

**NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION**

**MATERIALS AND RESEARCH
DIVISION**

Experimental Study ND 92-03

**Road Condition - Weather Monitor
System to Determine Pavement Surface
And Atmospheric Conditions**

Final Report

Project IR-094-8(102)352

September 1997

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

BISMARCK, NORTH DAKOTA

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MATERIALS AND RESEARCH DIVISION

Ron Horner

Experimental Feature ND 92-03

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To Determine Pavement Surface And
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By
Mike Marquart

Disclaimer

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To Determine Pavement Surface and
Atmospheric Conditions
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Final Report

Objective

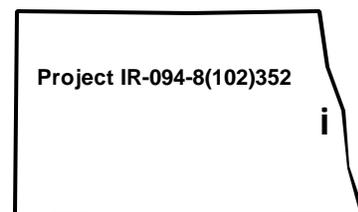
The object of this experimental project was to install a road condition-weather monitoring system to provide data on pavement surface and atmospheric conditions. This equipment should enable maintenance supervisors to evaluate the weather conditions at various locations. Supervisors could dispatch snow and ice removal equipment without sending an operator to check conditions on site.

The Department of Transportation expects this system to reduce the incidence of ice related accidents occurring on the I-94 Red River structure. This would be accomplished by alerting maintenance forces to predicted icing conditions and by tracking and forecasting incoming weather systems. The ultimate goal is to provide safer roads for the traveling public and reduce maintenance costs.

Location

The Road Condition - Weather Monitoring System is located on Interstate I-94 in the Fargo District and covers the area of the Red River Structure.

Remote processing units (RPUs) were installed at two locations. Site one is located on ND Highway 38 ten miles north of the Buffalo Interchange. Site two is located on Interstate 94 at the Red River Bridge in Fargo. See Appendix A.



Traffic

Year	Cars	Trucks	Total ADT	Rigid Pvmn't ESAL's
1997	41,610	3,770	45,380	5,055
2017	62,420	5,660	68,080	7,585
This is daily traffic for both directions				

Design

The Scan (surface condition analyzer) System was selected for this project based on equipment reliability, long-term stability of the provider, progressive technology, and qualified expertise necessary to install, maintain and upgrade the system. The Fargo District Engineer and a Surface Systems, Inc. (SSI) representative selected the RPU locations.

SSI of St. Louis, Missouri supplied and guided the installation of the system. The system includes RPUs with associated sensors for monitoring remote roadway conditions. Each RPU is a microprocessor based weather station powered by commercial 110 VAC (Volts Alternating Current). See Appendix B for plan details and drawings. A full complement of atmospheric sensors are mounted at each RPU for collection of environmental weather data (see Appendix C).

Construction

Construction work began on the project during the fall of 1991 and resumed in the 1992 construction season. The entire east and west bound lanes were reconstructed from Highway 81 to Minnesota 75. Most of the SCAN equipment was installed by state personnel. The DOT contracted the conduit trenching, base work, concrete foundation, and other necessary work to ready the sites for tower erection.

The central monitoring equipment is located at the Fargo District and includes the Data Handler. The brain of the Data Handler is the SCAN Plus Central Processing Unit (CPU). It is microprocessor based and used for collection, storage and presentation of all sensor data. All wiring and hookups took place during the construction phase.

The RPUs receive data from the pavement sensors by way of cables inside conduit in the pavement. The RPUs send data to the CPUs by utilizing radio waves. Data collected from these stations include pavement and air temperature, wind speed, dew point, visibility, chemical concentration, and whether the pavement is wet or dry. Sensors in the roadway can detect the presence of ice, snow or frost.

Cost

The cost of the SCAN Weather System was \$131,216.26. This included all construction and installation costs. A price breakdown is shown below.

1.	SCAN equipment system and services	\$98,224.00
2.	WIVIS sensor upgrade	7,773.00
3.	NDDOT radio services	10,148.00
4.	Allstate Tower Services, Inc.	710.00
5.	Traffic counter shop services	1,561.26
6.	(contracted) Tower foundation, conduit, and power supply (each tower \$6,400.00) x (2)	12,800.00

Evaluation

The DOT contracts with SSI to receive forecasts twice a day at the Fargo District. This service is obtained for the winter months only. It usually covers from October 15 to April 15. The last contract was for \$3,270.00. Forecasts are received at 3:00 AM and updated at 3:30 PM. The department responds to these forecasts in a manner that will provide the safest driving conditions for the public.

SSI notifies the Fargo District of any severe incoming weather that develops between regular reporting times. A snow and ice control plan is developed from the data stored in the CPU. The main forecast conditions a manager looks at are wind speed, air and pavement temperature, dew point, and visibility. It takes a few winter seasons to become fully comfortable in relying on the SCAN weather forecasts.

The Fargo District has used the SSI system to track the winds in the Red River Valley. They wanted to use this data to see if they should have employees start sanding the roads early in the morning. The SSI forecast predictions include when snow will occur, time and speed of the wind, and the pavement temperature on the Red River Bridge. The Fargo District reports the following accuracy of the items mentioned above.

FORECAST ACCURACY			
YEAR	SNOW	WIND	PAVEMENT TEMPERATURE ON RED RIVER BRIDGE
95/96	55%	65%	70%
96/97	35%	40%	60%

These percentages are estimates by the Fargo District and not based on recorded data. Photo 1 shows a surface sensor on the Red River Bridge.



Appendix A Project location----weather sites

The Precipitation and Pavement Condition Forecast for the Red River Bridge was not

always on track. The river plays a big part in the ever changing conditions on the bridge. Two things come into play here. One is that the sensor is on a bridge and second, there is usually open water under the bridge. Temperature inversion and changing air currents under the bridge cause changes in relative humidity, air temperature, and dew points. These can cause rapid changes in the surface condition of the bridge.

Most weather comes into the Fargo area from the west or northwest. With only one remote processing unit to the west of Fargo, the Fargo District and SSI find it difficult to forecast and track a storm coming in from the west. Additional sensors scattered to the west of Fargo would provide a time reference that would increase forecast accuracy. Although the NDDOT has installed RPU's in other districts, the Fargo District is too far away from other districts weather sensors to be very useful.

The Fargo District reports that the SSI system forecasts are not always reliable and updated. In referring to the "forecast accuracy" table on the previous page, one can see that the accuracy has dropped significantly. The Fargo District also reports that the SCAN Weather System failed many times and was not useable. Some system failures are shown below.

SCAN WEATHER SYSTEM FAILURES	
Date	Remarks
January 16, 1997	COM FAILURE-----system failed at 4:00 AM
January 21, 1997	COM FAILURE-----system failed again at 3:00 PM
January 22, 1997	COM FAILURE-----system failed again at 7:00 AM
February 13, 1997	COM FAILURE-----failed again
February 14, 1997	COM FAILURE-----still fail
March 27, 1997	COM FAILURE-----system failed
April 6, 1997	COM FAILURE-----Highway 38 --- Buffalo site failed
May 21, 1997	COM FAILURE-----system failed
July 7, 1997	COM FAILURE-----system failed half of the time

A "com failure" is when two or more computers can not make the connection. This connection was from SSI in Saint Louis, Missouri to Fargo, or the Fargo office to the I-94 or Buffalo site.

The Fargo District does not plan on obtaining services from SSI in 1998. They state cost and reliability as reasons for their decision. Another less costly system will be used along with the present SCAN weather and roadway sensors.

Accident data was obtained from the department's traffic safety records. Computer records begin in January of 1989 and end in March of 1997. The data covers I-94 from mile 349.000 to 352.000. See the table below.

Vehicle Accidents -----I-94 Mile 349 to 352	
Red River Bridge	
Date	Total Accidents
1990 - 1991	52
1992 - 1996	40
1996 - 1997	62

After the reconstruction of the roadway in 1992, the accident numbers decreased. In one year, March 1996 to March 1997, the accident number increased from 40 to 62. This is most likely due to the severe winter we had in 1996/1997. The "ACCIDENT DATA" table on the next page shows the influencing factors that caused or have contributed to the accidents. It shows 61% of the collisions were vehicles in transport. The weather was clear only 30% of the time that accidents occurred. Ice/snow was present at 51% of the accidents. Of the vehicles involved in an accident, 33% were driving too fast for conditions. This relates to the surface conditions of the roadway. Visibility and road conditions, along with excess speed for conditions, are the reasons for the jump in accident numbers for 1996/1997 winter season.

ACCIDENT DATA--I-94 MILE 349.0000 TO 352.0000					
COVERAG E PERIOD	TYPE OF COLLISION	LIGHT	WEATHER	SURFACE CONDITION	CONTRIBUTING FACTOR
Jan 89 to March 96	39% rear end	70% dayligh t	60% clear	52% dry	50% no clear contributing factor 23% speed -- driving to fast
March 96 to March 97	61% non collision (veh-in-trnsprt)	62% dayligh t	30% clear	22% dry 51% Ice/Snow	33%-- speed too fast for conditions 24% --no clear contributing factor

The SCAN weather system contributes to reducing the chance of an accident occurring. Just how great a part this weather system plays in reducing accidents is difficult to determine. Many other variables come into play from the roadway improvements. A few are:

- The roadway was completely reconstructed
- More lanes to carry traffic after construction
- Better sight distance and lighting
- Better skid resistant surface
- Better turn lanes and off/on ramps

Another thing to keep in mind is that traffic increases each year. This creates more situations for accidents to happen. Speed plays a part in this also. People tend to drive faster on improved roads. The SCAN weather system is just a tool to help in planning maintenance activities and is not a guarantee to reduce the number of accidents.

Summary

The North Dakota Department of Transportation contracts with Surface Systems, Inc. (SSI) to receive weather forecasts twice a day at the Fargo District during the winter months. The cost for six months of service during the winter of 1995/1996 was \$2,750.00 or \$458.50 a month. For the winter of 1996/1997 the cost was \$3,270.00.

The Fargo District uses the forecasts and the system to plan their daily activities along with a snow and ice control plan. The access to this data improves the ability to plan the proper action. The Fargo District has experienced many SSI system breakdowns during the past year. The system has not been very reliable at peak times. The system accuracy during the past winter was about 50%. The Fargo District pays for another service that they find more useful than the SSI service. They do not plan on contracting with SSI in the upcoming winter season.

The SCAN system sensors are all located in the City of Fargo except for one, which is located west of town on Highway 38. The DOT receives data from some city installed sensors in the city limits. It is rather hard to track an incoming storm using only two sensor locations.

The Fargo District reports that the SCAN weather system has saved the Department of Transportation \$10,000 to \$15,000 over a five year period. However, this is a tough figure to estimate. No one knows how many accidents were prevented or lives saved by using this system.

The cost of constructing and installing the SCAN weather system was \$131,216.26.

The subsurface sensors may be a tool used to help determine when load restrictions should be applied. This use of soil temperature will increase in value as more sensors are installed in the state roadway system.

The North Dakota Department of Transportation continues to use the technologies available in this and other weather systems to help accomplish the objective of achieving a timely and effective method for snow and ice control. And also provide the safest driving conditions to the public.

Recommendations

We recommended that the DOT not contract with SSI for their forecast service. We refer to the ever increasing cost for the weather forecasting service and a decrease in system reliability. The DOT is using a less costly weather radar system that operators find easy to use and accurate. This system, along with the data from the SCAN sensors, should be used for our forecasting/monitoring program.

Appendix A

DESIGN DATA

Traffic
 Current (1985) 13,400 Pass. 1600 Trucks 15,000 Total
 Forecast (2005) 21,076 Pass. 2900 Trucks 24,876 Total
 Design Speed 70 MPH
 Traffic Classification "M"
 Minimum Sight Distance (Stopping) 626'
 Minimum Sight Distance (Safe Passing)
 Minimum Passing Sight Distance for Marking
 Bridges 11s 2s

Est. 30th
 Max. Hr.
 1600
 2488

**NORTH DAKOTA
 DEPARTMENT OF TRANSPORTATION**

**Cass County
 IR-094-8(124)351
 Contract 2
 F IR-094-8(102)352
 Grading, Surfacing, Sewer, Structural,
 Signing, Marking & Incidentals.**

JOB# 1

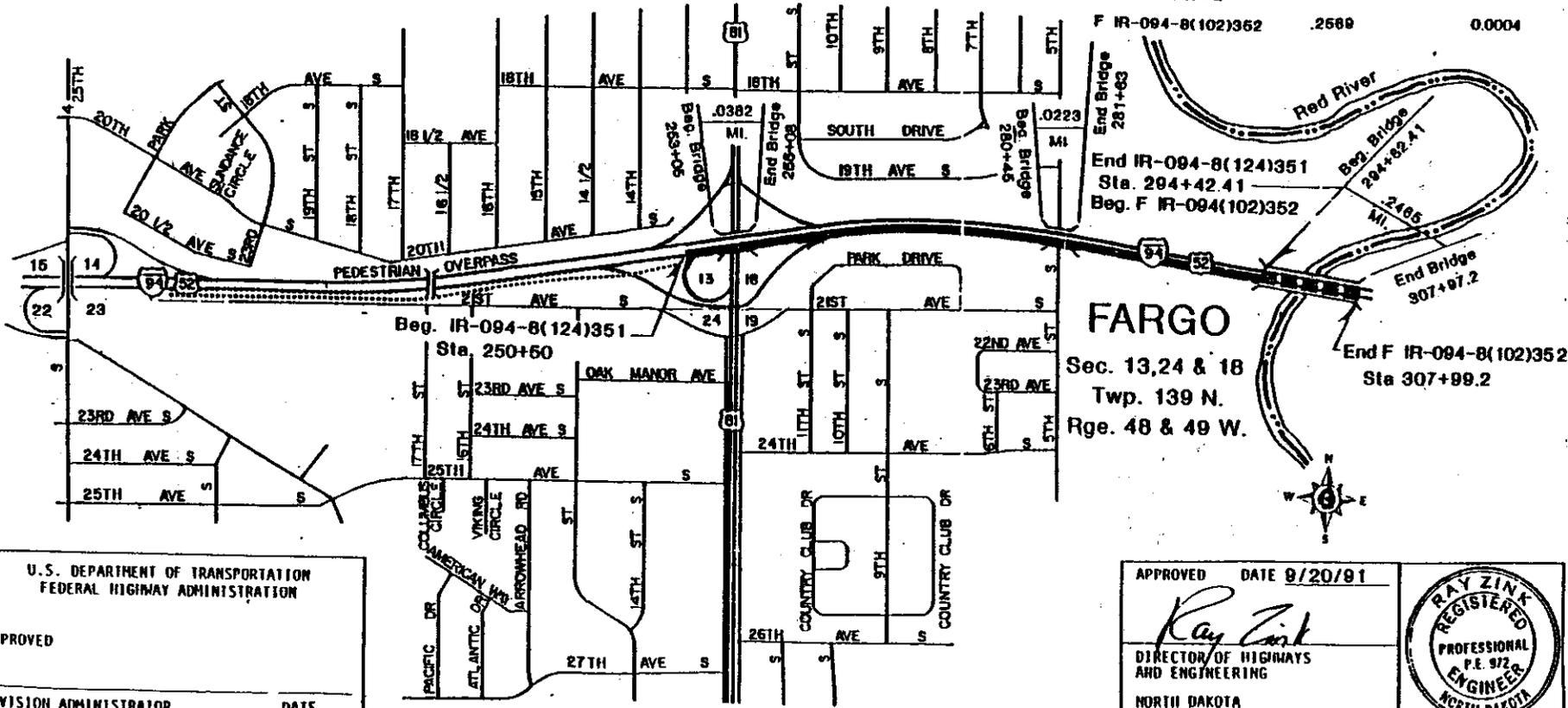
TIME REGION	STATE	PROJECT	SHEET NO.
8	N.D.	IR-094-8(124)351 F IR-094-8(102)352	1

GOVERNING SPECIFICATIONS:

Standard Specifications for Road and Bridge Construction, adopted by the North Dakota State Highway Department, November 1986, shall apply to all North Dakota Department of Transportation contracts, standard drawings currently in effect, and other contract provisions submitted herein.

LENGTH OF PROJECT

Project	Miles-Gross	Miles-Net
IR-094-8(124)351 Contract #2	0.8318	0.7712
F IR-094-8(102)352	.2589	0.0004



I-V

U.S. DEPARTMENT OF TRANSPORTATION
 FEDERAL HIGHWAY ADMINISTRATION
 APPROVED _____
 DIVISION ADMINISTRATOR DATE

APPROVED DATE 9/20/91
Ray Zink
 DIRECTOR OF HIGHWAYS
 AND ENGINEERING
 NORTH DAKOTA
 DEPARTMENT OF TRANSPORTATION

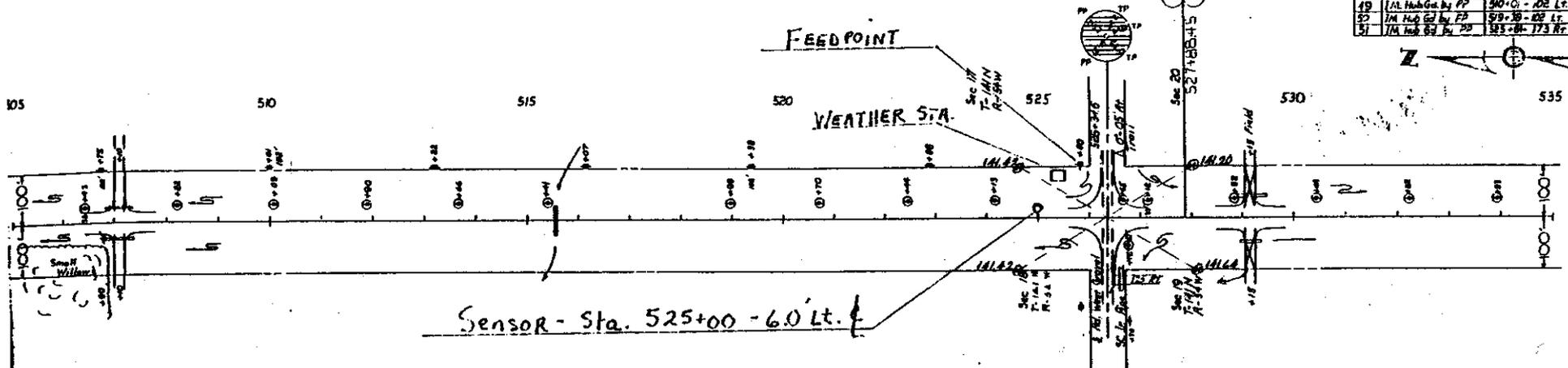


Highway 38 - Sensor Location.

INSTALL PIPE CONCRETE
 516+58 E 24" x 36" RCP - 2 FEET
 526+36 RT+LN. 15' x 30' CMP.

HELAL PIPE CONCRETE
 507+10 LT. 12" x 36" RCP From Salv.
 507+10 RT 12" x 36" RCP From Salv.

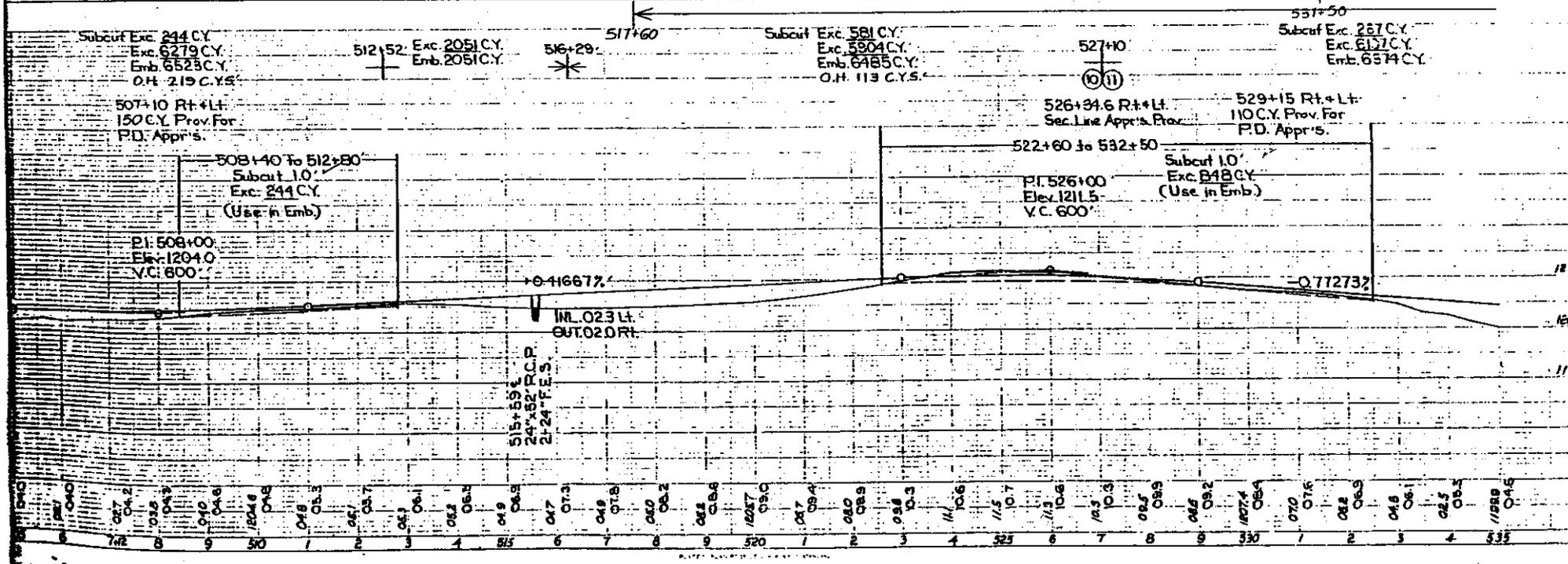
BENCH MARKS			
NA	Description	Location	Elev.
49	TM Mark. By PP	507+00 - 08 Lt.	1805.23
50	TM Mark. By PP	509+30 - 08 Lt.	1805.62
51	TM Mark. By PP	525+00 - 173 Rt.	1806.71



507+10
 29 Rt+Lt.
 2-18" x 30" CMP
 Remove Salv.

515+59 E
 18" x 36" RCP
 Remove Salv.

A-2



Subcut Exc. 244 CY
 Exc. 6279 CY
 Emb. 6523 CY
 O.H. 219 C.Y.S.

512+52 Exc. 2051 CY
 Emb. 2051 CY

516+29

Subcut Exc. 581 CY
 Exc. 5904 CY
 Emb. 6485 CY
 O.H. 113 C.Y.S.

531+50
 Subcut Exc. 267 CY
 Exc. 6177 CY
 Emb. 6574 CY

507+10 Rt+Lt
 150 CY Prov. For
 P.D. Apprs.

508+40 To 512+80
 Subcut 1.0'
 Exc. 244 CY
 (Use in Emb.)

PI: 508+00
 Elev: 1204.0
 V.C. 600

526+34.6 Rt+Lt
 Sec. Line Apprs. Prov.

522+60 to 532+50
 PI: 526+00
 Elev: 1211.5
 V.C. 600

Subcut 1.0'
 Exc. 848 CY
 (Use in Emb.)

529+15 Rt+Lt
 110 CY Prov. For
 P.D. Apprs.

0.41667%

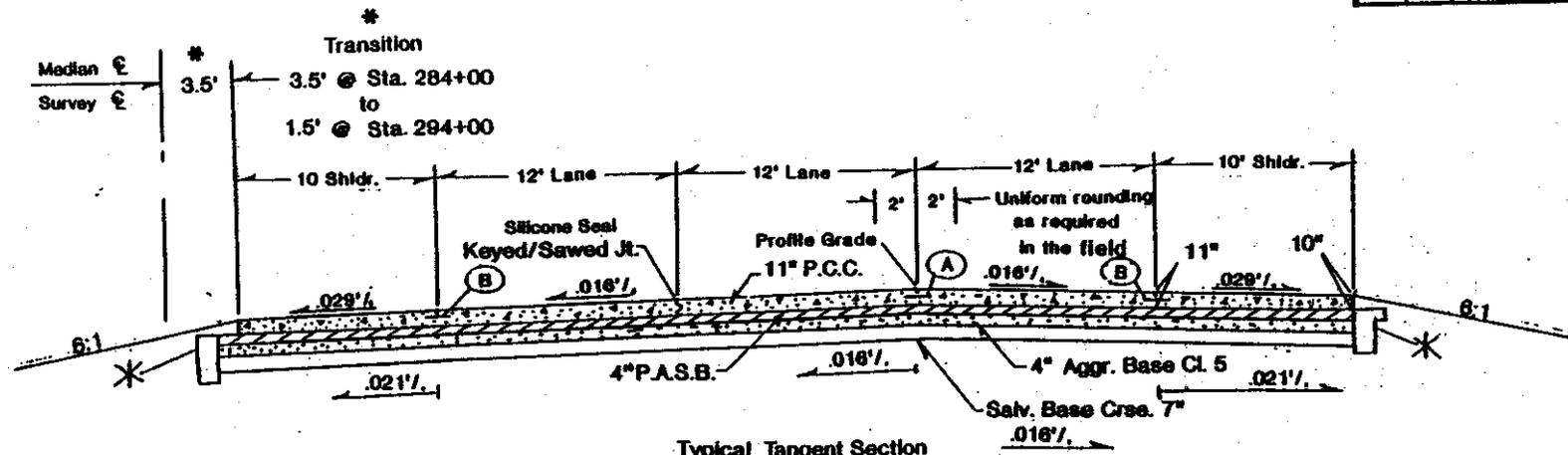
INT. 0.23 LT.
 OUT. 0.20 RT.

515+59 E
 24" x 36" RCP
 2-24" FE.S.

505 510 515 520 525 530 535
 0+00 0+10 0+20 0+30 0+40 0+50 0+60 0+70 0+80 0+90 1+00 1+10 1+20 1+30 1+40 1+50 1+60 1+70 1+80 1+90 2+00 2+10 2+20 2+30 2+40 2+50 2+60 2+70 2+80 2+90 3+00 3+10 3+20 3+30 3+40 3+50 3+60 3+70 3+80 3+90 4+00 4+10 4+20 4+30 4+40 4+50 4+60 4+70 4+80 4+90 5+00 5+10 5+20 5+30 5+40 5+50 5+60 5+70 5+80 5+90 6+00 6+10 6+20 6+30 6+40 6+50 6+60 6+70 6+80 6+90 7+00 7+10 7+20 7+30 7+40 7+50 7+60 7+70 7+80 7+90 8+00 8+10 8+20 8+30 8+40 8+50 8+60 8+70 8+80 8+90 9+00 9+10 9+20 9+30 9+40 9+50 9+60 9+70 9+80 9+90 10+00 10+10 10+20 10+30 10+40 10+50 10+60 10+70 10+80 10+90 11+00 11+10 11+20 11+30 11+40 11+50 11+60 11+70 11+80 11+90 12+00 12+10 12+20 12+30 12+40 12+50 12+60 12+70 12+80 12+90 13+00 13+10 13+20 13+30 13+40 13+50 13+60 13+70 13+80 13+90 14+00 14+10 14+20 14+30 14+40 14+50 14+60 14+70 14+80 14+90 15+00 15+10 15+20 15+30 15+40 15+50 15+60 15+70 15+80 15+90 16+00 16+10 16+20 16+30 16+40 16+50 16+60 16+70 16+80 16+90 17+00 17+10 17+20 17+30 17+40 17+50 17+60 17+70 17+80 17+90 18+00 18+10 18+20 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51+50 51+60 51+70 51+80 51+90 52+00 52+10 52+20 52+30 52+40 52+50 52+60 52+70 52+80 52+90 53+00 53+10 53+20 53+30 53+40 53+50 53+60 53+70 53+80 53+90 54+00 54+10 54+20 54+30 54+40 54+50 54+60 54+70 54+80 54+90 55+00 55+10 55+20 55+30 55+40 55+50 55+60 55+70 55+80 55+90 56+00 56+10 56+20 56+30 56+40 56+50 56+60 56+70 56+80 56+90 57+00 57+10 57+20 57+30 57+40 57+50 57+60 57+70 57+80 57+90 58+00 58+10 58+20 58+30 58+40 58+50 58+60 58+70 58+80 58+90 59+00 59+10 59+20 59+30 59+40 59+50 59+60 59+70 59+80 59+90 60+00 60+10 60+20 60+30 60+40 60+50 60+60 60+70 60+80 60+90 61+00 61+10 61+20 61+30 61+40 61+50 61+60 61+70 61+80 61+90 62+00 62+10 62+20 62+30 62+40 62+50 62+60 62+70 62+80 62+90 63+00 63+10 63+20 63+30 63+40 63+50 63+60 63+70 63+80 63+90 64+00 64+10 64+20 64+30 64+40 64+50 64+60 64+70 64+80 64+90 65+00 65+10 65+20 65+30 65+40 65+50 65+60 65+70 65+80 65+90 66+00 66+10 66+20 66+30 66+40 66+50 66+60 66+70 66+80 66+90 67+00 67+10 67+20 67+30 67+40 67+50 67+60 67+70 67+80 67+90 68+00 68+10 68+20 68+30 68+40 68+50 68+60 68+70 68+80 68+90 69+00 69+10 69+20 69+30 69+40 69+50 69+60 69+70 69+80 69+90 70+00 70+10 70+20 70+30 70+40 70+50 70+60 70+70 70+80 70+90 71+00 71+10 71+20 71+30 71+40 71+50 71+60 71+70 71+80 71+90 72+00 72+10 72+20 72+30 72+40 72+50 72+60 72+70 72+80 72+90 73+00 73+10 73+20 73+30 73+40 73+50 73+60 73+70 73+80 73+90 74+00 74+10 74+20 74+30 74+40 74+50 74+60 74+70 74+80 74+90 75+00 75+10 75+20 75+30 75+40 75+50 75+60 75+70 75+80 75+90 76+00 76+10 76+20 76+30 76+40 76+50 76+60 76+70 76+80 76+90 77+00 77+10 77+20 77+30 77+40 77+50 77+60 77+70 77+80 77+90 78+00 78+10 78+20 78+30 78+40 78+50 78+60 78+70 78+80 78+90 79+00 79+10 79+20 79+30 79+40 79+50 79+60 79+70 79+80 79+90 80+00 80+10 80+20 80+30 80+40 80+50 80+60 80+70 80+80 80+90 81+00 81+10 81+20 81+30 81+40 81+50 81+60 81+70 81+80 81+90 82+00 82+10 82+20 82+30 82+40 82+50 82+60 82+70 82+80 82+90 83+00 83+10 83+20 83+30 83+40 83+50 83+60 83+70 83+80 83+90 84+00 84+10 84+20 84+30 84+40 84+50 84+60 84+70 84+80 84+90 85+00 85+10 85+20 85+30 85+40 85+50 85+60 85+70 85+80 85+90 86+00 86+10 86+20 86+30 86+40 86+50 86+60 86+70 86+80 86+90 87+00 87+10 87+20 87+30 87+40 87+50 87+60 87+70 87+80 87+90 88+00 88+10 88+20 88+30 88+40 88+50 88+60 88+70 88+80 88+90 89+00 89+10 89+20 89+30 89+40 89+50 89+60 89+70 89+80 89+90 90+00 90+10 90+20 90+30 90+40 90+50 90+60 90+70 90+80 90+90 91+00 91+10 91+20 91+30 91+40 91+50 91+60 91+70 91+80 91+90 92+00 92+10 92+20 92+30 92+40 92+50 92+60 92+70 92+80 92+90 93+00 93+10 93+20 93+30 93+40 93+50 93+60 93+70 93+80 93+90 94+00 94+10 94+20 94+30 94+40 94+50 94+60 94+70 94+80 94+90 95+00 95+10 95+20 95+30 95+40 95+50 95+60 95+70 95+80 95+90 96+00 96+10 96+20 96+30 96+40 96+50 96+60 96+70 96+80 96+90 97+00 97+10 97+20 97+30 97+40 97+50 97+60 97+70 97+80 97+90 98+00 98+10 98+20 98+30 98+40 98+50 98+60 98+70 98+80 98+90 99+00 99+10 99+20 99+30 99+40 99+50 99+60 99+70 99+80 99+90 100+00 100+10 100+20 100+30 100+40 100+50 100+60 100+70 100+80 100+90 101+00 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115+40 115+50 115+60 115+70 115+80 115+90 116+00 116+10 116+20 116+30 116+40 116+50 116+60 116+70 116+80 116+90 117+00 117+10 117+20 117+30 117+40 117+50 117+60 117+70 117+80 117+90 118+00 118+10 118+20 118+30 118+40 118+50 118+60 118+70 118+80 118+90 119+00 119+10 119+20 119+30 119+40 119+50 119+60 119+70 119+80 119+90 120+00 120+10 120+20 120+30 120+40 120+50 120+60 120+70 120+80 120+90 121+00 121+10 121+20 121+30 121+40 121+50 121+60 121+70 121+80 121+90 122+00 122+10 122+20 122+30 122+40 122+50 122+60 122+70 122+80 122+90 123+00 123+10 123+20 123+30 123+40 123+50 123+60 123+70 123+80 123+90 124+00 124+10 124+20 124+30 124+40 124+50 124+60 124+70 124+80 124+90 125+00 125+10 125+20 125+30 125+40 125+50 125+60 125+70 125+80 125+90 126+00 126+10 126+20 126+30 126+40 126+50 126+60 126+70 126+80 126+90 127+00 127+10 127+20 127+30 127+40 127+50 127+60 127+70 127+80 127+90 128+00 128+10 128+20 128+30 128+40 128+50 128+60 128+70 128+80 128+90 129+00 129+10 129+20 129+30 129+40 129+50 129+60 129+70 129+80 129+90 130+00 130+10 130+20 130+30 130+40 130+50 130+60 130+70 130+80 130+90 131+00 131+10 131+20 131+30 131+40 131+50 131+60 131+70 131+80 131+90 132+00 132+10 132+20 132+30 132+40 132+50 132+60 132+70 132+80 132+90 133+00 133+10 133+20 133+30 133+40 133+50 133+60 133+70 133+80 133+90 134+00 134+10 134+20 134+30 134+40 134+50 134+60 134+70 134+80 134+90 135+00 135+10 135+20 135+30 135+40 135+50 135+60 135+70 135+80 135+90 136+00 136+10 136+20 136+30 136+40 136+50 136+60 136+70 136+80 136+90 137+00 137+10 137+20 137+30 137+40 137+50 137+60 137+70 137+80 137+90 138+00 138+10 138+20 138+30 138+40 138+50 138+60 138+70 138+80 138+90 139+00 139+10 139+20 139+30 139+40 139+50 139+60 139+70 139+80 139+90 140+00 140+10 140+20 140+30 140+40 140+50 140+60 140+70 140+80 140+90 141+00 141+10 141+20 141+30 141+40 141+50 141+60 141+70 141+80 141+90 142+00 142+10 142+20 142+30 142+40 142+50 142+60 142+70 142+80 142+90 143+00 143+10 143+20 143+30 143+40 143+50 143+60 143+70 143+80 143+90 144+00 144+10 144+20 144+30 144+40 144+50 144+60 144+70 144+80 144+90 145+00 145+10 145+20 145+30 145+40 145+50 145+60 145+70 145+80 145+90 146+00 146+10 146+20 146+30 146+40 146+50 146+60 146+70 146+80 146+90 147+00 147+10 147+20 147+30 147+40 147+50 147+60 147+70 147+80 147+90 148+00 148+10 148+20 148+30 148+40 148+50 148+60 148+70 148+80 148+90 149+00 149+10 149+20 149+30 149+40 149+50 149+60 149+70 149+80 149+90 150+00 150+10 150+20 150+30 150+40 150+50 150+60 150+70 150+80 150+90 151+00 151+10 151+20 151+30 151+40 151+50 151+60 151+70 151+80 151+90 152+00 152+10 152+20 152+30 152+40 152+50 152+60 152+70 152+80 152+90 153+00 153+10 153+20 153+30 153+40 153+50 153+60 153+70 153+80 153+90 154+00 154+10 154+20 154+30 154+40 154+50 154+60 154+70 154+80 154+90 155+00 155+10 155+20 155+30 155+40 155+50 155+60 155+70 155+80 155+90 156+00 156+10 156+20 156+30 156+40 156+50 156+60 156+70 156+80 156+90 157+00 157+10 157+20 157+30 157+40 157+50 157+60 157+70 157+80 157+90 158+00 158+10 158+20 158+30 158+40 158+50 158+60 158+70 158+80 158+90 159+00 159+10 159+20 159+30 159+40 159+50 159+60 159+70 159+80 159+90 160+00 160+10 160+20 160+30 160+40 160+50 160+60 160+70 160+80 160+90 161+00 161+10 161+20 161+30 161+40 161+50 161+60 161+7

Appendix B

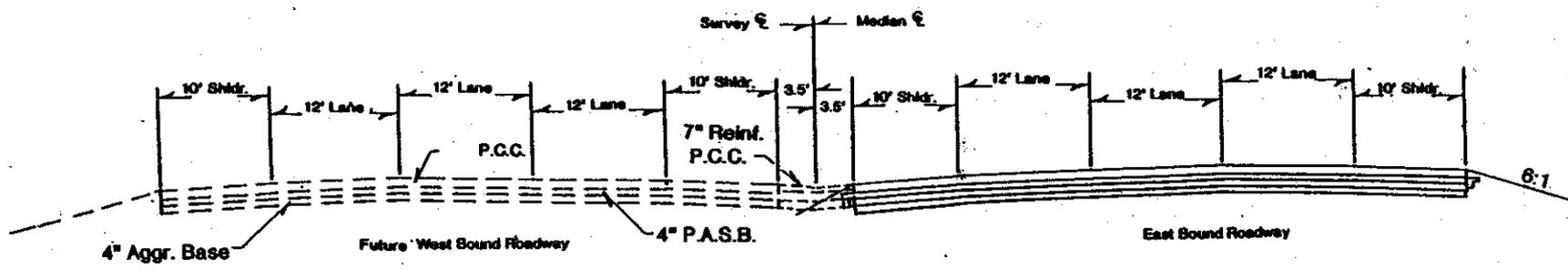
FED. REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	W-084-8(124)351	23



Typical Tangent Section
East Bound Roadway
Sta. 281+63 to 284+00

A - #4 Tie Bars spaced @ 2' - 6" C-C
B - #4 Tie Bars spaced @ 3' C-C

* See Typ. Perm. Base
& Drain Detail

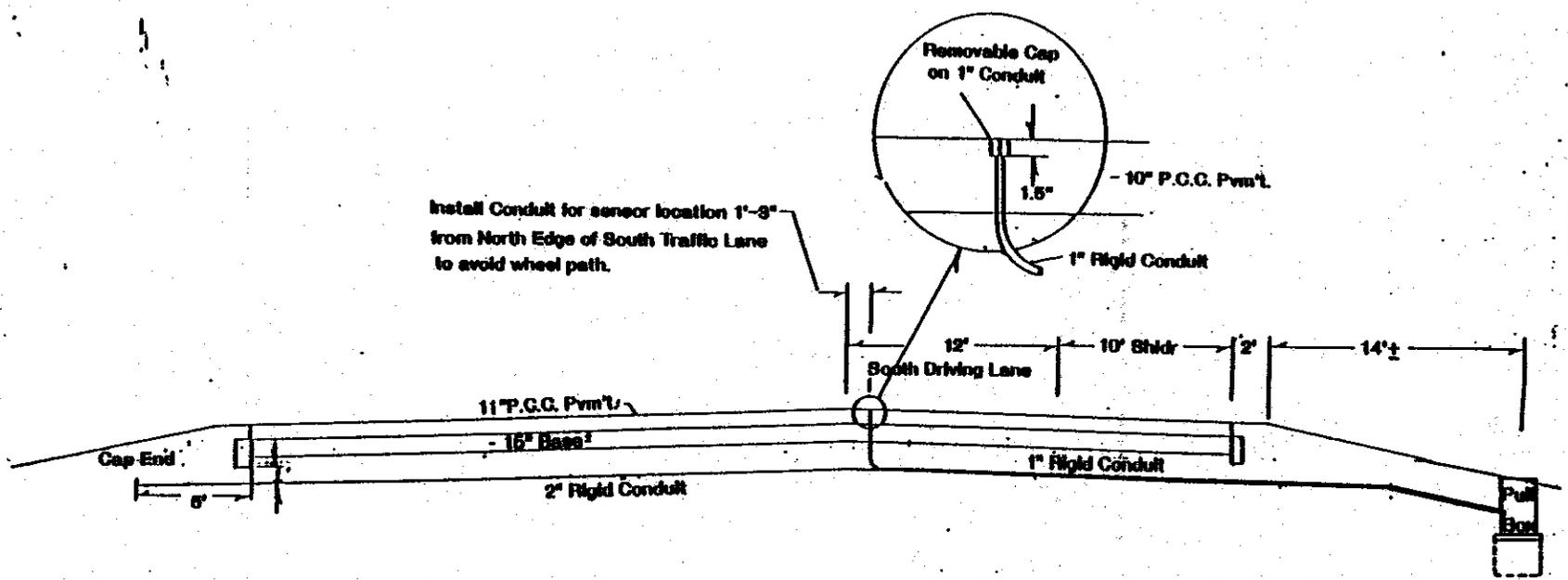


Future Typical Tangent Section

B-1

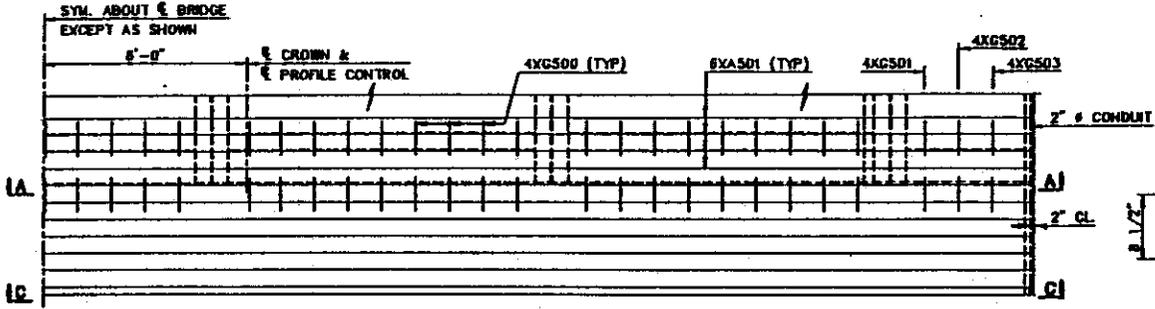
Project No.	STATE	FED. AID PROJ. NO.	Sheet No.
0	N.D.	RI-094-(124)35	32

B-2

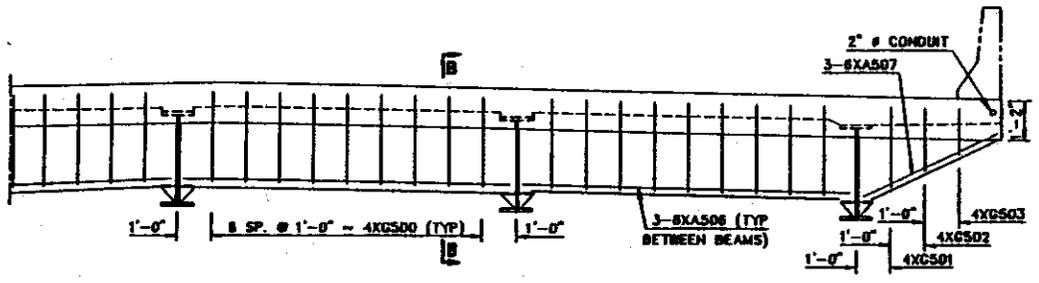


Conduit Pipe to be Layed in same trench approximately 42" below Surface of Rdwy.

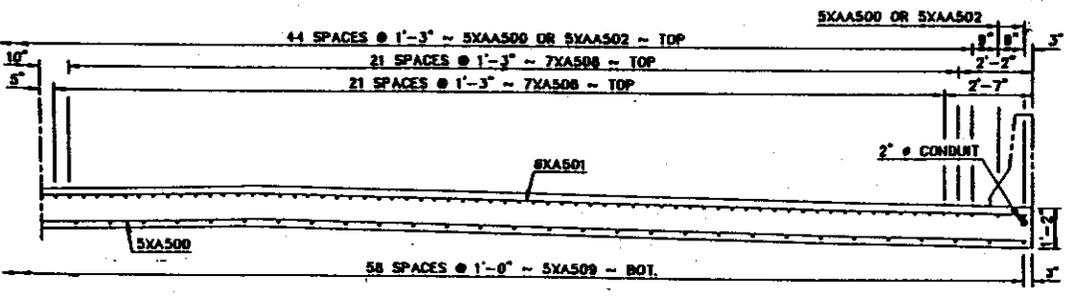
Conduit X-ing Detail
Sta. 293+00



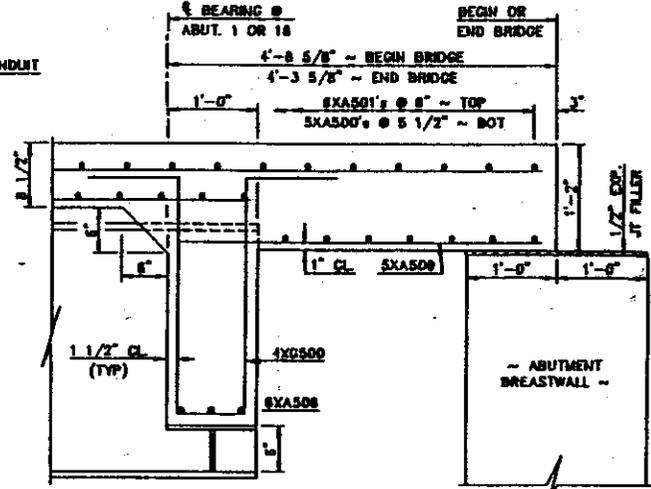
(LONGITUDINAL REINFORCING NOT SHOWN)
HALF END BEAM PLAN



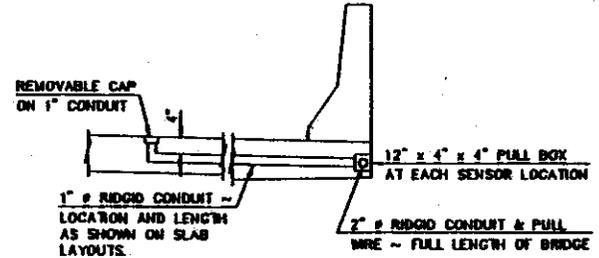
A-A



C-C



B-B



CONDUIT DETAIL

NOTE:

PULL WIRE: THE PULL WIRE SHALL CONSIST OF NO. 10 GAGE GALVANIZED BIRMINGHAM WIRE SINGLE STRAND STEEL. THERE SHALL BE 6 FEET ADDITIONAL PULL WIRE AT EACH PULL BOX.

ALL MATERIAL SHALL MEET THE REQUIREMENTS OF SECTION 700 OF THE NORTH DAKOTA STANDARD SPECIFICATIONS.

QUANTITIES

SEE DWG. 94-352.453-70

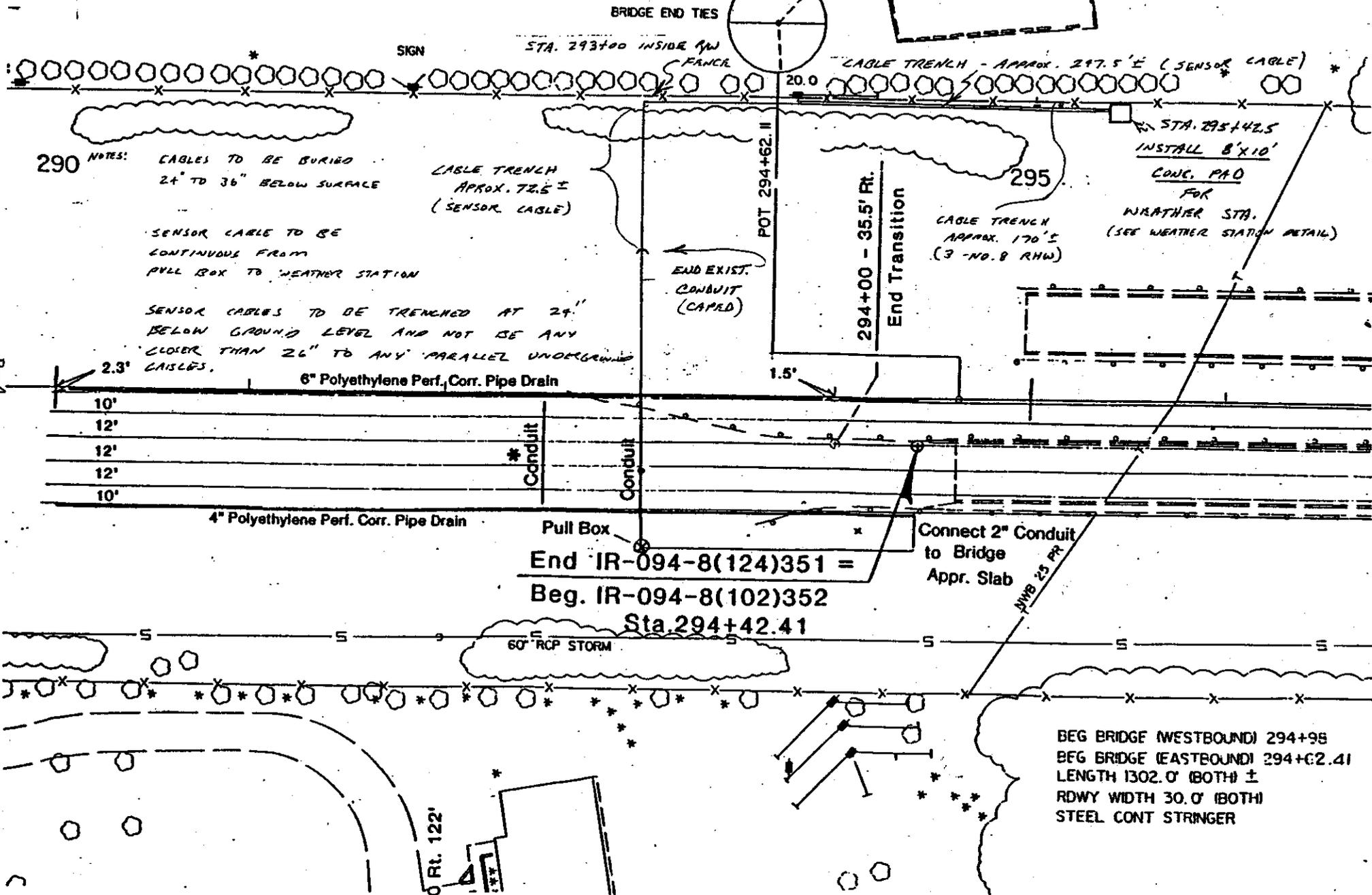
1-94 ~ RED RIVER
FARGO ~ MOORHEAD

SLAB END BEAM DETAILS

B-3

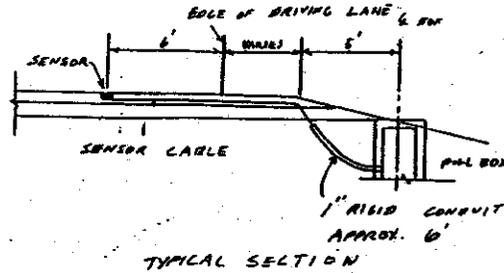
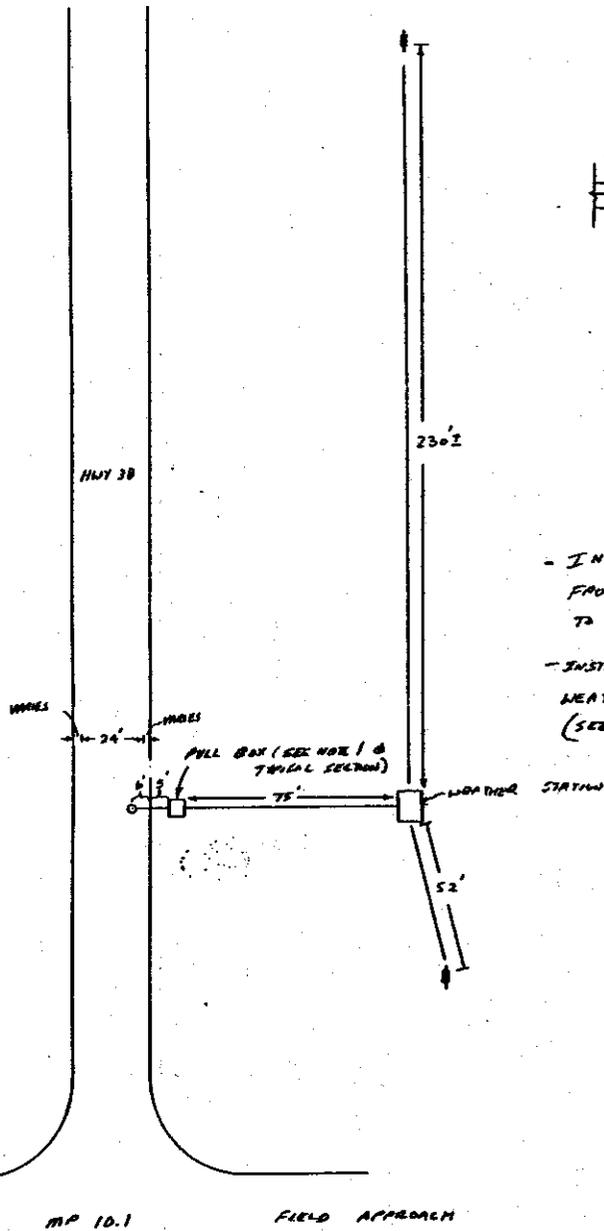
-INSTALL 3-NO. 8 RHW
STA 293+76.5 TO 295+42.5

-INSTALL 26' RIGID CONDUIT PLUS WEATHER HEAD @
POWER POLE STA. 293+76.5



N

B-5



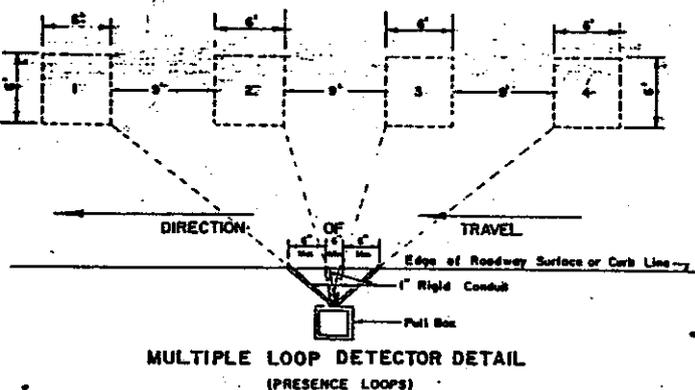
NOTES:

- ① SEE STANDARD DRAWING D-778-5 SAW SLOT TO PULL BOX DETAILS RURAL SECTION.
- ② CABLES TO BE BURIED 24" TO 36" BELOW SURFACE
- ③ SENSOR CABLE TO BE CONTINUOUS FROM PULL BOX TO WEATHER STATION.
- ④ SEE SERVICE CONNECTION DETAIL

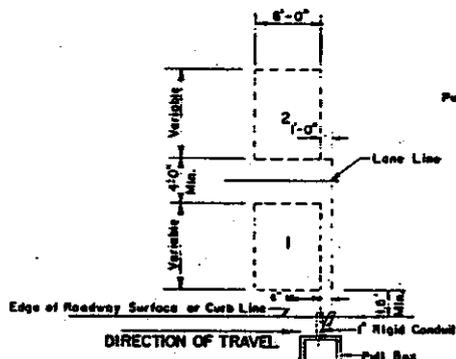
- INSTALL 3-NO. 8 RHW
FROM NEAREST POWER POLE
TO WEATHER STATION

- INSTALL RIGID CONDUIT PLUS
WEATHER HEAD @ POWER POLE
(SEE NOTE 4)

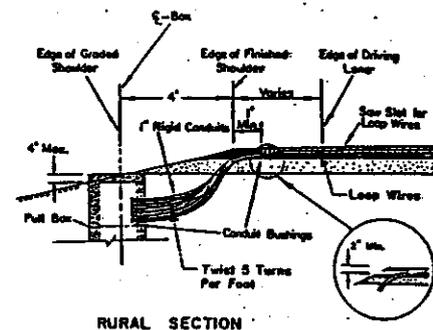
LOOP DETECTORS DETAILS



**MULTIPLE LOOP DETECTOR DETAIL
(PRESENCE LOOPS)**

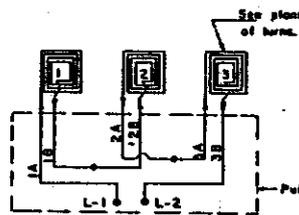


CURB SECTION

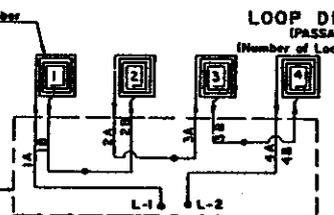


RURAL SECTION

**SAW SLOT TO PULL BOX
DETAILS**

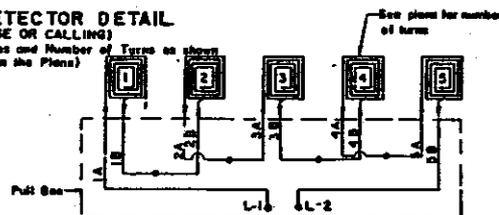


MULTIPLE LOOP CONNECTION
All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)
The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, 2A to 3A, and 3B to L-2

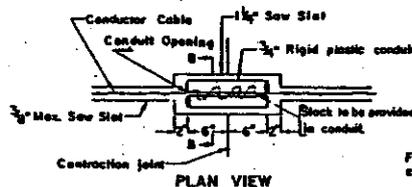


MULTIPLE LOOP CONNECTION
All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)
The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, 2A to 3A, 3B to 4B, and 4A to L-2

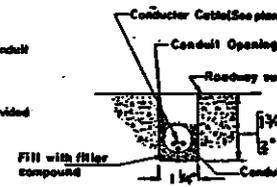
**LOOP DETECTOR DETAIL
(PASSAGE OR CALLING)**
(Number of Loops and Number of Turns as shown in the Plans)



MULTIPLE LOOP CONNECTION
All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)
The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B, 2A to 3A, 3B to 4B, 4A to 5A, and 5B to L-2



PLAN VIEW



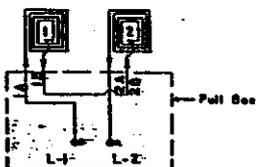
SECTION BB

CONTRACTION JOINT DETAIL

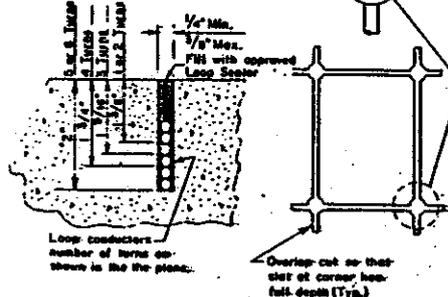
(This detail shall also be used whenever a crack in the roadway is encountered.)

NOTES:

1. Each loop shall be saw cut in the roadway.
2. The number of turns, size of loop and size of conductor shall be as shown on the plans. The first loop dimension figure is the length in the direction of travel and the second dimension is the width across the traffic lane.
3. The lead routing shall be in separate slots to conduit leading to pull box to minimize interaction.

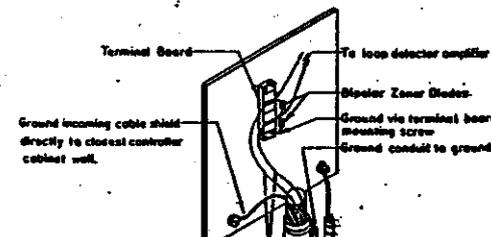


MULTIPLE LOOP CONNECTION
All conductors shall be labeled in the pull box as shown. (1A, 1B, 2A, etc.)
The loop connections shall be spliced in the pull box: 1A to L-1, 1B to 2B; and 2A to L-2.



SAW SLOT DETAILS:

Drill detector loop corners 2" deep. Use saw pavement slots to form loops. Dimensions and location shall be as shown in plans.

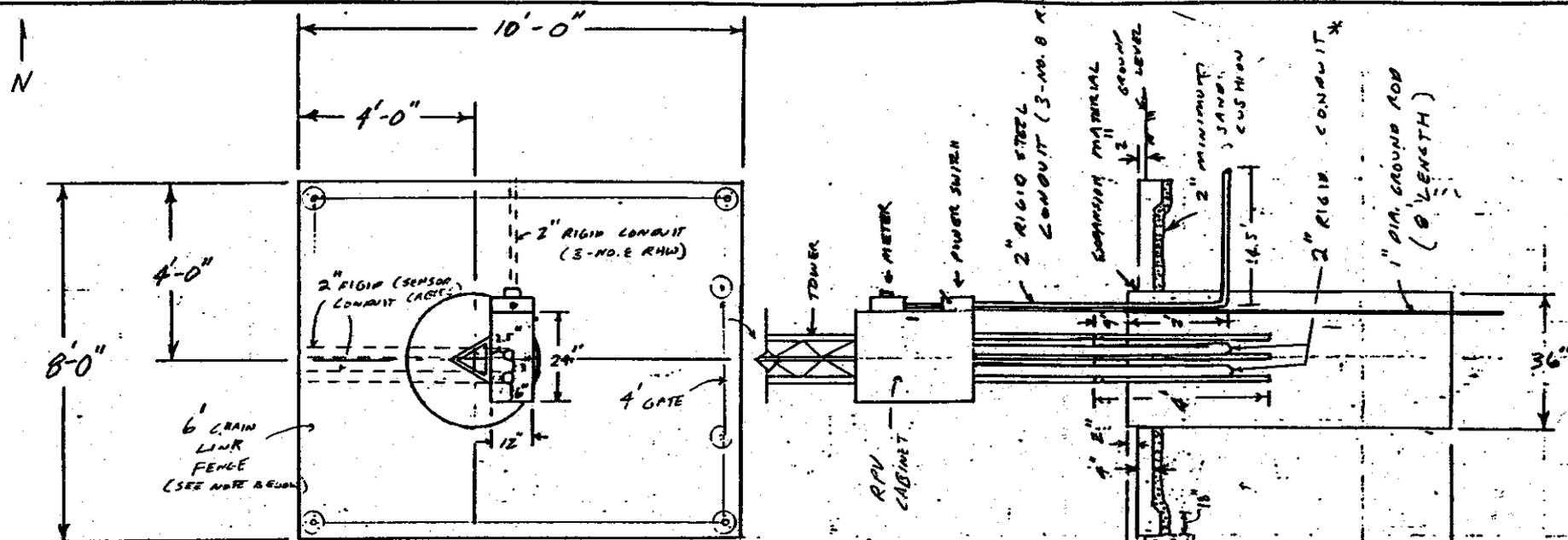


LOOP LEAD-IN CONDUCTOR LIGHTNING PROTECTION

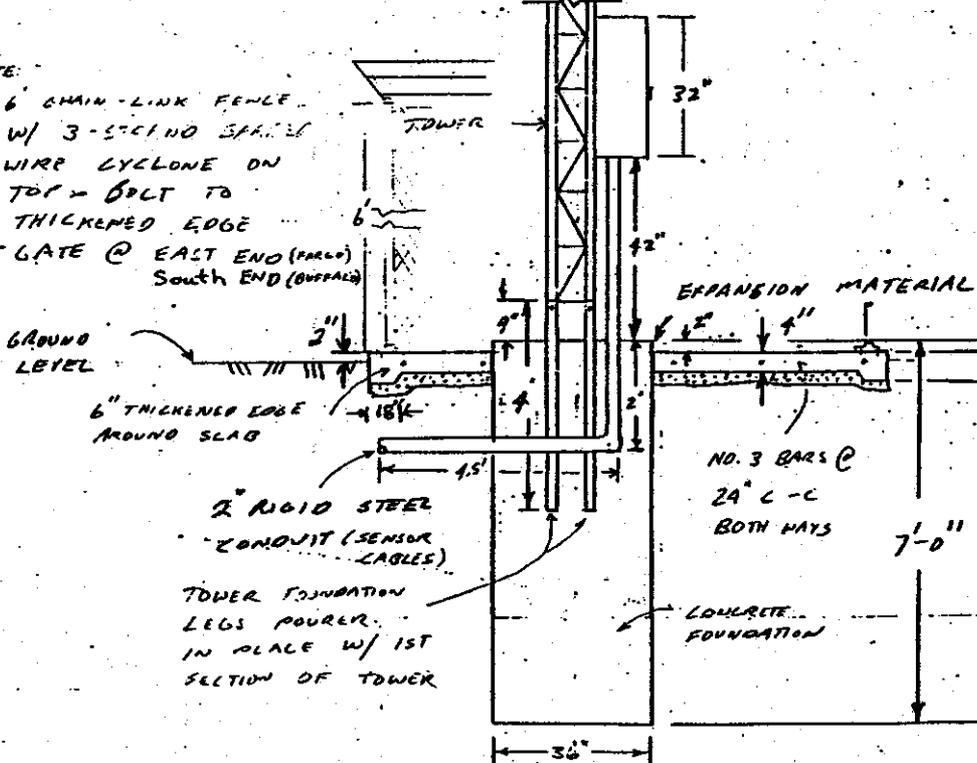
10-1-88		REVISIONS	
DATE	BY	CHANGES	
8-3-87		NOTE	
11-20-88		REMOVE CONDUIT AT CURB SPACING	
12-2-88		MULTIPLE LOOP CONNECTION	

NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION
APPROVED: *[Signature]*
ELMER CHURCH

B-8

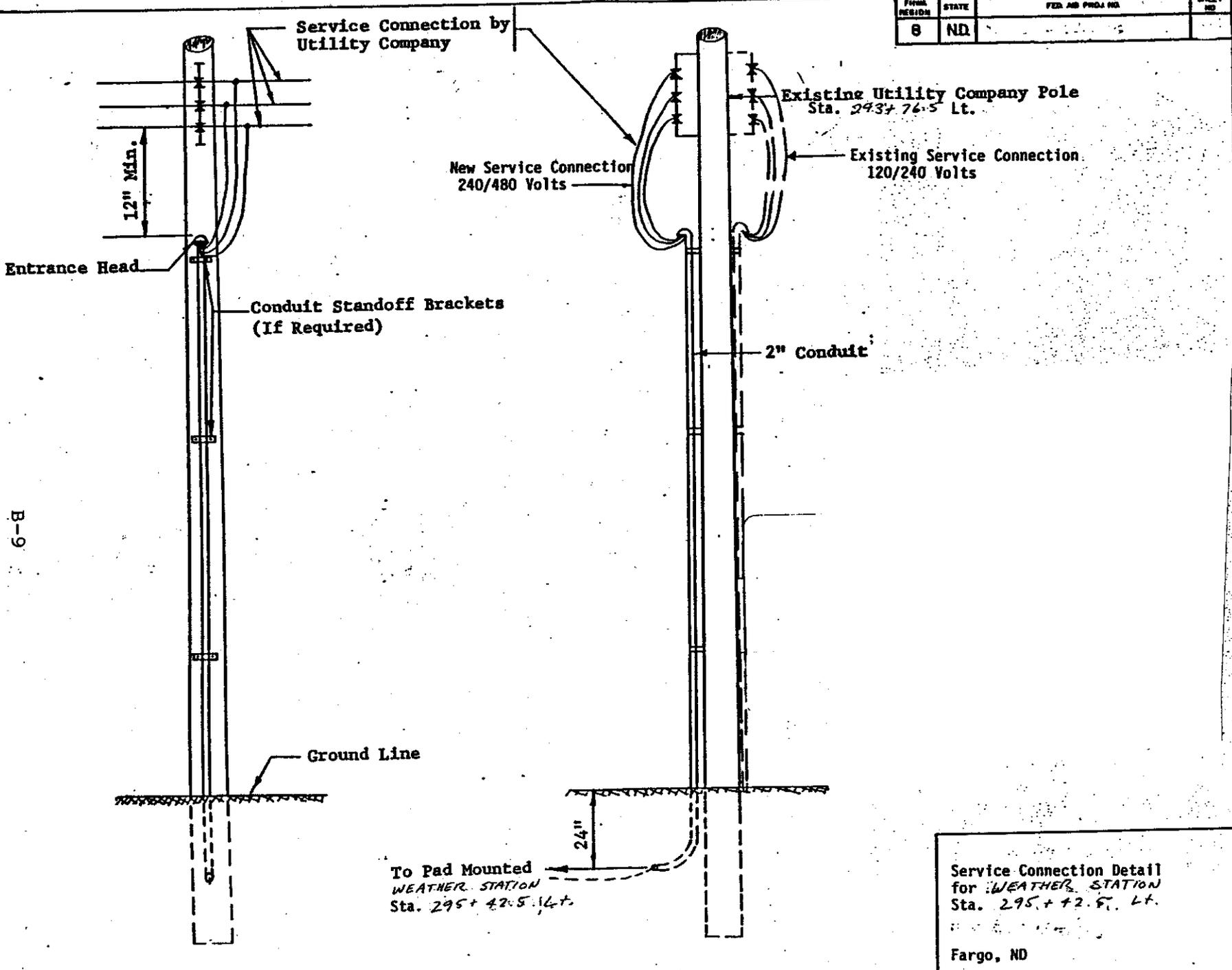


NOTE:
 6' CHAIN-LINK FENCE
 W/ 3-SECTION SPACED
 WIRE CYCLONE ON
 TOP - BOLT TO
 THICKENED EDGE
 4' GATE @ EAST END (PARLO)
 South END (BUFFALO)



NOTE: SEE STANDARD DRAWING.
 NO. D-770-1 CONCRETE
 FOUNDATIONS (TRAFFIC SIGNALS
 AND HIGHWAY LIGHTING).
 REFER TO DESCRIPTIONS.
 LIGHT STANDARD - 50' MOUNTING
 HEIGHT, 26" DIAMETER, 7' DEEP.

FORM REVISION	STATE	FED. AID PROJ. NO.	SHEET NO.
6	ND.		

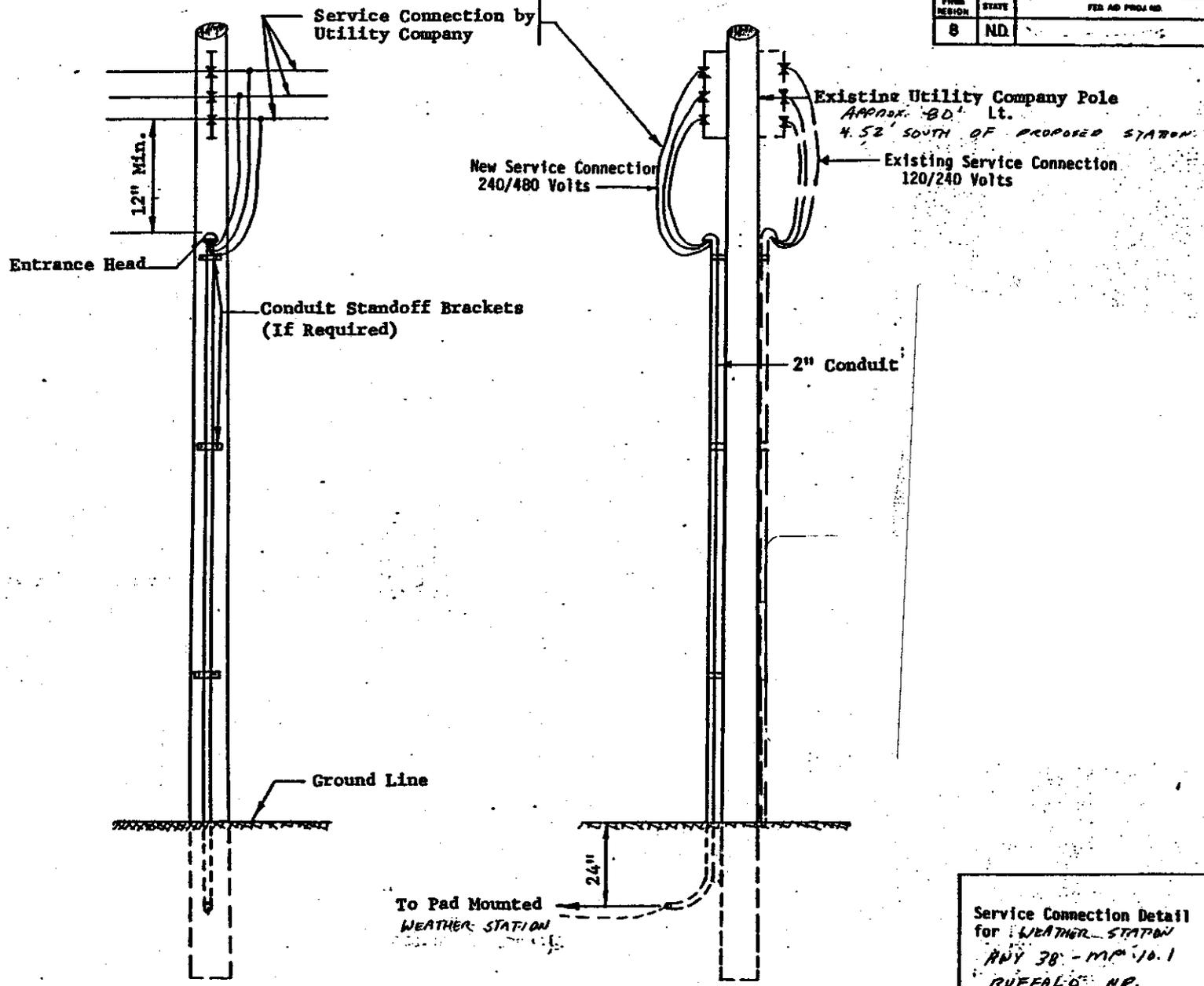


B-9

To Pad Mounted
WEATHER STATION
Sta. 295+42.5 Lt.

Service Connection Detail
for WEATHER STATION
Sta. 295+42.5 Lt.
 Fargo, ND

FYRM REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	ND.		

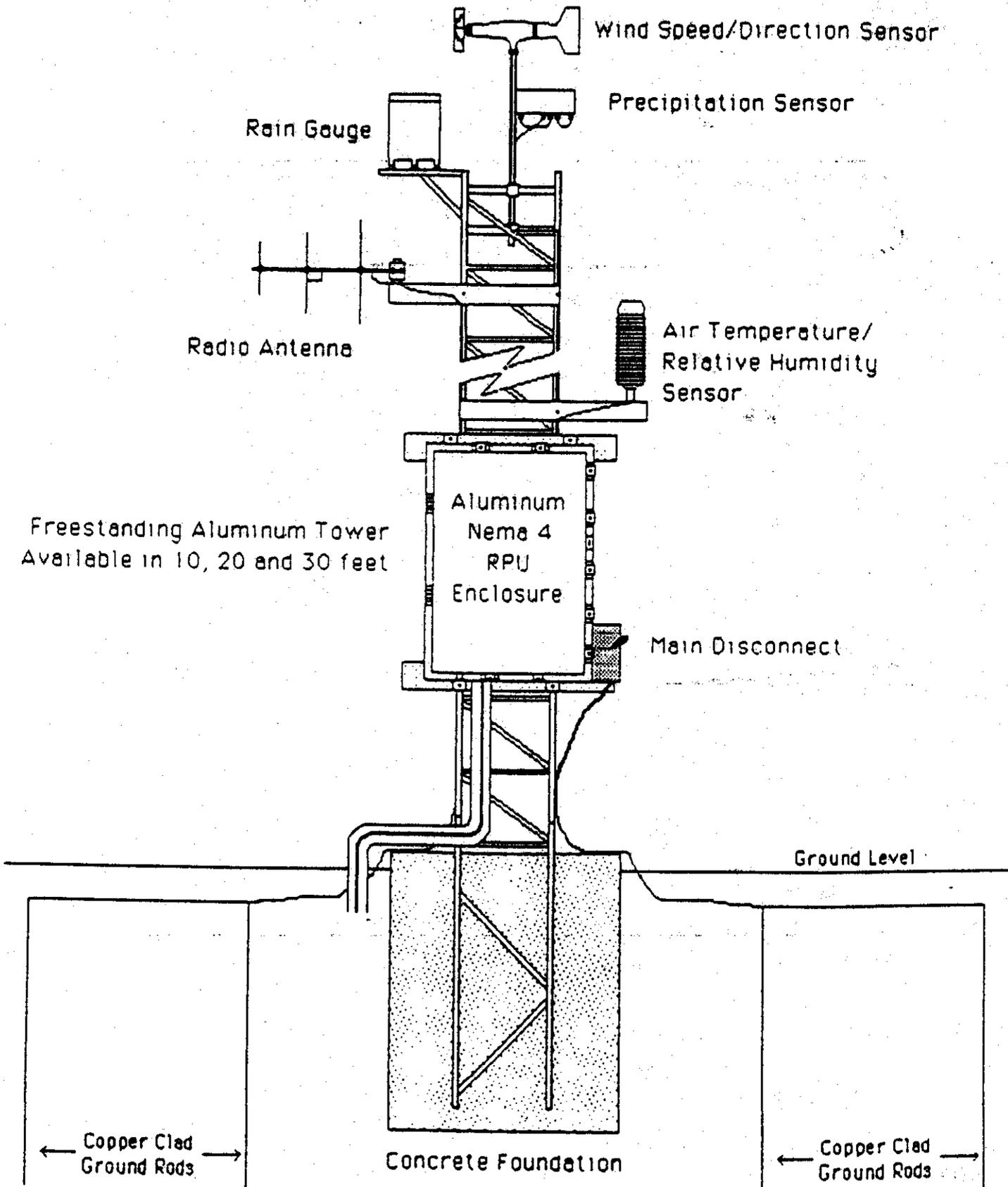


Service Connection Detail
 for WEATHER STATION
 RMY 38 - MP 10.1
 BUFFALO, ND.

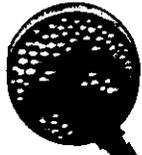
B-10

Appendix C

Typical Highway Remote Processing Unit (RPU) Showing Radio Communications

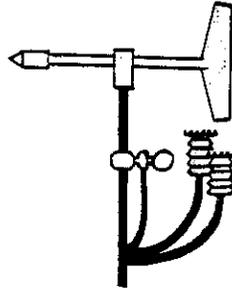


SCAN® SYSTEMS



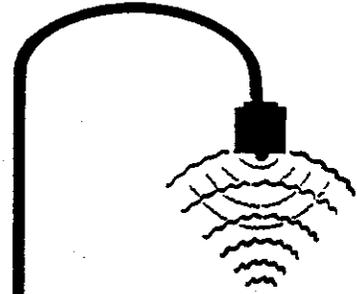
Surface Sensor
Monitors surface conditions:

- Temperature
- Presence of ice, frost, water and chemicals



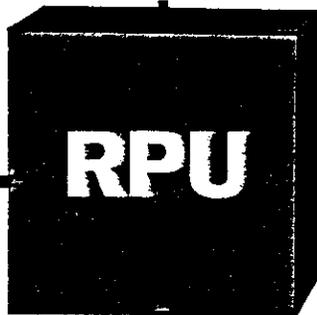
Atmospheric Sensors

- Air Temperature
- Dew Point
- Relative humidity
- Precipitation
- Wind direction and speed
- And others...

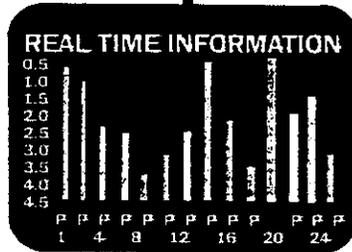


Water Level And Rain Gauge Sensors
Monitor levels in streams, rivers and sewers:

- Alert you to rapidly rising levels
- Provide flood stage alarms
- Indicate rainfall rates



Remote Processing Unit
Collects and transmits sensor data

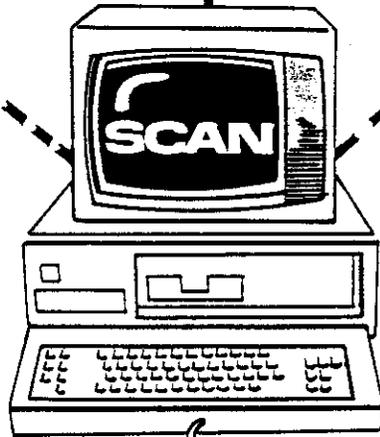


TAILOR MODELS

24-HOUR PROJECTIONS SURFACE TEMP

24-HOUR PROJECTIONS WATER LEVEL

(SIMULATIONS)

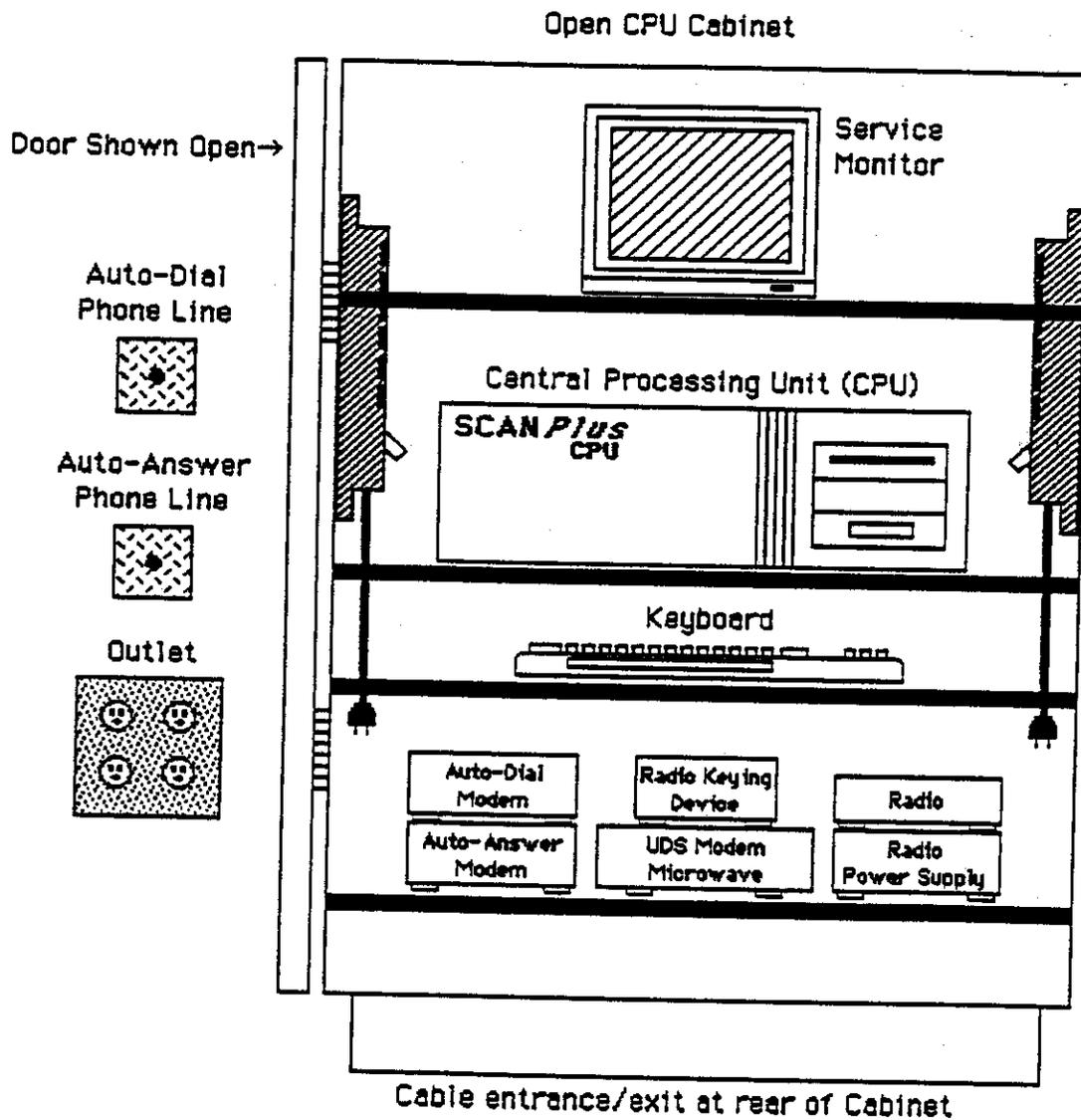


Access Weather Information From Nationwide Computer Data Base

- Snow and ice warnings
- Severe storm warnings
- Weather maps
- Public and pilot weather

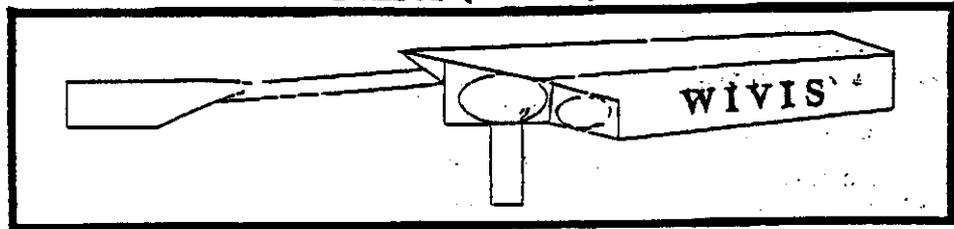
ssi® surface systems, inc.
2605 s. hanley rd.
st. louis, missouri 63144
(314) 781-5320
(800) 325-7226

Data Handler with Central Processing Unit





**Weather Identifier and VISibility
Sensor (WIVIS)**



- **Type of precipitation detection**
- **Intensity of precipitation (rain and snow)**
- **Measurement of precipitation**
- **Measurement of visibility**

SCAN[®] Road Weather Information System (RWIS) Features

- Automatic Identification of precipitation types:
Rain, Snow, Drizzle, and Mixture (Rain/Snow)
- Measures true dynamic precipitation rate range
- Fast resolution rate, even in light precipitation
- Highly accurate for all Intensities of precipitation
- Positive Identification Of Precipitation State (Yes/No)
- Measures snowfall intensity
- Insensitive to background light, evaporation & splash
- Completely automatic/unattended operation
- Rugged modular design and very reliable
- No moving part - all solid state - long life
- Eye safe long life LED source

**Available To Surface Transportation Agencies ONLY From
SURFACE SYSTEMS, INC. (SSI)**