Appendix H
Application: Upper Saginaw River, MI Navigation Project--Second-Order GPS Photo Mapping Control Surveys (Detroit District)

The purpose of this 1993 project was to establish Second-Order control, using static GPS survey methods, for the navigation project on the Upper Saginaw River (Michigan) leading into Saginaw Bay in Lake Huron. The survey area started at Green Point and went to the railroad bridge at the upper end of the project area. Control stations established during this survey were designed to support digital mapping of the Upper Saginaw River. A total of 8 stations in the project area were occupied, and 6 new stations were established. External NGRS control was brought in from two First-Order NGS horizontal control stations--JONAS and PARRISH. The Saginaw Area Office, Detroit District, performed all the observations and adjustments. This appendix illustrates the observation, reduction, and adjustment phases of this project.

H-1. Planning Phase

a. The GPS survey was planned for 24-25 March 1993, Julian Day 083 and 084 in the vicinity of Saginaw, Michigan.

b. Four Ashtech Dual Frequency (L1/L2) GPS receivers and antennas with ground planes were used for this project, simultaneously occupying 4 stations during each session--observing 6 baselines, 3 of which are independent.

c. Prior to any data collection, a preplanning survey was conducted to determine any obstructions (see typical example in Figure H-1) and examine existing control. Control station JONAS and PARRISH had some sinking problems due to thawing ground. Station JONAS was readjusted during the survey but station PARRISH was not.

d. A satellite visibility chart was run to determine occupation times for each session on both Day 083 and Day 084. The chart included the number of satellites and PDOP for the project area. The charts were run with an elevation mask of 20 deg (Figure H-2) and 25 deg (see Figure H-3).

e. There were three survey sessions held on Day 083 and one on Day 084. Below are listed sessions, occupation times and stations occupied for Day 083 and Day 084.

Day 083			**Day 084**
Session A 0900-1000	Session B 1030-1130	Session C 1340-1540	Session A 1335-1535
HOYT GENESSEE HOLLAND EWALD	WICKES RUST HOLLAND EWALD	WICKES RUST **JONAS** **PARRISH**	HOYT GENESSEE **JONAS** **PARRISH**

H-2. Actual Survey

The survey was performed as planned, with three sessions on Day 083 and one session on Day 084. An Observation Log for each station was recorded by the observer. This information was used during post-processing.

H-3. Data Processing and Adjustment

a. The GPS baselines were processed using Ashtech baseline reduction software LINECOMP (GPPS-L, Version 4.5). All four sessions were processed. A typical output file from this program is shown in figure H-4 (a-e). From these results, session 083 A & B and 084 seemed to be satisfactory. Session 083 C tagged all the float solutions except for the vector between 4008 and 4009. The plots for these vectors, between 4008 and 4009, appeared to have been effected by the ionosphere.

b. After baseline processing was completed, a loop closure was performed--see typical output in Figure H-5--and one was performed to show closures between the unknown control stations.

c. Once the loop closures were completed, a FILLNET (Version 3.0) free adjustment and constrained adjustment was performed on all processed baselines for Julian days 083 and 084. Data shown in Figure H-6 is typical of the input file used for the free adjustment. The constrained adjustment held fixed station PARRISH (in X-Y-Z) and station JONAS (in X-Y). The results of the constrained adjustment are shown in Figure H-7 (a-f).

d. After the final adjustment of the data, CORPSCON was used to convert the station latitude, longitude to NAD 1983 SPCS coordinates. A sample output is shown in Figure H-8.

H-4. Station Descriptions

Station descriptions with adjusted coordinates for each control station set were formulated. A sample description is shown in Figure H-9.

" G.P.S. PREPLANNING SURVEY "

PROJECT: UPPER SAGINAW

STATION NAME: HoyT RIGHT OF ENTRY YES DATE:

HORIZONTAL CONTROL: KNOWN_____ UNKNOWN ✓ (IF UNKNOWN GIVE APPROX. LAT/LONG)

IF KNOWN GIVE VALUES: DATUM_____ PROJECTION_____ ZONE_____

LATITUDE_____ NORTH_____

LONGITUDE_____ EAST _____

VERTICAL CONTROL: KNOWN_____ UNKNOWN ✓ (IF UNKNOWN GIVE APPROX. ELEV.)

IF KNOWN GIVE VALUES: DATUM_____ ELEV. FT._____ METERS_____

OBSEVATION SITE: COMPLETE OBSTRUCTION POLAR MAP (SEE BELOW)

ACCESSABILITY: CAR/TRUCK ✓ HIKE_____ BOAT ✓

DISTANCE VEHICLE CAN BE PARKED TO STATION:_____

PRIVATE PROPERTY_____ PUBLIC PROPERTY ✓ KEY FOR GATE REQUIRED_____

NOTIFICATION OF PROPERTY OWNER REQUIRED PRIOR TO ACCESS NO

NAME: SAG. RIVER WALK IF YES PHONE #_____

OBSTRUCTION POLAR MAP:

INDICATE OBSTRUCTIONS:
EX. TREES, BUILDINGS,...
(SEE EXAMPLE ON BACK)

REMARKS:

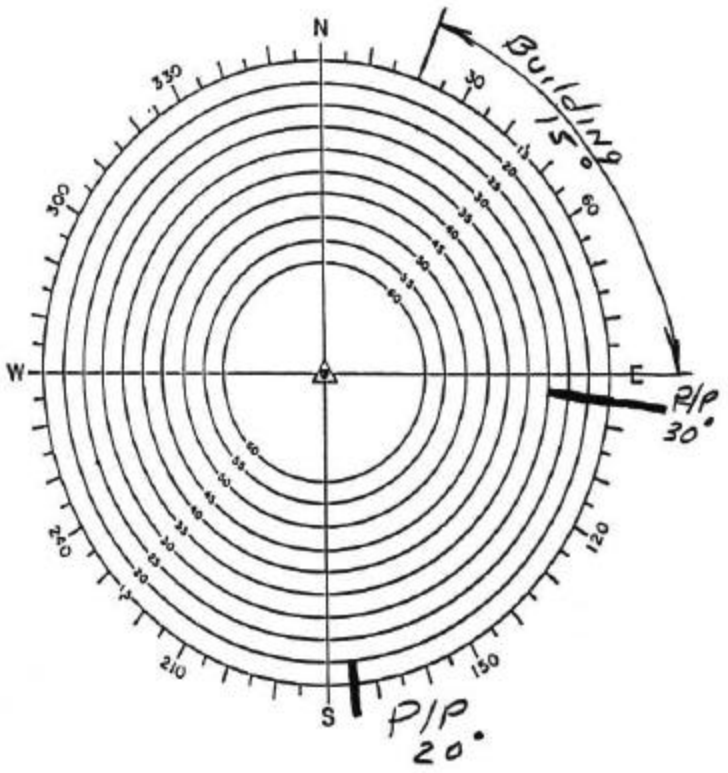

Figure H-1. Preplanning survey diagram for station HOYT (Upper Saginaw River Project)

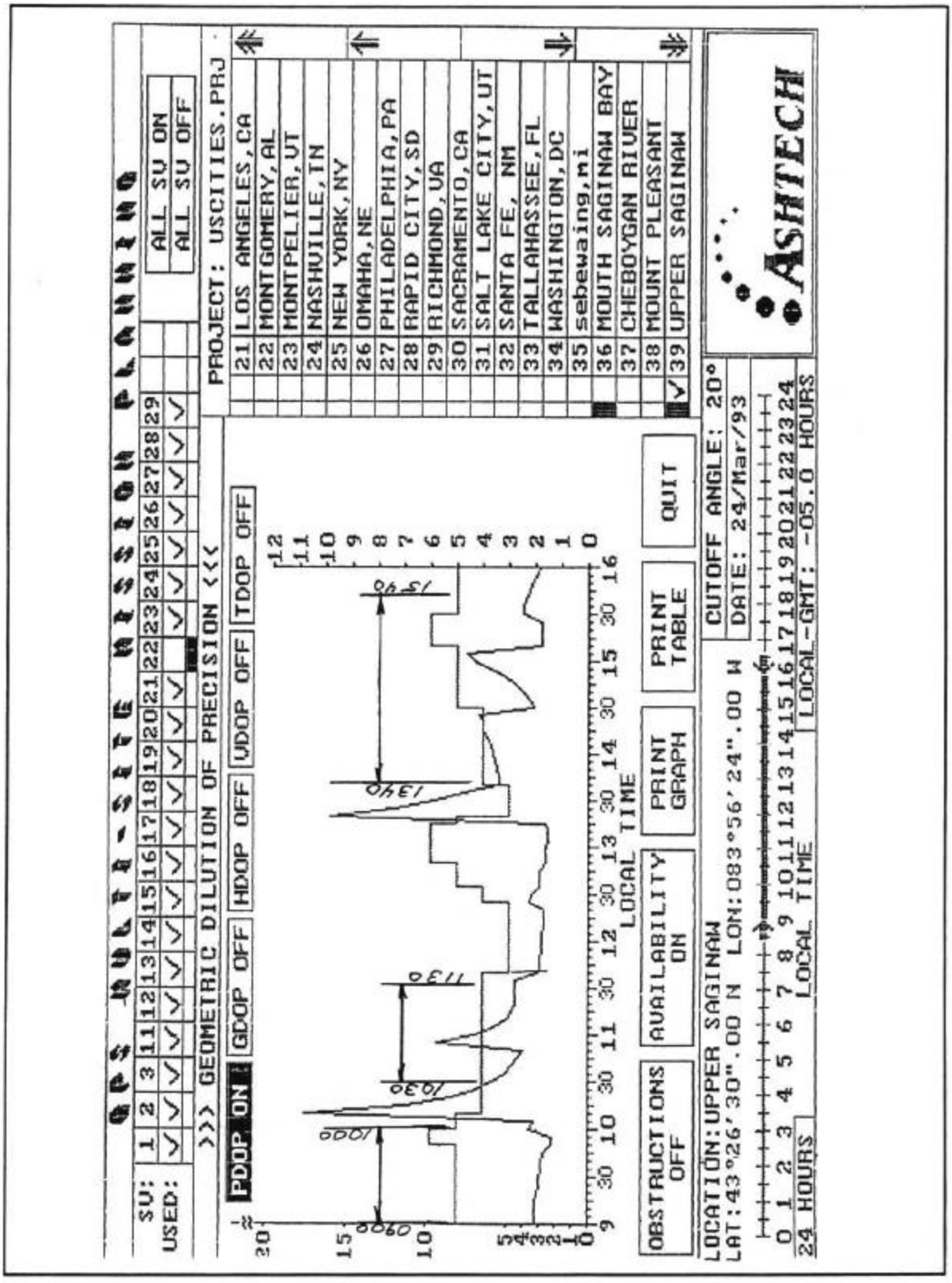

Figure H-2. Satellite visibility diagram for elevation mask of 20 degrees

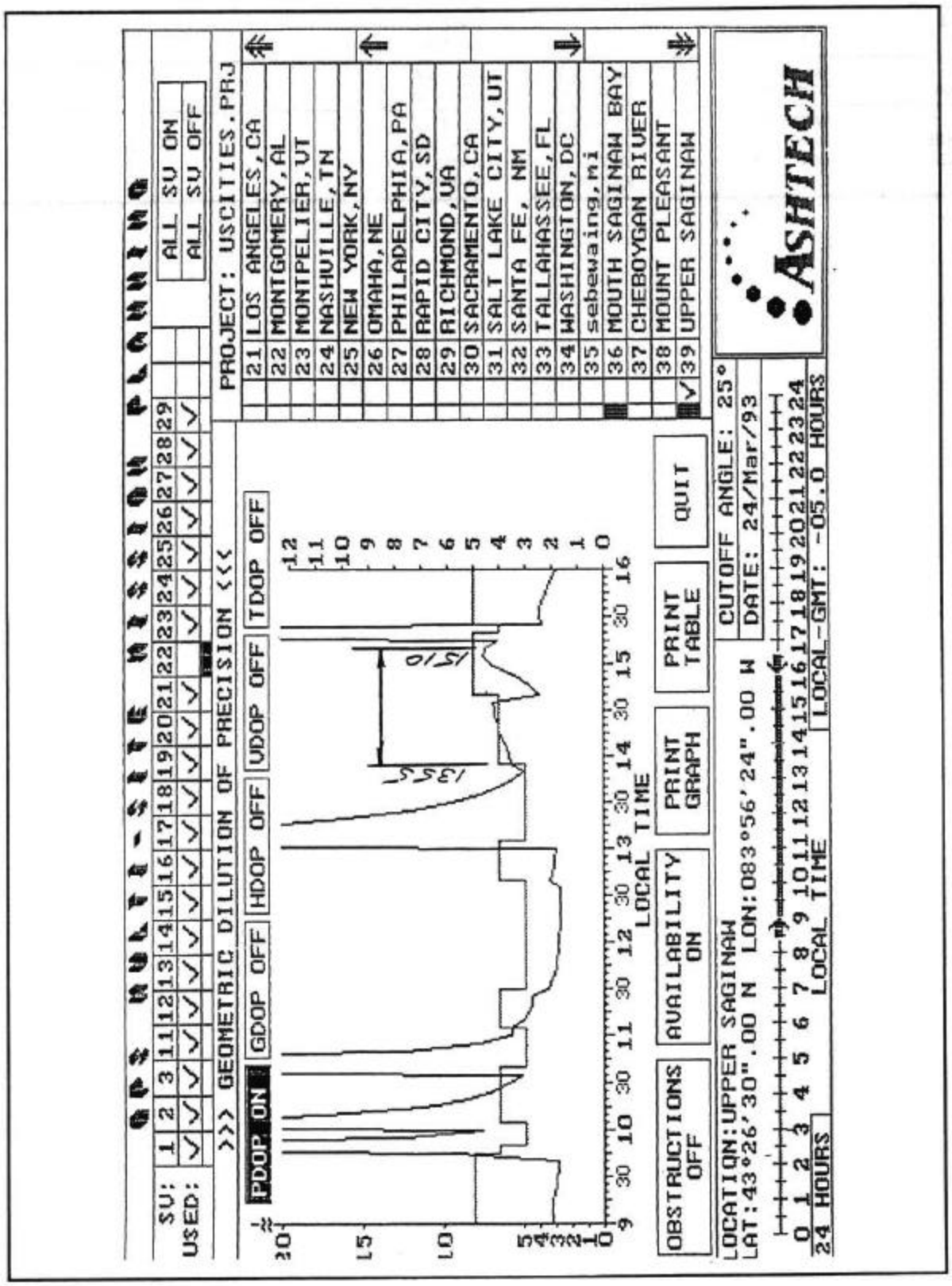

Figure H-3. Satellite visibility diagram for elevation mask of 25 degrees

```
Ashtech, Inc. GPPS-L          Program: LINECOMP          Version: 4.5.00
                            Fri Mar 26 10:34:33 1993
_____________________________________________________________________
Project information
GPS Survey                  |25-character project name  [ The | is in column 26
. ]
0843A                       |5-character session name
Project information

Known-station parameters
00                          |Receiver identifier used in "LOGTIMES" file
000000                      |Project station number
1001                        |4-character short name
FIXED STATION               |25-character long name
503 003 005 _____________   |25-character comment field
0                           |Position extraction (0=below,1=U-file,2=proj. file
)
N  43 33 32.67131           |Latitude deg-min-sec  (g=good;b=bad)
E 276 11 32.13854           |E-Longitude deg-min-sec (g=good;b=bad)
W  83 48 27.86146           |W-Longitude deg-min-sec (g=good;b=bad)
   150.7356                 |Ellipsoidal height  (m) (g=good;b=bad)
     0.0000                 |North antenna offset(m)
     0.0000                 |East antenna offset (m)
  1.6990  0.1150  0.0000    |Vert antenna offset (m): slant/radius/added_offset
    20.0                    |Temperature (degrees C)
    50.0                    |Humidity (percent)
  1010.0                    |Pressure (millibars)
U1001A93.084                |Measurement filename (restricted to 24 characters)
Known-station parameters

Unknown-station parameters
00                          |Receiver identifier used in "LOGTIMES" file
000000                      |Project station number
4005                        |4-character short name
UNKNOWN STATION             |25-character long name
504 004 007 _____________   |25-character comment field
0                           |Position extraction (0=below,1=U-file,2=proj. file
)
N  43 26  1.65174           |Latitude deg-min-sec  (g=good;b=bad)
E 276  3 25.93899           |E-Longitude deg-min-sec (g=good;b=bad)
W  83 56 34.06101           |W-Longitude deg-min-sec (g=good;b=bad)
   149.5289                 |Ellipsoidal height  (m) (g=good;b=bad)
     0.0000                 |North antenna offset(m)
     0.0000                 |East antenna offset (m)
  1.6350  0.1150  0.0000    |Vert antenna offset (m): slant/radius/added_offset
    20.0                    |Temperature (degrees C)
    50.0                    |Humidity (percent)
  1010.0                    |Pressure (millibars)
U4005A93.084                |Measurement filename (restricted to 24 characters)
Unknown-station parameters
```

Figure H-4a. Ashtech LINECOMP baseline reduction output file (Baseline 1001-4004)

```
Run-time parameters
    1                       |First epoch to process
   -1                       |Final epoch to process (-1 = last available)
20.0                        |Elevation cutoff angle (degrees)
1                           |Data to process (0=Wdln;1=L1;2=L2;3=L1c;6=RpdSt)
0.010000                    |Convergence criterion (meters)
00 00 00 00 00 00 00        |Omit these satellites (up to 7)
10                          |Maximum iterations for tlsq and dlsq
00 00 00 00 00 00 00        |Forbidden reference SVs (up to 7)
yes                         |Apply tropo delay correction
Run-time parameters

LINECOMP 4.5.00 12/11/92

FIXED U-File from L1 only receiver.
UNKWN U-File from L1 only receiver.

FIXED U-File used BROADCAST orbits.
UNKWN U-File used BROADCAST orbits.

Common start of two UFILES: 1993/03/25 18:35:60.00
Common end   of two UFILES: 1993/03/25 20:32:60.00
    Selected first epoch:  1
    Selected last  epoch:  352
For SV 11 there are   221 triple-difference measurements.
For SV 18 there are   351 triple-difference measurements.
For SV 19 there are   351 triple-difference measurements.
For SV 27 there are    73 triple-difference measurements.
For SV 28 there are   348 triple-difference measurements.
For SV 29 there are   338 triple-difference measurements.
Epoch interval (seconds): 20.000000


THE TRIPLE DIFFERENCE SOLUTION (L1)
Measure of geometry: 0.640415
num_meas =  1329        num_used =  1323        rms_resid = 0.002595(m)
Post-Fit Chisq =  3459.383          NDF      =    12.250


  Sigmax (m):      0.870234
  Sigmay (m):      0.572256
  Sigmaz (m):      0.270963
  x     y     z
x 1.00
y 0.71y 1.00
z-0.40z-0.59z 1.00

del_station: 0.005074 0.001394 -0.000650
     Station1: FIXED STATION             Station2: UNKNOWN STATION

               (00000)    (1001)                    (00000)    (4005)
```

Figure H-4b. Ashtech LINECOMP baseline reduction output file (Baseline 1001-4004)

```
Latitude:  43.55907536  43 33 32.67131          43.43379221  43 26  1.65195

E-Long  : 276.19226071 276 11 32.13854         276.05720501 276  3 25.93803

W-Long  :  83.80773929  83 48 27.86146          83.94279499  83 56 34.06197

E-Height: 150.7356                              149.5416

Baseline vector:      -9839.2603    -10690.9170    -10098.3296

Mark1_xyz  :    499359.2995  -4602470.6194   4372824.2683
Az1 El1 D1 :       218.17046       -0.0834     17694.1519
E1 N1 U1   :    -10912.4583    -13919.7439        -1.1940
Mark2_xyz  :    489520.0392  -4613161.5364   4362725.9387
Az2 El2 D2 :        38.07750       -0.0757     17694.1519
E2 N2 U2   :     10935.0401     13919.4351         1.1940

Double-Difference Epochs:
  Prn:  11  Start epoch:  132  End epoch:  352
  Prn:  18  Start epoch:    2  End epoch:  352
  Prn:  19  Start epoch:    2  End epoch:  352
  Prn:  27  Start epoch:  280  End epoch:  352
  Prn:  28  Start epoch:    5  End epoch:  352
  Prn:  29  Start epoch:    2  End epoch:  339


THE FLOAT DOUBLE DIFFERENCE SOLUTION (L1)
Measure of geometry: 0.103203     Wavelength = 0.190294 (m/cycle)
num_meas =  1332        num_used =  1317         rms_resid = 0.004061(m)
Post-Fit Chisq =    42.171          NDF      =    12.194

Reference SV: 18
  SV     Ambiguity       FIT    Meas      SV     Ambiguity       FIT    Meas
  11      22406589.878f  0.024   211      19      21161231.999f  0.018   350
  27      10785453.076f  0.024    72      28      28836460.832f  0.022   348
  29       5129536.945f  0.021   336

  Sigmax (m):       0.015558
  Sigmay (m):       0.010159
  Sigmaz (m):       0.004803
  SigmaN (cy):      0.075992
  SigmaN (cy):      0.018403
  SigmaN (cy):      0.034642
  SigmaN (cy):      0.089934
  SigmaN (cy):      0.033807
  x     y     z     N     N     N     N     N
x 1.00
y 0.72y 1.00
z-0.50z-0.65z 1.00
N 0.97N 0.72N-0.59N 1.00
N-0.10N 0.42N-0.05N-0.05N 1.00
```

Figure H-4c. Ashtech LINECOMP baseline reduction output file (Baseline 1001-4004)

```
N-0.31N 0.26N-0.05N-0.26N 0.67N 1.00
N 0.99N 0.76N-0.52N 0.98N-0.00N-0.24N 1.00
N 0.89N 0.57N-0.60N 0.93N-0.11N-0.32N 0.90N 1.00

del_station: 0.000000 0.000000 0.000000
     Station1: FIXED STATION              Station2: UNKNOWN STATION

                (00000)     (1001)                    (00000)     (4005)
 Latitude:  43.55907536  43 33 32.67131          43.43379217  43 26  1.65179

 E-Long  : 276.19226071 276 11 32.13854         276.05720515 276  3 25.93854

 W-Long  :  83.80773929  83 48 27.86146          83.94279485  83 56 34.06146

 E-Height: 150.7356                              149.5272

 Baseline vector:      -9839.2497    -10690.9086    -10098.3429

 Mark1_xyz  :    499359.2995  -4602470.6194   4372824.2683
 Az1 El1 D1 :       218.17042       -0.0834     17694.1485
 E1 N1 U1   :    -10912.4468    -13919.7486        -1.2084
 Mark2_xyz  :    489520.0498  -4613161.5280   4362725.9254
 Az2 El2 D2 :        38.07746       -0.0756     17694.1485
 E2 N2 U2   :     10935.0287     13919.4398         1.2084


AMBIGUITY RESOLUTION
                         1          2          3          4
Abs Contrast         0.008      0.000      0.000      0.000
Contrast                      100.000    100.000    100.000
Change Chi2         38.426   4588.301   4624.842   5296.077
Bias S18:11       22406590   22406591   22406589   22406590
Bias S18:19       21161232   21161232   21161232   21161232
Bias S18:27       10785453   10785453   10785453   10785454
Bias S18:28       28836461   28836462   28836460   28836461
Bias S18:29        5129537    5129537    5129537    5129537
NDF=136.7000 Chi2=42.1709


THE FIXED DOUBLE DIFFERENCE SOLUTION (L1)
Measure of geometry: 0.030142     Wavelength = 0.190294 (m/cycle)
num_meas =  1332        num_used =  1315        rms_resid = 0.005514(m)
Post-Fit Chisq =    77.434          NDF      =    12.176

Reference SV: 18                  Integer Search Ratio =  100.000
  SV     Ambiguity        FIT    Meas      SV     Ambiguity        FIT    Meas
  11      22406590.000X  0.031   213       19      21161232.000X  0.029   350
  27      10785453.000X  0.053    65       28      28836461.000X  0.025   349
  29       5129537.000X  0.024   338

  Sigmax (m):      0.002257
```

Figure H-4d. Ashtech LINECOMP baseline reduction output file (Baseline 1001-4004)

```
  Sigmay (m):       0.005658
  Sigmaz (m):       0.004546
  x      y      z
x 1.00
y 0.19y 1.00
z 0.12z-0.72z 1.00

del_station: 0.000016 0.000949 -0.000715
     Station1: FIXED STATION              Station2: UNKNOWN STATION

                (00000)     (1001)                    (00000)     (4005)
 Latitude:  43.55907536  43 33 32.67131          43.43379220  43 26  1.65191

 E-Long  : 276.19226071 276 11 32.13854         276.05720552 276  3 25.93986

 W-Long  :  83.80773929  83 48 27.86146          83.94279448  83 56 34.06014

 E-Height: 150.7356                              149.5220

 Baseline vector:      -9839.2208    -10690.8991    -10098.3438

 Mark1_xyz  :   499359.2995  -4602470.6194   4372824.2683
 Az1 El1 D1 :      218.17035       -0.0835     17694.1272
 E1 N1 U1   :   -10912.4172    -13919.7449       -1.2136
 Mark2_xyz  :   489520.0787  -4613161.5185   4362725.9246
 Az2 El2 D2 :       38.07739       -0.0756     17694.1272
 E2 N2 U2   :    10934.9990     13919.4360         1.2136
Fri Mar 26 10:39:26 1993
```

Figure H-4e. Ashtech LINECOMP baseline reduction output file (Baseline 1001-4004)

```
 PROGRAM SHOOTER
Input: FILLNET.IN                          Output: 083084aa.lop


STARTING STATION NAME: 1001
 LINE FROM          TO                    DX          DY          DZ         LENGTH
   1  1001          4008      0833C  -11172.423 -14312.145 -13760.192  22781.646
  17  4008          4009      0833B    -412.530   1492.440   1614.982   2237.348
  14  4007          4009      0833B    -313.662   -602.201   -613.237    914.926
  11  4006          4007      0833A    -864.616   -467.386   -388.225   1056.754
   9  4006          4004      0833A     628.445    613.864    569.761   1047.091
  24  4005          4004      0843A      60.920   -445.464   -475.513    654.417
  20  1001          4005      0843A   -9839.221 -10690.899 -10098.344  17694.127

      STATION          LATITUDE          LONGITUDE        ELEV.        GH
      1001          43 33 32.67152    83 48 27.85821    150.615     0.000
      4008          43 23 18.39708    83 57 49.93702    146.842     0.000
      4009          43 24 30.42613    83 58  1.19491    146.545     0.000
      4007          43 24 57.46166    83 57 44.51670    156.913     0.000
      4006          43 25 14.92267    83 57  4.10971    152.264     0.000
      4004          43 25 40.45135    83 56 33.44979    148.694     0.000
      4005          43 26  1.65131    83 56 34.05326    149.238     0.000
      1001          43 33 32.67072    83 48 27.85454    150.452     0.000

 TRAVERSE LENGTH =  46.386 kilometers
 MISCLOSURES (LAT., LON., ELEV., meters):   -0.025  -0.082  -0.163
                                          LOOP MISCLOSURE =    4.0 ppm
    Since geoid heights are not given, the
    computed elevations may be seriously in error.


STARTING STATION NAME: 1002
 LINE FROM          TO                    DX          DY          DZ         LENGTH
  23  1002          4005      0843A    7853.486 -20463.167 -22275.296  31250.716
  10  4006          4005      0833A     567.529   1059.329   1045.274   1592.754
  12  4006          4007      0833B    -864.618   -467.386   -388.229   1056.757
  16  4008          4007      0833B     -98.867   2094.641   2228.220   3059.781
  18  4009          4008      0833C     412.552  -1492.436  -1614.997   2237.360
  13  4006          4009      0833B   -1178.280  -1069.587  -1001.466   1880.238
   9  4006          4004      0833A     628.445    613.864    569.761   1047.091
  24  4005          4004      0843A      60.920   -445.464   -475.513    654.417
   8  4005          4007      0833A   -1432.144  -1526.716  -1433.499   2537.088
  14  4007          4009      0833B    -313.662   -602.201   -613.237    914.926
   5  1002          4009      0833C    6107.640 -22591.898 -24322.208  33753.028

      STATION          LATITUDE          LONGITUDE        ELEV.        GH
      1002          43 42 37.45123    84 00 46.44187    162.300     0.000
      4005          43 26  1.65174    83 56 34.06100    149.529     0.000
      4006          43 25 14.92309    83 57  4.11762    152.555     0.000
      4007          43 24 57.46199    83 57 44.52470    157.201     0.000
      4008          43 23 18.39740    83 57 49.94506    147.130     0.000
```

Figure H-5. Sample loop closure (Upper Saginaw River Project)

```
                                        FILLNET.IN
6378137.0   298.2572221  W    Y A 50 Y N N N N
Fillnet Input File  083084 FREE ADJ      43.5  83.9
      1001           43 33 32.67152  083 48 27.85821   150.615
    1    0
      4008           43 23 18.39709  083 57 49.93704   146.842
    2    0
      4009           43 24 30.42636  083 58  1.19634   146.561
    3    0
FFF   1002           43 42 37.45123  084  0 46.44187   162.300
    4    0
      4004           43 25 40.44276  083 56 33.45850   148.717
    5    0
      4005           43 26  1.64290  083 56 34.06171   149.245
    6    0
      4007           43 24 57.45316  083 57 44.52581   156.933
    7    0
      4006           43 25 14.91409  083 57  4.11839   152.287
    8    0
*
  24 3 510  510 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
    4 1001           4008      0833C  -11172.423 -14312.145 -13760.192  610201020
    1    2
    4 1001           4009      0833C  -11584.984 -12819.715 -12145.194  610201020
    1    3
    4 1002           1001      0833C   17692.643  -9772.176 -12177.017  610201020
    4    1
    4 1002           4008      0833C    6520.196 -24084.335 -25937.204  610201020
    4    2
    4 1002           4009      0833C    6107.640 -22591.898 -24322.208  610201020
    4    3
    4 4004           4005      0833A     -60.916    445.465    475.513
    5    6
    4 4004           4007      0833A   -1493.060  -1081.250   -957.986
    5    7
    4 4005           4007      0833A   -1432.144  -1526.716  -1433.499
    6    7
    4 4006           4004      0833A     628.445    613.864    569.761
    8    5
    4 4006           4005      0833A     567.529   1059.329   1045.274
    8    6
    4 4006           4007      0833A    -864.616   -467.386   -388.225
    8    7
    4 4006           4007      0833B    -864.618   -467.386   -388.229
    8    7
    4 4006           4009      0833B   -1178.280  -1069.587  -1001.466
    8    3
    4 4007           4009      0833B    -313.662   -602.201   -613.237
    7    3
    4 4008           4006      0833B     765.751   2562.026   2616.450
    2    8
    4 4008           4007      0833B     -98.867   2094.641   2228.220
    2    7
    4 4008           4009      0833B    -412.530   1492.440   1614.982
    2    3
    4 4009           4008      0833C     412.552  -1492.436  -1614.997
    3    2
    4 1001           4004      0843A   -9778.301 -11136.364 -10573,856
```

Figure H-6. Partial sample of input file for FILLNET Free Adjustment

```
 PROGRAM FILLNET, Version 3.0.00
 LICENSED TO: ASHTECH INC.


 Fillnet Input File  083084 CONSTRAINED      43.5    83.9

 a =  6378137.000    1/f =  298.2572221   W      Longitude positive WE
ST

 PRELIMINARY COORDINATES:
                        LAT.              LON.         ELEV.    G.H.  CON
STR.

   1  FF     1001 43 33 32.66675   83 48 27.86095    150.615   0.000
   2         4008 43 23 18.39709   83 57 49.93704    146.842   0.000
   3         4009 43 24 30.42636   83 58  1.19634    146.561   0.000
   4  FFF    1002 43 42 37.45123   84  0 46.44187    162.300   0.000
   5         4004 43 25 40.44276   83 56 33.45850    148.717   0.000
   6         4005 43 26  1.64290   83 56 34.06171    149.245   0.000
   7         4007 43 24 57.45316   83 57 44.52581    156.933   0.000
   8         4006 43 25 14.91409   83 57  4.11839    152.287   0.000

 GROUP 1, NO. OF VECTORS AND BIAS CONSTRAINTS:

  24       0.000  0.001    0.000  0.001    0.000  0.000    0.000  0.000

 VECTORS:
                     DX          DY          DZ       LENGTH   ERROR CODES

 1001    4008  -11172.423 -14312.145 -13760.192  22781.646  6102.0 102.
0  4
 1001    4009  -11584.984 -12819.715 -12145.194  21120.196  6102.0 102.
0  4
 1002    1001   17692.643  -9772.176 -12177.017  23596.711  6102.0 102.
0  4
 1002    4008    6520.196 -24084.335 -25937.204  35990.370  6102.0 102.
0  4
 1002    4009    6107.640 -22591.898 -24322.208  33753.028  6102.0 102.
0  4
 4004    4005     -60.916    445.465    475.513    654.418  3 51.0  51.
0  4
 4004    4007   -1493.060  -1081.250   -957.986   2077.515  3 51.0  51.
0  4
 4005    4007   -1432.144  -1526.716  -1433.499   2537.088  3 51.0  51.
0  4
 4006    4004     628.445    613.864    569.761   1047.091  3 51.0  51.
0  4
 4006    4005     567.529   1059.329   1045.274   1592.754  3 51.0  51.
0  4
 4006    4007    -864.616   -467.386   -388.225   1056.754  3 51.0  51.
0  4
```

Figure H-7a. Results of Constrained Adjustment (Upper Saginaw River Project)

```
 4006    4007     -864.618    -467.386    -388.229    1056.757  3 51.0   51.
0  4
 4006    4009    -1178.280   -1069.587   -1001.466    1880.238  3 51.0   51.
0  4
 4007    4009     -313.662    -602.201    -613.237     914.926  3 51.0   51.
0  4
 4008    4006      765.751    2562.026    2616.450    3741.145  3 51.0   51.
0  4
 4008    4007      -98.867    2094.641    2228.220    3059.781  3 51.0   51.
0  4
 4008    4009     -412.530    1492.440    1614.982    2237.348  3 51.0   51.
0  4
 4009    4008      412.552   -1492.436   -1614.997    2237.360  3 51.0   51.
0  4
 1001    4004    -9778.301  -11136.364  -10573.856   18205.499  3 51.0   51.
0  4
 1001    4005    -9839.221  -10690.899  -10098.344   17694.127  3 51.0   51.
0  4
 1002    1001    17692.725   -9772.257  -12176.953   23596.773  3 51.0   51.
0  4
 1002    4004     7914.403  -20908.632  -22750.807   31896.832  3 51.0   51.
0  4
 1002    4005     7853.486  -20463.167  -22275.296   31250.716  3 51.0   51.
0  4
 4005    4004       60.920    -445.464    -475.513     654.417  3 51.0   51.
0  4

  SHIFTS:
    1   0.000   0.000   0.102
    2  -0.190  -0.260   0.238
    3  -0.181  -0.230   0.226
    4   0.000   0.000   0.000
    5   0.097  -0.045   0.222
    6   0.095  -0.047   0.238
    7   0.091  -0.049   0.223
    8   0.095  -0.051   0.222

 ADJUSTED VECTORS, GROUP 1:
                              DX,DY,DZ    V        DN,DE,DU    v       v'

 1001    4008      0833C   -11172.608 -0.063  -18960.149   0.017   0.3
                           -14312.293 -0.093  -12630.231  -0.073  -1.1
                           -13760.130  0.105     -10.059   0.135   2.0

 1001    4009      0833C   -11585.141 -0.039  -16736.980   0.014   0.2
                           -12819.845 -0.085  -12881.834  -0.048  -0.8
                           -12145.133  0.095      -6.620   0.124   2.0

 1002    1001      0833C    17692.745  0.058  -16815.857  -0.014  -0.2
                            -9772.339 -0.070   16554.120   0.051   0.7
                           -12177.068  0.052      30.106   0.090   1.3
```

Figure H-7b. Results of Constrained Adjustment (Upper Saginaw River Project)

1002	4008	0833C	6520.137	0.019	-35776.006	0.007	0.1
			-24084.632	-0.149	3923.889	0.003	0.0
			-25937.198	0.152	20.048	0.214	2.1
1002	4009	0833C	6107.605	0.038	-33552.837	0.000	0.0
			-22592.184	-0.148	3672.286	0.022	0.2
			-24322.201	0.144	23.486	0.208	2.2
4004	4005	0833A	-60.916	-0.001	654.286	-0.000	-0.0
			445.467	-0.000	-13.234	-0.001	-0.2
			475.516	0.000	1.327	0.000	0.0
4004	4007	0833A	-1493.074	-0.001	-1325.757	-0.001	-0.2
			-1081.252	0.001	-1599.518	-0.001	-0.2
			-957.990	-0.002	5.347	-0.002	-0.3
4005	4007	0833A	-1432.158	0.000	-1980.043	-0.000	-0.0
			-1526.719	0.002	-1586.285	0.000	0.0
			-1433.505	-0.002	4.020	-0.003	-0.4
4006	4004	0833A	628.451	-0.000	787.486	-0.000	-0.1
			613.865	-0.001	690.124	-0.000	-0.1
			569.763	0.000	-2.121	0.001	0.1
4006	4005	0833A	567.535	-0.002	1441.772	-0.000	-0.1
			1059.333	-0.001	676.890	-0.002	-0.3
			1045.278	0.000	-0.794	0.001	0.1
4006	4007	0833A	-864.623	-0.001	-538.271	-0.001	-0.3
			-467.387	0.000	-909.394	-0.001	-0.1
			-388.227	-0.002	3.227	-0.002	-0.2
4006	4007	0833B	-864.623	0.001	-538.271	0.001	0.3
			-467.387	0.000	-909.394	0.001	0.2
			-388.227	0.002	3.227	0.001	0.2
4006	4009	0833B	-1178.293	-0.003	-1372.338	0.002	0.3
			-1069.590	0.001	-1285.281	-0.002	-0.3
			-1001.467	0.001	-8.729	0.000	0.0
4007	4009	0833B	-313.670	-0.004	-834.066	0.000	0.1
			-602.203	0.001	-375.887	-0.004	-0.5
			-613.240	-0.000	-11.955	-0.001	-0.1
4008	4006	0833B	765.761	-0.006	3595.507	0.001	0.2
			2562.037	-0.001	1033.678	-0.006	-0.7
			2616.464	0.002	12.167	0.002	0.2
4008	4007	0833B	-98.862	-0.004	3057.236	0.003	0.4
			2094.651	-0.002	124.284	-0.005	-0.6

Figure H-7c. Results of Constrained Adjustment (Upper Saginaw River Project)

```
                          2228.237  0.005      15.393  0.005   0.6

4008   4009     0833B     -412.532 -0.007    2223.169  0.004   0.7
                 1492.448 -0.002    -251.603 -0.007  -1.0
                 1614.997  0.006       3.438  0.004   0.6

4009   4008     0833C      412.532 -0.015   -2223.169  0.006   1.2
                -1492.448 -0.002     251.603 -0.015  -1.9
                -1614.997  0.009      -3.438  0.007   0.9

1001   4004     0843A    -9778.397  0.005  -14577.156 -0.004  -0.1
                -11136.390  0.014  -10906.429  0.006   0.2
                -10573.904 -0.017      -0.012 -0.022  -0.8

1001   4005     0843A    -9839.312  0.007  -13922.870 -0.003  -0.1
                -10690.923  0.013  -10919.663  0.009   0.3
                -10098.389 -0.016       1.314 -0.020  -0.8

1002   1001     0843A    17692.745 -0.024  -16815.857  0.001   0.0
                 -9772.339  0.011   16554.120 -0.022  -0.7
                -12177.068 -0.012      30.106 -0.019  -0.5

1002   4004     0843A     7914.349  0.002  -31393.013  0.001   0.0
                -20908.729  0.036    5647.691  0.006   0.1
                -22750.972 -0.032      30.094 -0.048  -1.0

1002   4005     0843A     7853.433  0.002  -30738.727  0.003   0.1
                -20463.262  0.036    5634.457  0.005   0.1
                -22275.456 -0.030      31.421 -0.046  -1.0

4005   4004     0843A       60.916 -0.003    -654.286 -0.000  -0.1
                 -445.467 -0.001      13.234 -0.003  -0.4
                 -475.516 -0.000      -1.327  0.000   0.0

S.E. OF UNIT WEIGHT =     0.843

NUMBER OF -
  OBS. EQUATIONS            74
  UNKNOWNS                  23
  DEGREES OF FREEDOM        51
  ITERATIONS                 0


GROUP  1 ROT. ANGLES (sec.) AND SCALE DIFF. (ppm):

HOR. SYSTEM          0.000   0.000   0.657   5.277
STD. ERRORS          0.001   0.001   0.166   0.804
XYZ SYSTEM           0.051  -0.473   0.452

ADJUSTED POSITIONS:
```

Figure H-7d. Results of Constrained Adjustment (Upper Saginaw River Project)

		LAT.	LON.	ELEV.	STD. ERRORS (m)		
1	1001	43 33 32.66675	83 48 27.86095	150.717	0.000	0.000	0.019
2	4008	43 23 18.39093	83 57 49.94860	147.080	0.024	0.024	0.019
3	4009	43 24 30.42050	83 58 1.20657	146.787	0.022	0.023	0.019
4	1002	43 42 37.45123	84 0 46.44187	162.300	0.000	0.000	0.000
5	4004	43 25 40.44591	83 56 33.46051	148.939	0.020	0.020	0.019
6	4005	43 26 1.64599	83 56 34.06378	149.483	0.020	0.020	0.019
7	4007	43 24 57.45612	83 57 44.52799	157.156	0.022	0.022	0.019
8	4006	43 25 14.91718	83 57 4.12068	152.509	0.021	0.021	0.019

ACCURACIES (m):

		D. LAT.	D. LON.	VERT.
1001	4008	0.024	0.024	0.014
1001	4009	0.022	0.023	0.014
1002	1001	0.000	0.000	0.019
1002	4008	0.024	0.024	0.019
1002	4009	0.022	0.023	0.019
4004	4005	0.002	0.004	0.004
4004	4007	0.003	0.004	0.004
4005	4007	0.003	0.004	0.004
4006	4004	0.003	0.004	0.004
4006	4005	0.003	0.004	0.004
4006	4007	0.002	0.003	0.003
4006	4007	0.002	0.003	0.003
4006	4009	0.003	0.004	0.004
4007	4009	0.003	0.004	0.004
4008	4006	0.004	0.005	0.004
4008	4007	0.004	0.005	0.004
4008	4009	0.003	0.004	0.004
4009	4008	0.003	0.004	0.004
1001	4004	0.020	0.020	0.014
1001	4005	0.020	0.020	0.014
1002	1001	0.000	0.000	0.019
1002	4004	0.020	0.020	0.019
1002	4005	0.020	0.020	0.019
4005	4004	0.002	0.004	0.004

****
**** ****

Figure H-7e. Results of Constrained Adjustment (Upper Saginaw River Project)

**** ESTIMATES OF PRECISION ****

**** Based on the VECTOR ACCURACIES produced by FILLNET ****

**** This is a reasonable estimate of the accuracies of the vectors in the network at 1 SIGMA. ****

VECTOR		LENGTH	PPM(h)	RATIO(h)	PPM(v)	RATIO(v)
1001	4008	22781.793	1.5	1: 671215	0.6	1: 1627271
1001	4009	21120.326	1.5	1: 663584	0.7	1: 1508595
1002	1001	23596.882	0.0	1: 0	0.8	1: 1241941
1002	4008	35990.553	0.9	1: 1060382	0.5	1: 1894240
1002	4009	33753.209	0.9	1: 1060499	0.6	1: 1776485
4004	4005	654.421	6.8	1: 146333	6.1	1: 163605
4004	4007	2077.527	2.4	1: 415504	1.9	1: 519382
4005	4007	2537.102	2.0	1: 507420	1.6	1: 634275
4006	4004	1047.096	4.8	1: 209419	3.8	1: 261774
4006	4005	1592.761	3.1	1: 318552	2.5	1: 398190
4006	4007	1056.761	3.4	1: 293091	2.8	1: 352254
4006	4007	1056.761	3.4	1: 293091	2.8	1: 352254
4006	4009	1880.249	2.7	1: 376046	2.1	1: 470062
4007	4009	914.932	5.5	1: 182971	4.4	1: 228733
4008	4006	3741.164	1.7	1: 584269	1.1	1: 935291
4008	4007	3059.800	2.1	1: 477854	1.3	1: 764950
4008	4009	2237.364	2.2	1: 447472	1.8	1: 559341
4009	4008	2237.364	2.2	1: 447472	1.8	1: 559341
1001	4004	18205.594	1.6	1: 643665	0.8	1: 1300400
1001	4005	17694.218	1.6	1: 625585	0.8	1: 1263873
1002	1001	23596.882	0.0	1: 0	0.8	1: 1241941
1002	4004	31897.000	0.9	1: 1127729	0.6	1: 1678789
1002	4005	31250.879	0.9	1: 1104885	0.6	1: 1644783
4005	4004	654.421	6.8	1: 146333	6.1	1: 163605

Figure H-7f. Results of Constrained Adjustment (Upper Saginaw River Project)

```
                                        083084C.SPC
;Software: CORPSCON v3.01, Agency: CORPS OF ENGINEERS SAGINAW
;Project: UPPER SAGINAW MAPPING,
;Original Coordinates on NAD 83 Geographic Coordinates
;Translated Coordinates on NAD 83 State Plane Zone 2113,U.S. FOOT

1001 JONAS          ,13271491.47735,  750899.10875
4008 WICKS          ,13230401.67183,  688469.29439
4009 RUST           ,13229535.79827,  695757.90291
1002 PARRISH        ,13216876.80162,  805765.50958
4004 HOYT           ,13235976.88650,  702879.28348
4005 GENESSEE       ,13235921.56530,  705025.46304
4007 EWALD          ,13230753.74995,  698500.99009
4006 HOLLAND        ,13233727.24329,  700283.34945
```

Figure H-8. CORPSCON file of translated coordinates to NAD 83

Figure H-9. Final station description of point RUST (typical)