Appendix C

Crash Evaluation Methodology

Crash Evaluation Methodology

The crash rate calculations uses equations found in the *Highway Safety Improvement Program Handbook* (HSIPHB) by ADOT&PF, and NCHRP Report 162 from Transportation Research Board, *Methods for Evaluating Highway Safety Improvements* by John C. Laughland, *et al.,* National Research Council, Washington, D.C. 1975. These formulae appear in many other references as well.

Segment crash rates are calculated as:

Equation C-1. $$R = \frac{1{,}000{,}000 \times A}{365 \times N \times ADT \times L}$$, where

R= Crash rate for the intersection expressed as crashes per million vehicle miles (MVM),
A= Frequency of crashes in the study period,
N= Number of years of data,
ADT= Segment Average Annual Daily Traffic (AADT) volumes, both directions (average over study period),
L= Segment length, miles.

Rate analysis is especially useful when there is a population of facilities to which we can compare the study area. Rates are a good indicator of the individual's risk in being involved in a crash when using the facility because rates consider the motorist's exposure by volume and length of road. ADOT&PF has developed statewide populations for segments and intersections, and provides this data in the HSIPHB and supplements and the 2001 *Traffic Accident Report,* May 2003 (*Traffic Accident Report* is published annually by DOT&PF).

We can calculate crash rates using Equation C-1 to compare the facility to the corresponding State of Alaska average crash rate population. However, by only comparing the rate of the facility under analysis to an average rate, we may erroneously infer that those facilities with higher than average rates are problem areas.

Instead, we would like to establish an upper limit, or *critical* rate that is our threshold of concern. The Rate Quality Control Method establishes an upper control limit (UCL) to determine if the facility's crash rate, as calculated in Equation 1, is significantly higher than crash rates in facilities with similar characteristics. The UCL or critical rate is determined statistically as a function of the statewide average crash rate for the facility category (i.e., highway or intersection) and the vehicle exposure at the location being considered. UCL is calculated with the following equation:

Equation C-2. $$UCL = R_a + Z \times \sqrt{\frac{R_a}{M}} + \frac{1}{2 \times M},$$

The variables in this equation are:

R_a= Average crash rate for the population in crashes per MVM (road segments);

M= Facility exposure in MVM for roadway section, using N, ADT, and L stated above and computed as:

Equation C-3. $$M = \frac{365 \times N \times ADT \times L}{10^6}$$

Z= Normal Distribution Transformation Variable (usually 1.64 for a 95% confidence level)

Segments with rates that exceed the UCL are inferred to be well above the population average at the confidence level reflected in the selection of the "Z" variable, and would therefore have significant crash experience.

Where there are sufficient numbers of crashes, hypothesis testing compares each intersection's accident types and factors to the intersection and accident type population statistics. This can determine if the proportion of the accident type or contributing factor exceeds the populations, and whether these types or factor should be the focus of countermeasures. Populations for accident types are available from the Municipality of Anchorage. Environmental factors and severity population percentages are published in the annual State of Alaska Department of Transportation and Public Facilities *Alaska Traffic Accidents*.

In hypothesis testing, the null hypothesis, H_o, states that the attribute of the intersection that we are interested in, for example proportion of collisions of a certain type, or proportion of damage type crashes, are less than or equal to state populations. The alternative hypothesis, H_a, states that the intersection's proportions exceed the comparative populations.

The crashes are binomially distributed samples. Normal distribution provides a reasonable approximation to binomial probabilities when the sample is sufficiently large. If so, then the standardized value is calculated as:

Equation C-4. $$Z = \frac{\hat{p} - p}{\sqrt{p(1-p)/n}}$$

Where:

Z = Normal Distribution Transformation Variable, the value within the normal distribution curve;

$\hat{p}$ =Sample proportion;

p = Population proportion; and

n = Number of crashes at location.

The large-sample assumption is checked by testing whether $np \geq 5$, and $n(1-p) \geq 5$.

A p-value (not to be confused with $\hat{p}$ or p) is determined by the area (probability) between the z-value and the tail within the standard normal distribution curve. The p-value is the probability of a Type-I error in hypothesis testing. That is, the p-value is the probability that we reject the null hypothesis, H_o, in this case simply stated that "This intersection accident attribute proportion is less than or equal to the proportion of the control population", when H_o is true. A low p-value, usually 0.05 or less indicates that there is strong statistical evidence favoring the alternative hypothesis, H_a, or we could say, "This intersection attribute proportion exceeds the control population proportion".

If an intersection does not have enough crashes to meet the large sample assumption; that is np <5, or $n(1-p)$<5; we use the Poisson distribution to check accident significance. If K is the number of crashes under examination then the probability that there are less than K crashes is:

Equation C-5. $P(<K) = P(0 \quad acc) + P(1 \quad acc) + ... + P((K-1) \quad acc)$.

In this case, the Poisson probability formula estimates the probability of discrete numbers of crashes, and the probability that there are less than *K* crashes is calculated as:

Equation C-6. $P(<K) = \sum_{i=0}^{i=K-1} (e^{-np}(np)^i)/i!$

Where:

K = number of occurring crashes of type, severity or environmental factor;

e = Base of natural logarithms;

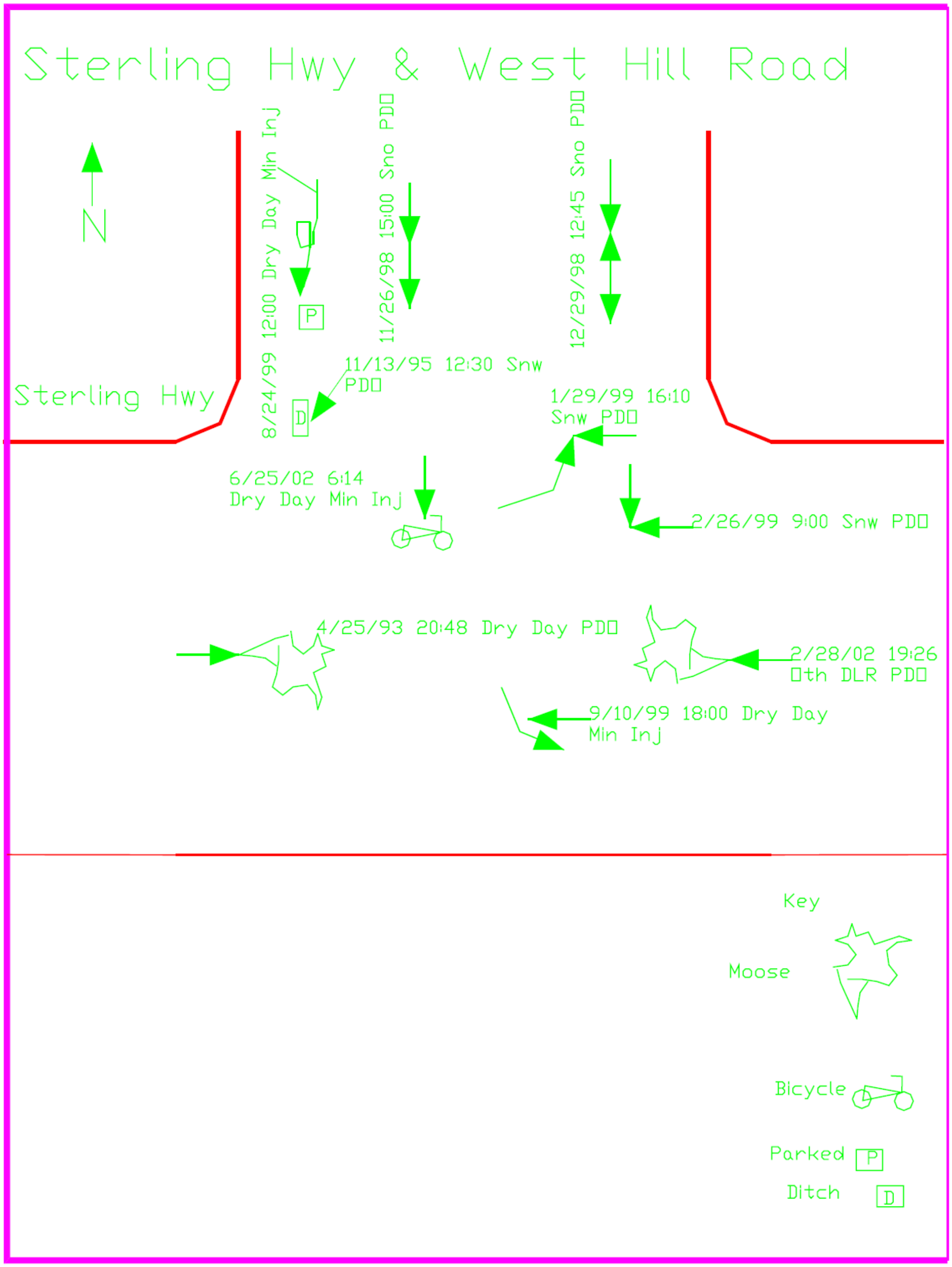
p = Population proportion; and

n = Number of crashes at location.

If the probability of *K* accident of type or contributing factor is calculated to be extremely low, say 5% or less, and *K* crashes occur, we infer that the accident trend is statistically significant.

Appendix D

Collision Diagrams



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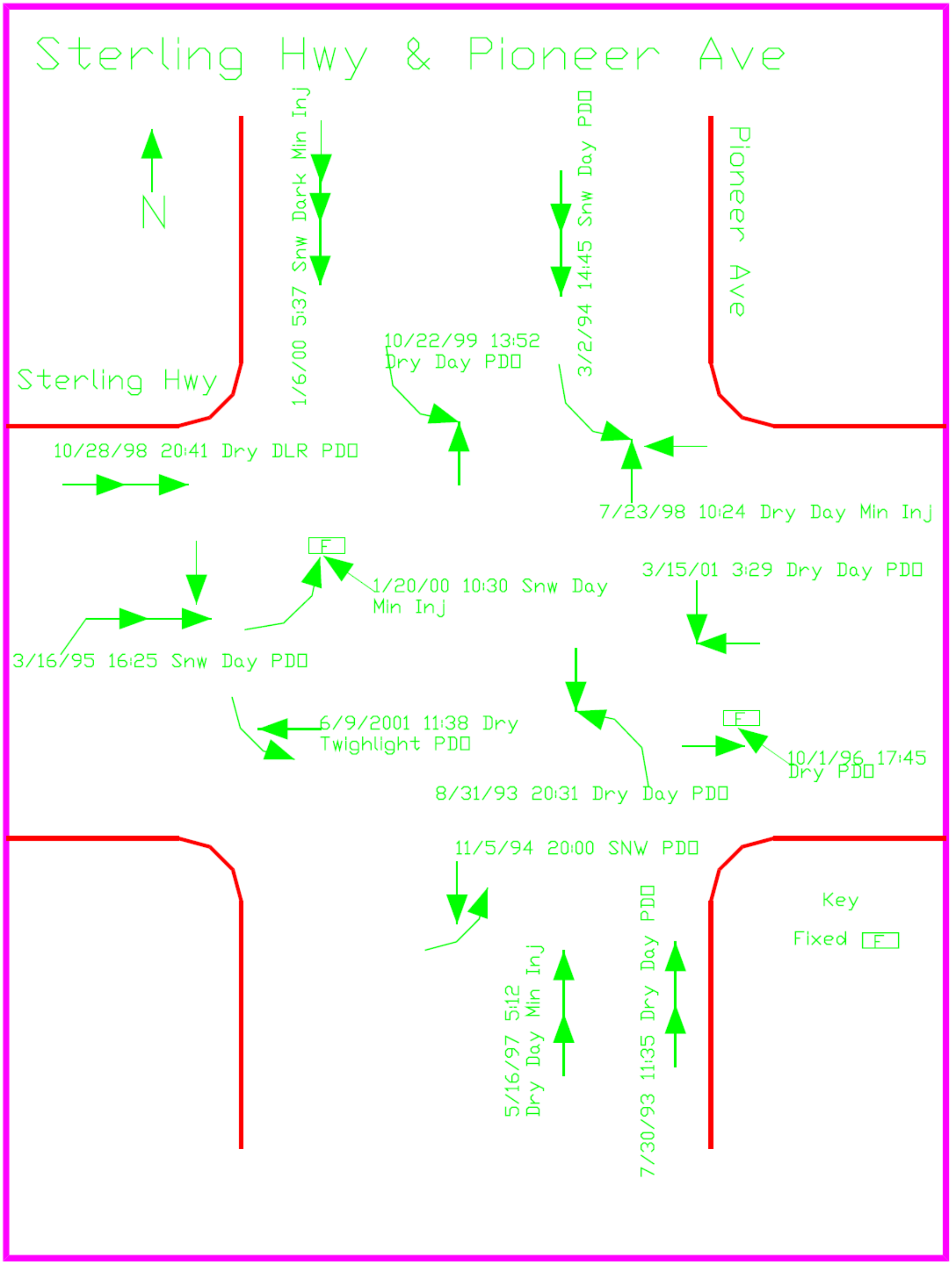
P
11/26/98 15:00 Sno PDO
12/29/98 12:45 Sno PDO
11/13/95 12:30 Snw PDO
D
1/29/99 16:10 Snw PDO
6/25/02 6:14 Dry Day Min Inj
2/26/99 9:00 Snw PDO
4/25/93 20:48 Dry Day PDO
2/28/02 19:26 Dth DLR PDO
9/10/99 18:00 Dry Day Min Inj
Key
Moose
Bicycle
Parked
P
Ditch
D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Dry Day PDO
10/28/98 20:41 Dry DLR PDO
7/23/98 10:24 Dry Day Min Inj
F
1/20/00 10:30 Snw Day
Min Inj
3/15/01 3:29 Dry Day PDO
3/16/95 16:25 Snw Day PDO
6/9/2001 11:38 Dry
Twighlight PDO
F
10/1/96 17:45
Dry PDO
8/31/93 20:31 Dry Day PDO
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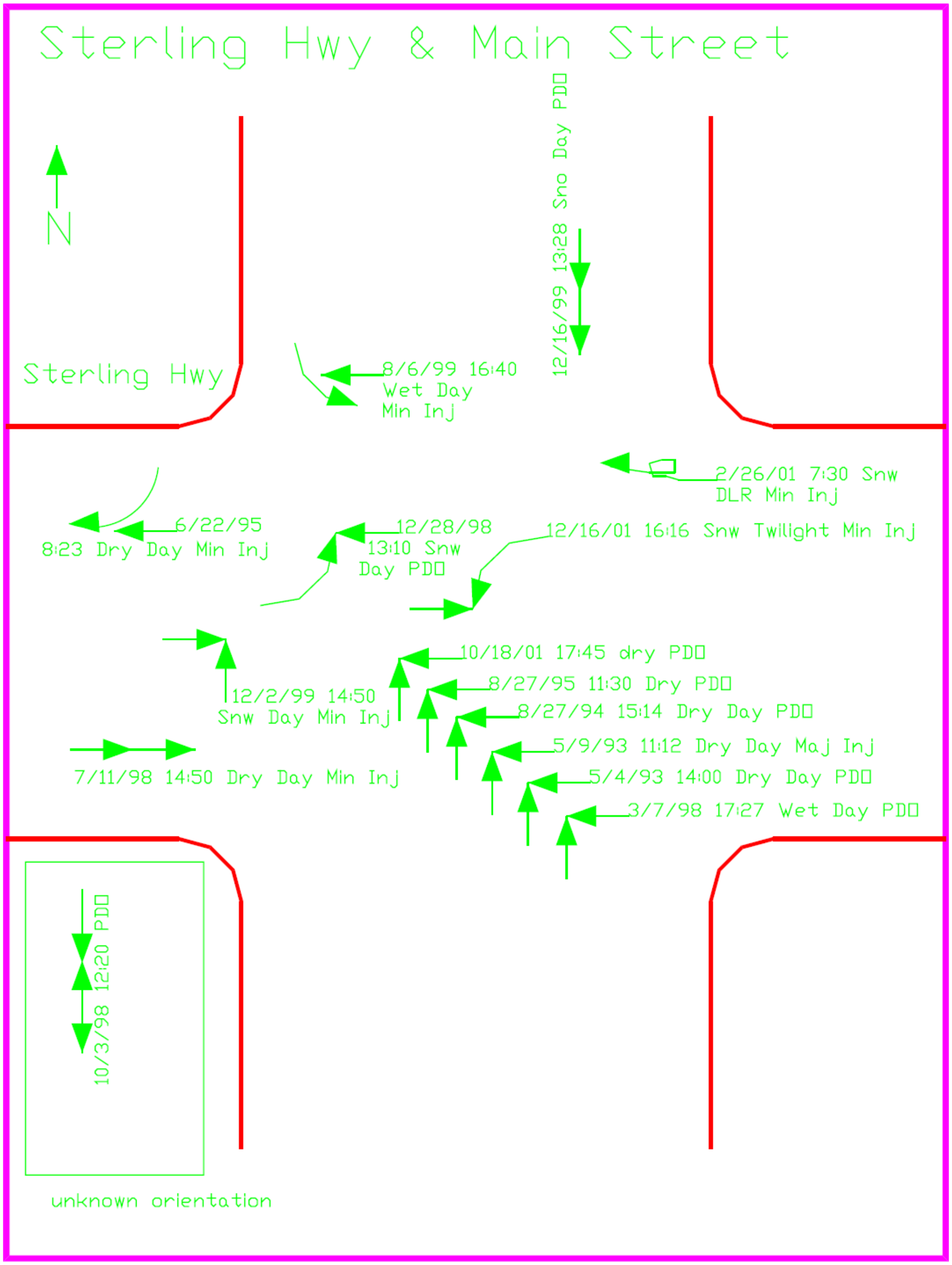
Key
Fixed F
5/16/97 5:12
Dry Day Min Inj
7/30/93 11:35 Dry Day PDO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DLR Min Inj
6/22/95
8:23 Dry Day Min Inj
12/28/98
13:10 Snw
Day PDO
12/16/01 16:16 Snw Twilight Min Inj
10/18/01 17:45 dry PDO
8/27/95 11:30 Dry PDO
12/2/99 14:50
Snw Day Min Inj
8/27/94 15:14 Dry Day PDO
5/9/93 11:12 Dry Day Maj Inj
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10/3/98 12:20 PDO
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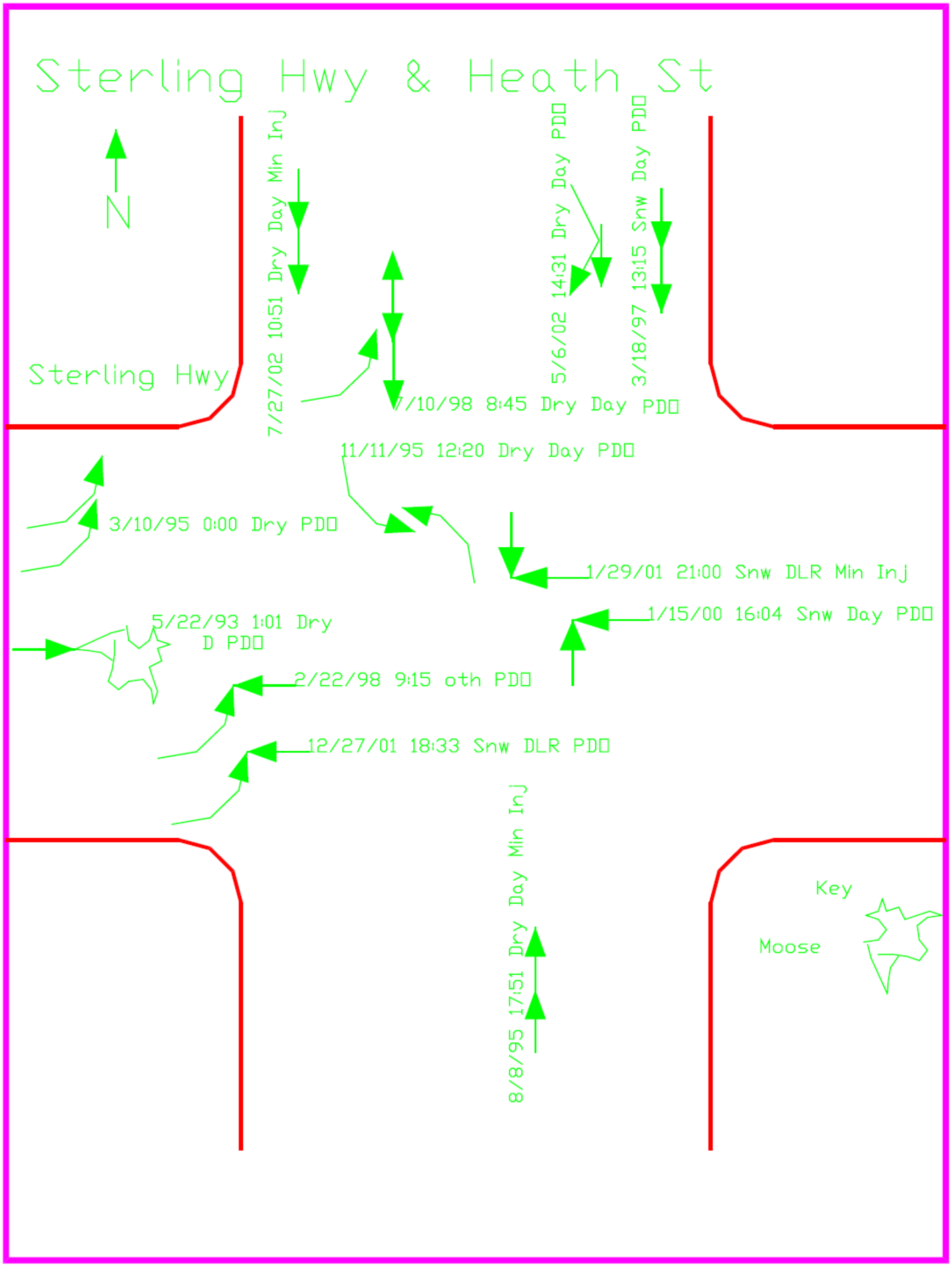

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5/6/02 14:31 Dry Day PDO
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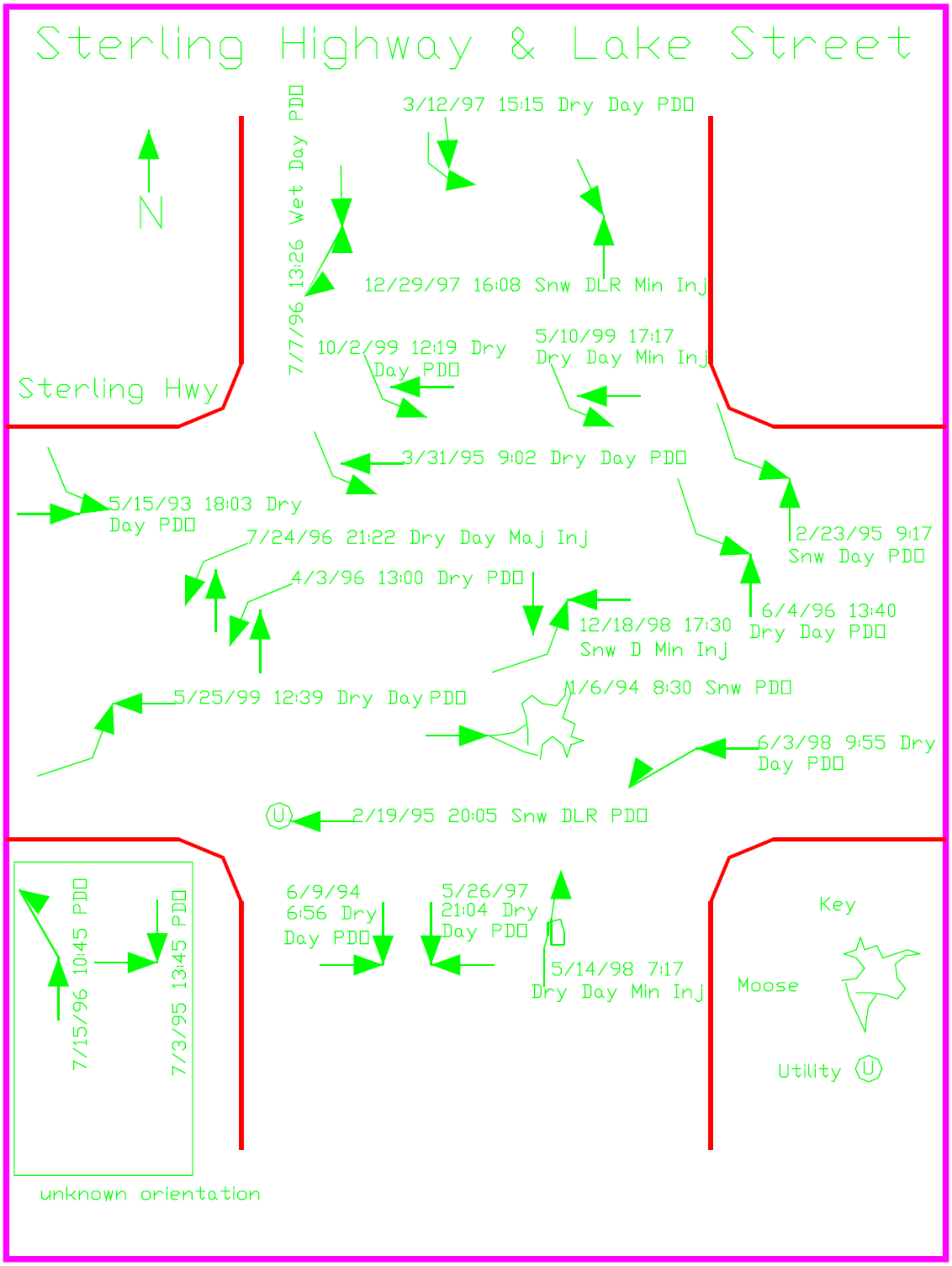
7/10/98 8:45 Dry Day PDO
11/11/95 12:20 Dry Day PDO
3/10/95 0:00 Dry PDO
1/29/01 21:00 Snw DLR Min Inj
1/15/00 16:04 Snw Day PDO
5/22/93 1:01 Dry
D PDO
2/22/98 9:15 oth PDO
12/27/01 18:33 Snw DLR PDO
8/8/95 17:51 Dry Day Min Inj
Key
Moose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Sterling Hwy
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7/7/96 13:26 Wet Day PD□
12/29/97 16:08 Snw DLR Min Inj
10/2/99 12:19 Dry Day PD□
5/10/99 17:17 Dry Day Min Inj
3/31/95 9:02 Dry Day PD□
5/15/93 18:03 Dry Day PD□
7/24/96 21:22 Dry Day Maj Inj
2/23/95 9:17 Snw Day PD□
4/3/96 13:00 Dry PD□
12/18/98 17:30 Snw D Min Inj
6/4/96 13:40 Dry Day PD□
5/25/99 12:39 Dry Day PD□
1/6/94 8:30 Snw PD□
6/3/98 9:55 Dry Day PD□
2/19/95 20:05 Snw DLR PD□
7/15/96 10:45 PD□
7/3/95 13:45 PD□
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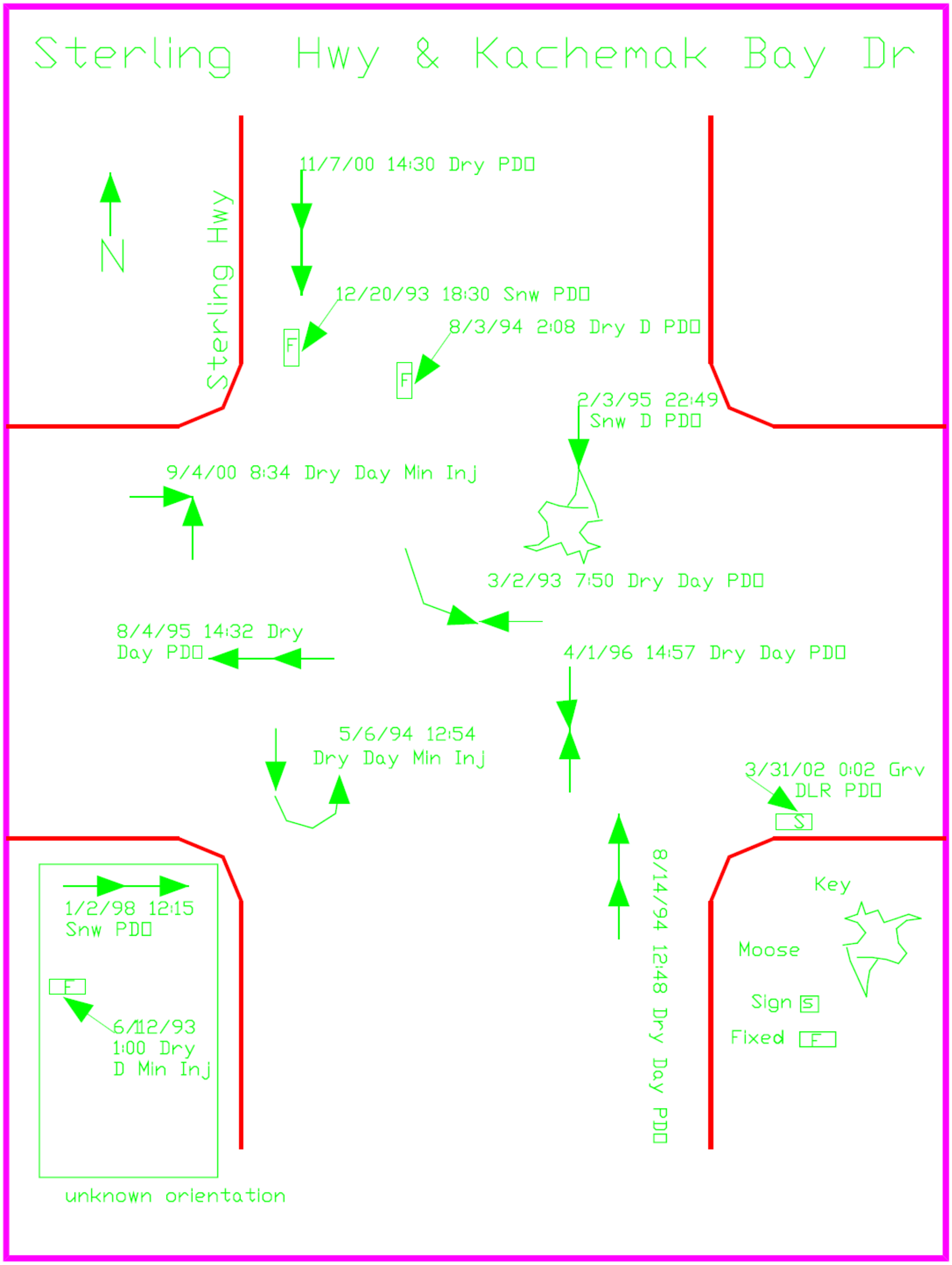
5/14/98 7:17 Dry Day Min Inj
Key
Moose
Utility
unknown orientation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N
Sterling Hwy
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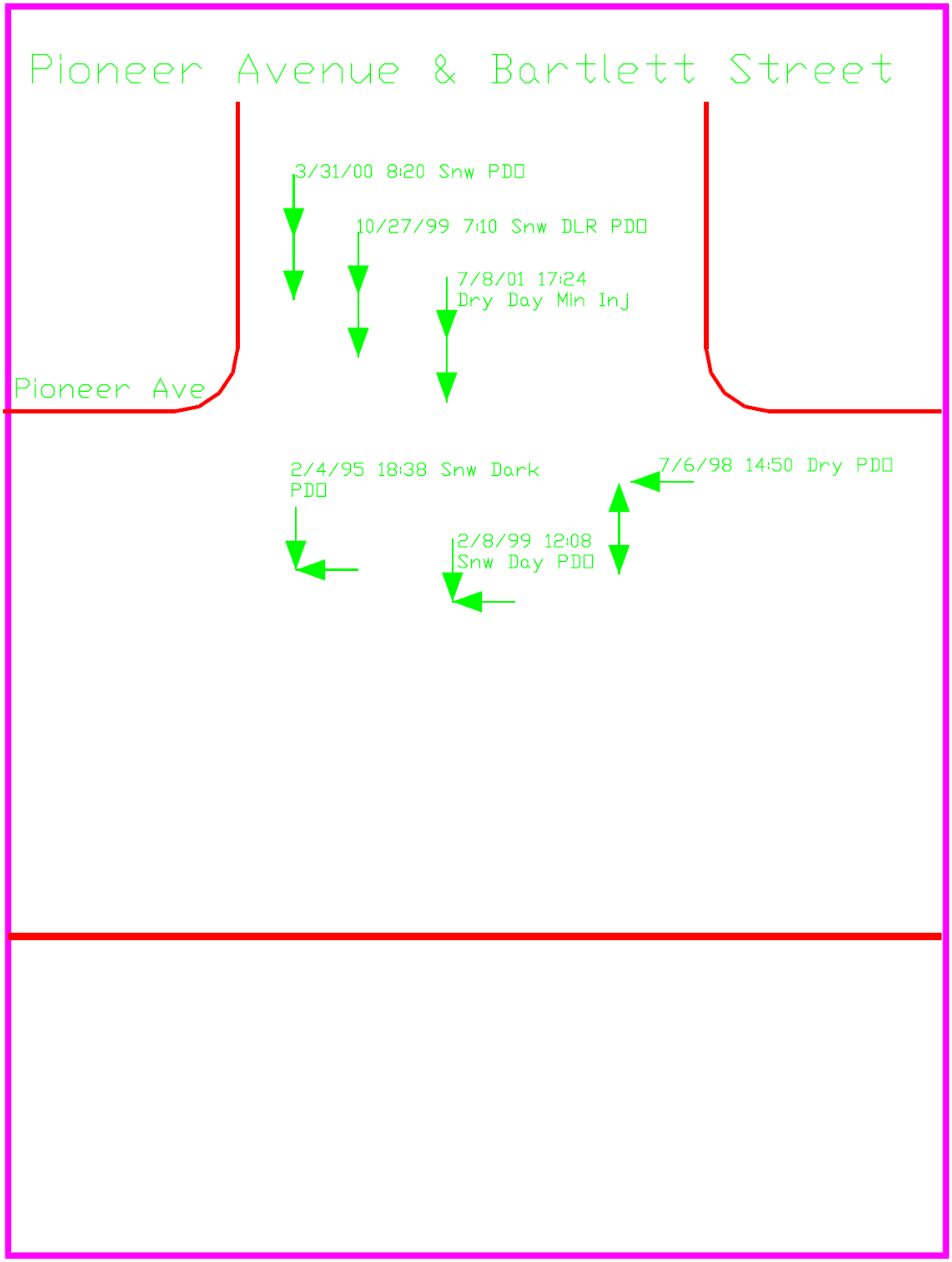
12/20/93 18:30 Snw PDO
8/3/94 2:08 Dry D PDO
2/3/95 22:49
Snw D PDO
9/4/00 8:34 Dry Day Min Inj
3/2/93 7:50 Dry Day PDO
8/4/95 14:32 Dry
Day PDO
4/1/96 14:57 Dry Day PDO
5/6/94 12:54
Dry Day Min Inj
3/31/02 0:02 Grv
DLR PDO
1/2/98 12:15
Snw PDO
6/12/93
1:00 Dry
D Min Inj
8/14/94 12:48 Dry Day PDO
Key
Moose
Sign
Fixed
unknown orientation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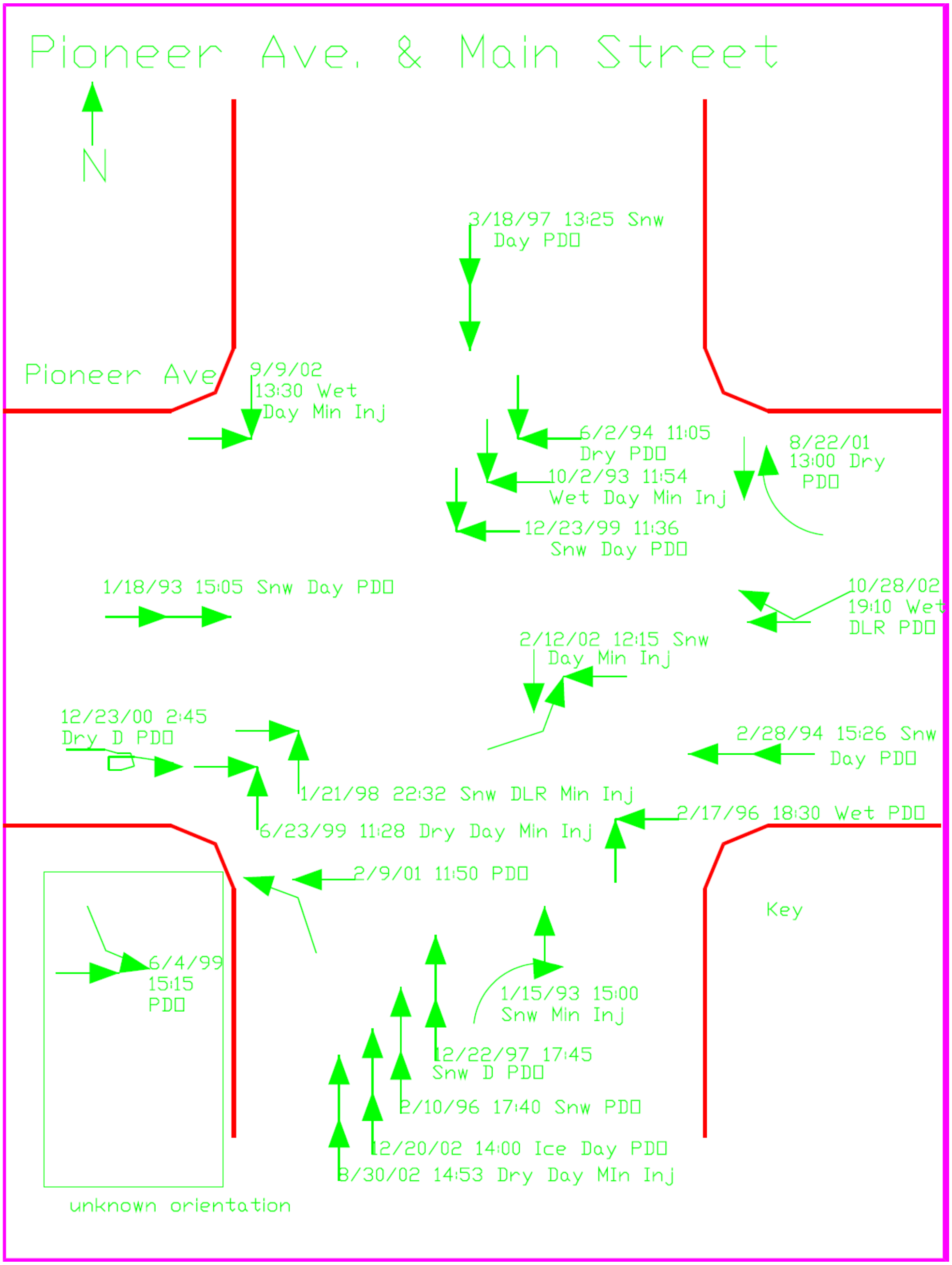
10/27/99 7:10 Snw DLR PDO
7/8/01 17:24
Dry Day Min Inj
Pioneer Ave
2/4/95 18:38 Snw Dark
PDO
7/6/98 14:50 Dry PDO
2/8/99 12:08
Snw Day PDO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Pioneer Ave
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Day PD□
9/9/02
13:30 Wet
Day Min Inj
6/2/94 11:05
Dry PD□
10/2/93 11:54
Wet Day Min Inj
12/23/99 11:36
Snw Day PD□
8/22/01
13:00 Dry
PD□
1/18/93 15:05 Snw Day PD□
10/28/02
19:10 Wet
DLR PD□
2/12/02 12:15 Snw
Day Min Inj
12/23/00 2:45
Dry D PD□
2/28/94 15:26 Snw
Day PD□
1/21/98 22:32 Snw DLR Min Inj
6/23/99 11:28 Dry Day Min Inj
2/17/96 18:30 Wet PD□
2/9/01 11:50 PD□
Key
6/4/99
15:15
PD□
1/15/93 15:00
Snw Min Inj
12/22/97 17:45
Snw D PD□
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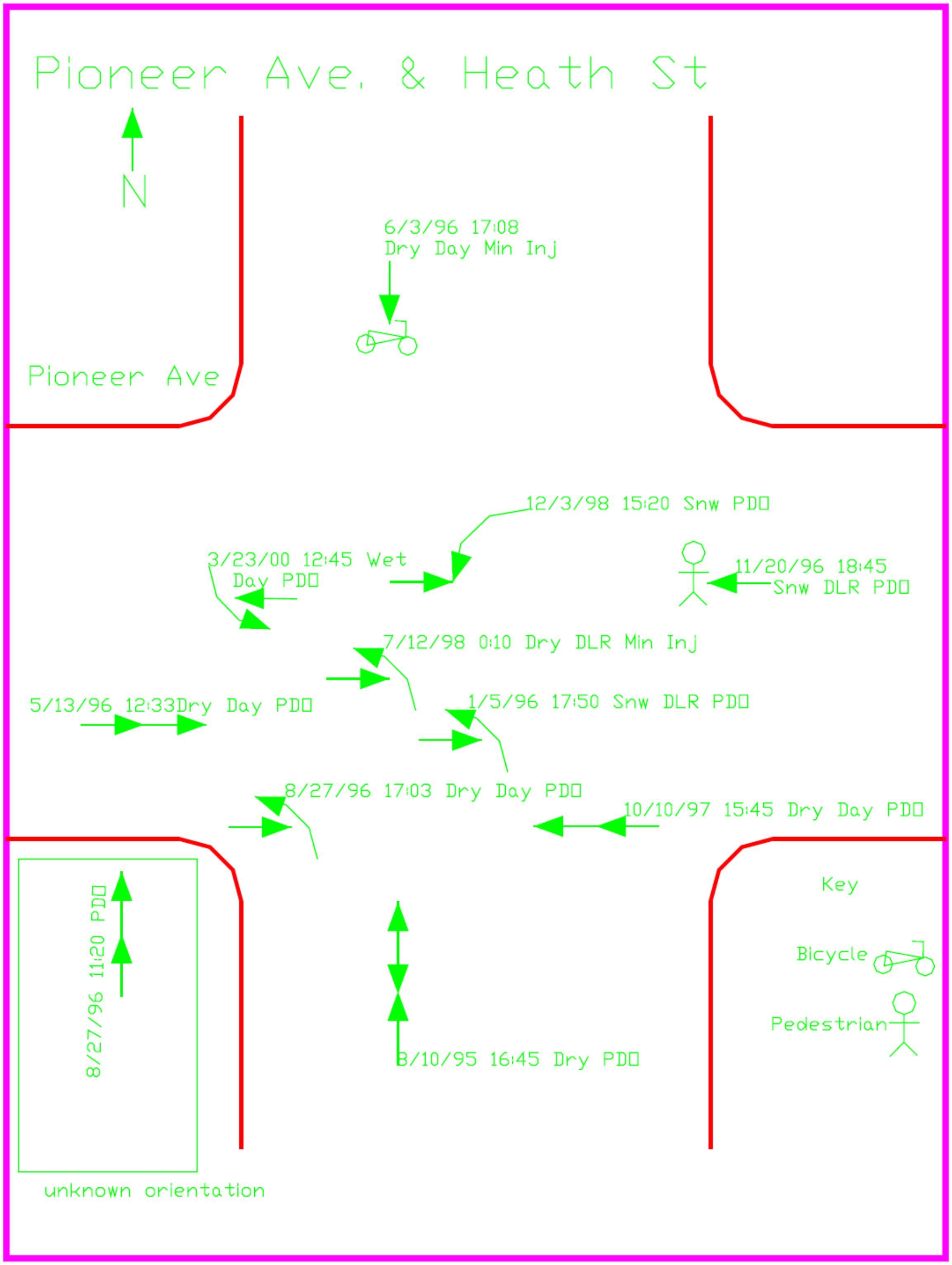
unknown orientation



Pioneer Ave. & Heath St
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Pioneer Ave
6/3/96 17:08
Dry Day Min Inj
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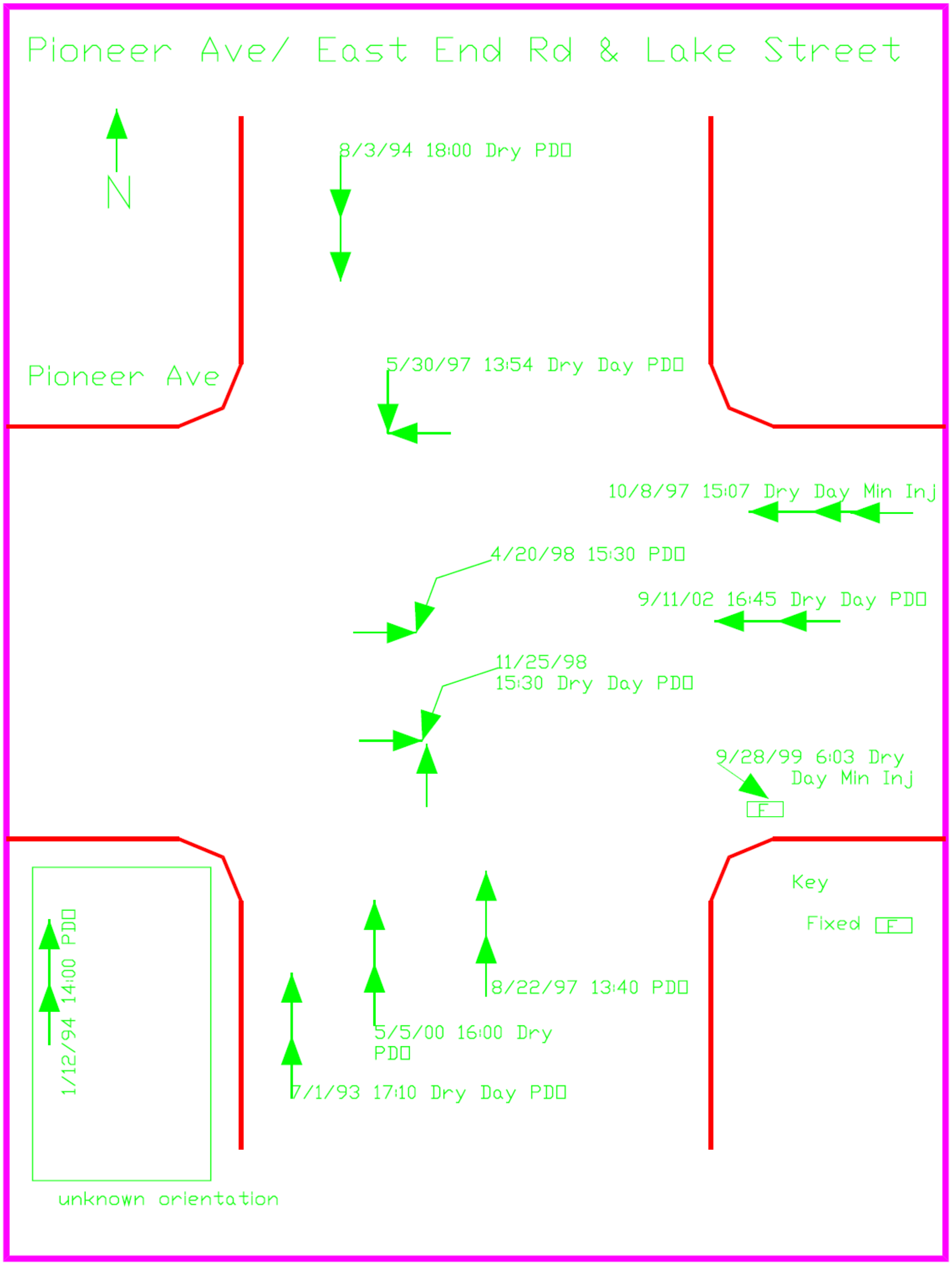
Day PD□
11/20/96 18:45
Snw DLR PD□
7/12/98 0:10 Dry DLR Min Inj
5/13/96 12:33Dry Day PD□
1/5/96 17:50 Snw DLR PD□
8/27/96 17:03 Dry Day PD□
10/10/97 15:45 Dry Day PD□
8/27/96 11:20 PD□
Key
Bicycle
Pedestrian
8/10/95 16:45 Dry PD□
unknown orientation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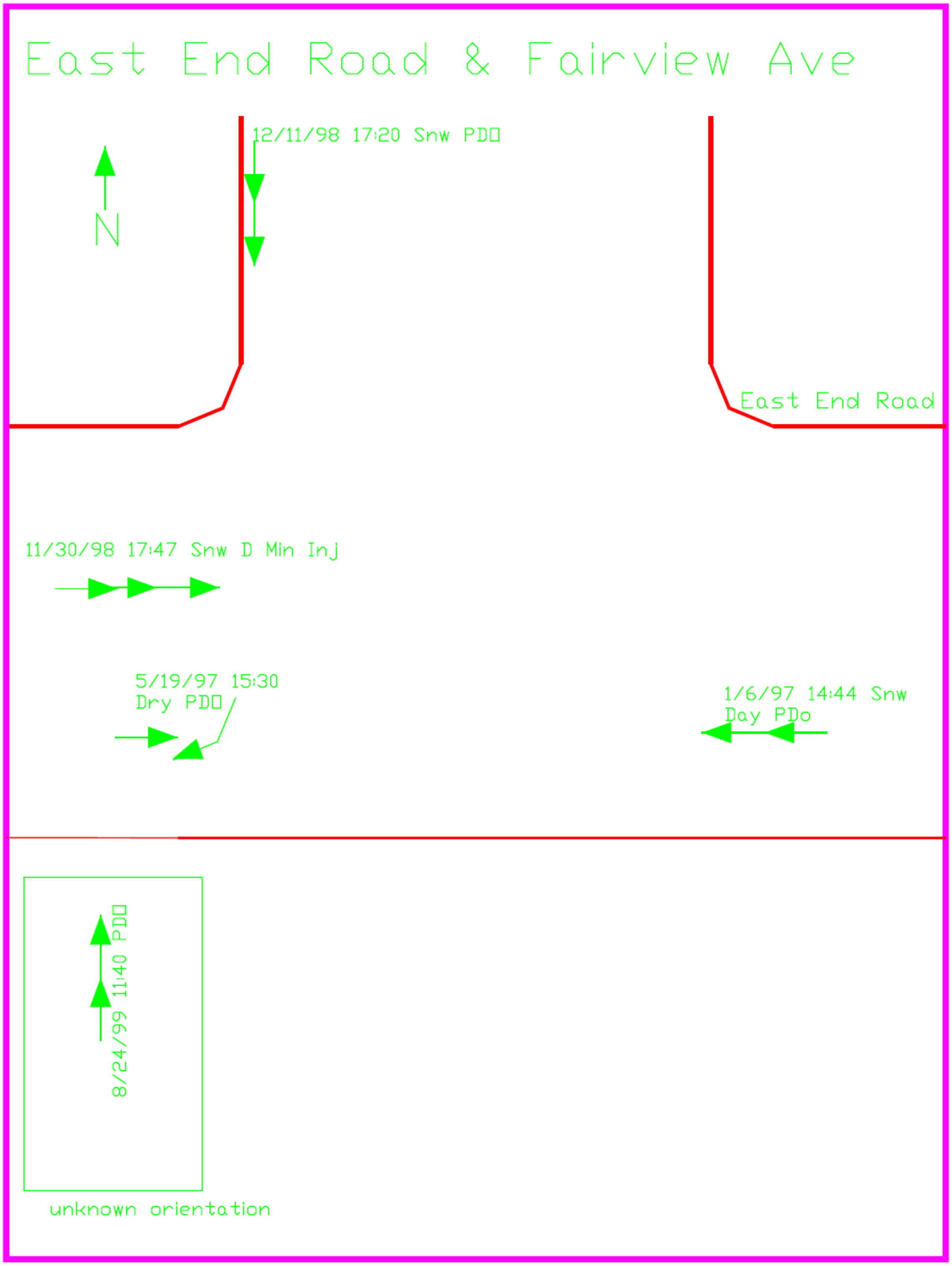
Pioneer Ave
5/30/97 13:54 Dry Day PDO
10/8/97 15:07 Dry Day Min Inj
4/20/98 15:30 PDO
9/11/02 16:45 Dry Day PDO
11/25/98
15:30 Dry Day PDO
9/28/99 6:03 Dry
Day Min Inj
F
Key
Fixed F
1/12/94 14:00 PDO
8/22/97 13:40 PDO
5/5/00 16:00 Dry
PDO
7/1/93 17:10 Dry Day PDO
unknown orientation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East End Road
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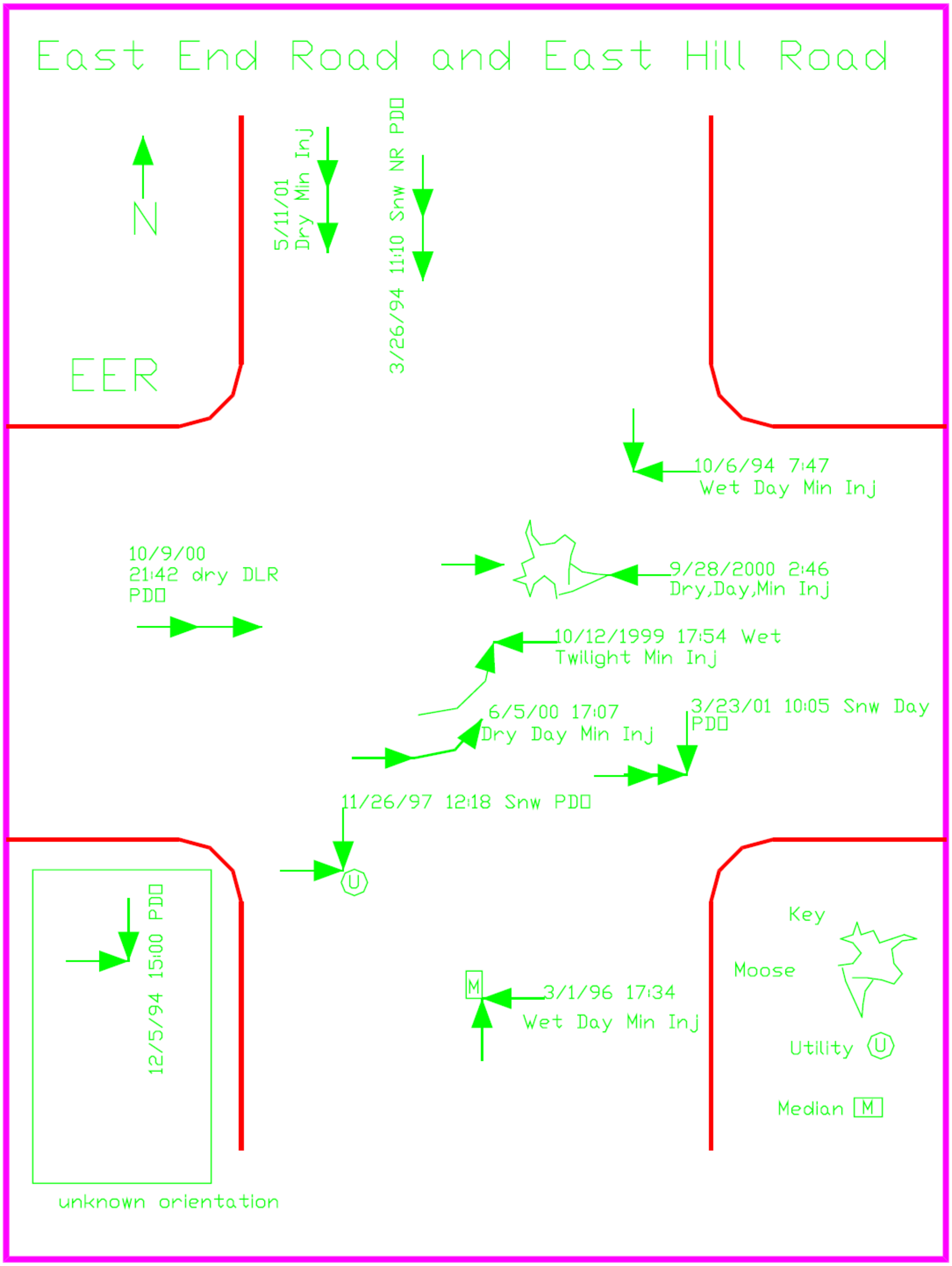
5/19/97 15:30
Dry PDO
1/6/97 14:44 Snw
Day PDo
8/24/99 11:40 PDO
unknown orientation


East End Road and East Hill Road
N
EER
5/11/01
Dry Min Inj
3/26/94 11:10 Snw NR PDO
10/6/94 7:47
Wet Day Min Inj
10/9/00
21:42 dry DLR
PDO
9/28/2000 2:46
Dry,Day,Min Inj
10/12/1999 17:54 Wet
Twilight Min Inj
6/5/00 17:07
Dry Day Min Inj
3/23/01 10:05 Snw Day
PDO
11/26/97 12:18 Snw PDO
U
12/5/94 15:00 PDO
unknown orientation
M
3/1/96 17:34
Wet Day Min Inj
Key
Moose
Utility
U
Median
M

Appendix E

Capacity Analysis Description

Capacity Analysis Description

The following narrative from Chapter 10 of HCM2000 defines LOS for signalized intersections.

- LOS A describes operations with very low control delay, up to 10 seconds per vehicle. This level of service occurs when progression is extremely favorable and most vehicles arrive during the green phase. Most vehicles do not stop at all. Short cycle lengths may also contribute to low delay.

- LOS B describes operations with control delay greater than 10 and up to 20 seconds per vehicle. This level generally occurs with good progression, short cycle lengths, or both. More vehicles stop than with LOS A, causing higher levels of average delay.

- LOS C describes operations with control delay greater than 20 and up to 35 seconds per vehicle. These higher delays may result from fair progression, longer cycle lengths, or both. Individual cycle failures may begin to appear at this level. The number of vehicles stopping is significant at this level, though many still pass through the intersection without stopping.

- LOS D describes operations with control delay greater than 35 and up to 55 seconds per vehicle. At level D, the influence of congestion becomes more noticeable. Longer delays may result from some combination of unfavorable progression, long cycle lengths, or high v/c ratios. Many vehicles stop and the proportion of vehicles not stopping declines. Individual cycle failures are noticeable.

- LOS E describes operations with control delay greater than 55 and up to 80 seconds per vehicle. This level is considered by many agencies to be the limit of acceptable delay. These high delay values generally indicate poor progression, long cycle lengths, and high v/c ratios. Individual cycle failures are frequent occurrences.

- LOS F describes operations with control delay in excess of 80 seconds per vehicle. This level, considered unacceptable to most drivers, often occurs with over saturation, that is, when arrival flow rates exceed the capacity of the intersection. It may also occur at high v/c ratios below 1.0 with many individual cycle failures. Poor progression and long cycle lengths may also be major contributing factors to such delay.

The methodology for unsignalized intersections only computes LOS for the minor movements of the intersection, which include the minor street approaches under sign control, or major movements that must yield to oncoming traffic, such as left-turning traffic. Unsignalized LOS is defined as follows (HCM Exhibit 17-2):

- LOS A: ≤10 seconds of control delay per vehicle

- LOS B: >10 and ≤15 seconds of control delay per vehicle
- LOS C: >15 and ≤25 seconds of control delay per vehicle
- LOS D: >25 and ≤35 seconds of control delay per vehicle
- LOS E: >35 and ≤50 seconds of control delay per vehicle
- LOS F: >50 seconds of control delay per vehicle

This study addresses pedestrian levels of service. Chapter 18 of the HCM2000 address pedestrians. Equation 18-21 gives pedestrian delay as:

$$d_p = \frac{1}{v}\left(e^{vt_G} - vt_G - 1\right)$$

d_p= pedestrian delay, seconds

v= average vehicle flow, vehicles/second

t_G= critical gap time, seconds. t_G=3 + W/3.5+ (N-1)/2, W= width of street or crossing (feet), N=number of pedestrian rows,1 in this case.

Pedestrian LOS is defined as follows (HCM Exhibit 18-13):

- LOS A: <5 seconds of average delay per pedestrian, low likelihood of accepting gaps that are less than t_G
- LOS B: ≥5 and ≤10 seconds average delay per pedestrian
- LOS C: >10 and ≤20 seconds average delay per pedestrian, moderate likelihood of accepting gaps that are less than t_G
- LOS D: >20 and ≤30 seconds average delay per pedestrian
- LOS E: >30 and ≤45 seconds average delay per pedestrian, high likelihood of accepting gaps that are less than t_G
- LOS F: >45 seconds average delay per pedestrian, very high likelihood of accepting gaps that are less than t_G

HCM2000 offers comments on likelihood of risk taking behavior (underlined) with the associated LOS description.

Appendix F

Summary of ADOT&PF Files-

Safety Oriented Correspondence

Summary of ADOT&PF Files- Safety Oriented Correspondence

Date: 12/2/85
Subject: Kachemak Bay Drive Speed Study
Actions Taken: Speed set at 35 mph

Date: 12/2/85
Subject: East Hill Road Speed Study
Actions Taken: Speed set at 30 mph

Date: 9/26/90
Subject: Left Turn Channelization on homer bypass at Pioneer Avenue and Lake Street.
Actions: Left turn lanes added in the spring of 1991
From: Dennis Morford
To: Robert Boyd

Date: 12/2/91
Subject: Installation of "business district" and "hospital" signs 200' north of Pioneer Avenue, removal of "side road" 400' north of Pioneer Avenue.
From: Tony Barter
To: Robert Boyd

Date: 9/23/92
Subject: Sterling Highway Pioneer Avenue to lands end DSR Comments.
Actions Taken: Most recommendations are currently in effect.
From: Tony Barter
To: John Burkholder

Date: 3/3/93

Subject: East End Road/Pioneer Avenue and Lake Street Intersection Sight Problems. Drivers in north eastbound lane unable to see stop sign

Actions Taken: Flashing red beacon put in

From: Director of Public Safety City of Homer

To: Kenai Peninsula Superintendent DOT&PF

Date: 11/10/93

Subject: Citizen complaint of problems on Sterling Highway

Actions Taken: no action required

To: Rowe b Redick

From: Boyd Brownsfield

Date: 12/22/94

Subject: Speed limits on Kachemak bay Drive. Request made to change

Actions Taken: No changes

To: Rep Gail Phillips

From: John Horn

Date: 5/27/97

Subject: left turn lane on Sterling Highway to Soundview Avenue and school warning lights for West Homer Elementary

Actions Taken: Left turn lane added, lights determined unnecessary.

From: Mayor of Homer

To: Regional Director DOT&PF

Date: 5/13/97

Subject: Pedestrian signage on East End Road near Homer High School

Actions Taken: Speed lowered to 25 mph (from 35mph). School Flasher system installed in 1999

To: Mayor of Homer

From: Regional Director DOT&PF

Date: 4/6/99

Subject: Citizen complaint of problems on Sterling Highway

Actions Taken: no action required

To: Dennis Morford

From: George Church

Date:1/28/00

Subject: City of homer wished to construct an additional access to the high school at Heath Street and install a four way stop at Heath & Pioneer.

Action Taken: access constructed 4 way stop not installed

Date: 8/9/02

Subject: Sterling Highway speed studies. 900' south of West Hill to 500' north of Bluff Road

Actions Taken: Speed set at 45 mph

Date: 11/3/03

Subject: Application for construction of a hockey rink. 27,000 sq ft generating 70 trips/ hr. Located between Waddell Way and Lake Street

From: Homer Hockey Association

To: US Army Corps of Engineers

Date: 8/31/04

Subject: Sterling highway pedestrian island concerns. Concerns about islands causing accidents, affect commerce, plowing, and impeding traffic.

Actions Taken: Concerns addressed. Islands removable after 1 year.

From: Scott Thomas

To: Jan Jonker

Date: 4/21/04

Subject: Homer Crosswalks on Pioneer Avenue

Actions Taken: Crosswalks added on Pioneer at Bartlett Street, Main Street, Svedlund Street, Kachemak Way and Heath Street

To: Jan Jonker

From: Scott Thomas

Date: July 28 2004

Subject: Left turn lanes on East end Road at Fairview Ben Walters lane East Hill road, Paul Banks Elementary and Kachemak Bay Dr.

Actions Taken: Ben Walters excluded all other recommend left turn lane.

To: Steve Horn

From: Bob Lundell

Date: March 3, 2005

Subject: Pedestrian cross walks on Sterling Highway

Actions Taken: Citizen cites a near-collision experience involving a pedestrian at the new crossing on Lake Street. She is concerned that new crossings are not clear as to who has right of way and create false security for pedestrians. Response was that the cross walks were not completed yet (missing crosswalk striping), and that the crossing were designed with best practices in mind. The crossings as designed rely an individual's ability to make judgments. Education and enforcement are key to these crossing success. Additional special signs may be considered in the future.

To: Scott Thomas

From: Julie Davies