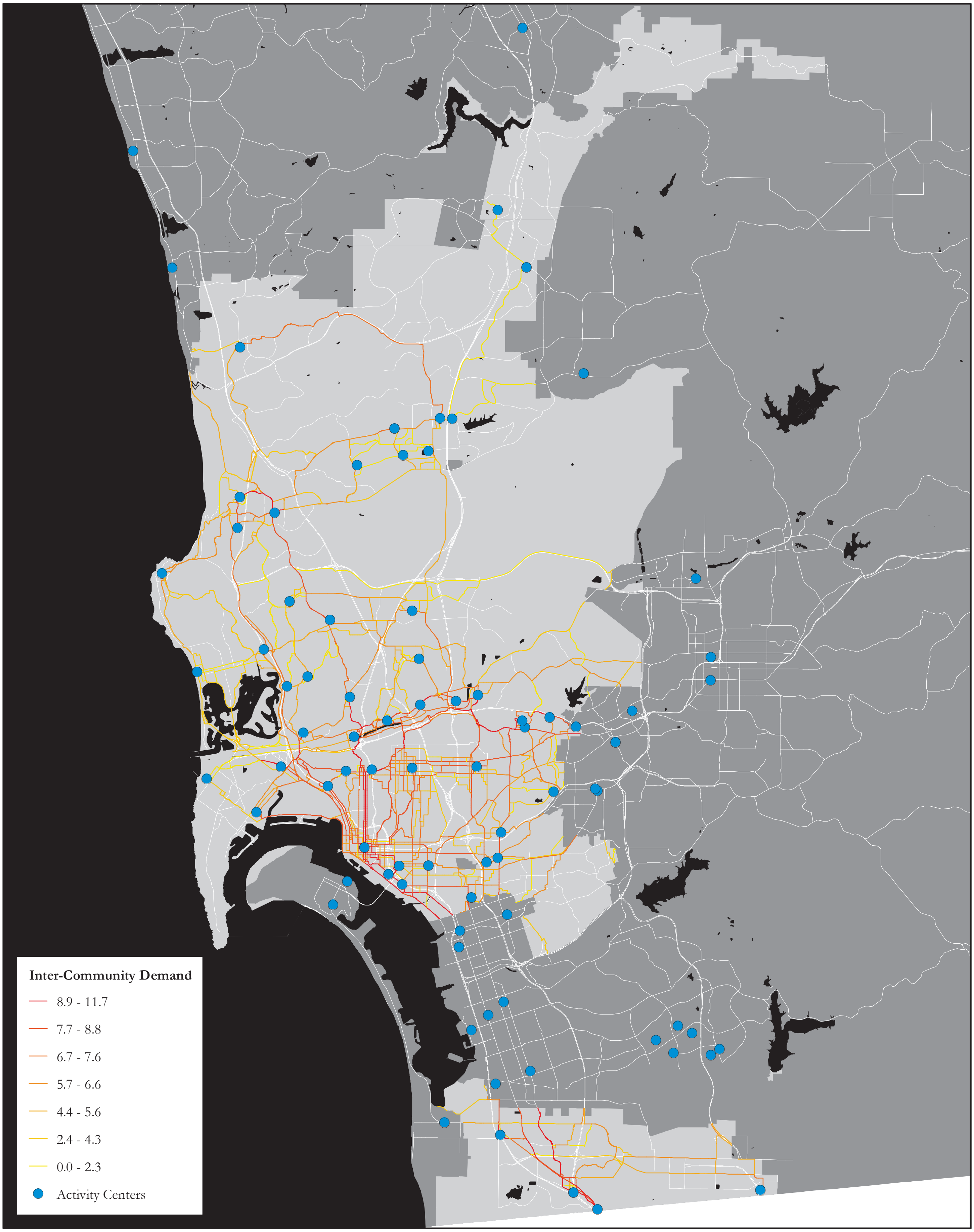


Figure 4-8

Inter-Community Submodel Demand Scores

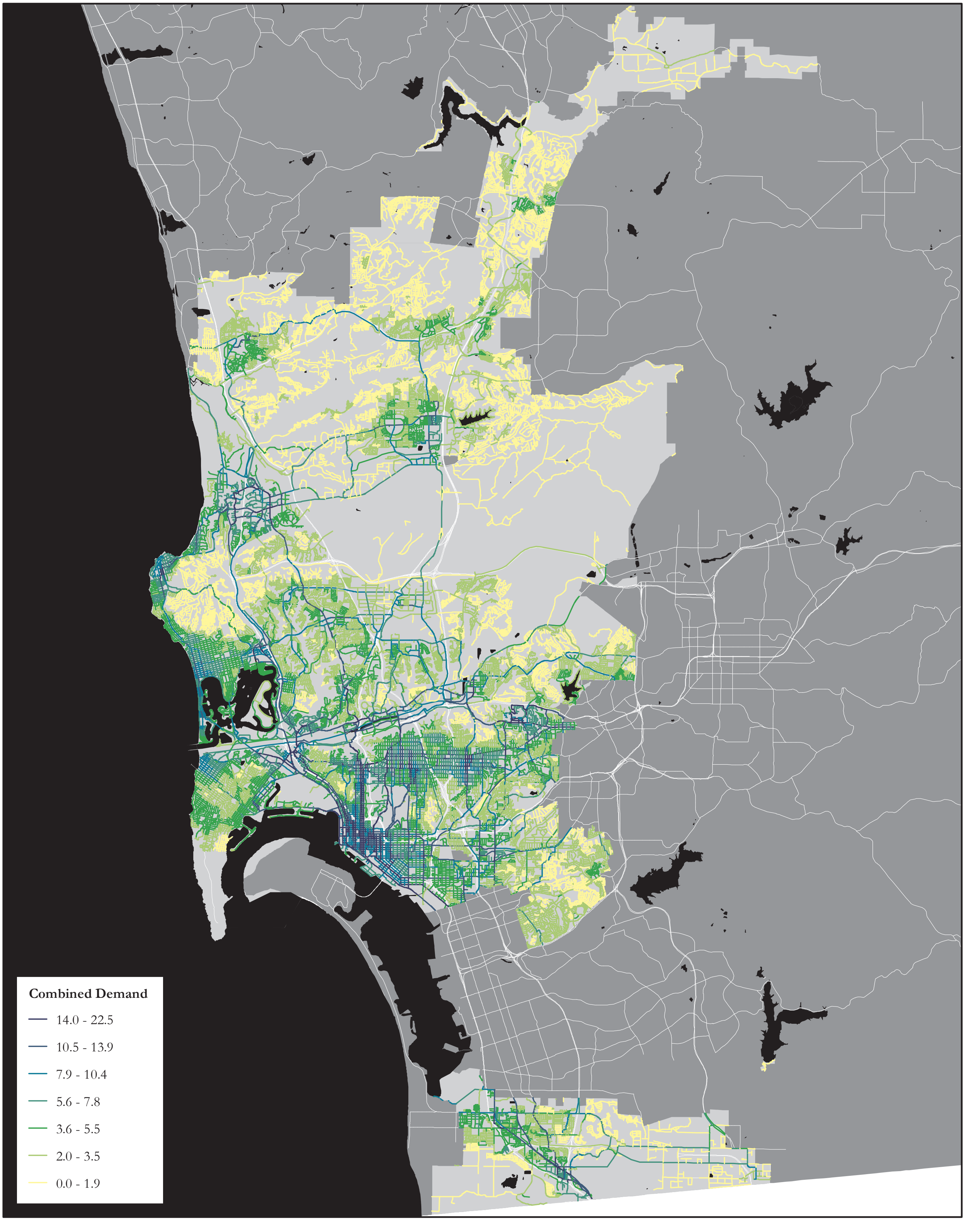


Figure 4-9

Final BDM Score - Combined Intra- and Inter-Community Demand

5.0 GIS Steps

This section of the report presents detailed analysis steps for developing the BDM in ArcGIS 10.1. It is intended to facilitate other consultant's and City staff's ability to replicate or modify the inputs and model development process. Section 5.1 presents GIS steps for creating the intra-community demand submodel – including its bicycle attractors and generators, Section 5.2 focuses on the inter-community demand submodel, and Section 5.3 summarizes steps to create the final BDM model.

To facilitate ease of reading, the following formatting rules were applied:

- Single quotes are used (' ') to denote text input in ArcGIS 10.1.
- ArcGIS tools and tool suites are noted in blue, bold text.
- All fieldnames are capitalized.
- All data inputs are referred to by the "Model Input" and "Input #" fields from Tables 3.1 and 3.2.

5.1 Intra-Community Bicycle Demand Submodel GIS Steps

5.1.1 Bicycle Attractors

There are a total of 10 inputs used to create the intra-community submodel's bicycle attractor raster surface. Eight of these inputs are land use polygon shapefiles (Inputs #3-#10 in Table 3.1), while two of these inputs are point shapefiles (Inputs #1 and #2 in Table 3.1). Development of the bicycle attractor raster surface requires 6 key steps as summarized in the list below:

- **Step 1.0** describes how to develop the land use inputs from the regional land use shapefile.
- **Steps 2.0** and **3.0** describe the process for creating a network dataset and developing street network buffers around the attractor inputs.
- **Step 4.0** describes buffer creation, rasterization and point assignment for the eight land use inputs and the pedestrian intensive border crossings input (Inputs #1-#3-#10).
- **Step 5.0** explains how Input #4 (transit ridership) was processed in its entirety, since this data type is different than the other attractor inputs.
- **Step 6.0** describes the map algebra employed to sum the points associated with each of the attractor inputs into a common raster surface reflecting pedestrian attractors.

Each of these steps is described in detail in terms of the ArcGIS 10.1 techniques employed.

Step 1.0: Create Attractor Input Shapefiles *(Inputs #1-#3, #6-#8, and #10-#11 shown in Table 3.1)* from the Regional Land Use and Regional Class I Input Shapefile (Input #5)

1.1 Export attractor input land use shapefiles from the LANDUSE_CURRENT shapefile.

Refer to Table 3-1 for documentation of which land use category names comprise each land use input in the attractor submodel. Use **Select by Attributes** to select the land use category names needed for each attractor input, then export data.

1.2 Generate point shapefiles from each attractor input shapefile.

a) Input each of the attractor input land use shapefiles into the **Feature Vertices to Point** tool, which is located in the **ArcToolbox** under **Data Management Tools/Features**.

b) Use the **Select by Location** tool on the point shapefile generated in Step 1.2a to select all points within 65 feet of the roads centerline shapefile. Export selection.

1.3 Perform Steps 1.1 and 1.2 for all attractor inputs which are polygon shapefiles (all inputs except for Transit Ridership Input #4 and Smart Growth Opportunity Areas Input #9).

1.4 Export all Regional Class I Bicycle Paths from the bike shapefile into separate shapefile.

1.5 Perform Step 1.2 on the Regional Class I Bicycle Path shapefile created in previous step.

Step 2.0: Prepare Roads Shapefile for Network Analysis

2.1 Eliminate unwanted features from roads shapefile.

Modify the Roads_all shapefile by selecting and removing (or exporting the inverse of the selection) all functional classification categories (fieldname = FUNCLASS) which should not be included in the pedestrian network. The following FUNCLASS categories were deemed unsuitable to include in the network dataset and should be removed:

- Freeway (F)
- Ramps (R)
- Expressway (E)
- Military Base Roads (M)
- Paper Streets (P)
- Alleys (A)
- Freeway-to-Freeway Ramps (1)

2.2 Create a network dataset.

Create a network dataset from the modified or newly exported Roads_all shapefile. Open **ArcCatalog** and browse to the location of the shapefile. Right-click and choose New, then choose **New Network Dataset** to open the new network dataset wizard.

2.3 *Follow the steps of the new network dataset wizard:*

a) Enter a name for the network dataset. Click Next.

b) Choose No for modeling turns. Click Next.

c) Select End Point for the connectivity policy. Click Next.

d) Choose Using Elevation Fields and specify the fields F_LEVEL under From End and T_LEVEL under To End. Click Next.

e) Double-click Length and specify the length attribute fieldname from the modified Roads_all shapefile (make sure your length attribute is in feet). Remove One-Way so that Length is the only attribute. Click Next.

f) Choose No for establishing driving directions. Click Next. Click Finish.

g) Choose Yes to build the network dataset.

2.4 *Activate the **Network Analyst Extension**.*

Go to **Customize** on the Main Menu, choose Extensions and check the box next to Network Analyst. Click Close.

*2.5 Add the **Network Analyst Toolbar** to your screen.*

Go to **Customize** on the Main Menu, choose Toolbars, then choose **Network Analyst**.

Step 3.0: Create Street Network (or Service Area) Buffers from the Attractor Inputs

3.1 Perform service area analysis.

From the **Network Analyst Toolbar** drop-down list, choose **New Service Area**. Activate the network analyst window by clicking on the button next to the **Network Analyst Toolbar** drop-down list.

3.2 *Establish correct service area settings under the various properties tabs.*

a) Click the Service Area Properties box in the network analyst window.

b) Under the Polygon Generation tab, make sure the Detailed, Merge by Break Value and Rings setting buttons are selected.

c) Under the Network Locations tab, make sure the Exclude Restricted Portions of the Network box in the lower left corner is checked.

d) Under the Analysis Settings tab, enter '1320, 2649, 3960, 5280' into the text box. These are the buffer distances used in the attractor raster surface development process. Close out of the service area properties window when these settings are completed. Once these settings are made, they will remain unchanged. Due to the extensive geographic coverage of Input #10 Retail, only buffer that input at the quarter-mile (1320) distance.

3.3 Load attractor input point shapefile into Facilities in the network analyst window.

In the network analyst window, right-click Facilities and choose Load Locations. When the load locations window opens, specify the attractor input point shapefile to be analyzed. Choose OK and the locations will begin loading.

3.4 Solve service area.

Once the locations have been loaded, click the **Solve** tool on the **Network Analyst Toolbar**. This will generate a set of street network buffers at the four specified distances set in Step 3.2d.

3.5 Export buffer outputs.

Right-click the word Polygon in the network analyst window and export buffer outputs as a shapefile.

3.6 Repeat Steps 3.3 through 3.5 for all attractor inputs except for the Transit Ridership Input #4 and Smart Growth Input #9.

Repeat Steps 3.3 through 3.5 for each attractor input point shapefile except for the Inputs #4 and #9. Prior to each new buffering process for each subsequent attractor input, delete the cached Facilities and Polygons from the previous attractor input analyzed in the network analyst window. Subsequent steps will explain how to process Inputs #4 and #9.

Step 4.0: Create Raster Files from Buffer Outputs

4.1 Generate a raster file from the street network buffer shapefile created in Step 3.5.

Use the **Polygon to Raster** tool located in the **ArcToolbox** under **Conversion Tools/To Raster**. When the polygon to raster tool window opens, add the street network buffer shapefile created in Step 3.5 under Input Features. Specify 'Name' under Value. Specify a location for saving the raster output file. Change Cellsize to '75'. Hit OK.

4.2 *Add point values to the street network buffer raster from the previous step using the **Reclassify** tool.*

The **Reclassify** tool is located in the **ArcToolbox** under **Spatial Analyst Tools/Reclass**. When the reclassify tool window opens, add the street network buffer raster under Input Raster. The Old Values should display the distance ranges. Under New Values, enter the point values associated with land use attractor points, weights and buffer distances presented in Tables 3.1 and 3.2. The **Reclassify** tool does not recognize decimals, so each point value will have to be multiplied by 4 (the lowest common denominator of distance multipliers which creates whole numbers). Assign '0' points under NoData. Specify a location for saving the output under Output Raster. Click the Environments button, expand Processing Extent, and choose the City of San Diego boundary shapefile. Click OK to exit Environments. Click OK to run the tool.

4.3 Repeat Steps 4.1 and 4.2 for each remaining attractor input point shapefile except for Transit Ridership Input #2.

Step 5.0: Create Street Network Buffers and Rasters from Transit Ridership Input #4

5.1 Extract transit stops with combined boardings and alightings greater than 1,000 from the transit ridership shapefile.

5.2 Perform Steps 3.3 through 3.5 (creating buffers) for the extracted transit ridership shapefile resulting from Step 5.1.

5.3 Generate a raster file from the transit ridership buffer shapefile created in the Step 5.2.

Use the **Polygon to Raster** tool located in the **ArcToolbox** under **Conversion Tools/To Raster**. When the polygon to raster window opens, add the transit ridership shapefile under Input Features. Select the Points field under Value. Specify a location for saving the transit ridership raster output file. Change Cell size to '75'. Hit OK.

5.4 Add point values to transit ridership raster from Step 5.3 using the ***Reclassify*** *tool.*

The **Reclassify** tool is located in the **ArcToolbox** under **Spatial Analyst Tools/Reclass**. When the reclassify tool window opens, add the transit ridership raster from Step 5.3 under Input Raster. The Old Values should display the distance ranges. Under New Values, enter the point values associated with attractor points, weights and buffer distances presented in Tables 3.1 and 3.2. Specify a location for saving the file under Output Raster. Click the Environments button, expand Processing Extent, and choose the City of San Diego boundary shapefile. Click OK to exit Environments. Click OK to run the tool.

Step 6.0: Create Smart Growth Opportunity Area Input #9 Buffers and Rasters

6.1 Export the Smart Growth Opportunity Area input shapefile from the SmartGrowthAreas2014 shapefile.

Refer to Table 3-1 for documentation of which category names comprise the Smart Growth Opportunity Area input in the attractor submodel. Use **Select by Attributes** to select the category names, then export data.

6.2 Convert the Smart Growth Opportunity Area shapefile from polygon to lines

Use the **Polygon to Line** tool located in the **ArcToolbox** under **Data Management/Features**. When the tool window opens, add the Smart Growth Opportunity Area shapefile created in under Input Features. Specify a location for saving the output file. Hit OK.

6.3 Intersect the Smart Growth Opportunity Area line shapefile with the Roads shapefile.

Use the **Intersect** tool located in the **ArcToolbox** under **Analysis Tools/Overlay**. When the tool window opens, add the Smart Growth Opportunity Area line shapefile created in the previous step and the Roads shapefile under Input Features. Specify a location for saving the output file. Change the Output Type to point. Hit OK.

6.4 Perform Steps 3.3 through 3.5 (creating buffers) for the point shapefile resulting from intersect in Step 6.3.

6.5 Generate a raster file from the Smart Growth Opportunity buffer shapefile created in the Step 6.4.

Use the **Polygon to Raster** tool located in the **ArcToolbox** under **Conversion Tools/To Raster**. When the polygon to raster window opens, add the Smart Growth Opportunity Area buffer shapefile under Input Features. Select the Points field under Value. Specify a location for saving the raster output file. Change Cell size to '75'. Hit OK.

*6.6 Add point values to Smart Growth Opportunity Area raster from Step 6.5 using the **Reclassify** tool.*

The **Reclassify** tool is located in the **ArcToolbox** under **Spatial Analyst Tools/Reclass**. When the reclassify tool window opens, add the Smart Growth Opportunity Area raster from Step 6.5 under Input Raster. The Old Values should display the distance ranges. Under New Values, enter the point values associated with attractor points, weights and buffer distances presented in Tables 3.1 and 3.2. Specify a location for saving the file under Output Raster. Click the Environments button, expand Processing Extent, and choose the City of San Diego boundary shapefile. Click OK to exit Environments. Click OK to run the tool.

Step 7.0: Combine Input Rasters to Create Attractor Raster Surface

6.1 Create a composite attractor raster surface from the reclassified rasters generated in Step 4.2, Step 5.4 and Step 6.6.

Open the **Raster Calculator** tool located in the **ArcToolbox** under **Spatial Analyst Tools/Map Algebra**. Add each reclassified raster into a summation equation. Specify a location for saving the output rasters and hit OK. This last step generates the final bicycle attractor raster surface.

5.1.2 Bicycle Generators

There are a total of 5 inputs used to create the intra-community submodel bicycle generator raster surface. All five of these inputs are obtained from census data (Inputs #1 - #5 in Table 3.2). Development of the bicycle generator raster surface requires 8 key steps as summarized in the list below:

- **Step 1.0** describes how to download and prepare tabular census data used to create generator Inputs #1, #2, #4 and #5.
- **Steps 2.0** and **3.0** describe the process for preparing a Census Block Group (CBG) shapefile for joining and processing tabular census data.
- **Step 4.0** describes the process for calculating Input #3 (employment density) and joining the data to the CBG shapefile.
- **Step 5.0** describes the rasterization and point assignment used for Inputs #1 - #5.
- **Step 6.0** describes the map algebra employed to sum the points associated with each of the generator inputs on a common raster surface.

Each of these steps is described in detail in terms of the ArcGIS 10.1 techniques employed.

Step 1.0: Download and Prepare Census Data

1.1 Use the US Census American Fact Finder Download Center to download the 2013 American Community (ACS) Survey 5-Year Estimate tabular datasets for all CBGs in San Diego County.
http://factfinder.census.gov/faces/nav/jsf/pages/download_center.xhtml

The following census tables should be downloaded by CBG:

- TOTAL POPULATION (Table B01003)
- MEANS OF TRANSPORTATION TO WORK (Table B08301)
- TENURE BY VEHICLES AVAILABLE (Table B25044)

1.2 Open each dataset from Step 1.1, remove unnecessary data fields, and then prepare the spreadsheet for tabular joining in GIS.

Refer to Table 3.2 to determine which data fields from the downloaded ACS datasets are necessary for producing the generator inputs. Some inputs may require calculation of multiple fields, as shown in Table 3.2. After cleaning each spreadsheet, save them as .csv files.

Step 2.0: Prepare the Census Block Group Shapefile

2.1 Download the 2010 CBG shapefile for San Diego County.

A CBG shapefile may be downloaded from the US Census TIGER/Line Data Clearinghouse. https://www.census.gov/cgi-bin/geo/shapefiles2010/main

2.2 Change the coordinate system of the data frame to AD_1983_StatePlane_California_VI_FIPS_0406_Feet.

Open a new map document. Right-click Layers in the Table of Contents and choose Properties. Navigate to the Coordinate System tab. Set your data frame coordinate system to *NAD_1983_StatePlane_California_VI_FIPS_0406_Feet.*

You can type the coordinate system name into the search box for instant navigation.

2.3 Re-export the CBG shapefile so that it assumes the coordinate system of the data frame.

Re-export the CBG shapefile. When the export data window appears, click the button next to Use the Same Coordinate System as the Data Frame. Discard the previous CBG shapefile and use the newly exported CBG shapefile.

2.4 Add new fields to the CBG shapefile to store generator inputs and acreage data.

a) Open the CBG shapefile attribute table and add new fields (using the Double field type) called Population, Population Density, Total Commuters, Bike Commuters, Percent Bike Commuters, Youth Population, Youth Density, Median Income, Employment and Employment Density. There are character limits on field headers, so choose abbreviated titles for each.

b) Add three additional fields (using the Double field type) to the attribute table of the CBG shapefile named Acres, Water Acres and Adjusted Acres. Select Area in the calculate geometry window under Properties. Select Acres US [ac] in the calculate geometry window under units.

2.5 Merge the ocean and lakes shapefiles and intersect with the CBG shapefile.

Download the SanGIS lakes and Pacific Ocean shapefiles. Combine them by activating **Edit Mode** on the lakes shapefile and select, copy and paste the Pacific Ocean feature into the lakes shapefile. Save edits and exit **Edit Mode**. Use the **Intersect** tool in the **ArcToolbox** under **Analysis/Overlay** to intersect the lakes and ocean shapefile with the CBG shapefile.

2.6 Calculate and summarize water acreage by CBG and then join water acreage to CBG shapefile.

a) Open the lakes and ocean intersect shapefile and create a new field (using the Double field type) called Water Acres. Right-click the header of the Water Acres field and choose **Calculate Geometry**. Select Area in the calculate geometry window under Properties. Select Acres US [ac] under Units in the calculate geometry window. Right-click the field called CBG ID, choose **Summarize**. Select the Water Acres field in the window, summarize and check Sum. Click OK and add the newly created Water Acres summary table to the map document.

b) Join the Water Acres summary table to the CBG attribute table, and copy Water Acres from the summary file to the Water Acres field in the CBG shapefile using **Field Calculator**. Calculate the Adjusted Acres by subtracting Acres from Water Acres using the **Field Calculator**. All density calculations should be processed using the Adjusted Acres.

Step 3.0: Join the Tabular Census Data and Calculate Population Densities, Commute Mode Share Percentages and Percentage of Households with Zero Vehicles in the CBG Shapefile

3.1 Join the tabular census data to the CBG shapefile.

Add each .csv file created in Step 1.2. Join each .csv file to the CBG shapefile and copy the relevant data, which includes population, percent bike commuters, percent of combined walk and transit commuters and percent of zero-vehicle households into the attribute fields created in Step 2.4a. Join, copy data and remove each joined .csv file one-by-one.

3.2 Calculate density for population.

Right-click the respective Density fieldnames and use **Field Calculator** to divide the relevant census data by Adjusted Acres. For instance, to calculate Population Density, divide Population by Adjusted Acres.

Step 4.0: Join the Employment Data to the CBG Shapefile

4.1 Add the employment shapefile from (points_2012 shapefile) to the map document and perform a spatial join with the CBG shapefile.

Join the points_2012 shapefile to the CBG shapefile. When the join window opens, change the drop-down from "What do you want to join to this layer?" to "Join data from another layer based on spatial location." In the upper drop-down, choose points_2012.shp. In the lower dropdown, make sure the first button is selected and check the box next to Sum. Specify a location for saving the spatial join output file and click OK.

4.2 Perform a tabular join using the spatial join shapefile from Step 4.1 to the CBG shapefile.

Populate the Employment field in the CBG shapefile with the field called Sum_c000 from the spatial join shapefile. In the Employment Density field, divide Employment by Adjusted Acres.

Step 5.0: Generate Rasters from the Population and Employment data in the CBG Shapefile

5.1 Generate raster files from the data in the CBG shapefile.

Use the **Polygon to Raster** tool in the **ArcToolbox** under **Conversion Tools/To Raster**. When the **Polygon to Raster** tool window opens, add the CBG shapefile under Input Features. Under Value, specify one of following fields:

- Population Density
- Youth Density
- Percent Bike Commuters
- Median Income
- Employment Density

Specify a location for saving the population and employment raster output files. Change the Cellsize to '75.' Hit OK.

5.2 Repeat Step 5.1 until a raster output file has been created for each of the population and employment inputs.

5.3 Add point values to the population and employment rasters from the previous Step 5.2 using the ***Reclassify*** *tool.*

The **Reclassify** tool is located in the **ArcToolbox** under **Spatial Analyst Tools/Reclass**. When the reclassify tool window opens, add one of the population and employment rasters under Input Raster. Click the Classify button to set the category breaks specified in Table 4.3. Click OK. In the reclassify tools window, the Old Values will now show the class breaks. Under New Values, specify the Final Points values, also listed in Table 4.3, for the respective generator input being processed. Assign '0' points under NoData. Specify a location for saving the output file under Output Raster. Click the Environments button, expand Processing Extent, and choose the City of San Diego boundary shapefile. Click OK to exit Environments. Click OK to run the tool.

5.4 Repeat Step 5.3 until a reclassified raster file has been created for all population and employment inputs listed in Step 5.1.

Step 6.0: Combine Input Rasters to Create the Bicycle Generator Raster Surface

8.1 Create a composite bicycle generator raster surface from the reclassified rasters generated in Steps 5.3 and 5.4.

Open the **Raster Calculator** tool located in the **ArcToolbox** under **Spatial Analyst Tools/Map Algebra**. Add each reclassified raster into a summation equation. Specify a location for saving the generators raster output file and hit OK. This last step generates the bicycle generator raster surface.

5.2 Inter-Community Bicycle Demand Submodel GIS Steps

There are a total of 5 inputs required to create the inter-community submodel: an all-roadways shapefile, existing bicycle facilities, proposed bicycle facilities, Smart Growth Opportunity Areas (SGOAs) and Large Employment Centers. Development of the inter-community bicycle demand submodel requires 5 key steps as summarized in the list below:

- **Step 1.0** describes the process for creating a network dataset for all bikeable roadways Input #1.
- **Steps 2.0** describes the processing of SGOAs Input #4 and Large Employment Centers Input #5, as well as the shortest path analysis used to create inter-community paths and the subsequent processing of the path output for scoring.
- **Step 3.0** describes the process for creating a network dataset for the existing and proposed bicycle network Inputs #2 and #3.
- **Step 4.0** describes the shortest path analysis used to create inter-community paths and the subsequent processing of the path output for scoring.
- **Step 5.0** describes the process of combining the two sets of paths (from the bikeable roadways and the existing/planned bicycle facilities) into one dataset, as well as calculating the final inter-community points.

Each of these steps is described in detail in terms of the ArcGIS 10.1 techniques employed.

Step 1.0: Prepare a Roads Shapefile (Input #1) for Network Analysis

1.1 Eliminate unwanted features from Roads_all shapefile.

Modify the Roads_all shapefile by selecting and removing (or exporting the inverse of the selection) all functional classification categories (fieldname = FUNCLASS) which should not be included in the pedestrian network. The following FUNCLASS categories were deemed unsuitable to include in the network dataset and should be removed:

- Freeway (F)
- Ramps (R)
- Expressway (E)
- Military Base Roads (M)
- Paper Streets (P)
- Alleys (A)
- Freeway-to-Freeway Ramps (1)

1.2 Modify one-way roads attribute in the Roads_all shapefile.

Open the Roads_all attribute table and create two new fields (using the Short Integer field type) called F_ONEWAY and T_ONEWAY. Use **Select by Attributes** to select one-way road features from the original ONEWAY field. Select all features attributed with an 'F' from the original ONEWAY field and attribute those features with a ‘1’ in the F_ONEWAY field. Now use **Select by Attributes** to select all the features with a T in the original ONEWAY field and attribute those features with a 1 in the T_ONEWAY field.

1.3 Create a network dataset.

Create a network dataset from the modified or newly exported Roads_all shapefile. Open **ArcCatalog** and browse to the location of the shapefile. Right-click and choose New, then choose **New Network Dataset** to open the new network dataset wizard.

1.4 Follow the steps of the new network dataset wizard.

a) Enter a name for the network dataset. Click Next.

b) Choose No for modeling turns. Click Next.

c) Select End Point for the connectivity policy. Click Next.

d) Choose Using Elevation Fields and specify the fields F_LEVEL under From End and T_LEVEL under To End. Click Next.

e) Double-click Length and specify the length attribute fieldname from the modified Roads_all shapefile (make sure your length attribute is in feet). Double-click One-Way, specify the fields F_ONEWAY under From End and T_ONEWAY under To End. Click Next.

f) Choose No for establishing driving directions. Click Next. Click Finish.

g) Choose Yes to build the network dataset.

*1.5 Activate the **Network Analyst** extension.*

Go to **Customize** on the Main Menu, choose Extensions and check the box next to **Network Analyst**. Click Close.

*1.6 Add the **Network Analyst Toolbar** to your screen.*

Go to **Customize** on the Main Menu, choose Toolbars, then choose **Network Analyst**.

1.7 Digitize bike paths to the network dataset.

Activate **Edit Mode** and digitize all existing Class I Bike Paths not currently in the Roads_all shapefile being used in the network dataset. While digitizing, ensure proper connectivity by snapping the Class I bike path end points to the Roads_all endpoints. Also ensure that the elevation point values (in the F_LEVEL and T_LEVEL fields) for each snapped Class I bike path and Roads_all features are identical. Calculate segment length in the field chosen in Step 1.4e for any digitized Class I bike paths and split road features. Save edits and exit **Edit Mode**.

1.8 Rebuild network dataset.

Click the **Build Network Dataset** tool in the **Network Analyst Toolbar** to rebuild the network to include digitized bike path features.

1.9 Verify the connectivity of the network dataset by performing closest facility analysis testing.

a) Test the connectivity of the digitized Class I bike paths by performing a closest facility analysis. In the network analyst menu located in the **Network Analyst Toolbar**, choose **New Closest Facility**.

b) Open the network analyst window. In the window highlight Facilities. Zoom in close to a map location where a Class I bike path was digitized. Click the **Create Network Location** tool on the **Network Analyst Toolbar** and use the cursor to create a location point on the road network near one of the ends of a Class I bike path segment. In the network analyst window, now highlight Incidents. Click the **Create Network Location** tool on the **Network Analyst Toolbar** again and use the cursor to create a location point on the road network near the opposite end of the Class I bike path where the Facility location was added. Click the **Solve** tool.

c) If the route generated in Step 1.9b traverses the Class I bike path, then the Class I bike path is properly connected to the network dataset. If the route avoids the bike path, then no connectivity has been established between the Class I bike path and the roads in the network dataset. Choose the **Network Identify** tool and click on edge features, the tool window will indicate which edges are adjacent to the clicked edge feature. This will inform which adjacent edges are not properly connected. Once the improperly connected edges are identified, you will need to go back into **Edit Mode** and edit the features so that they have coincidental end points.

d) Continue the processes in Steps 1.9a through 1.9c until there is complete satisfaction with the connectivity of the manually digitize Class I bike path features with the road features.

Step 2.0: Closest Facility Analysis with Bikeable Roadway Network

2.1 Generate centroids for the Smart Growth Opportunity Area shapefile Input #4 and the select Large Employment Centers Input #5.

a) Combine the three features from the Large Employment Center shapefile indicated in Table 3.3 with the SGOA shapefile by activating **Edit Mode** on the SGOA shapefile and select, copy and paste the three Large Employment Center features into the SGOA shapefile. Save edits and exit **Edit Mode**.

b) Add two fields (using the Double field type) to the attribute table of the SGOA shapefile. One field should be called X and the other field called Y. Use **Calculate Geometry** to calculate the X field with X Coordinate of a Point and hit OK. Repeat the same process for the Y field, this time calculating the Y Coordinate of a Point.

c) Export the attribute table of the SGOA shapefile and add it to the map document.

d) Choose **Add Data/Add XY Data** from File on the Main Menu.

e) Under the input table, use the SGOA attribute table exported in Step 2.1b. Choose X as the X Field and Y as the Y Field. Click OK.

f) Export the SGOA centroid layer output into a shapefile.

g) Remove all proposed SGOAs from the shapefile (PROPOSED = 1). Also remove all existing Mixed-Use Transit Corridors (SG_TYPE = tco) and Rural Villages (SG_TYPE = rv) and all Special Use Centers (SG_TYPE = su) except for the two Special Use Centers located at major university campuses (NAME = SD-CO-2 and SD-UN-3).

h) Right-click the fieldname NAME in the SGOA centroid shapefile and use **Field Calculator** to copy the data from the fieldname SG_TYPE into the NAME field.

i) Enter **Edit Mode** to digitize points in the SGOA centroid shapefile at the San Ysidro and Otay Mesa border crossings. The San Ysidro point will assume the same value as Metropolitan Center (mc) and the Otay Mesa point will assume the same value as a Town Center (tc). Assign the terms 'mc' and 'tc', respectively, to their cells in the NAME field.

2.2 Perform closest facility analysis with the SGOA centroids.

a) Choose **New Closest Facility** located in the **Network Analyst Toolbar** in the network analyst menu.

b) In the network analyst window, right-click Facilities and choose Load Locations. Choose NAME as the Sort Field. Add all locations. Given the subtraction of unwanted SGOAs and the addition of the two border crossings, there should be a total of 87 SGOA centroid points. Now right-click Incidents and choose Load Locations. Load the same features into Incidents, again using NAME as the Sort Field.

c) Click the Closest Facility Properties in the upper right corner of the network analyst window. Navigate to the Analysis Settings tab and change the number of Facilities to Find to the maximum number of Facilities and Incidents loaded – in this case, 87. Click OK.

d) Click the **Solve** tool in the **Network Analyst Toolbar** to generate the closest facility paths.

e) After the paths have been generated, export the route outputs to a shapefile. In the network analyst window, right-click Routes and export data.

2.3 Add new data fields to the closest facility path shapefile (Miles, Base Points, Decay Points, Final Points).

Open the attribute table of the closest facility paths shapefile. Create four new fields: Miles (using the Double field type), Base Points (using the Short Integer field type), Decay (using the Double field type), and Final Points (using the Double field type). Right-click the Miles fieldname and choose **Calculate Geometry.** The units should be set to miles. Click OK.

2.4 Remove unwanted features from closest facility path shapefile.

Enter **Edit Mode** and then select and delete all paths that have 0 distance and all paths that are greater than 40 miles. Delete those selected routes. Use the **Select by Location** to query and select any routes that do not intersect the City of San Diego jurisdiction. Delete those selected routes. Save edits and exit **Edit Mode**.

2.5 Attribute the closest facility path features with Activity Center Intensity points.

a) Each feature from the closest facility path shapefile should have a name in the NAME field that combines the two SGOA types comprising the path's origin and destination, separated by a hyphen. For instance, a shortest path route feature between an Urban Center and Town Center would appear in this field as "uc – tc." Open **Select by Attributes** and double-click the NAME field from the window of attributes and click the Get Unique Values button. All NAME permutations generated from calculating shortest paths between SGOA place types will populate in the window. Use selection queries to select each origin-destination pair and fill the Base Point field with the appropriate Activity Center Intensity value shown in Table 4.4.

b) Repeat Step 2.5a until all origin-destination pairs have been attributed with the correct Activity Center Intensity values from Table 4.4.

2.6 Attribute the closest facility path features with Decay points.

a) Use **Select by Attributes** to select all route features 5 miles and under. In the attribute table, right-click the Decay fieldname to open the **Field Calculator** and use the equation presented in Table 4.5 in the formula box to divide mileage by 5 (only for the selected features).

b) Use **Select by Attributes** to select all route features greater than 5 miles and no more than 10 miles. In the attribute table, right-click the Decay fieldname to open the **Field Calculator** and enter the following equation from Table 4.5 in the formula box: '1 + (([Miles]-5)/5)*2' (only for the selected features).

c) Use **Select by Attributes** to select all route features greater than 10 miles and no more than 40 miles. In the attribute table, right-click the Decay fieldname to open the **Field Calculator** and enter the following equation from Table 4.6 in the formula box: '3 + (([Miles]-10)/30)*3' (only for the selected features).

2.7 Attribute the closest facility path features with Final Points.

Right-click the Final Points fieldname to open the **Field Calculator**, add Base Points to the formula box and subtract Decay from it.

2.8 Remove any closest facility path features with zero or negative Final Points.

Enter **Edit Mode**. Use **Select by Attributes** from **Selection** on the main menu to select all routes with a FinalPoints value that is 0 or negative and delete those features. Save edits and exit **Edit Mode**.

Step 3.0: Prepare Existing/Planned Bicycle Network Shapefiles for Network Analysis using Inputs #2 and #3.

3.1 Create a network dataset out of Existing/ Planned Bicycle Facilities Inputs #2 and #3.

a) Select all features from the Roads_all shapefile used in the previously created network dataset that are existing or planned bicycle facility. Add existing and planned bicycle network shapefiles to the map document and use the **Buffer** tool in the **ArcToolbox** under **Analysis Tools/Proximity** to create a 50-foot buffer around the bicycle networks. Use **Select by Location** queries to select bicycle features in the Roads_all network shapefile. Be sure to also select any Class I bike paths digitized from the previous network dataset. Export the selection to a new shapefile.

b) Follow Steps 1.4 through 1.6 to create a network dataset.

c) Activate **Edit Mode** and digitize all proposed Class I bike paths and freeway shoulders designated for cycling that are not already in the Roads_all shapefile in the network dataset. While digitizing, ensure proper connectivity by snapping the Class I bike path and freeway shoulder end points to the Roads_all endpoints. Also ensure that the elevation point values (in the F_LEVEL and T_LEVEL fields) for each snapped Class I bike path or freeway shoulder and Roads_all features are identical. Calculate segment length in field chosen in Step 1.4e for any digitized Class I bike paths or freeway shoulders and split road features. For any freeway shoulders added, be sure to reflect the accurate one-way status. Save edits and exit **Edit Mode** when complete.

d) Be mindful of any proposed contra-flow bicycle facilities along one-way roadways and change the one-way status accordingly to reflect directions where bicycle travel is permitted. That means eliminating any '1' attributes from F_ONEWAY or T_ONEWAY for any one-way roads slated to have two-way bicycle travel.

e) Click the **Build Network Dataset** button in the **Network Analyst Toolbar** to rebuild the network with the digitized bike path features.

3.2 Verify the connectivity of the Existing/Planned Bicycle Facilities network dataset by performing closest facility analysis testing.

Repeat Steps 1.9a through 1.9d, until all digitized features have been tested and the connectivity between digitized features and previously existing features has been confirmed.

Step 4.0: Closest Facility Analysis with Existing and Planned Bicycle Networks

4.1 Repeat Steps 2.2 through 2.8 using the existing and planned bicycle network dataset created in Step 3.0.

Repeat the processes described in Steps 2.2 through 2.8 to perform closest facility analysis with the Existing and Planned Bicycle network dataset, attributing and cleaning the output data.

Step 5.0: Process Inter-Community Demand Scoring

5.1 Merge the two closest facility shapefiles (from the bikeable roadway network dataset and the existing/planning bicycle facilities network dataset) to create a single Shortest Paths shapefile.

Export the data of one shapefile into a separate new shapefile called Shortest Paths. Combine the two network datasets by activating **Edit Mode** on the Shortest Paths shapefile and select, copy and paste features from the other closest facilities shapefile into the Shortest Paths shapefile.

5.2 Export a second copy of the Shortest Paths shapefile generated in the previous step and dissolve this shapefile into one feature.

Export the Shortest Paths shapefile generated in Step 5.1. Dissolve this shapefile into one feature with the **Dissolve** tool located in the **ArcToolbox** under **Data Management/Generalization**.

5.3 Split lines of the Dissolved Shortest Paths shapefile at intersections.

Activate the **Edit Mode** on the Dissolved Shortest Paths shapefile. In the Editor Menu located in the **Editor Toolbar**, navigate to **More Editing Tools** and choose **Advanced Editing**. Select the single dissolved feature from the Dissolved Shortest Paths shapefile and click on the **Planarize Lines** tool. When the Planarize Lines dialog box opens click OK. Save edits and exit **Edit Mode**.

5.4 Add Identification, Maximum Points, Sum Points, Log of Sum Points and Final Points attribute fields to the Planarized Shortest Paths shapefile.

a) Add a feature identification field (using the Long Integer field type) to the Planarized Shortest Paths shapefile and populate the field with identification numbers. To populate identification numbers, open **Field Calculator** enter into the formula box: '[FID] + 1'.

b) Add four more fields to the Planarized Shortest Paths shapefile (using the Double field type): Max Points, Sum Points, Log of Sum Points and Final Points.

5.5 Intersect the Merged Shortest Paths shapefile generated in Step 5.1 with the Planarized Shortest Paths shapefile generated in Step 5.3 to create a new shapefile called Intersected Shortest Paths.

Use the **Intersect** tool located in the **ArcToolbox** under **Analysis Tools/Overlay**.

5.6 Summarize Final Points data from the Intersected Shortest Paths shapefile.

Open the attribute table of the Intersected Routes shapefile and right-click the Identification fieldname populated in Step 5.4 and select **Summarize**. In the summarize dialog box, expand Final Points and check the boxes next to Maximum and Sum. Specify an output location for the Sum_Final Points table, and click OK. Allow the table to be added to the map document.

5.7 Join the Sum_Final Points summary table created in previous step to the Planarized Shortest Paths shapefile and copy the summary totals into Maximum Points and Sum Points.

Join the Sum_Final Points summary table to the Planarized Shortest Paths shapefile. Choose the common join fields in boxes 1 and 3 (that fieldname should be Identification). Click OK. Use the **Field Calculator** to copy the summary information into the unpopulated Max Points and Sum Points fields.

5.8 Calculate the Log of Sum Points attribute in the Planarized Shortest Paths shapefile.

Open **Field Calculator** and calculate the log of the Sum of Points by double-clicking the Log button into the formula box and putting the Sum of Points field into the parentheses. Click OK. Select and change any Log of Sum Points with negative values to '0', select and change any Log of Sum Points values greater than 6 to '6'.

5.9 Calculate Final Inter-Community Demand Points

Right-click the Final Points fieldname in the Planarized Shortest Paths shapefile to open **Field Calculator**, in the formula box, perform a summation of the Max Points and the Log of Sum Points. The point values should range from 0 to 12. Rename the Planarized Shortest Paths shapefile to Final Inter-Community Demand shapefile.

5.3 Final Bicycle Demand Model

Development of the final Bicycle Demand Model requires 3 key steps as summarized in the list below:

- **Step 1.0** describes of the process of converting the Intra-Community Demand model into a polygon shapefile.

- **Steps 2.0** describes the processing and preparation of a Final Demand Network shapefile that contains the necessary fields for accommodating both the Intra- and Inter-Community demand submodel point values.

- **Step 3.0** describes the process for attributing the intra- and inter-community demand values into the Final Demand Network shapefile.

Step 1.0: Create Intra-Community Demand Polygon Shapefile

1.1 Convert the attractors and generators bicycle demand raster into a polygon shapefile.

Open the **Raster to Polygon** located in the **ArcToolbox** under **Conversion Tools/From Raster**. Add the attractor raster file and specify GRIDCODE under the fieldname called Value Field. Specify a location for saving the output file. Uncheck the Simplify Polygons the button. Click OK. Repeat the same process for the generator raster file.

1.2 Intersect attractors and generators polygon shapefiles to create an intra-community demand composite shapefile.

Use the **Intersect** tool in the **ArcToolbox** under **Analysis/Overlay** to intersect the attractors polygon shapefile with the generators polygon shapefile. The point values in both shapefiles are stored in the respective GRIDCODE fields. In the intersect shapefile output, the GRIDCODE field in the second input shapefile will have the new name GRIDCODE_1.

1.3 Add Attractors 100, Generators 100 and AttGen 100 fields to the intra-community demand composite shapefile. Convert both attractors and generators scores in the polygon shapefile to a 100-point scale.

a) Add a fieldname called Attractors 100, Generators 100 and AttGen 100 fields (using the Double field type) to the intersected attractors and generators polygon shapefile.

b) Sort the fieldname GRIDCODE to determine the highest unadjusted attractor score. Use the **Field Calculator** to calculate Attractors 100 by entering into the formula box: '(100 / highest unadjusted attractor score) * GRIDCODE'.

c) Sort the fieldname GRIDCODE_1 to determine the highest unadjusted generators score. Use the **Field Calculator** to calculate Generators 100, entering into the formula box: '(100 / highest unadjusted generator score) * GRIDCODE_1'.

d) Use the **Field Calculator** to calculate AttGen100 by summing Attractors 100 and Generators 100.

Step 2.0: Prepare the Final Demand Network Shapefile for the combined intra- and inter-community demand values

2.1 Merge together the Final Inter-Community Demand shapefile from Step 5.9 with the roads shapefile used in the network dataset in Steps 1.2 through 1.9 of Section 5.2 Inter-Community Demand GIS steps.

Combine the Final Inter-Community Demand shapefile and the roads shapefile by activating **Edit Mode** on the roads shapefile and select, copy and paste the Final Inter-Community Demand features into the roads shapefile. Save edits and exit **Edit Mode**.

2.2 Dissolve the merged roadway shapefile from Step 2.1.

Dissolve merged roadway shapefile from Step 2.1 into one feature with the **Dissolve** tool located in the **ArcToolbox** under **Data Management/Generalization**. Save this new file as Dissolved Roadway shapefile.

2.3 Split lines of Dissolved Roadway shapefile at intersections.

Enter into **Edit Mode** and choose the Dissolved Roadway shapefile as the edit target. In the Editor Menu located in the **Editor Toolbar**, navigate to **More Editing Tools** and choose **Advanced Editing**. Select the single dissolved feature from the Dissolved Roadway shapefile and click on the **Planarize Lines** tool. When the planarize lines dialog box opens, click OK. Save the new file as Planarized Roadway shapefile and exit **Edit Mode**.

2.4 Add Identification, Inter-Community Points, Intra-Community Points and Total Points fields to the Planarized Roadway shapefile.

a) Add a feature identification field (using the Long Integer field type) to the Planarized Roadway shapefile and populate the field with identification numbers. To populate identification numbers, open **Field Calculator** enter into the formula box: '[FID] + 1'.

b) Add three more fields to the Planarized Roadway shapefile (using the Double field type): Inter-Community Points, Intra-Community Points and Total Points.

Step 3.0: Attributing Intra- and Inter-Community Demand Points to Final Demand Network Shapefile

3.1 Intersect the Planarized Roadway shapefile with the intra-community demand polygon shapefile from Step 1.0

Use the **Intersect** tool located in the ArcToolbox under Analysis Tools/Overlay. Save the new file as 'intersected roadways shapefile'.

3.2 Add New Length and Length Points fields to the Intersected Roadways shapefile.

a) Add New Length and Length Points fields (using the Double field type) to the intersected roadways shapefile.

b) Right-click the header of the New Length field and choose **Calculate Geometry**. Select Length in the calculate geometry window under Properties. Select Feet US [ft] under Units in the calculate geometry window.

c) Right-click the Length Points fieldname and open **Field Calculator**. Multiply New Length by AttGen 100.

3.3 Summarize intra-community demand points from Intersected Roadways shapefile.

Open the attribute of the Intersected Roadways shapefile and right-click the field header containing the Identification field generated in Step 2.4 and choose **Summarize**. In the **Summarize** dialog box, expand New Length and Length Points and check the box next to Sum. Specify an output location, name the summary table as Sum_Intra-community and click OK. Allow the table to be added to the map document.

3.4 Add two fieldnames called Weighted AttGen and AttGen 12 and calculate intra-community demand score in the Sum_Intra-community summary table.

a) Open the Sum_Intra-community summary table and create two new fields called Weighted AttGen and AttGen 12 (using the Double field type).

b) Right-click the Weighted AttGen fieldname and open **Field Calculator**. In the formula box, divide Length Points by New Length.

c) Right-click the AttGen 12 fieldname and open **Field Calculator**. In the formula box, divide Weighted AttGen by the highest value in the AttGen 100 field from the intra-community demand composite shapefile from Step 1.0 and then multiply that number by 12.

3.5 Join the Sum_Intra-community summary table created in previous step to the Planarized Roadway shapefile and copy the summary totals into Maximum Points and Sum Points.

Join the Sum_Intra-community summary table to the Planarized Roadway shapefile. Choose the common join fields in boxes 1 and 3 (that fieldname should be Identification). Click OK. Use the **Field Calculator** to copy the summary information from the AttGen 12 field into the unpopulated Intra-Community Points field in the Planarized Roadway shapefile.

3.6 Intersect the Planarized Roadway shapefile with the Final Inter-Community Demand shapefile from Step 5.9 in Section 5.2.

Use the **Intersect** tool located in the **ArcToolbox** under **Analysis Tools/Overlay**.

3.7 Join the Intersected Final Inter-Community Demand shapefile from previous step with the Planarized Roadways shapefile and attribute inter-community demand points.

Join the Intersected Final Inter-Community Demand shapefile to the Planarized Roadway shapefile. Choose the common join fields in boxes 1 and 3 (that fieldname should be Identification). Click OK. Use the **Field Calculator** to copy the values from the Final Points field of the intersected Final Inter-Community Demand shapefile into the Inter-Community Points field in the Planarized Roadway shapefile.

3.8 Calculate the Final Points in the Planarized Roadways shapefile.
Right-click the Final Points fieldname to open **Field Calculator**. Perform a summation of the values in the fields called Intra-Community Points and Inter-Community Points. Rename the Planarized Roadways shapefile as Final Demand Network shapefile. This shapefile contains the final intra- and inter-community demand scores.

List of References

City of San Diego. *City of San Diego Bicycle Master Plan.* 2002.

City of San Diego. *City of San Diego Bicycle Master Plan Update.* 2013.