MODELING THE TRANSPORT OF NON-ATTAINMENT POLLUTANTS IN THE "HOT SPOT" REGION OF THE NORTH CENTRAL PHOENIX VALLEY

Final Report 490

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16. Abstract

The main objective of this study was to investigate the effect of the addition of new stretches of freeways (Loop 101 and 51) in the north Phoenix Valley. The strengths and locations of pollution "Hot Spots" in this area have been found to be related to the meteorological conditions. Based on the model results, the new freeway extensions would increase the pollutant concentration (i.e., CO) in the surrounding area. Different scenarios have been used to simulate the pollutant dispersion over the Valley by using the CAL3QHC model.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	0.3048	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	6.452	centimeters squared	cm^2
ft^2	square feet	0.0929	meters squared	m^2
yd^2	square yards	0.836	meters squared	m^2
mi^2	square miles	2.59	kilometers squared	km^2
ac	acres	0.395	hectares	ha
		MASS (weight)		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
		VOLUME		
fl oz	fluid ounces	29.57	millimeters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0328	meters cubed	m^3
yd^3	cubic yards	0.765	meters cubed	m^3

Note: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

These factors conform to the requirement of FHWA Order 5190.1A

*SI is the symbol for the International System of Measurements

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
yd	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	millimeters squared	0.0016	square inches	in^2
m^2	meters squared	10.764	square feet	ft^2
yd^2	kilometers squared	0.39	square miles	mi^2
ha	hectares (10,000 m^2)	2.53	acres	ac
		MASS (weight)		
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1000 kg)	1.103	short tons	T
		VOLUME		
mL	millimeters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	meters cubed	35.315	cubic feet	ft^3
m^3	meters cubed	1.308	cubic yards	yd^3
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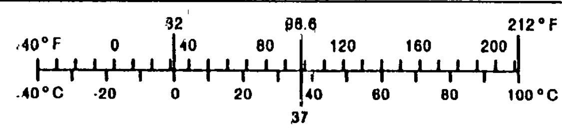
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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1 INTRODUCTION

The Maricopa County / Phoenix area is the only area in the state of Arizona that has been declared in non-attainment (unable to meet the National Ambient Air Quality Standards defined by the Clean Air Act of 1990) for all three primary pollutants: Ozone (O_3), Carbon monoxide (CO) and Particulate Matter (PM_{10}). The area is currently classified as “serious” for all three pollutants by the Environmental Protection Agency (EPA).

In this report we analyze several so called Hot Spots in the Phoenix area. Hot Spots are defined as localized regions of high air pollution (here we considered carbon monoxide). In the past, Hot Spots have been identified by the Arizona Department of Environmental Quality [5] for Carbon monoxide based on data accrued in Maricopa county. One such Hot Spot is located in north central part of the Phoenix Valley at 19th Avenue and Campbell Avenue. This location coincides with the ADEQ’s ‘super-site.’ The so-called super-site is a heavily instrumented location at which both meteorological and pollution measurements are made. Locations of Hot Spots vary depending on the type of the pollutant, the daily meteorology and the time of year. CO is a wintertime problem and reaches peak concentration from October through January. This occurs as winter temperature inversions trap polluted air close to the ground overnight or longer. O_3 is a summertime problem and can reach peak concentration from May through September. Particulate Matter is a year-round problem that is the result of a variety of emission sources.

On-road automobile emission is known as a primary source of these non-attainment pollutants in the Phoenix Valley. The rapid growth and spread of the Phoenix population has led to increased traffic volumes and increased levels of pollution. To meet the transportation needs of Valley residents, significant additions to the Regional Freeway System (RFS) have been planned and are under construction. These modifications to the existing freeway systems may have some effects on the pollutant concentrations and their distributions. In the wintertime, Phoenix’s meteorology is characterized by a stably stratified atmospheric boundary layer in the early morning and night that exhibits low wind speeds which inhibit the vertical mixing of locally generated pollutants. These characteristics present favorable conditions for high levels of CO and PM_{10}.

There are two objectives in this study. One is to investigate the effect of various meteorological conditions on the transport of inert pollutants (i.e., CO) and the location of pollution Hot Spots. Another objective is to determine the effect of the addition of new stretches of freeways North of Phoenix, namely, the effect of the new State Route 101 (SR-101) and State Route 51 (SR-51) stretches on the concentration distribution of CO over the region. Two models have been used to achieve these two objectives. The MOBILE5 model was used to calculate the composite emission factor of exhaust gases (i.e., Volatile Organic Compounds - VOC, Carbon Monoxide – CO, and Hydrocarbons - HC), which is the input information for the CAL3QHC. CAL3QHC was used to simulate the concentration and distribution of inert pollutants.

The study area is enclosed by the following highways and streets. 27th Avenue to the West, I-10 to the South, SR-101 to the North and SR 51 to the East. There are five chapters in this report. Chapter 1 contains the introduction including the motivation for the study. The MOBILE5 and CAL3QHC models are described in Chapter 2. In Chapter 3, the data acquisition for the input files to these two models is discussed. In Chapter 4, emission rates of CO under different vehicle speeds have been presented by using the MOBILE5. This section also includes results from the CAL3QHC model (Version 2.0) calculations. In particular, CO concentration distributions are presented for various meteorological conditions and traffic scenarios, as well as for both freeway configurations (with and without the SR-101 and SR-51 freeways). Chapter 5 summarizes the major results from the study, which is followed by References and Appendices.

It should be noted that a similar Hot Spot study was performed by the Maricopa Association of Governments (MAG) [1] twenty years prior to this study. The MAG study attempted to identify three intersections in the Phoenix area where there was the greatest potential for above normal concentrations of carbon monoxide. In fact, four were identified and all are contained in the domain that was chosen for the computations done for this study. The main difference in the findings between this report and the MAG report is the maximum concentration levels. While the locations of high CO pollution are similar, maximum levels based on the 1980 report were approximately 20-22 ppm, while the maximum CO concentrations from the current report were 3-4 ppm, indicating that significant improvement in air quality (CO based) has been achieved over the past 20 years.

2 MODEL DESCRIPTIONS

MOBILE5

The EPA's highway vehicle emission factor model, MOBILE5, is a FORTRAN program that provides emission factors for three primary pollutants: hydrocarbon (HC), carbon monoxide (CO), and oxides of nitrogen (NOx). The emission factor estimates depend on various conditions such as ambient temperatures, average traffic speeds and gasoline volatility. The model user may specify all of these variables. The model also considers the effect of various categories of vehicles (i.e., gasoline-fueled and diesel highway motor vehicles). MOBILE5 will estimate emission factors for any calendar year between 1960 and 2020. The 25 most recent model years are considered to be in operation in each calendar year.

The output data from the model are expressed as grams of pollutant per vehicle mile traveled (grams/mile). Emission factors from MOBILE5 can be combined with estimates of total vehicle miles traveled (VMT) to develop highway vehicle emission inventories (in terms of tons per day, per month, per season, per year). Therefore, this model can be used to evaluate control strategies for highway mobile sources.

CAL3QHC

CAL3QHC (Version 2.0) is a computer-based model developed to predict CO or other inert pollutant concentrations (i.e., PM_{10}) from motor vehicles travelling on roadways. The model contains the CALINE-3 line source dispersion model and traffic algorithms for estimating vehicular queue lengths at signalized intersections.

CAL3QHC enhances CALINE-3 by incorporating methods for estimating queue lengths and the contribution of emissions from idling vehicles. The model permits the estimation of total air pollution concentrations from both moving and idling vehicles. It is a reliable tool for predicting concentrations of inert air pollutants near signalized intersections. Because idle emissions account for a substantial portion of the total emissions at an intersection, the model is relatively insensitive to traffic speed, a parameter difficult to predict with a high degree of accuracy on congested urban roadways without a substantial data collection effort.

The reading-input structure of the CAL3QHC has been set to be free-format. The input information for the CAL3QHC contains roadway geometries, receptor locations, meteorological conditions and vehicular emission rates. In addition, several other parameters are necessary, including signal timing data and information describing the configuration of the intersection. CAL3QHC can accommodate up to 120 roadway links, 60 receptor locations, and 360 wind angles, an increase from the original version which could accommodate 55 links and 20 receptors. This allows the modeling of adjacent intersections that interact with each other within a short distance.

3 DATA AQUISITION

INPUT DATA FOR MOBILE5

The input information for MOBILE5 consists of three distinct sections: the control section, the one-time data section, and the scenario section. The control section consists primarily of a series of flag settings. The detailed meaning of each flag setting is described in the manual of MOBILE5. The annual mileage accumulation rates and registration rates for different vehicle types have been decided. One typical input file for the MOBILE5 is listed in Appendix A.

INPUT DATA FOR CAL3QHC

The input information for CAL3QHC includes: traffic rate, road geometries, receptor locations, meteorological data, vehicle emission rates and coordinates of free flow links and queue links.

The average weekday traffic volume in 1998 has been obtained from the Maricopa Association of Governments, Phoenix, Arizona. An appropriate estimate of the important highways and intersections using aerial photographs available at the Arizona State University library has been developed. The receptors are located 21.34 meters (70 feet) away from the intersections, which should be located outside the "mixing zone" of the free flow link. The mixing zone is considered to be the area of uniform emissions and turbulence, which is the total width of travel lanes plus 3 meters (10 feet) on each of the outside travel lanes. There are 55 receptors used in the model with a limit of 60 receptors. The surface roughness coefficient used in CAL3QHC is 175 cm, which is widely used for the urban landuse.

The meteorological data used in the CAL3QHC model was obtained from the PAFEX-I (Phoenix Air Flow Experiment) conducted by Arizona State University, 1/15 – 2/1, 1998 at Grand Canyon University. Grand Canyon University is located outside of the domain (northeast corner of 35th Avenue and Camelback Road). The terrain around the site is quite flat so that it is acceptable to use its meteorological data for the domain. During the daytime, the mixing height is set at 1000m as recommended by the manual. The mixing height would be very low at nights, which is about 50 meters indicated in the PAFEX-I experiment. This height rises in the early morning after the sunrise due to the entrainment from the above residual layer. The CAL3QHC is not sensitive to the mixing height except for extremely low values (much less than 100 m).

The vehicle emission rates for CO have been calculated by the MOBILE5. The idle emission rates are the output of MOBILE5 when the vehicle speed is set at 2.5 mile/hour. The output units for MOBILE5 are grams/mile, which need to be converted into units of grams/hour. The free flow links have been created by grouping roadways with similar traffic volumes. There are 96 free flow links and 16 queue links used in the model with the limitation of 120 links. After considering the construction of new freeways (SR-101 and SR-51), another two free flow links were added. Although it is not necessary to specify which way traffic is moving on a free flow link, two free flow links for one homogeneous section of road were used instead of one free flow link. This was because traffic volumes are different in both directions especially on the freeways I-17 and SR-51. It is believed that it is not proper to assume that the air mixes horizontally very well across the road.

Two intersections were selected as queue links due to the limitation of link numbers in the CAL3QHC. One of them is the intersection of Camelback Road and 19th Avenue. Another is the intersection of Indian School Road and 7th Street. The detailed instructions for input information is described in the manual of the CAL3QHC. These two intersections were selected because one possible Hot Spot location is at the intersection of 19th Avenue and Campbell Avenue. In addition, there are high traffic volumes from I-17 and SR-51 freeways.

4 RESULTS AND DISCUSSIONS

EMISSION RATE

MOBILE5 performs emissions estimates for the following range of vehicle speeds: 4.0 kph (2.5 miles/hour) to 105 kph (65 mile/hour). The exhaust CO varies with the vehicle speed, which is shown in Figure 1. This Figure shows exhaust CO for average vehicles. However, it should be noted that different types of vehicles have different composite emission factors.

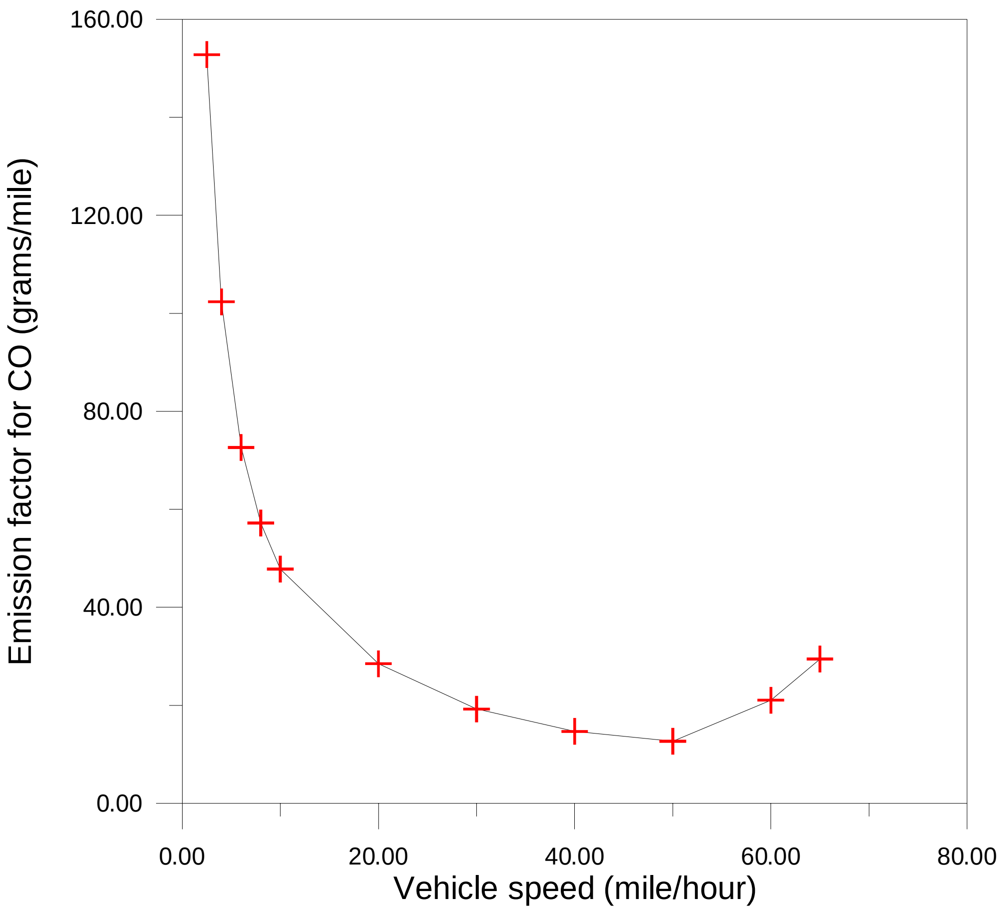

Figure 1 Composite Emission Factors of CO vs. vehicle speeds

CO CONCENTRATION DISTRIBUTION

Effects of Meteorological Conditions

The CO concentrations at the Hot Spot under different wind speeds and directions are listed in Table 1. In the simulations, the stability was set as “D” (Neutral) and average time is 40 minutes. The background concentration of pollutant CO is set to be zero. Receptor #17 is at the corner of 19th Avenue and Camelback Road. Receptor #20 is at the corner of 16th Street and Camelback Road. Receptor #38 is at the corner of 27th Avenue and Peoria Road. Receptor #40 is at the corner of the 27th Avenue and Cactus Road. From Table 1, it can be seen that the larger the wind speed, the lower the concentration of CO at the Hot Spot. The high wind speeds can lead to good mixing in the horizontal direction and dispose the pollutants from the high-concentration areas to low-concentration areas. At the same time, the high wind speed near the ground also means that there exists a large wind shear in the vertical direction, which leads to better vertical mixing and therefore reduces the concentrations of CO near the ground. Notice that the wind speed should be at least 1 m/s due to the limitation of the CAL3QHC. Table 1 also shows that the wind direction has a significant effect on the maximum CO concentration and the precise location of the Hot Spot. It seems that the concentration of pollutant CO at the Hot Spot reaches the peak with the wind direction of 90 degree (wind from the east).

Table 4.1 Maximum CO concentrations under different wind speeds and directions

Wind speed(m/s)	Wind direction(degree)	Max. CO concentration (PPM)	Hot Spot
1.0	70	9.00	Receptor #17
2.0	70	4.80	Receptor #17
3.0	70	3.30	Receptor #17
2.0	0	3.30	Receptor #38
2.0	90	4.10	Receptor #17
2.0	180	3.10	Receptor #40
2.0	270	2.00	Receptor #20

The CO concentrations at the Hot Spot under different atmospheric stabilities are listed in Table 2. In the simulation, the wind speed is 1 m/s and wind direction is 70 degrees from North (i.e, mostly easterly). The background concentration of CO is set to zero. The simulations are based on the 40-min average and do not include the effect of new highways (SR-101 and SR-51), which will be considered in a separate section. Table 2 shows that the atmospheric stability status has a very significant effect on the maximum CO concentration. The CO concentration could increase 60% when the stability of air changes from the neutral stability (D) to the moderately stable condition (E). In the Phoenix area, especially in wintertime, the air could be very stable because the large heat radiation loss of the surface keeps the air well stratified and has strong stability. In such condition, the pollutant concentration could be very large, which can reach an unhealthy level. If the wind speed is smaller than 1 m/s, the situation could be worse. In fact, such situations frequently happen at nights in the wintertime, during which the air is very calm (wind speed is less than 1 m/s) as indicated in the PAFEX I. It should be mentioned here that the CAL3QHC results might not be as accurate as expected since the studied domain is a region of complex terrain. The underlying homogeneous assumption in CAL3QHC would lessen the reliability of its results when it is used to simulate conditions in regions of complex terrain like the Phoenix Valley. It should be noted that there are some mountains (i.e., North Mountain, Phoenix Mountain, etc.) located in the studied domain. These mountains would change the pollutant distributions in the Valley since they can change the local wind flow.

Table 2 Maximum CO concentrations under different atmospheric stabilities

Stability class	Maximum CO concentration (PPM)	Hot Spot
D(neutral)	8.20	Receptor#17
E(slightly stable)	9.80	Receptor#17
F(moderate stable)	13.0	Receptor#17

Effects of Traffic Hours

Different traffic hours have different vehicle speeds and traffic volumes, which affect the concentration of pollutants. The traffic hours have been categorized into four scenarios: morning rush hours, afternoon rush hours, daytime, and nighttime.

During rush hours, the hourly vehicle flow rate is assumed to be 1.8 times the average vehicle flow rate. The average hourly vehicle flow rate is calculated by dividing the weekday traffic count data by 24 hours. During the daytime, the hourly vehicle flow rate is 1.2 times the average vehicle flow rate. During the nighttime, the hourly vehicle flow rate is 0.6 times the average vehicle flow rate. During the morning rush hours, 70% of vehicles are assumed to drive South on the I-17 and SR-51. The remaining 30% of vehicles travel North. On the other roads, the flow rates in both directions are assumed equivalent. During the daytime and nighttime scenarios, the vehicle flow rates on all roads are supposed to have equivalent portion in both driving directions. However, during the afternoon rush hours, the vehicle flow rates Northbound on I-17 and SR-51 are assumed to be 70% of total flow rates. These percentages are not precise measurements but a rational way to approach the practical situations in the simulations. They are believed not to be as important as the other factors, such as the meteorological conditions.

For free flow links, vehicle speeds on highways are assumed to be 64 kph (40 mph) and on local roads be to 48 kph (30 mph) during rush hours. During the daytime, the vehicle speed is assumed to be 80 kph (50 mph) on highways and 64 kph (40 mph) on local roads. For the nighttime scenario, the vehicle speed is assumed to be 96 kph (60 mph) on highways and 64 kph (40 mph) on local roads. These vehicle speeds are not accurate measurements but they are used to approach and simulate the real situations.

The simulations are based on the meteorological conditions on January 29, 1998 from PAFEX I. The meteorological data are listed in the Table 3. All simulations are based on the 60-min average and they do not include the new highways (SR-101 and SR-51). Included in the table are the various stability conditions which are the Pasquil-Gifford stability classes.

Table 3 Meteorological data on January 29, 1998

Scenarios	Wind speed (m/s)	Wind direction (degree)	Stability
Morning rush hours	2.0	130	C, D, or E
Afternoon rush hours	2.0	270	D
Daytime	3.0	270	C
Nighttime	1.0	80	E, or F

Scenario I – Morning rush hours

During the morning rush hours, the atmosphere was chosen to be in one of three possible stability regimes from the slightly stable (E) to the slightly unstable (C). Normally, in the early rush hour, the air is still and remains stable. The stable nocturnal boundary layer is not broken up yet though the residual layer may reduce the thickness of the nocturnal boundary layer. After the sun rises, the atmosphere starts to transform from stable to unstable , this period is called the transition period (neutral stability D). The transition period could be very short, it may last about 20 minutes. After the land is heated enough by the sun, the air in the atmospheric boundary layer becomes unstable and large eddies transport pollutants from the near ground region further up into the boundary layer. Figure 2 shows the CO concentration distribution in the Valley during the morning rush hour on January 29, 1998 under the stability of C. From Figure 2, it can be seen that the Hot Spot is located near the intersection of 19th Avenue and Camelback Road. The locations along I-17 also have high CO concentrations due to the heavy traffic on I-17. The model shows that the area near the intersection of 16th Street and Northern Avenue is a local Hot Spot. Figures 3 and 4 show these CO concentration distributions in the Valley under stability D and E respectively. Comparing these three figures, it can be concluded that the stability would not change the concentration distributions but does change the magnitudes of CO concentrations as discussed earlier under 'Effects of Meteorological Conditions'.

Scenario II – Afternoon rush hours

Figure 5 shows the CO concentration distribution in the Valley during the afternoon rush hours under the stability of D. The Hot Spot is near the intersection of 16th Street and Camelback Road. The area near the intersection of Indian School Road and 19th Avenue is a local Hot Spot. The pattern of CO concentration distribution is different from Scenario I, in which the Hot Spot is near the intersection of Camelback Road and 19th Street. It also is noticed that the pollutants are dispersed more widely over the Valley than those in Scenario I.

Scenario III – Daytime traffic hours

Figure 6 indicates the CO concentration distribution in the Valley during the daytime on January 29, 1998 under the stability of C. The Hot Spot is close to the intersection of 16th Street and Camelback Road. The area near the intersection of Indian School Road and 19th Avenue is a local Hot Spot. The CO concentration near the I-17 freeway is still higher compared to its surroundings. The intersection of 7th Avenue and Dunlap Avenue is another local Hot Spot.

Scenario IV – Nighttime traffic hours

Figure 7 shows the CO concentration distribution over the Valley during the nighttime on the January 29, 1998 under the stability of E. It clearly indicates that the intersection of Camelback Road and 19th Avenue is a Hot Spot. It also indicates that the intersection of 7th Street and Indian School Road is a local Hot Spot. There are no obvious reasons why the Hot Spots are located at those two intersections. A possible cause is that in the simulation, two queue links are placed on these two intersections. Therefore, it is quite important to identify the traffic situation during the nighttime. The more accurate the traffic data is, the better the simulation performs.

The CO concentration distribution in the Valley under the stability of F is shown in Figure 8. Compared with Figure 7, another local Hot Spot appears at the intersection of 7th Street and Bell Road. The other features of CO concentration distribution are similar to those in Figure 7.

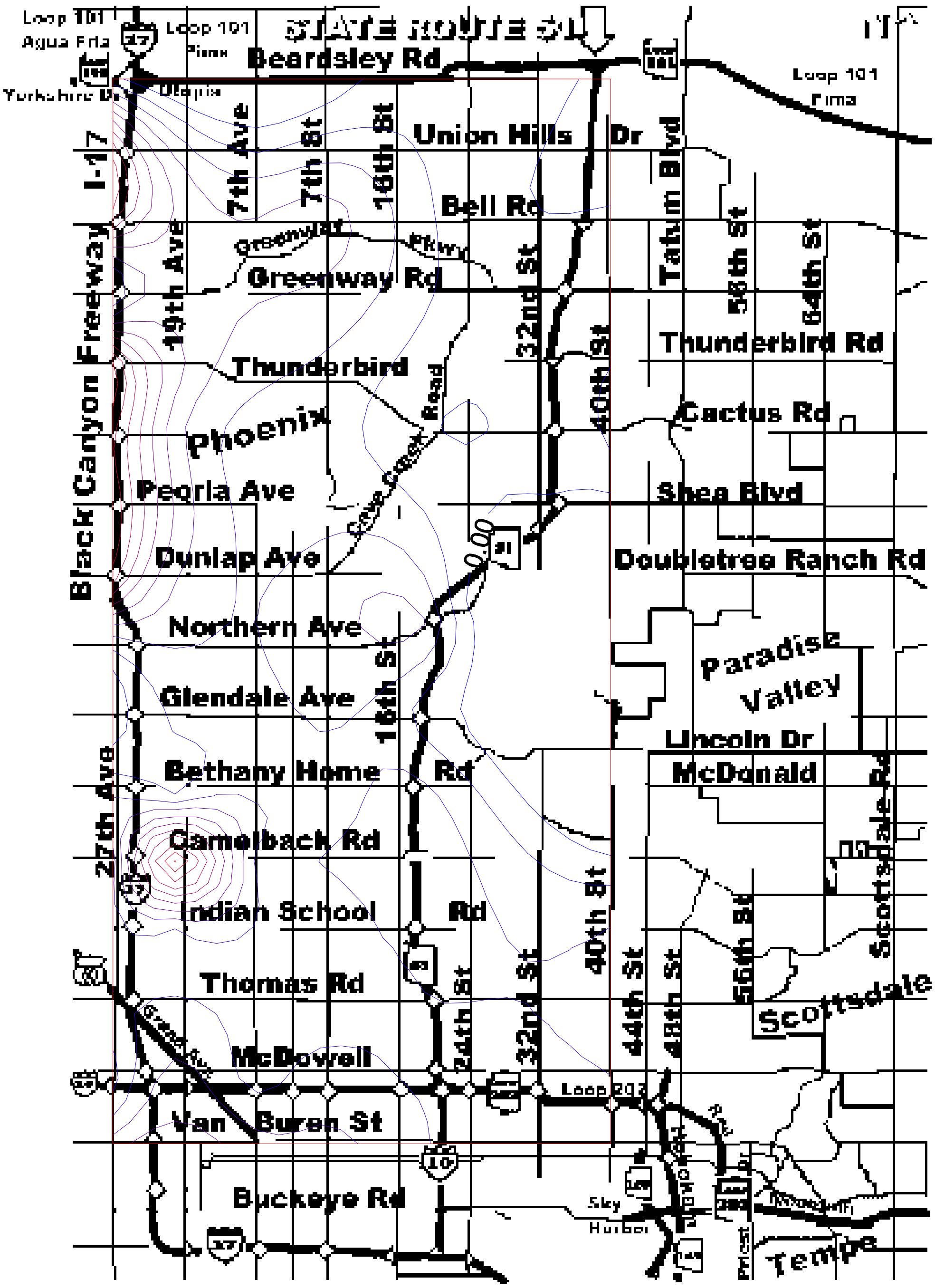

Figure 2 CO concentration distribution diagram during the morning rush hour on January 29, 1998 (wind vector is 130 degrees from true North, Stability C)

Note: Contour lines for all Figures start at 0.00 and increase by steps of 0.05.

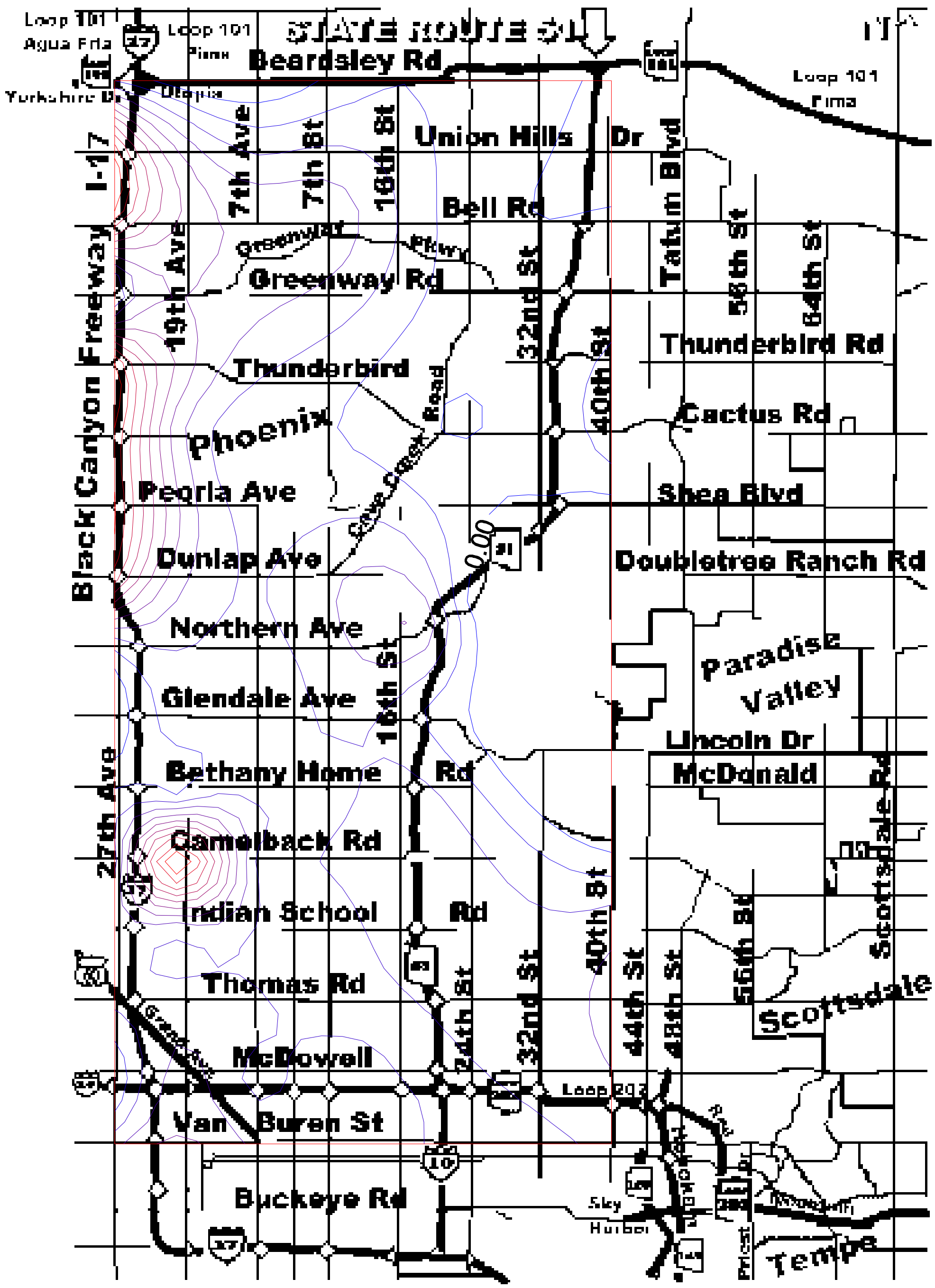

Figure 3 CO concentration distribution diagram during the morning rush hour on January 29, 1998 (same wind direction as Figure 2, Stability D)

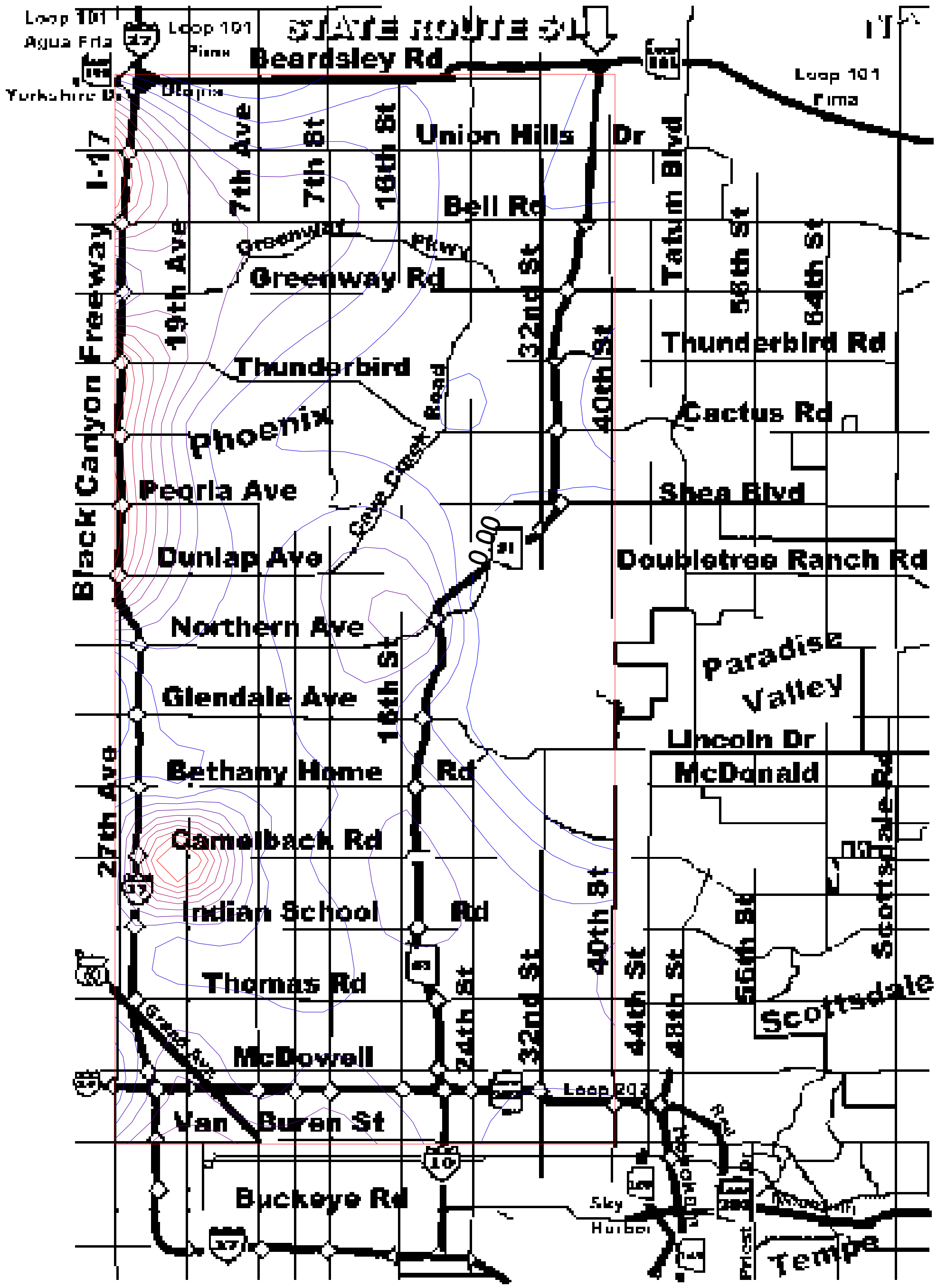

Figure 4 CO concentration distribution diagram during the morning rush hour on January 29, 1998 (same wind direction as Figure 2, Stability E)

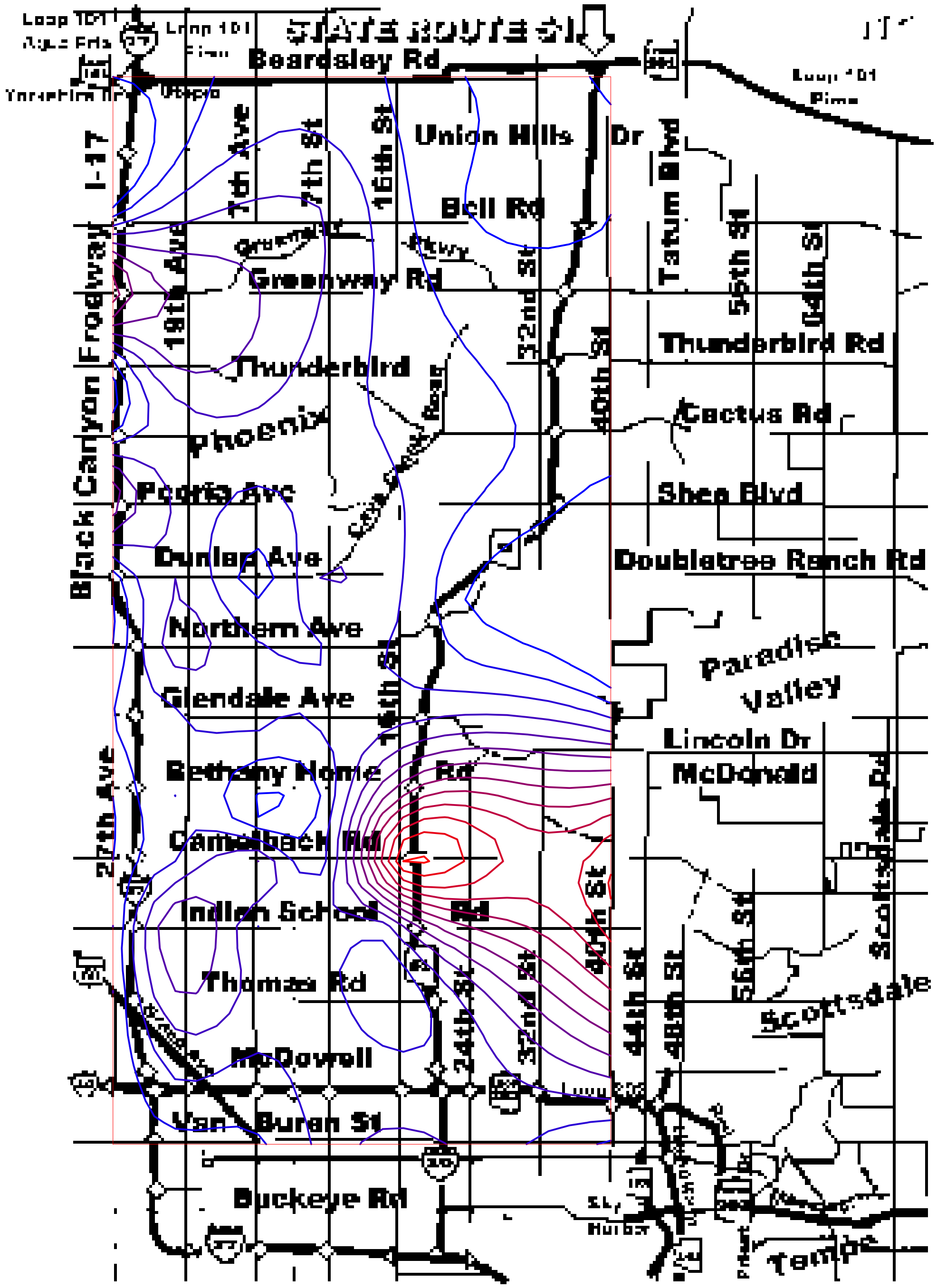

Figure 5 CO concentration distribution diagram during the afternoon rush hour on January 29, 1998 (wind vector is 270 degree, Stability D)

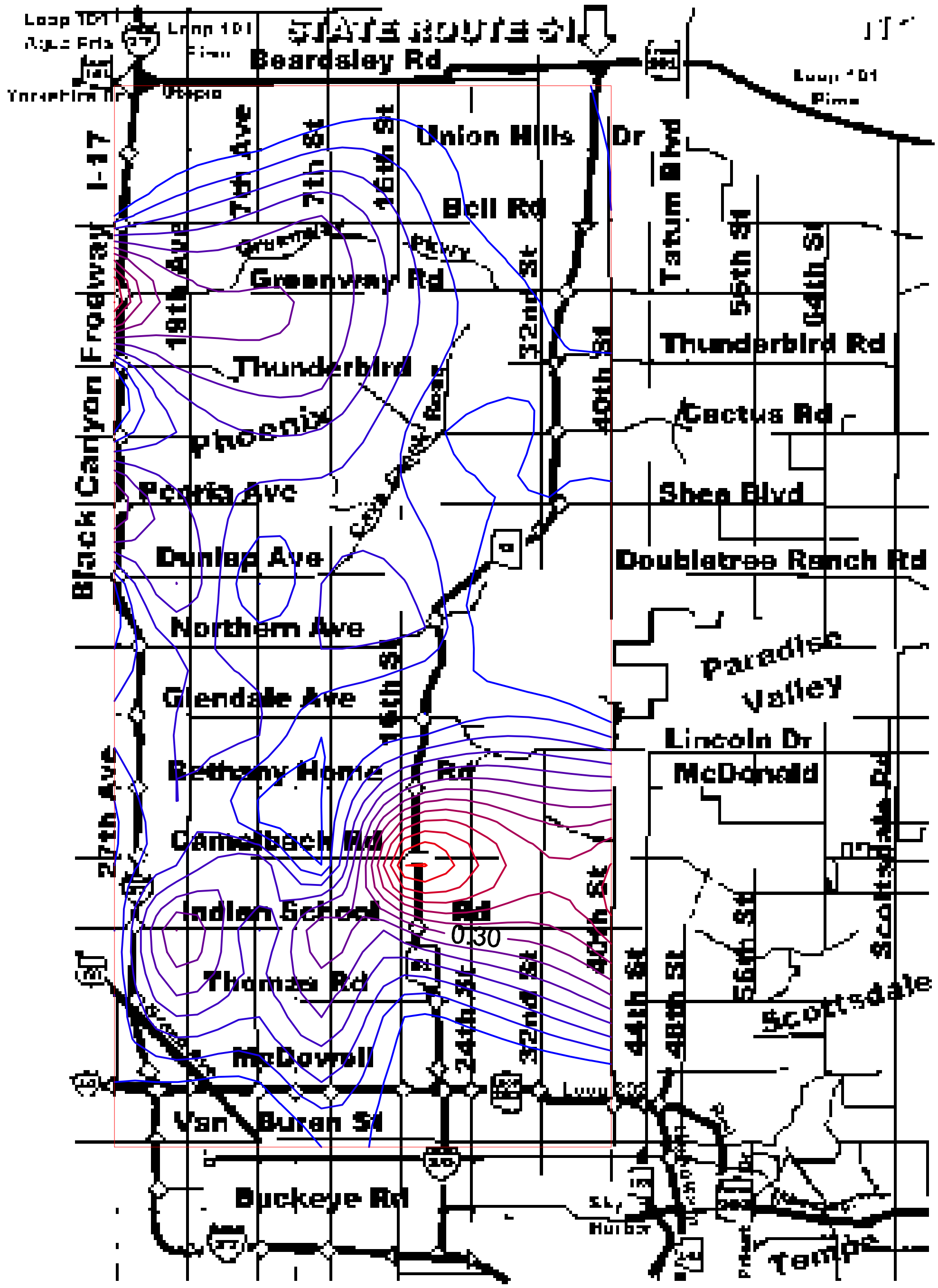

Figure 6 CO concentration distribution diagram during the daytime on January 29, 1998 (same wind direction as Figure 5, Stability C)

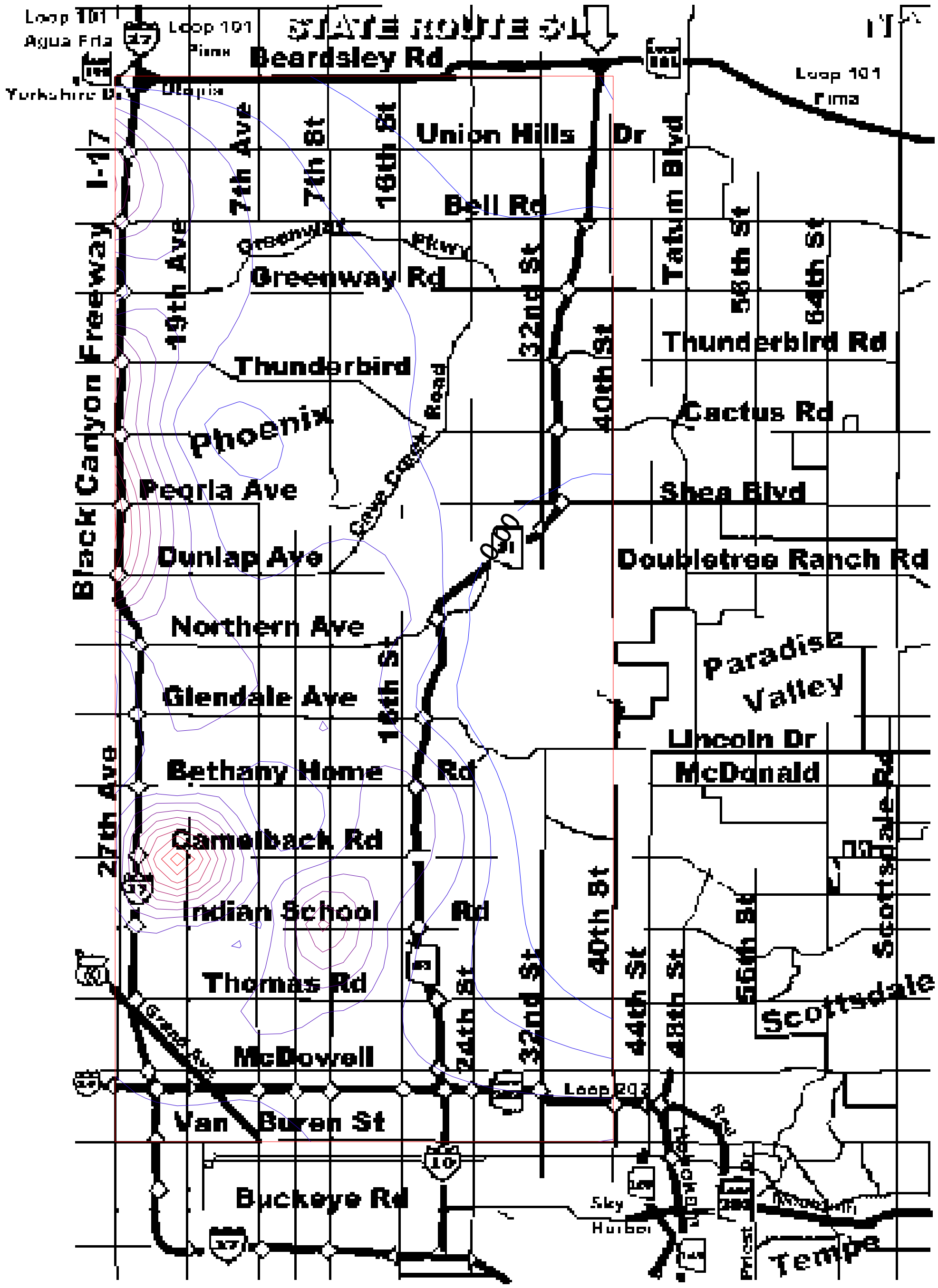

Figure 7 CO concentration distribution diagram during the nighttime on January 29, 1998 (wind vector is 80 degrees, Stability E)

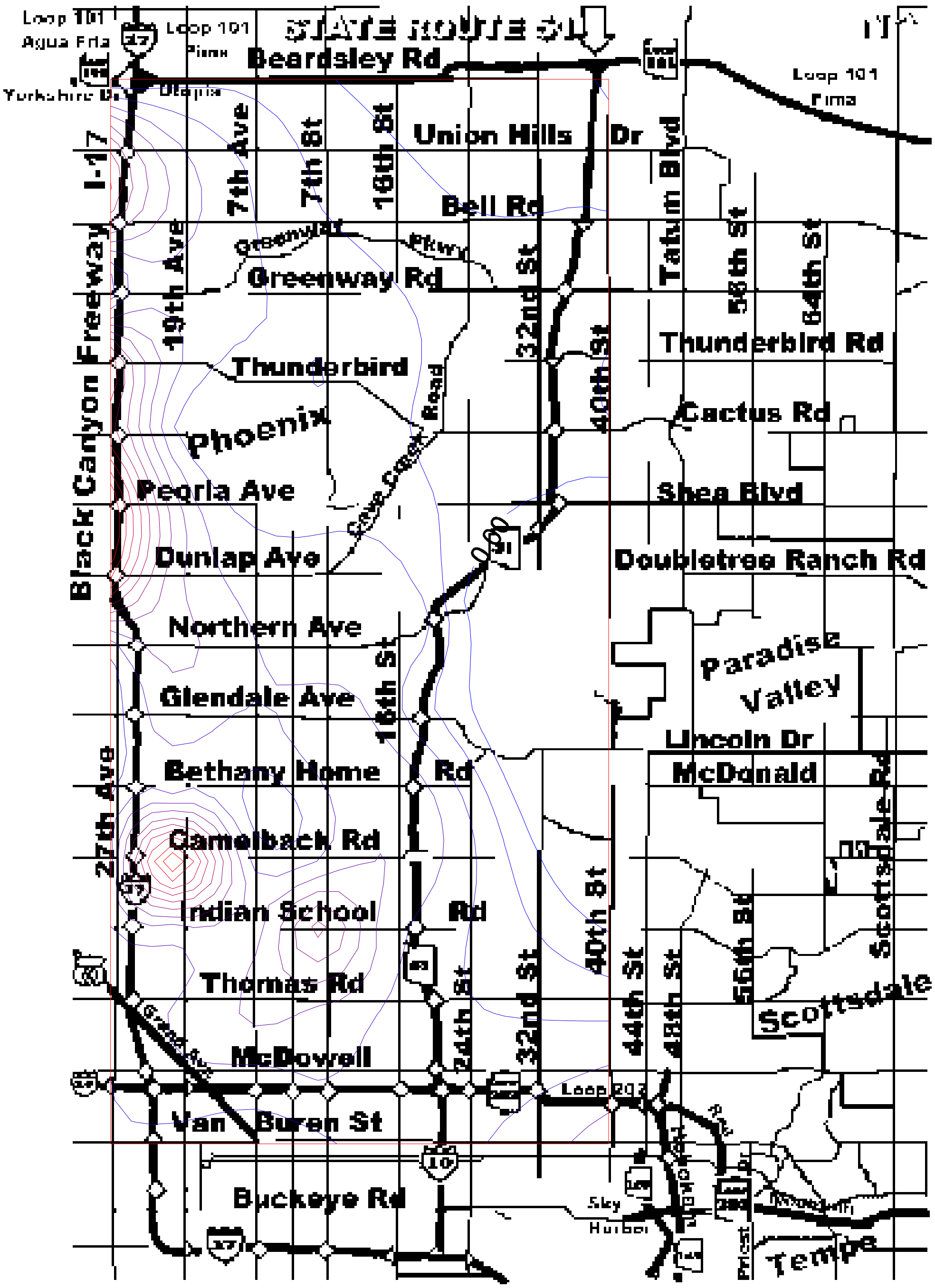

Figure 8 CO concentration distribution diagram during the nighttime on January 29, 1998 (same wind direction as Figure 7, Stability F)

Effects of New Freeways

Scenario V – Morning rush hours

Figure 9 shows the CO concentration distribution in the simulation domain during the morning rush hours on January 29, 1998. Compared with the Scenario I, the difference is that this simulation has considered the effects of new freeways: SR-101 and SR-51. SR-101 will be constructed over Beardsley Road and SR-51 has an extension from Bell Road to Beardsley Road. The traffic volume on Beardsley Road is low compared with the high traffic volume on the new SR-101. The weekday vehicle traffic on the new SR-101 is assumed to be100, 000 vehicles per day. The traffic rate on the new extension of SR-51 is assumed to be the same as that on the existing SR-51 (145,000 vehicles per weekday). These two assumptions are valid for the following three scenarios. A comparison of Figures 3 and Figure 9 shows that the new freeways have little effect on the pollutant distribution in the Valley, though the CO concentration has been increased significantly near the most northeastern corner. The limited effect of the new freeways is not surprising because on the day simulated the wind direction was 130 degree (from the southeast to the northwest). The new freeways are located on the northern most edge of the domain so that they don't have much influence on the studied domain. It is likely that a wind from the south east would produce similar high levels of pollution just outside the studied domain in what is now a "relatively" rural area.

Scenario VI – Afternoon rush hours

Figure 10 shows the CO concentration distribution in the Valley after considering the new freeway extensions. The atmospheric stability is considered as neutral (D) in this simulation. The wind direction on January 29, 1998 was 270 degree. Compared with the Scenario II, there is not much difference on these two distributions except at the northeast corner. Since the wind direction is 270 degree (from the west to the east), it is speculated that new freeways would increase the CO concentration at the downwind area, which is located out of the simulation domain.

Scenario VII – Daytime traffic hours

Figure 11 shows the CO concentration distribution in the Valley during the daytime after considering the new freeways. In this scenario, the atmospheric stability category was slightly unstable (C). The wind direction on January 29, 1998 was 270 degree during the daytime. Compared with the Scenario III (same input information except the new freeways), there is not much difference on south part of the Valley. The new freeways would contribute some pollutants (CO) to the area near the northeast corner of the domain. This can be explained using the same reasoning mentioned in the last paragraph, that is, the wind direction was 270 degree (from the west to the east). It is believed that new freeways would increase CO concentration at the downwind area, which is not in the simulation domain.

Scenario VIII – nighttime traffic hours

Figure 12 shows the CO concentration distribution in the Valley during the nighttime of January 29, 1998. Compared with the Scenario IV, not much difference exists on the south part of the domain for the CO concentration. However, due to the new freeways (SR-101 and SR-51), the CO concentration has been increased in the block between Bell Road and Beardsley Road. The wind direction was 80 degrees on that night so that the downwind area would receive more pollutants from the new freeways. It is also noted that the CO concentration along 32nd Street has also increased because of the new freeways. But the Hot Spot in the whole domain doesn't change though the local pollutant concentration in the north part of the domain has definitely increased due to these new freeways.

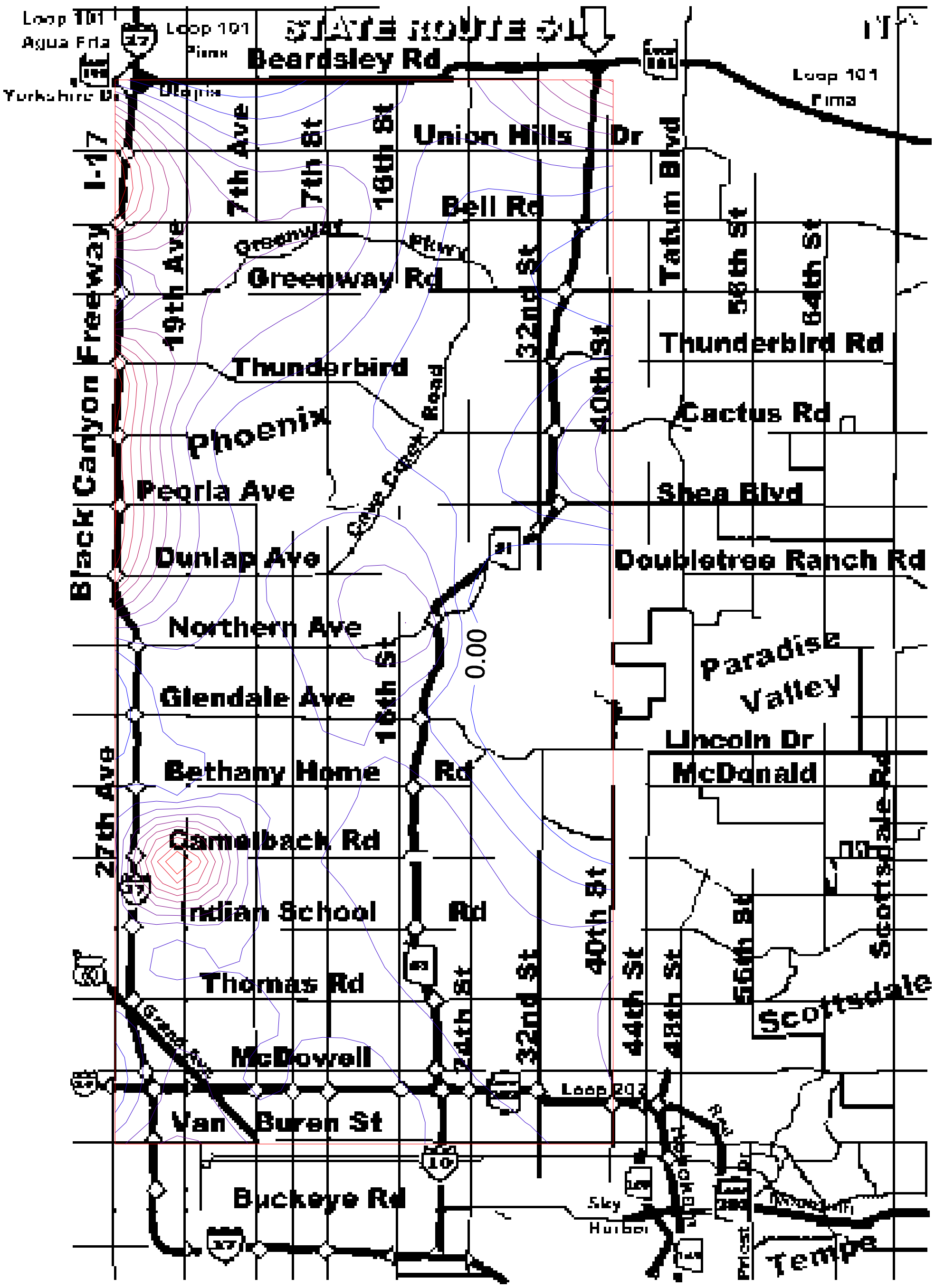

Figure 9 CO concentration distribution diagram during the morning rush hours on January 29, 1998 after the construction of SR-101 and SR-51 (wind vector is 130 degrees, Stability D)

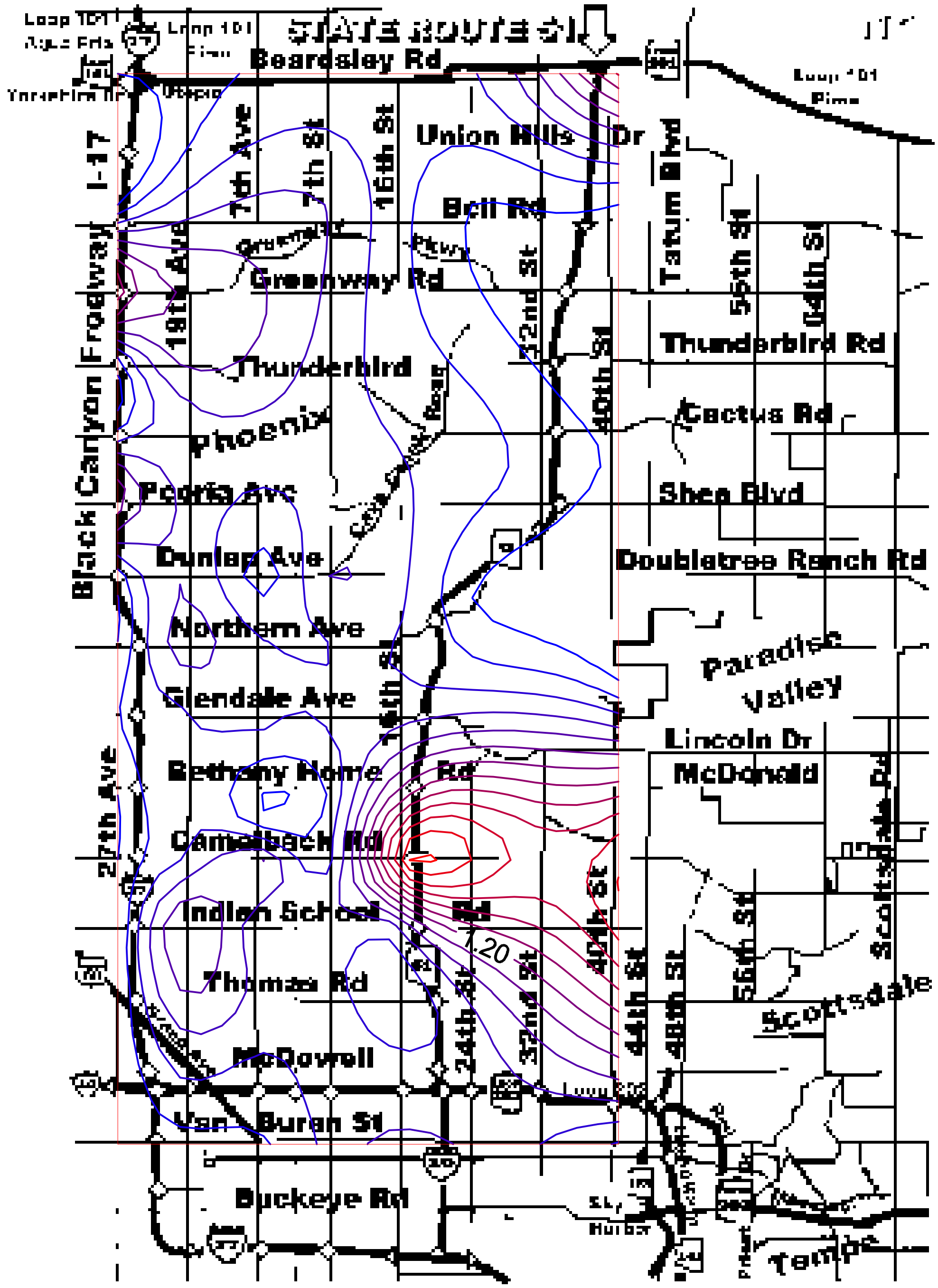

Figure 10 CO distribution diagram during the afternoon rush hours on January 29, 1998 after the construction of SR-101 and SR-51 (wind direction is 270 degrees, Stability D)

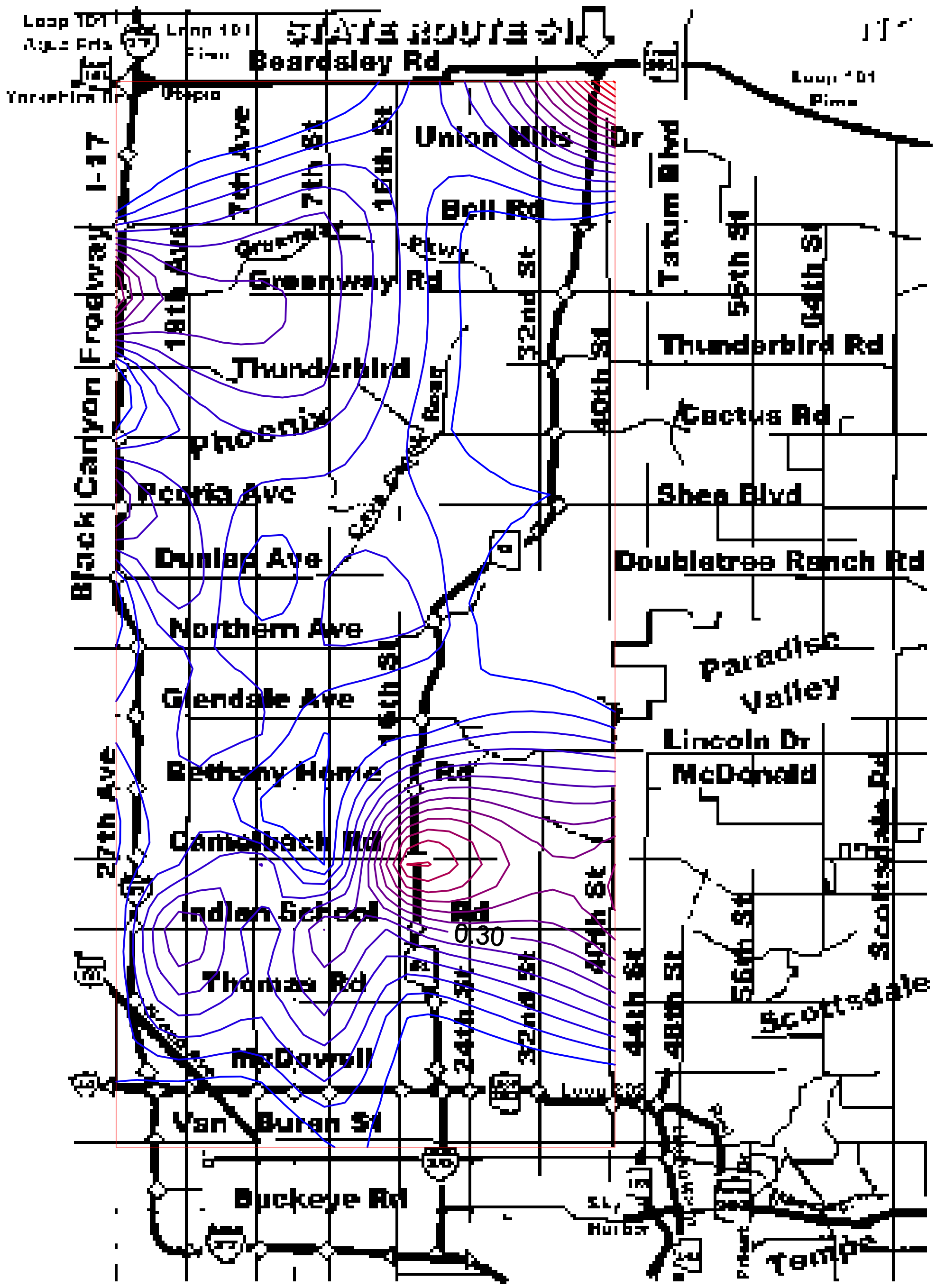

Figure 11 CO distribution diagram during the daytime on January 29, 1998 after the construction of SR-101 and SR-51 (wind direction is 270 degrees, Stability C)

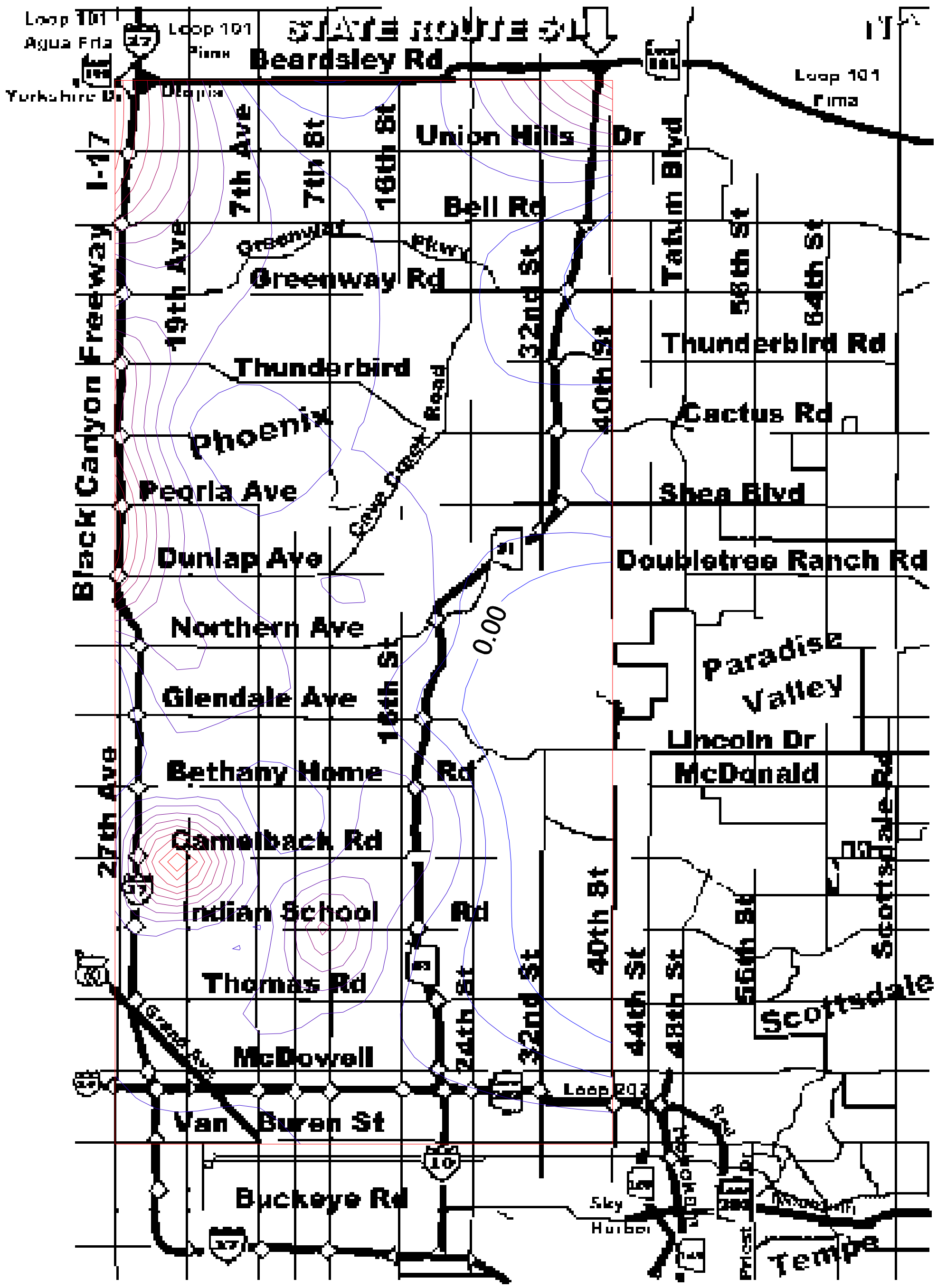

Figure 12 CO distribution diagram during the nighttime on January 29, 1998 after the construction of SR-101 and SR-51 (wind direction is 80 degrees, Stability E)

5 CONCLUSIONS

The combined effect of roadway emissions and local meteorology was modeled for this project. The first objective of the project had two parts: (1) to model the current freeway system in the north-central part of the Phoenix Valley and determine whether the model CAL3QHC was capable of predicting the known CO pollution Hot Spots, and (2) determine the effect of various meteorological conditions on the location of the Hot Spots. In order to simulate this scenario as accurately as possible, great effort was taken to obtain the most recent, relevant data from state and county agencies as input for CAL3QHC.

The vehicle emission factor for the pollutant (CO) was obtained using the MOBILE5 regulatory model. The output of MOBILE5 was used as the input to the CAL3QHC model. The effects of meteorological conditions on the pollutant distribution in the Phoenix Valley have been investigated. It can be concluded that the more stable and weak wind, the larger the maximum pollutant concentration. Different meteorological scenarios lead to different pollutant distribution over the valley. The calculations performed without the addition of the new freeway segments reproduced the location of the well know Hot Spot near 19th Avenue and Campbell Avenue fairly well. This result added confidence to several of the assumptions that were made in the modeling procedure. In particular, that the orographic effects of the Phoenix Mountains would be limited.

To address the second objective, the new freeways (State Route 101 and State Route 51) were added to the original case that was modeled. The results showed that the new additions would have a significant effect on the northern part of the domain. In particular, the region just southwest of the SR-101/SR-51 junction is a potential new Hot Spot. However, the results also indicate that areas beyond the part of the domain that was studied may also be effected (North of SR-101 and East of SR-51) under certain wind conditions. Another important result is that while the new freeways add a potential Hot Spot, they would not change the location of the current 19th Avenue and Campbell Avenu Hot Spot.

It should be noted that modeled Hot Spots that result from the new freeway segments may not result in actual Hot Spots in the real world. The reason for this is that there is a certain amount of uncertainty in the model assumption as well as the input data for both MOBILE5 and CAL3QHC segment. In particular, for the new sections of freeway, the actual traffic flows are unknown. The model results should be considered as a qualitative estimate of the location of possible new Hot Spots that may result from the new freeway sections. A possible use of this report could be to aid in the determination of locations of air quality monitoring devices after the new freeway has been completed.

REFERENCES

1. Carbon monoxide hot spot analysis in the Phoenix urban area, Maricopa Association of Governments, Transportation and Planning Office, REPORT #T133-80-4, 1980.
2. User's guide to MOBILE5 (Mobile Source Emission Factor Model), May 1994, U.S. Environmental Protection Agency.
3. Guidelines for preparing ATRC research reports, Arizona Transportation Research Center, October 1999.
4. User's guide to CAL3QHC version 2.0: a modeling methodology for predicting pollutant concentrations near roadway intersections, EPA-454/R-92-006, U.S. Environmental Protection Agency.
5. 1996 Air Quality Data for Arizona, Arizona Department of Environmental Quality, 1996.

APPENDIX A

INPUT FILE FOR MOBILE5

(for vehicle speed 30 mile/hour):

```
1       PROMPT
         User supplied mileage accumulation rates and registration rates.
1       TAMFLG
1       SPDFLG
1       VMFLAG
3       MYMRFG - User supplied registration rates and national mileage accumulation.
1       NEWFLG
1       IMFLAG
1       ALHFLG
1       ATPFLG
5       RLFLAG
1       LOCFLG - LAP record, one for each scenario.
2       TEMFLG
4       OUTFMT - 80-column descriptive format.
4       PRTFLG - Print exhaust HC, CO and NOx results.
1       IDLFLG - this feature is disabled, 1 necessary.
1       NMHFLG - Total hydrocarbon (THC) emission factors
1       HCFLAG - No component emission factor output
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016
.014 .010 .006 .008 .070
.075 .087 .094 .092 .070 .051 .045 .041 .053 .045
.030 .042 .035 .025 .014 .015 .017 .013 .023 .024
.021 .014 .009 .011 .054
.044 .062 .090 .074 .082 .037 .038 .039 .056 .060
.036 .046 .044 .032 .015 .018 .016 .021 .038 .023
.020 .012 .016 .013 .067
.074 .089 .091 .077 .071 .059 .059 .056 .059 .053
.051 .047 .042 .032 .020 .015 .012 .010 .013 .012
.009 .006 .003 .004 .036
.071 .090 .089 .084 .060 .047 .047 .042 .049 .044
.042 .057 .041 .032 .020 .017 .016 .012 .016 .016
.014 .010 .006 .008 .070
.073 .098 .121 .077 .066 .045 .045 .077 .068 .052
.046 .047 .042 .033 .014 .013 .014 .014 .015 .010
.006 .004 .004 .003 .014
.053 .080 .073 .061 .059 .042 .032 .033 .034 .033
.040 .459 .000 .000 .000 .000 .000 .000 .000 .000
.000 .000 .000 .000 .000
1 98 30.  55.1 20.6 27.3 20.6
Phoenix Hot Spot  44.6 69.8 9.0 9.0 20 2 1
.000 1.00 .000 .035 1
```

APPENDIX B

INPUT FILE FOR SCENARIO I

```
‘Hot Spot’ 60.  175.   0.     0.    55  0.3048   1    1
'F 27+ M'       -70           5311          6.0
'G 19+ M'       5067.5        5199          6.0
'H 7E+ M'       10254         5104          6.0
'I 7W+ M'       15566         5117          6.0
'J 16+ M'       20723.5       5108          6.0
'K 27+ T'       -70           10511         6.0
'L 19+ T'       5061          10455         6.0
'M 7E+ T'       10161         10361         6.0
'N 7W+ T'       15567         10329         6.0
'O 16+ T'       20817         10233         6.0
'Q 27+ I'       -70           15761         6.0
'R 19+ I'       5117.5        15655         6.0
'S 7E+ I'       10017.5       15592         6.0
'T 7W+ I'       15480         15591         6.0
'U 16+ I'       20730         15502         6.0
'W 27+ C'       -70           21005         6.0
'X 19+ C'       5105          20911         6.0
'Y 7E+ C'       10367         20745         6.0
'Z 7W+ C'       15617         20724         6.0
'A1 16+ C'      20892         20872         6.0
'B1 27+ B'      -70           26423         6.0
'C1 19+ B'      5092          26218         6.0
'D1 7E+ B'      10223         24032         6.0
'E1 7W+ B'      15473         25999         6.0
'F1 16+ B'      20770         26153         6.0
'H1 19+ G'      5167          31365         6.0
'I1 7E+ G'      10304         31210         6.0
'J1 7W+ G'      15582         31249         6.0
'K1 16+ G'      22871         31415         6.0
'L1 27+ N'      -70           36878         6.0
'M1 19+ N'      5267          36627         6.0
'O1 7W+ N'      15629         36519         6.0
'P1 16+ N'      23754         38749         6.0
'Q1 27+ D'      -70           42047.5       6.0
'R1 19+ D'      5242          41952         6.0
'S1 7E+ D'      10354         41741         6.0
'T1 7W+ D'      15554         42034         6.0
'U1 27+ P'      -70           47469         6.0
'X1 51+ P'      32625         47469         6.0
'Y1 27+ C'      -70           52738         6.0
'Z1 19+ C'      5161          52471         6.0
'A2 7W+ C'      24131         52471         6.0
'B2 27+ T'      -70           58045         6.0
'C2 19+ Tb'     5092          57740         6.0
'D2 7E+ Tb'     15592         56427         6.0
'E2 17+ Gr'     112.5         63157         6.0
```

```
'F2 19+ Gr'     5192        57880       6.0
'G2 24+ Gr'     26362       40111       6.0
'H2 27+ Bl'     -70         68482       6.0
'K2 7E+ Bl'     15755       68482       6.0
'M2 24+ Bl'     26292       68482       6.0
'O2 40+ Bl'     36862       68482       6.0
'R2 7AV+ UH'    10475       73266       6.0
'X2 27+ BE'     -70         78753       6.0
'E3 40+ BE'     35067       78753       6.0
'w-27AVE, e-Squaw Peak, s-I10, n-Beardsley RD' 112 1 1 'C'
1
'1NB 17'    'AG'   15      42118 15        73586 3971     14.66   0      50
1
'1SB 17'    'AG'   -15     73586 -15       42118   9267 14.66     0      50
1
'1aNB 17'   'AG'   1400    36808   15      42118   4185   14.66   0      50
1
'1aSB 17'   'AG'   -15     42118   1370    36808   9766   14.66   0      50
1
'2NB 17'    'AG'   1400    7881    1400    36808   4320   14.66   0      50
1
'2SB 17'    'AG'   1370    36808   1370    7881    10080  14.66   0      50
1
'2aNB 17'   'AG'   2720    3731    1400    7881    4500   14.66   0      50
1
'2aSB 17'   'AG'   1370    7881    2690    3731    10501  14.66   0      50
1
'3EB 10'    'AG'   2700    3691    24007   3845    9226   14.66   12.0   60
1
'3WB 10'    'AG'   24007   3925    2700    3771    9226   14.66   12.0   60
1
'4NB 51'    'AG'   24027   3885    24027   38166   3263   14.66   0      50
1
'4SB 51'    'AG'   23947   38166   23947   3885    7613   14.66   0      50
1
'5NB 51'    'DP'   24027   38166   30265 47387     3263   14.66   -12.0  50
1
'5SB 51'    'DP'   30185   47387   23947   38166   7613   14.66   -12.0  50
1
'6NB 51'    'AG'   30265 47387     32265   68328   3263   14.66   0      50
1
'6SB 51'    'AG'   32185   68328   30185   47687   7613   14.66   0      50
1
'8EB M'     'AG'   1176    5355    10325   5169    732    19.21   0      40
1
'8WB M'     'AG'   10325   5219    1176    5405    732    19.21   0      40
1
'9EB M'     'AG'   10325   5169    24242   5228    1200   19.21   0      40
1
'9WB M'     'AG'   24242   5278    10325   5219    1200   19.21   0      40
1
```

'10E T'	'AG'	406	10556	5131	10500	1613	19.21	0	40	1
'10W T'	'AG'	5131	10550	406	10406	1613	19.21	0	40	1
'11E T'	'AG'	5131	10500	10231	10406	1087	19.21	0	40	1
'11W T'	'AG'	10231	10456	5131	10550	1087	19.21	0	40	1
'12E T'	'AG'	10231	10406	23644	10398	1407	19.21	0	40	1
'12W T'	'AG'	23644	10358	10231	10456	1407	19.21	0	40	1
'13E I'	'AG'	662.5	15846	5187.5	15700	2326	19.21	0	40	1
'13W I'	'AG'	5187.5	15750	662.5	15896	2326	19.21	0	40	1
'14E I'	'AG'	5187.5	15780	22499	15577	1688	19.21	0	40	1
'14W I'	'AG'	22499	15627	5187.5	15750	1688	19.21	0	40	1
'15E C'	'AG'	820	21050	22474.5	20847	1575	19.21	0	40	1
'15W C'	'AG'	22474.5	20897	820	21100	1575	19.21	0	40	1
'16E B'	'AG'	837.5	26328	22540	26128	1120	19.21	0	40	1
'16W B'	'AG'	22540	26178	837.5	26368	1120	19.21	0	40	1
'17E G'	'AG'	800	31515	22440	31340	1681	19.21	0	40	1
'17W G'	'AG'	22440	31390	800	31565	1681	19.21	0	40	1
'18E BR'	'AG'	50	78387	35137	78387	562	19.21	0	40	1
'18W BR'	'AG'	35137	78437	50	78437	562	19.21	0	40	1
'19N 7AVE'	'AG'	10525	67887	10525	78387	637	19.21	0	40	1
'19S 7AVE'	'AG'	10175	78387	10525	67837	637	19.21	0	40	1
'20E N'	'AG'	825	36783	10462	36524	1238	19.21	0	40	1
'20W N'	'AG'	10462	36574	825	36833	1238	19.21	0	40	1
'21E N'	'AG'	10462	36524	24184	38724	1537	19.21	0	40	1
'21W N'	'AG'	24184	38774	10462	36574	1537	19.21	0	40	1
'22E D'	'AG'	-700	42162	5312	41997	1613	19.21	0	40	1
'22W D'	'AG'	5312	42047	-700	42212	1613	19.21	0	40	

1									
'23E D'	'AG'	5312	41997	15624	42079	1163	19.21	0	40
1									
'23W D'	'AG'	15624	42129	5312	42047	1163	19.21	0	40
1									
'24E P'	'AG'	-400	47374	5275	47266	1537	19.21	0	40
1									
'24W P'	'AG'	5275	48316	-400	47424	1537	19.21	0	40
1									
'25E P'	'AG'	5275	47266	10425	47073	563	19.21	0	40
1									
'25W P'	'AG'	10425	47123	5275	47316	563	19.21	0	40
1									
'26E CC'	'AG'	-585	52643	5233	52516	1050	19.21	0	40
1									
'26W CC'	'AG'	5233	52566	-585	52693	1050	19.21	0	40
1									
'27E TB'	'AG'	-585	57950	15662	56472	1688	19.21	0	40
1									
'27W TB'	'AG'	15662	56522	-585	58000	1688	19.21	0	40
1									
'28E TB'	'AG'	15662	56472	23907	52516	1500	19.21	0	40
1									
'28W TB'	'AG'	23907	52566	15662	56522	1500	19.21	0	40
1									
'29E GR'	'AG'	625	63062	5262	57785	1500	19.21	0	40
1									
'29W GR'	'AG'	5262	57835	625	63112	1500	19.21	0	40
1									
'30N 24'	'AG'	23932	52541	26432	78387	1275	19.21	0	40
1									
'30S 24'	'AG'	26382	78387	23882	52541	1275	19.21	0	40
1									
'31E B'	'AG'	50	68387	34137	63206	1800	19.21	0	40
1									
'31W B'	'AG'	34137	63256	50	68437	1800	19.21	0	40
1									
'32N 7A'	'AG'	5262	57785	15825	62156	1500	19.21	0	40
1									
'32S 7A'	'AG'	15825	62206	5262	57835	1500	19.21	0	40
1									
'33N 7S'	'AG'	15687	56497	15850	78387	2063	19.21	0	40
1									
'33S 7S'	'AG'	15800	78387	15637	56497	2063	19.21	0	40
1									
'34N 24'	'AG'	15825	62150	26432	40156	1950	19.21	0	40
1									
'34S 24'	'AG'	26432	40206	15825	62200	1950	19.21	0	40
1									
'35E UH'	'AG'	50	73387	34137	73387	1125	19.21	0	40
1									

'35W UH'	'AG'	34137	73437	50	73437	1125	19.21	0	40	1
'36N 19'	'AG'	5137	3801	5362	36697	1125	19.21	0	40	1
'36S 19'	'AG'	5312	36697	5087	3801	1125	19.21	0	40	1
'37N 19'	'AG'	5362	36697	5187	57740	1556	19.21	0	40	1
'37S 19'	'AG'	5137	57740	5312	36697	1556	19.21	0	40	1
'38N 19'	'AG'	5187	57740	5425	78387	1200	19.21	0	40	1
'38S 19'	'AG'	5375	78387	5137	57740	1200	19.21	0	40	1
'39N 7A'	'AG'	10520	2895	10490	5334	1388	19.21	0	40	1
'39S 7A'	'AG'	10440	5334	10470	28951	1388	19.21	0	40	1
'40N 7A'	'AG'	10490	5334	10318	26102	1312	19.21	0	40	1
'40S 7A'	'AG'	10268	26102	10440	5334	1312	19.21	0	40	1
'41N 7A'	'AG'	10318	26102	10450	47098	825	19.21	0	40	1
'41S 7A'	'AG'	10400	47098	10268	26102	825	19.21	0	40	1
'42N 7S'	'AG'	15776	3357.5	15802	5327	2175	19.21	0	40	1
'42S 7S'	'AG'	15752	5327	15726	3357.5	2175	19.21	0	40	1
'43N 7S'	'AG'	15802	5327	15649	42104	1570	19.21	0	40	1
'43S 7S'	'AG'	15599	42104	15752	5327	1570	19.21	0	40	1
'44N 7S'	'AG'	15649	42104	23932	52541	1238	19.21	0	40	1
'44S 7S'	'AG'	23882	52541	15599	42104	1238	19.21	0	40	1
'45N 16'	'AG'	21062	3270	20825	15572	1350	19.21	0	40	1
'45S 16'	'AG'	20775	15572	21012	3270	1350	19.21	0	40	1
'46N 16'	'AG'	20825	15572	20996	31315	1112	19.21	0	40	1
'46S 16'	'AG'	20946	31315	20775	15572	1112	19.21	0	40	1
'47N 16'	'AG'	20996	31315	20979	36665	938	19.21	0	40	1
'47S 16'	'AG'	20929	36665	20946	31315	938	19.21	0	40	2
'Q1 CamL19 Q N'	'AG'	5202	20951	5202	19951	0	20.0	2		

90 50 3.0 1000 382.00 0 0 0
2
'Q2 CamL19 QTurnN' 'AG' 5182 20951 5182 19981 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q3 CamL19 Q S' 'AG' 5167 21011 5167 22011 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q4 CamL19 QTurnS' 'AG' 5182 21011 5182 21981 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q5 CamL19 Q E' 'AG' 5157 20986 4167 20986 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q6 CamL19 QTurnE' 'AG' 5167 21011 5157 20986 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q7 CamL19 Q W' 'AG' 5217 21001 6217 21001 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q8 CamL19 QTurn' 'AG' 5217 20986 6187 20986 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q9 Ind7S Q N' 'AG' 15565 15361 15565 14361 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q10 Ind7S QTurnN' 'AG' 15545 15361 15545 14361 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q11 Ind7S Q S' 'AG' 15530 15691 15530 16691 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q12 Ind7S QTurnS' 'AG' 15545 15961 15545 16661 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q13 Ind7S Q E' 'AG' 15520 15646 14520 15646 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q14 Ind7S QTurnE' 'AG' 15520 15666 14550 15666 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q15 Ind7S Q W' 'AG' 15580 15681 16580 15681 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2
'Q16 Ind7S QTurnW' 'AG' 15580 15661 16580 15661 0 20.0 2
90 50 3.0 1000 382.00 0 0 0
2.0 130. 4 100. 0. 'N' 10 0 36

APPENDIX C

INPUT FILE FOR SCENARIO III

'Hot Spot'	60.	175.	0.	0.	55	0.3048	1	1
'F 27+ M'	-70			5311		6.0		
'G 19+ M'	5067.5			5199		6.0		
'H 7E+ M'	10254			5104		6.0		
'I 7W+ M'	15566			5117		6.0		
'J 16+ M'	20723.5			5108		6.0		
'K 27+ T'	-70			10511		6.0		
'L 19+ T'	5061			10455		6.0		
'M 7E+ T'	10161			10361		6.0		
'N 7W+ T'	15567			10329		6.0		
'O 16+ T'	20817			10233		6.0		
'Q 27+ I'	-70			15761		6.0		
'R 19+ I'	5117.5			15655		6.0		
'S 7E+ I'	10017.5			15592		6.0		
'T 7W+ I'	15480			15591		6.0		
'U 16+ I'	20730			15502		6.0		
'W 27+ C'	-70			21005		6.0		
'X 19+ C'	5105			20911		6.0		
'Y 7E+ C'	10367			20745		6.0		
'Z 7W+ C'	15617			20724		6.0		
'A1 16+ C'	20892			20872		6.0		
'B1 27+ B'	-70			26423		6.0		
'C1 19+ B'	5092			26218		6.0		
'D1 7E+ B'	10223			24032		6.0		
'E1 7W+ B'	15473			25999		6.0		
'F1 16+ B'	20770			26153		6.0		
'H1 19+ G'	5167			31365		6.0		
'I1 7E+ G'	10304			31210		6.0		
'J1 7W+ G'	15582			31249		6.0		
'K1 16+ G'	22871			31415		6.0		
'L1 27+ N'	-70			36878		6.0		
'M1 19+ N'	5267			36627		6.0		
'O1 7W+ N'	15629			36519		6.0		
'P1 16+ N'	23754			38749		6.0		
'Q1 27+ D'	-70			42047.5		6.0		
'R1 19+ D'	5242			41952		6.0		
'S1 7E+ D'	10354			41741		6.0		
'T1 7W+ D'	15554			42034		6.0		
'U1 27+ P'	-70			47469		6.0		
'X1 51+ P'	32625			47469		6.0		
'Y1 27+ C'	-70			52738		6.0		
'Z1 19+ C'	5161			52471		6.0		
'A2 7W+ C'	24131			52471		6.0		
'B2 27+ T'	-70			58045		6.0		
'C2 19+ Tb'	5092			57740		6.0		
'D2 7E+ Tb'	15592			56427		6.0		
'E2 17+ Gr'	112.5			63157		6.0		

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'F2 19+ Gr'   5192    57880   6.0
'G2 24+ Gr'   26362   40111   6.0
'H2 27+ Bl'   -70     68482   6.0
'K2 7E+ Bl'   15755   68482   6.0
'M2 24+ Bl'   26292   68482   6.0
'O2 40+ Bl'   36862   68482   6.0
'R2 7AV+ UH'  10475   73266   6.0
'X2 27+ BE'   -70     78753   6.0
'E3 40+ BE'   35067   78753   6.0
'w-27AVE, e-Squaw Peak, s-I10, n-Beardsley RD' 112 1 1 'C'
1
'1NB 17'   'AG'  15     42118 15     73586 4413   12.66  0      50
1
'1SB 17'   'AG'  -15    73586 -15    42118  4413 12.66   0      50
1
'1aNB 17'  'AG'  1400   36808  15     42118  4650   12.66  0      50
1
'1aSB 17'  'AG'  -15    42118  1370   36808  4650   12.66  0      50
1
'2NB 17'   'AG'  1400   7881   1400   36808  4800   12.66  0      50
1
'2SB 17'   'AG'  1370   36808  1370   7881   4800   12.66  0      50
1
'2aNB 17'  'AG'  2720   3731   1400   7881   5000   12.66  0      50
1
'2aSB 17'  'AG'  1370   7881   2690   3731   5000   12.66  0      50
1
'3EB 10'   'AG'  2700   3691   24007  3845   6151   12.66  12.0   60
1
'3WB 10'   'AG'  24007  3925   2700   3771   6151   12.66  12.0   60
1
'4NB 51'   'AG'  24027  3885   24027  38166  3625   12.66  0      50
1
'4SB 51'   'AG'  23947  38166  23947  3885   3625   12.66  0      50
1
'5NB 51'   'DP'  24027  38166  30265 47387   3625   12.66  -12.0  50
1
'5SB 51'   'DP'  30185  47387  23947  38166  3625   12.66  -12.0  50
1
'6NB 51'   'AG'  30265 47387   32265  68328  3625   12.66  0      50
1
'6SB 51'   'AG'  32185  68328  30185  47687  3625   12.66  0      50
1
'8EB M'    'AG'  1176   5355   10325  5169   488    14.66  0      40
1
'8WB M'    'AG'  10325  5219   1176   5405   488    14.66  0      40
1
'9EB M'    'AG'  10325  5169   24242  5228   800    14.66  0      40
1
'9WB M'    'AG'  24242  5278   10325  5219   800    14.66  0      40
1
```

'10E T'	'AG'	406	10556	5131	10500	1075	14.66	0	40	1
'10W T'	'AG'	5131	10550	406	10406	1075	14.66	0	40	1
'11E T'	'AG'	5131	10500	10231	10406	725	14.66	0	40	1
'11W T'	'AG'	10231	10456	5131	10550	725	14.66	0	40	1
'12E T'	'AG'	10231	10406	23644	10398	938	14.66	0	40	1
'12W T'	'AG'	23644	10358	10231	10456	938	14.66	0	40	1
'13E I'	'AG'	662.5	15846	5187.5	15700	1551	14.66	0	40	1
'13W I'	'AG'	5187.5	15750	662.5	15896	1551	14.66	0	40	1
'14E I'	'AG'	5187.5	15780	22499	15577	1125	14.66	0	40	1
'14W I'	'AG'	22499	15627	5187.5	15750	1125	14.66	0	40	1
'15E C'	'AG'	820	21050	22474.5	20847	1050	14.66	0	40	1
'15W C'	'AG'	22474.5	20897	820	21100	1050	14.66	0	40	1
'16E B'	'AG'	837.5	26328	22540	26128	747	14.66	0	40	1
'16W B'	'AG'	22540	26178	837.5	26368	747	14.66	0	40	1
'17E G'	'AG'	800	31515	22440	31340	1121	14.66	0	40	1
'17W G'	'AG'	22440	31390	800	31565	1121	14.66	0	40	1
'18E BR'	'AG'	50	78387	35137	78387	375	14.66	0	40	1
'18W BR'	'AG'	35137	78437	50	78437	375	14.66	0	40	1
'19N 7AVE'	'AG'	10525	67887	10525	78387	425	14.66	0	40	1
'19S 7AVE'	'AG'	10175	78387	10525	67837	425	14.66	0	40	1
'20E N'	'AG'	825	36783	10462	36524	825	14.66	0	40	1
'20W N'	'AG'	10462	36574	825	36833	825	14.66	0	40	1
'21E N'	'AG'	10462	36524	24184	38724	1025	14.66	0	40	1
'21W N'	'AG'	24184	38774	10462	36574	1025	14.66	0	40	1
'22E D'	'AG'	-700	42162	5312	41997	1075	14.66	0	40	1
'22W D'	'AG'	5312	42047	-700	42212	1075	14.66	0	40	

1									
'23E D'	'AG'	5312	41997	15624	42079	775	14.66	0	40
1									
'23W D'	'AG'	15624	42129	5312	42047	775	14.66	0	40
1									
'24E P'	'AG'	-400	47374	5275	47266	1025	14.66	0	40
1									
'24W P'	'AG'	5275	48316	-400	47424	1025	14.66	0	40
1									
'25E P'	'AG'	5275	47266	10425	47073	375	14.66	0	40
1									
'25W P'	'AG'	10425	47123	5275	47316	375	14.66	0	40
1									
'26E CC'	'AG'	-585	52643	5233	52516	700	14.66	0	40
1									
'26W CC'	'AG'	5233	52566	-585	52693	700	14.66	0	40
1									
'27E TB'	'AG'	-585	57950	15662	56472	1125	14.66	0	40
1									
'27W TB'	'AG'	15662	56522	-585	58000	1125	14.66	0	40
1									
'28E TB'	'AG'	15662	56472	23907	52516	1000	14.66	0	40
1									
'28W TB'	'AG'	23907	52566	15662	56522	1000	14.66	0	40
1									
'29E GR'	'AG'	625	63062	5262	57785	1000	14.66	0	40
1									
'29W GR'	'AG'	5262	57835	625	63112	1000	14.66	0	40
1									
'30N 24'	'AG'	23932	52541	26432	78387	850	14.66	0	40
1									
'30S 24'	'AG'	26382	78387	23882	52541	850	14.66	0	40
1									
'31E B'	'AG'	50	68387	34137	63206	1200	14.66	0	40
1									
'31W B'	'AG'	34137	63256	50	68437	1200	14.66	0	40
1									
'32N 7A'	'AG'	5262	57785	15825	62156	1000	14.66	0	40
1									
'32S 7A'	'AG'	15825	62206	5262	57835	1000	14.66	0	40
1									
'33N 7S'	'AG'	15687	56497	15850	78387	1375	14.66	0	40
1									
'33S 7S'	'AG'	15800	78387	15637	56497	1375	14.66	0	40
1									
'34N 24'	'AG'	15825	62150	26432	40156	1300	14.66	0	40
1									
'34S 24'	'AG'	26432	40206	15825	62200	1300	14.66	0	40
1									
'35E UH'	'AG'	50	73387	34137	73387	750	14.66	0	40
1									

'35W UH'	'AG'	34137	73437	50	73437	750	14.66	0	40	1
'36N 19'	'AG'	5137	3801	5362	36697	750	14.66	0	40	1
'36S 19'	'AG'	5312	36697	5087	3801	750	14.66	0	40	1
'37N 19'	'AG'	5362	36697	5187	57740	1037	14.66	0	40	1
'37S 19'	'AG'	5137	57740	5312	36697	1037	14.66	0	40	1
'38N 19'	'AG'	5187	57740	5425	78387	800	14.66	0	40	1
'38S 19'	'AG'	5375	78387	5137	57740	800	14.66	0	40	1
'39N 7A'	'AG'	10520	2895	10490	5334	925	14.66	0	40	1
'39S 7A'	'AG'	10440	5334	10470	28951	925	14.66	0	40	1
'40N 7A'	'AG'	10490	5334	10318	26102	875	14.66	0	40	1
'40S 7A'	'AG'	10268	26102	10440	5334	875	14.66	0	40	1
'41N 7A'	'AG'	10318	26102	10450	47098	550	14.66	0	40	1
'41S 7A'	'AG'	10400	47098	10268	26102	550	14.66	0	40	1
'42N 7S'	'AG'	15776	3357.5	15802	5327	1450	14.66	0	40	1
'42S 7S'	'AG'	15752	5327	15726	3357.5	1450	14.66	0	40	1
'43N 7S'	'AG'	15802	5327	15649	42104	1047	14.66	0	40	1
'43S 7S'	'AG'	15599	42104	15752	5327	1047	14.66	0	40	1
'44N 7S'	'AG'	15649	42104	23932	52541	825	14.66	0	40	1
'44S 7S'	'AG'	23882	52541	15599	42104	825	14.66	0	40	1
'45N 16'	'AG'	21062	3270	20825	15572	900	14.66	0	40	1
'45S 16'	'AG'	20775	15572	21012	3270	900	14.66	0	40	1
'46N 16'	'AG'	20825	15572	20996	31315	741	14.66	0	40	1
'46S 16'	'AG'	20946	31315	20775	15572	741	14.66	0	40	1
'47N 16'	'AG'	20996	31315	20979	36665	625	14.66	0	40	1
'47S 16'	'AG'	20929	36665	20946	31315	625	14.66	0	40	2
'Q1 CamL19 Q N'	'AG'	5202	20951	5202	19951	0	20.0	2		

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        90      50      3.0     1000    382.00  0       0       0
2
'Q2 CamL19 QTurnN'      'AG'    5182    20951   5182    19981   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q3 CamL19 Q S'         'AG'    5167    21011   5167    22011   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q4 CamL19 QTurnS'      'AG'    5182    21011   5182    21981   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q5 CamL19 Q E'         'AG'    5157    20986   4167    20986   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q6 CamL19 QTurnE'      'AG'    5167    21011   5157    20986   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q7 CamL19 Q W'         'AG'    5217    21001   6217    21001   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q8 CamL19 QTurn'       'AG'    5217    20986   6187    20986   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q9 Ind7S Q N'          'AG'    15565   15361   15565   14361   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q10 Ind7S QTurnN'      'AG'    15545   15361   15545   14361   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q11 Ind7S Q S'         'AG'    15530   15691   15530   16691   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q12 Ind7S QTurnS'      'AG'    15545   15961   15545   16661   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q13 Ind7S Q E'         'AG'    15520   15646   14520   15646   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q14 Ind7S QTurnE'      'AG'    15520   15666   14550   15666   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q15 Ind7S Q W'         'AG'    15580   15681   16580   15681   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
2
'Q16 Ind7S QTurnW'      'AG'    15580   15661   16580   15661   0       20.0    2
        90      50      3.0     1000    382.00  0       0       0
3.0     270.    3       1000.   0.      'N'     10      0       36
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APPENDIX D

INPUT FILE FOR SCENARIO VIII

'Hot Spot' 60.	175.	0.	0.	55	0.3048	1	1
'F 27+ M'	-70		5311		6.0		
'G 19+ M'	5067.5		5199		6.0		
'H 7E+ M'	10254		5104		6.0		
'I 7W+ M'	15566		5117		6.0		
'J 16+ M'	20723.5		5108		6.0		
'K 27+ T'	-70		10511		6.0		
'L 19+ T'	5061		10455		6.0		
'M 7E+ T'	10161		10361		6.0		
'N 7W+ T'	15567		10329		6.0		
'O 16+ T'	20817		10233		6.0		
'Q 27+ I'	-70		15761		6.0		
'R 19+ I'	5117.5		15655		6.0		
'S 7E+ I'	10017.5		15592		6.0		
'T 7W+ I'	15480		15591		6.0		
'U 16+ I'	20730		15502		6.0		
'W 27+ C'	-70		21005		6.0		
'X 19+ C'	5105		20911		6.0		
'Y 7E+ C'	10367		20745		6.0		
'Z 7W+ C'	15617		20724		6.0		
'A1 16+ C'	20892		20872		6.0		
'B1 27+ B'	-70		26423		6.0		
'C1 19+ B'	5092		26218		6.0		
'D1 7E+ B'	10223		24032		6.0		
'E1 7W+ B'	15473		25999		6.0		
'F1 16+ B'	20770		26153		6.0		
'H1 19+ G'	5167		31365		6.0		
'I1 7E+ G'	10304		31210		6.0		
'J1 7W+ G'	15582		31249		6.0		
'K1 16+ G'	22871		31415		6.0		
'L1 27+ N'	-70		36878		6.0		
'M1 19+ N'	5267		36627		6.0		
'O1 7W+ N'	15629		36519		6.0		
'P1 16+ N'	23754		38749		6.0		
'Q1 27+ D'	-70		42047.5		6.0		
'R1 19+ D'	5242		41952		6.0		
'S1 7E+ D'	10354		41741		6.0		
'T1 7W+ D'	15554		42034		6.0		
'U1 27+ P'	-70		47469		6.0		
'X1 51+ P'	32625		47469		6.0		
'Y1 27+ C'	-70		52738		6.0		
'Z1 19+ C'	5161		52471		6.0		
'A2 7W+ C'	24131		52471		6.0		
'B2 27+ T'	-70		58045		6.0		
'C2 19+ Tb'	5092		57740		6.0		
'D2 7E+ Tb'	15592		56427		6.0		
'E2 17+ Gr'	112.5		63157		6.0		

```
'F2 19+ Gr'   5192    57880   6.0
'G2 24+ Gr'   26362   40111   6.0
'H2 27+ Bl'   -70     68482   6.0
'K2 7E+ Bl'   15755   68482   6.0
'M2 24+ Bl'   26292   68482   6.0
'O2 40+ Bl'   36862   68482   6.0
'R2 7AV+ UH'  10475   73266   6.0
'X2 27+ BE'   -70     78753   6.0
'E3 40+ BE'   35067   78753   6.0
'w-27AVE, e-Squaw Peak, s-I10, n-Beardsley RD' 114 1 1 'C'
1
'1NB 17'   'AG'  15     42118 15     73586 2207   21.03  0      50
1
'1SB 17'   'AG'  -15    73586 -15    42118  2207 21.03  0      50
1
'1aNB 17'  'AG'  1400   36808  15     42118  2325   21.03  0      50
1
'1aSB 17'  'AG'  -15    42118  1370   36808  2325   21.03  0      50
1
'2NB 17'   'AG'  1400   7881   1400   36808  2400   21.03  0      50
1
'2SB 17'   'AG'  1370   36808  1370   7881   2400   21.03  0      50
1
'2aNB 17'  'AG'  2720   3731   1400   7881   2500   21.03  0      50
1
'2aSB 17'  'AG'  1370   7881   2690   3731   2500   21.03  0      50
1
'3EB 10'   'AG'  2700   3691   24007  3845   3075   21.03  12.0   60
1
'3WB 10'   'AG'  24007  3925   2700   3771   3075   21.03  12.0   60
1
'4NB 51'   'AG'  24027  3885   24027  38166  1813   21.03  0      50
1
'4SB 51'   'AG'  23947  38166  23947  3885   1813   21.03  0      50
1
'5NB 51'   'DP'  24027  38166  30265 47387   1812   21.03  -12.0  50
1
'5SB 51'   'DP'  30185  47387  23947  38166  1812   21.03  -12.0  50
1
'6NB 51'   'AG'  30265 47387   32265  68328  1812   21.03  0      50
1
'6SB 51'   'AG'  32185  68328  30185  47687  1812   21.03  0      50
1
'7NB 51'   'AG'  32240 68328   35152  78823  2719   21.03  0      50
1
'7SB 51'   'AG'  35122  78823  32210  38328  2719   21.03  0      50
1
'8EB M'    'AG'  1176   5355   10325  5169   244    14.66  0      40
1
'8WB M'    'AG'  10325  5219   1176   5405   244    14.66  0      40
1
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'9EB M'	'AG'	10325	5169	24242	5228	400	14.66	0	40	1
'9WB M'	'AG'	24242	5278	10325	5219	400	14.66	0	40	1
'10E T'	'AG'	406	10556	5131	10500	537	14.66	0	40	1
'10W T'	'AG'	5131	10550	406	10406	537	14.66	0	40	1
'11E T'	'AG'	5131	10500	10231	10406	363	14.66	0	40	1
'11W T'	'AG'	10231	10456	5131	10550	363	14.66	0	40	1
'12E T'	'AG'	10231	10406	23644	10398	469	14.66	0	40	1
'12W T'	'AG'	23644	10358	10231	10456	469	14.66	0	40	1
'13E I'	'AG'	662.5	15846	5187.5	15700	776	14.66	0	40	1
'13W I'	'AG'	5187.5	15750	662.5	15896	776	14.66	0	40	1
'14E I'	'AG'	5187.5	15780	22499	15577	563	14.66	0	40	1
'14W I'	'AG'	22499	15627	5187.5	15750	563	14.66	0	40	1
'15E C'	'AG'	820	21050	22474.5	20847	525	14.66	0	40	1
'15W C'	'AG'	22474.5	20897	820	21100	525	14.66	0	40	1
'16E B'	'AG'	837.5	26328	22540	26128	373	14.66	0	40	1
'16W B'	'AG'	22540	26178	837.5	26368	373	14.66	0	40	1
'17E G'	'AG'	800	31515	22440	31340	560	14.66	0	40	1
'17W G'	'AG'	22440	31390	800	31565	560	14.66	0	40	1
'18E 101'	'AG'	50	78808	35137	78808	1875	21.03	0	40	1
'18W 101'	'AG'	35137	78838	50	78838	1875	21.03	0	40	1
'19N 7AVE'	'AG'	10525	67887	10525	78387	213	14.66	0	40	1
'19S 7AVE'	'AG'	10175	78387	10525	67837	213	14.66	0	40	1
'20E N'	'AG'	825	36783	10462	36524	413	14.66	0	40	1
'20W N'	'AG'	10462	36574	825	36833	413	14.66	0	40	1
'21E N'	'AG'	10462	36524	24184	38724	516	14.66	0	40	1
'21W N'	'AG'	24184	38774	10462	36574	516	14.66	0	40	

1									
'22E D'	'AG'	-700	42162	5312	41997	538	14.66	0	40
1									
'22W D'	'AG'	5312	42047	-700	42212	538	14.66	0	40
1									
'23E D'	'AG'	5312	41997	15624	42079	388	14.66	0	40
1									
'23W D'	'AG'	15624	42129	5312	42047	388	14.66	0	40
1									
'24E P'	'AG'	-400	47374	5275	47266	513	14.66	0	40
1									
'24W P'	'AG'	5275	48316	-400	47424	513	14.66	0	40
1									
'25E P'	'AG'	5275	47266	10425	47073	188	14.66	0	40
1									
'25W P'	'AG'	10425	47123	5275	47316	188	14.66	0	40
1									
'26E CC'	'AG'	-585	52643	5233	52516	350	14.66	0	40
1									
'26W CC'	'AG'	5233	52566	-585	52693	350	14.66	0	40
1									
'27E TB'	'AG'	-585	57950	15662	56472	563	14.66	0	40
1									
'27W TB'	'AG'	15662	56522	-585	58000	563	14.66	0	40
1									
'28E TB'	'AG'	15662	56472	23907	52516	500	14.66	0	40
1									
'28W TB'	'AG'	23907	52566	15662	56522	500	14.66	0	40
1									
'29E GR'	'AG'	625	63062	5262	57785	500	14.66	0	40
1									
'29W GR'	'AG'	5262	57835	625	63112	500	14.66	0	40
1									
'30N 24'	'AG'	23932	52541	26432	78387	425	14.66	0	40
1									
'30S 24'	'AG'	26382	78387	23882	52541	425	14.66	0	40
1									
'31E B'	'AG'	50	68387	34137	63206	600	14.66	0	40
1									
'31W B'	'AG'	34137	63256	50	68437	600	14.66	0	40
1									
'32N 7A'	'AG'	5262	57785	15825	62156	500	14.66	0	40
1									
'32S 7A'	'AG'	15825	62206	5262	57835	500	14.66	0	40
1									
'33N 7S'	'AG'	15687	56497	15850	78387	688	14.66	0	40
1									
'33S 7S'	'AG'	15800	78387	15637	56497	688	14.66	0	40
1									
'34N 24'	'AG'	15825	62150	26432	40156	650	14.66	0	40
1									

'34S 24'	'AG'	26432	40206	15825	62200	650	14.66	0	40	1
'35E UH'	'AG'	50	73387	34137	73387	375	14.66	0	40	1
'35W UH'	'AG'	34137	73437	50	73437	375	14.66	0	40	1
'36N 19'	'AG'	5137	3801	5362	36697	375	14.66	0	40	1
'36S 19'	'AG'	5312	36697	5087	3801	375	14.66	0	40	1
'37N 19'	'AG'	5362	36697	5187	57740	519	14.66	0	40	1
'37S 19'	'AG'	5137	57740	5312	36697	519	14.66	0	40	1
'38N 19'	'AG'	5187	57740	5425	78387	400	14.66	0	40	1
'38S 19'	'AG'	5375	78387	5137	57740	400	14.66	0	40	1
'39N 7A'	'AG'	10520	2895	10490	5334	463	14.66	0	40	1
'39S 7A'	'AG'	10440	5334	10470	28951	463	14.66	0	40	1
'40N 7A'	'AG'	10490	5334	10318	26102	438	14.66	0	40	1
'40S 7A'	'AG'	10268	26102	10440	5334	438	14.66	0	40	1
'41N 7A'	'AG'	10318	26102	10450	47098	275	14.66	0	40	1
'41S 7A'	'AG'	10400	47098	10268	26102	275	14.66	0	40	1
'42N 7S'	'AG'	15776	3357.5	15802	5327	725	14.66	0	40	1
'42S 7S'	'AG'	15752	5327	15726	3357.5	725	14.66	0	40	1
'43N 7S'	'AG'	15802	5327	15649	42104	524	14.66	0	40	1
'43S 7S'	'AG'	15599	42104	15752	5327	524	14.66	0	40	1
'44N 7S'	'AG'	15649	42104	23932	52541	413	14.66	0	40	1
'44S 7S'	'AG'	23882	52541	15599	42104	413	14.66	0	40	1
'45N 16'	'AG'	21062	3270	20825	15572	450	14.66	0	40	1
'45S 16'	'AG'	20775	15572	21012	3270	450	14.66	0	40	1
'46N 16'	'AG'	20825	15572	20996	31315	370	14.66	0	40	1
'46S 16'	'AG'	20946	31315	20775	15572	370	14.66	0	40	1
'47N 16'	'AG'	20996	31315	20979	36665	313	14.66	0	40	

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1
'47S 16'           'AG'     20929    36665    20946    31315    313      14.66    0        40
2
'Q1 CamL19 Q N'             'AG'     5202     20951    5202     19951    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q2 CamL19 QTurnN'          'AG'     5182     20951    5182     19981    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q3 CamL19 Q S'             'AG'     5167     21011    5167     22011    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q4 CamL19 QTurnS'          'AG'     5182     21011    5182     21981    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q5 CamL19 Q E'             'AG'     5157     20986    4167     20986    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q6 CamL19 QTurnE'          'AG'     5167     21011    5157     20986    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q7 CamL19 Q W’             'AG'     5217     21001    6217     21001    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q8 CamL19 QTurn'           'AG'     5217     20986    6187     20986    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q9 Ind7S Q N'              'AG'     15565    15361    15565    14361    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q10 Ind7S QTurnN'          'AG'     15545    15361    15545    14361    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q11 Ind7S Q S'             'AG'     15530    15691    15530    16691    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q12 Ind7S QTurnS'          'AG'     15545    15961    15545    16661    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q13 Ind7S Q E'             'AG'     15520    15646    14520    15646    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q14 Ind7S QTurnE'          'AG'     15520    15666    14550    15666    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q15 Ind7S Q W'             'AG'     15580    15681    16580    15681    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
2
'Q16 Ind7S QTurnW'          'AG'     15580    15661    16580    15661    0        20.0     2
         90       50        3.0      1000     382.00   0        0        0
1.0   80.   5    50.        0.       'N'      10 0     36
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