Integrating GPS into a Cadastral GIS

Mark Goetz, GISP

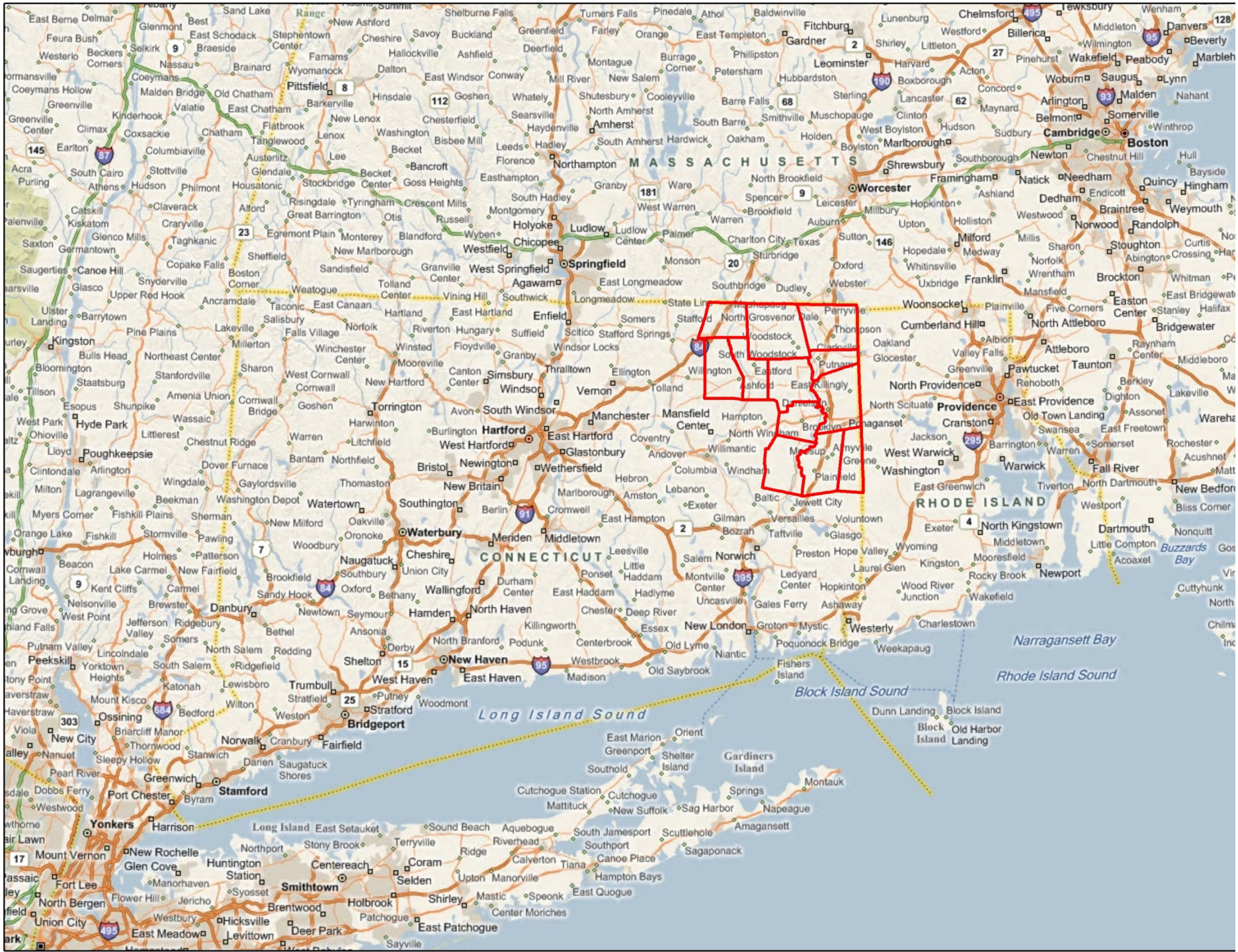
Northeastern Connecticut Council of Governments

Bio

- GIS Director – Northeastern Connecticut Council of Governments (NECCOG)
- Chairman – State of Connecticut Geospatial Information Systems Council Data Inventory and Assessment Working Group Cadastral Data Subcommittee (CTGISC – DIAWG – CDS)
- Geographic Information Systems Professional (GISP)
- 12 Years GIS Experience – Municipal / Consulting
- GIS/GPS/CAD/Database – Data Centric

Project Background

- NECCOG – Northeastern Connecticut Council of Governments
- Rural. 12 towns ~500 square miles ~80K pop
- NECCOG GIS Program – Grant Funded
- Create/Update parcel mapping with most town parcel mapping in poor shape
- Jurisdictional boundaries inaccurate
- GPS - Trimble GeoXH 2008 and Zephyr Antenna


MASSACHUSETTS
CONNECTICUT
RHODE ISLAND
Long Island Sound
Block Island Sound
Narragansett Bay
Rhode Island Sound
Springfield
Worcester
Boston
Hartford
New Haven
Bridgeport
Providence
Stamford
Waterbury
Yonkers
New London
Northampton
Pittsfield
Fall River
New Bedford
Newport
Westerly
Block Island
Gardiners Island
Montauk
Long Island
Smithtown

GIS Cadastral Data Subcommittee

- Website: http://www.ct.gov/gis/cwp/view.asp?a=3034&q=400016
- Ultimate Vision – Statewide Parcel Dataset
  - Economic Development, Resource Protection, Tax Assessment/Collection, Emergency Management…
- NECCOG a model for Statewide Cadastral Dataset
- Policy Issues:
  - $$$
  - Town/State Boundary Issues
  - 169 Towns, Multiple State Agencies, Minimal Federal Involvement
  - Parcel data not just to make assessor tax maps

GIS Cadastral Standard

- Latest Draft dated January 2011

  http://www.ct.gov/gis/lib/gis/CAD_Standard_v1_20110118_-_with_draft_watermark.doc
- Based on MassGIS Parcel Standard, National Cadastral Standard, IAAO Standards, and many other

  http://www.mass.gov/mgis/ParstndrdVer1_5_1.pdf

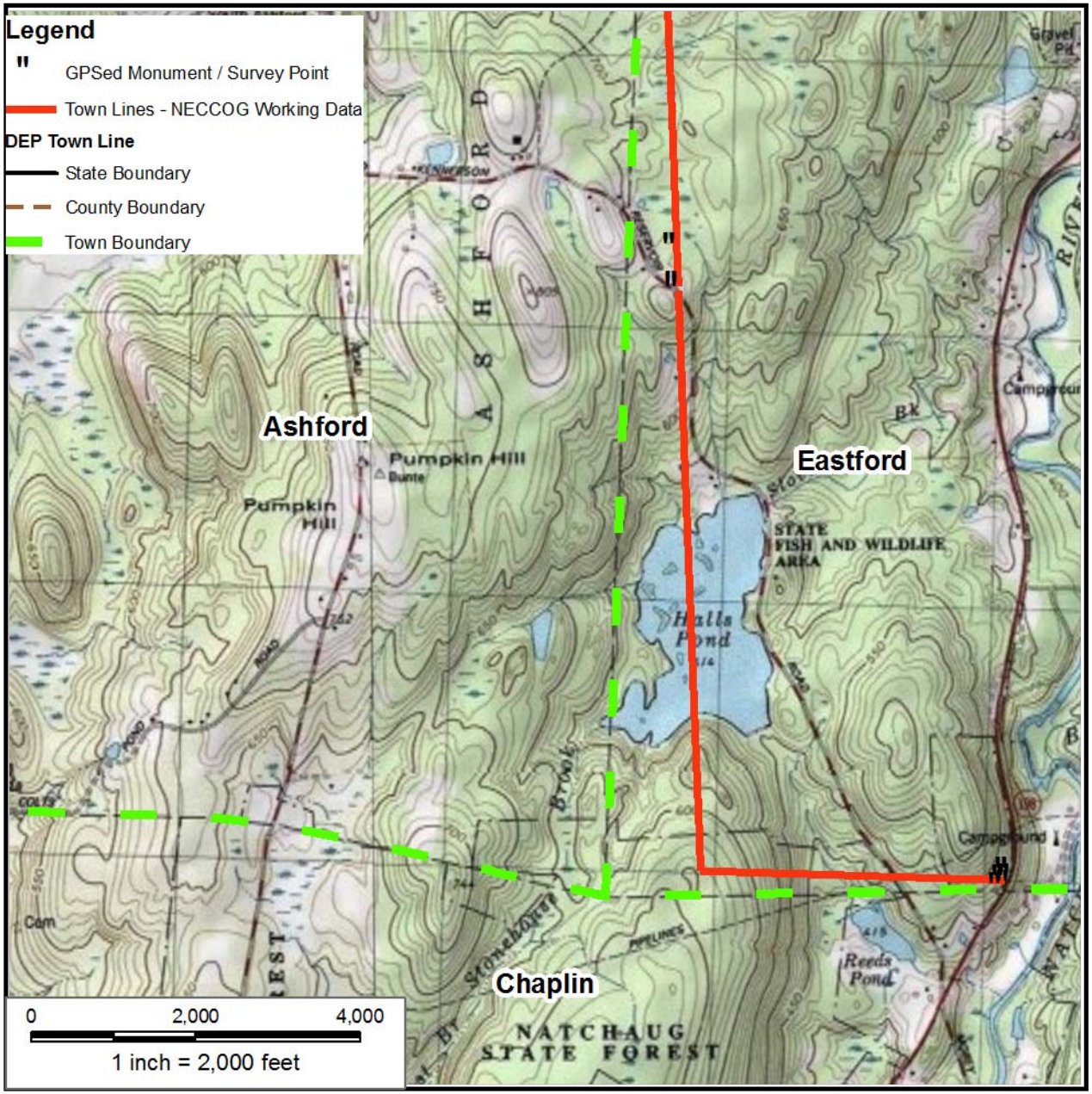
  http://www.nationalcad.org/data/documents/CADSTAND.v.1.4.pdf
- Production and Publication components
- Focused on Local data management
- Implementation guidelines being developed

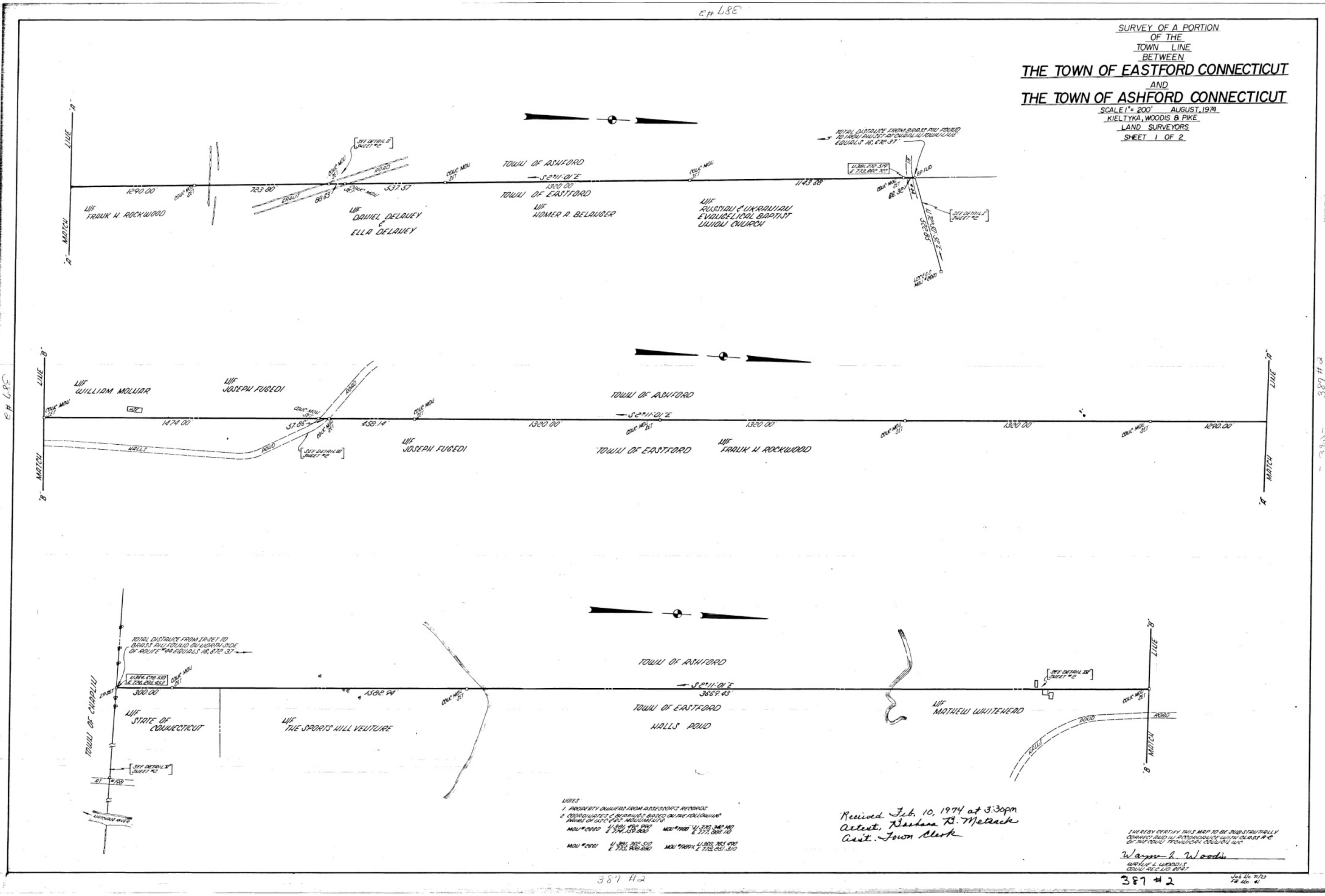
GIS Accuracy Requirements

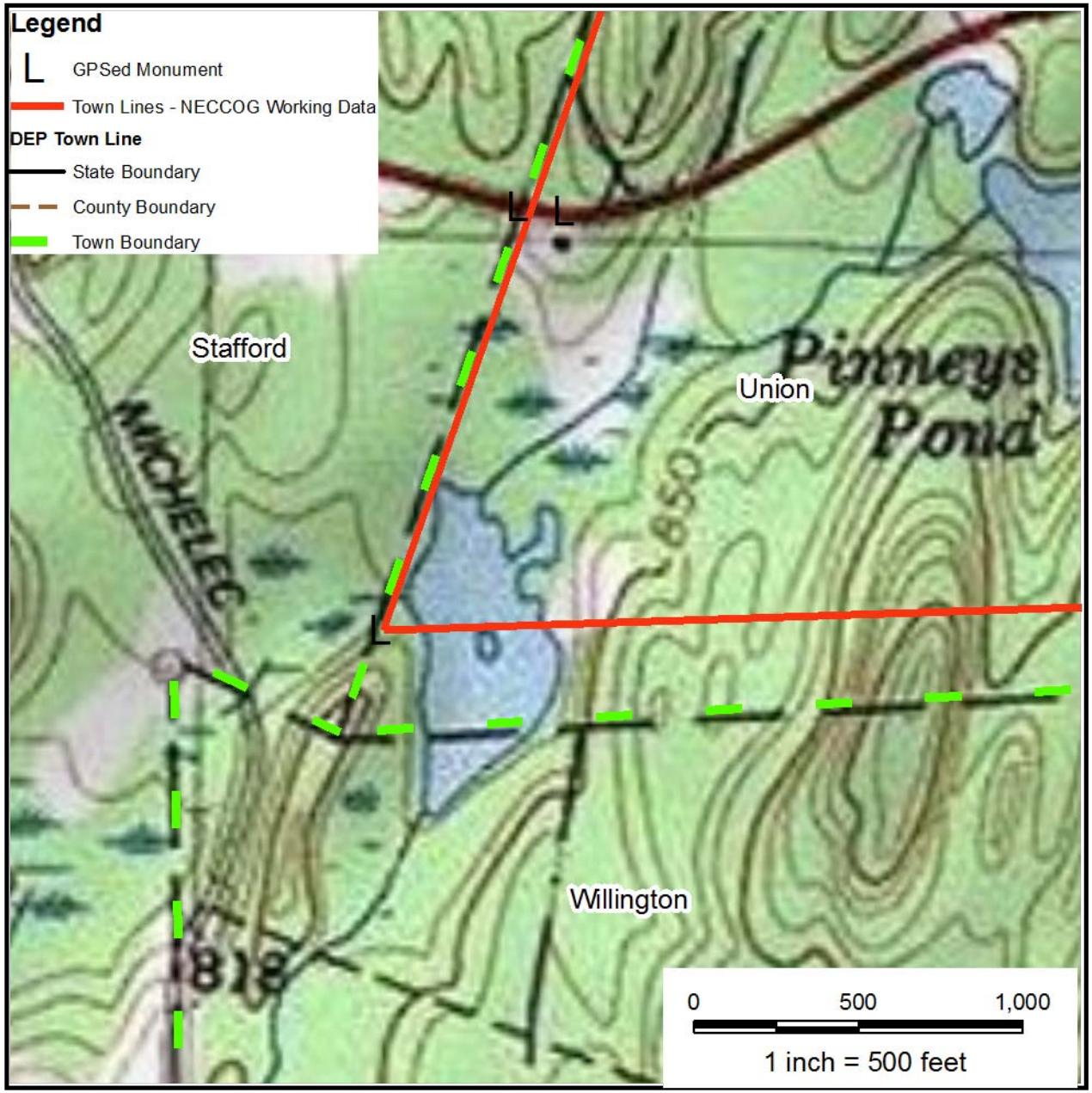
- Best source available – Best methods as appropriate
- Parcel boundaries via COGO if available
  - Surveys filed with town clerks
- CT DOT ROW & Railroad Valuation Maps
- 2004 State of Connecticut B&W Orthoimagery
  - **Map Scale and Accuracy -** The scale of the accuracy of imagery, data and products meets horizontal National Map Accuracy Standards (NMAS) for 200-scale mapping. The ground resolution for this imagery is 0.8 feet per image pixel.
  - **Use** - Basemap used in the identification and location of lines of occupation (stonewalls, fences, landscape changes, etc) that are used in the placement and rotation of unreferenced and/or uncoordinated surveys. Also used to "digitize" boundaries without COGO source based on lines of occupation.
- 2011 USGS/NGA/State of CT available 2012
- Not producing "survey" but using survey sources when available.

Why GPS?

- Personal experience
- Jurisdictional boundary issues
  - Existing parcel mapping overlap/gaps
  - No “authoritative” jurisdictional boundaries
  - Numerous varying sources
  - Most used from 1:24,000 USGS Topos (DLG’s)
- Extensive State ROW & RR Valuation mapping
  - Some tied to state plane coordinates
  - Rural - not much development along state roads


Legend
GPSed Monument / Survey Point
Town Lines - NECCOG Working Data
DEP Town Line
State Boundary
County Boundary
Town Boundary
Ashford
Eastford
Chaplin
Pumpkin Hill
Pumpkin Hill
STATE FISH AND WILDLIFE AREA
Halls Pond
Reeds Pond
NATCHAUG STATE FOREST
0
2,000
4,000
1 inch = 2,000 feet


SURVEY OF A PORTION
OF THE
TOWN LINE
BETWEEN
THE TOWN OF EASTFORD CONNECTICUT
AND
THE TOWN OF ASHFORD CONNECTICUT
SCALE 1"= 200' AUGUST, 1974
KIELTYKA, WOODIS & PIKE
LAND SURVEYORS
SHEET 1 OF 2
TOWN OF ASHFORD
S 2°11'01" E
TOWN OF EASTFORD
1290.00'
723.80'
537.57'
1320.00'
1143.88'
N/F FRANK H. ROCKWOOD
N/F DANIEL DELANEY & ELLA DELANEY
N/F HOMER A. BELANGER
N/F RUSSIAN & UKRAINIAN EVANGELICAL BAPTIST UNION CHURCH
N/F WILLIAM MOLNAR
N/F JOSEPH FUGEDI
1474.00'
N/F JOSEPH FUGEDI
N/F FRANK H. ROCKWOOD
N/F STATE OF CONNECTICUT
N/F THE SPORTS HILL VENTURE
300.00'
3669.43'
HALLS POND
N/F MATHEW WHITEHEAD
TOWN OF CHAPLIN
NOTES:
1. PROPERTY OWNERS FROM ASSESSOR'S RECORDS
2. COORDINATES & BEARINGS BASED ON THE FOLLOWING PAIRS OF U.S.C.&G.S. MONUMENTS
MON #2660 N 381,492.990 E 774,159.800
MON #1988 N 370,342.140 E 777,886.110
MON #2661 N 381,762.510 E 775,908.690
MON #1989X N 369,785.490 E 778,851.310
Received Feb. 10, 1974 at 3:30pm
Attest, Barbara B. Metsack
Ass't. Town Clerk
I HEREBY CERTIFY THIS MAP TO BE SUBSTANTIALLY CORRECT AND IN ACCORDANCE WITH CLASS A-2 OF THE CONN. TECHNICAL COUNCIL INC.
Wayne L. Woodis
WAYNE L. WOODIS
CONN. REG. NO. 6847
387 #2
Job No. 71/23
FB No. 41


Legend
GPSed Monument
Town Lines - NECCOG Working Data
DEP Town Line
State Boundary
County Boundary
Town Boundary
Stafford
Union
Pinneys Pond
MICHELEC
850
818
Willington
0
500
1,000
1 inch = 500 feet


WILLINGTON
04.24.2009 11:20

NECCOG GPS GIS Data

- Town Boundary Monuments
  - Material
  - Height
  - Condition
  - Photos
- CT DOT ROW Monuments
- Anything else while looking for above

NECCOG GPS Software

- ESRI GIS data centric approach
- Trimble GPS Analyst – ESRI ArcGIS extension
- GPSCorrect with ESRI ArcPad
- Workflow
  - Single GPS enabled geodatabase to manage
  - Export data to ArcPad
  - Forms created from data structure – pick lists, etc.
  - Field data collection
  - Import data from ArcPad – options to review GPS features
  - Post processing
  - Copy/Paste to Enterprise GIS dataset

Trimble GeoXH 2008

- Trimble Handheld
  - All in one, Windows Mobile, Bluetooth, WiFi
  - GPS/SBAS with L1/L2 internal antenna
  - Ability to connect to external antenna – **Zephyr**
- H-Star Technology
  - Multipath rejection
  - Consistent sub-foot post-processed accuracies in ideal conditions
- WiFi enabled Camera – link photos to features

GeoXH Accuracy Statements

Current Equivalent - GeoXH 3000:
http://trl.trimble.com/docushare/dsweb/Get/Document-414893/022501-162G_GeoXH%203000%20Series_DS_0211_MGIS_lr.pdf

GeoXH 2008

Accuracy (HRMS)[7] after differential correction

Real-time positioning
- H-Star[8] with internal antenna (within a VRS network, or <80 km). . . .Subfoot (30 cm)
- H-Star[8] with optional Zephyr antenna
  - Short baseline (within a VRS network, or <30 km). . . . . 10 cm
  - Long baseline (30–80 km). . . . . .Subfoot (30 cm)
- Code corrections (SBAS[1] or external correction source) . . . . . Submeter

Postprocessed positioning
- H-Star[8] with internal antenna (<80 km, or 3 bases within 200 km) . . .Subfoot (30 cm)
- H-Star[8] with optional Zephyr antenna
  - Short baseline (<30 km) . . . . . 10 cm
  - Long baseline (30–80 km, or 3 bases within 200 km). . . . . 20 cm
- Code postprocessed . . . . . Submeter

1 SBAS (Satellite Based Augmentation System). Includes WAAS available in North America only, EGNOS available in Europe only, and MSAS available in Japan only.
2 NMEA output of real-time H-Star corrected data is not supported.
3 Power/serial clip also required.
4 With backlight at default setting (50% brightness).
5 Power draw will vary depending on radio usage.
6 Bluetooth and wireless LAN type approvals are country specific. GeoExplorer 2008 series handhelds have Bluetooth and wireless LAN approval in the U.S. and in most European countries. For further information please consult your local reseller.
7 Horizontal Root Mean Squared accuracy, 1-sigma (63%). Requires data to be collected with minimum of 5 satellites, maximum PDOP of 6, minimum SNR of 39 dBHz, minimum elevation of 15 degrees, and reasonable multipath conditions. Ionospheric disturbances, multipath signals or obstruction of the sky by buildings or tree canopy may degrade precision by interfering with signal reception. Except when using VRS corrections, accuracy varies with proximity to base station by +1 ppm for postprocessing and real-time.
8 H-Star specified accuracy is typically achieved within 2 minutes. Requires data to be collected using Trimble field software.

GeoXH 3000

Accuracy (HRMS)[7] after differential correction

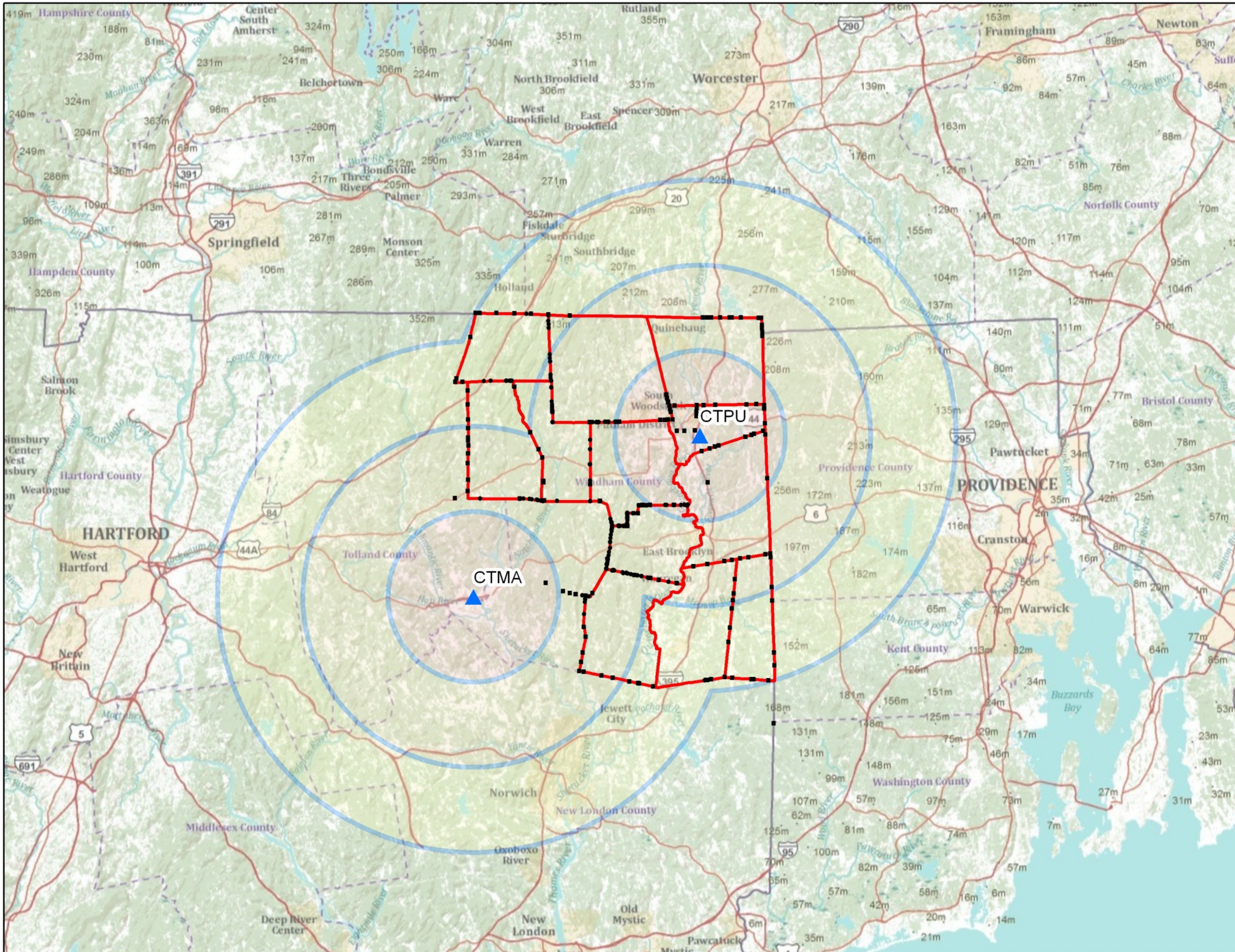
Real-time positioning
- H-Star[8] with internal antenna (within a VRS network, or <80 km). . Subfoot (<30 cm)
- H-Star[8] with optional Tornado antenna
  - Short baseline (within a VRS network, or <30 km). . . . . 10 cm
  - Long baseline (30–80 km). . . . . Subfoot (<30 cm)
- Code corrections (SBAS[1] or external correction source) . . . . . Submeter

Postprocessed positioning
- H-Star horizontal accuracy . . . . . 10 cm + 1 ppm[9]
- Carrier postprocessed accuracy with 45 minutes tracking satellites . . . 1 cm + 2 ppm[10]
- Code postprocessed . . . . . 50 cm

1 SBAS (Satellite Based Augmentation System). Includes WAAS available in North America only, EGNOS available in Europe only, and MSAS available in Japan only.
2 NMEA output of real-time H-Star corrected data is not supported.
3 Power/serial clip also required.
4 With backlight at default setting (50% brightness).
5 Power draw will vary depending on radio usage.
6 Bluetooth and wireless LAN type approvals are country specific. GeoExplorer 3000 series handhelds have Bluetooth and wireless LAN approval in the U.S. and in most European countries. For further information please consult your local reseller.
7 Horizontal Root Mean Squared accuracy, 1-sigma (68%). Except in conditions where most GPS signals are affected by trees, or buildings, or other objects. Except when using VRS corrections, accuracy varies with proximity to base station by +1 ppm for code postprocessing and real-time.
8 H-Star specified accuracy is typically achieved within 2 minutes. Requires data to be collected using Trimble field software.
9 The following factors increase the availability of decimeter (10 cm / 4 inch) accuracy after H-Star postprocessing: longer elapsed time tracking uninterrupted L1/L2 carrier phase data, use of the optional external Tornado antenna, tracking of more satellites with L2 measurements, shorter distance to the base station(s), and use of more (than one) base stations for postprocessing.
10 45 minute carrier capability applies only to the GPS Pathfinder Office software and is limited to 10 km from the base station.

Differential Corrections

- CT DOT CORS Stations
  - Putnam (CTPU) or Mansfield (CTMA)
  - 30 km at most to any point in NECCOG region
  - Use H-Star with single station in most locations
- CT DOT RTK/VRS network in the Future?
  - Future NECCOG project (utilities)
  - Local surveyors – plans with NAD83 Coordinates



CTPU
CTMA
Worcester
Springfield
HARTFORD
PROVIDENCE
Pawtucket
Cranston
Warwick
Framingham
Newton
Belchertown
Ware
North Brookfield
West Brookfield
East Brookfield
Spencer
Warren
Bondsville
Three Rivers
Palmer
Monson Center
Fiskdale
Sturbridge
Southbridge
Holland
Quinebaug
South Woodstock
Windham County
East Brooklyn
Tolland County
Jewett City
Norwich
New London County
New London
Old Mystic
Mystic
Pawcatuck
Deep River Center
Oxoboxo River
Middlesex County
Hartford County
Hampden County
Hampshire County
Norfolk County
Bristol County
Providence County
Kent County
Washington County
Salmon Brook
Simsbury Center
West Hartford
New Britain
Weatogue
Center South Amherst
Rutland
Buzzards Bay

Town Boundary Monument Effort

- Research town boundaries
  - Maps, Perambulation reports, Town history…
- Pre-process
  - Compile survey descriptions, Rotate and best fit, Load into GPS
- Field Capture
  - Navigate, Locate, Attributes and photos
- Post-process
  - Differential Corrections, Filter out “pile of stones”
- Copy monuments to enterprise Cadastral GIS dataset
  - Leave as-is if no other location source, move if survey source
  - Boundary features (parcels, town boundaries) to be “snapped” to town boundary monuments

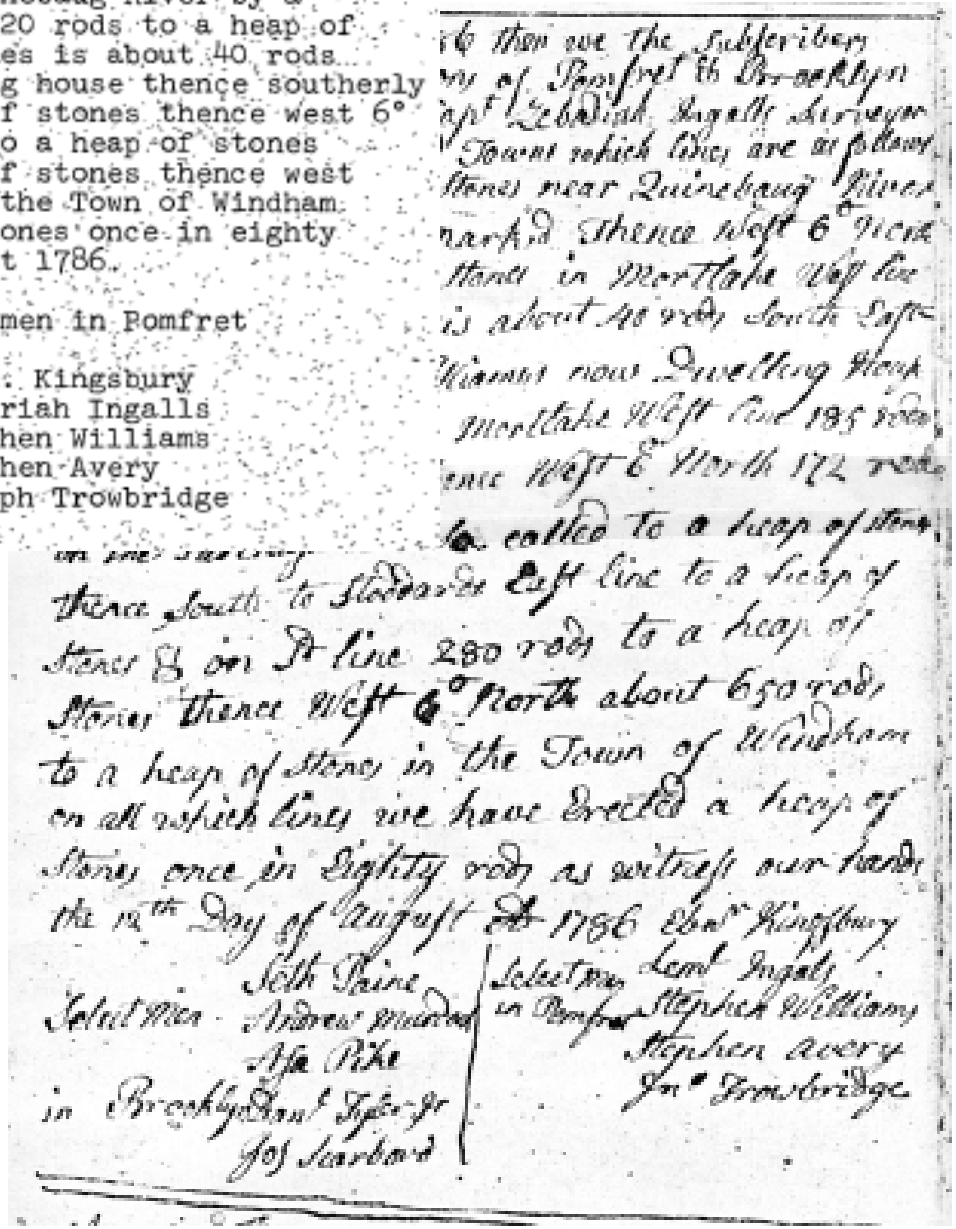
August 11th and 12th, 1786 then we the Subscribers Selectmen for the Town of Pomfret and Brooklyn with the assistance of Capt. Zebariah Ingalls surveyor for the lines between said Towns which lines are as follows, beginning at a heap of stones near Quinebaug River by a buttonwood tree marked, thence west 6° north 1120 rods to a heap of stones in Mortlake west line which heap of stones is about 40 rods south easterly from Joseph Williams now dwelling house thence southerly in said Mortlake west line 185 rods to a heap of stones thence west 6° north 172 rods on the Purchase line so called to a heap of stones thence south to Stoddards east line to a heap of stones thence west 6° north about 650 rods to a heap of stones in the Town of Windham on all which lines we have erected a heap of stones once in eighty rods as witness our hands the 12th day of August 1786.

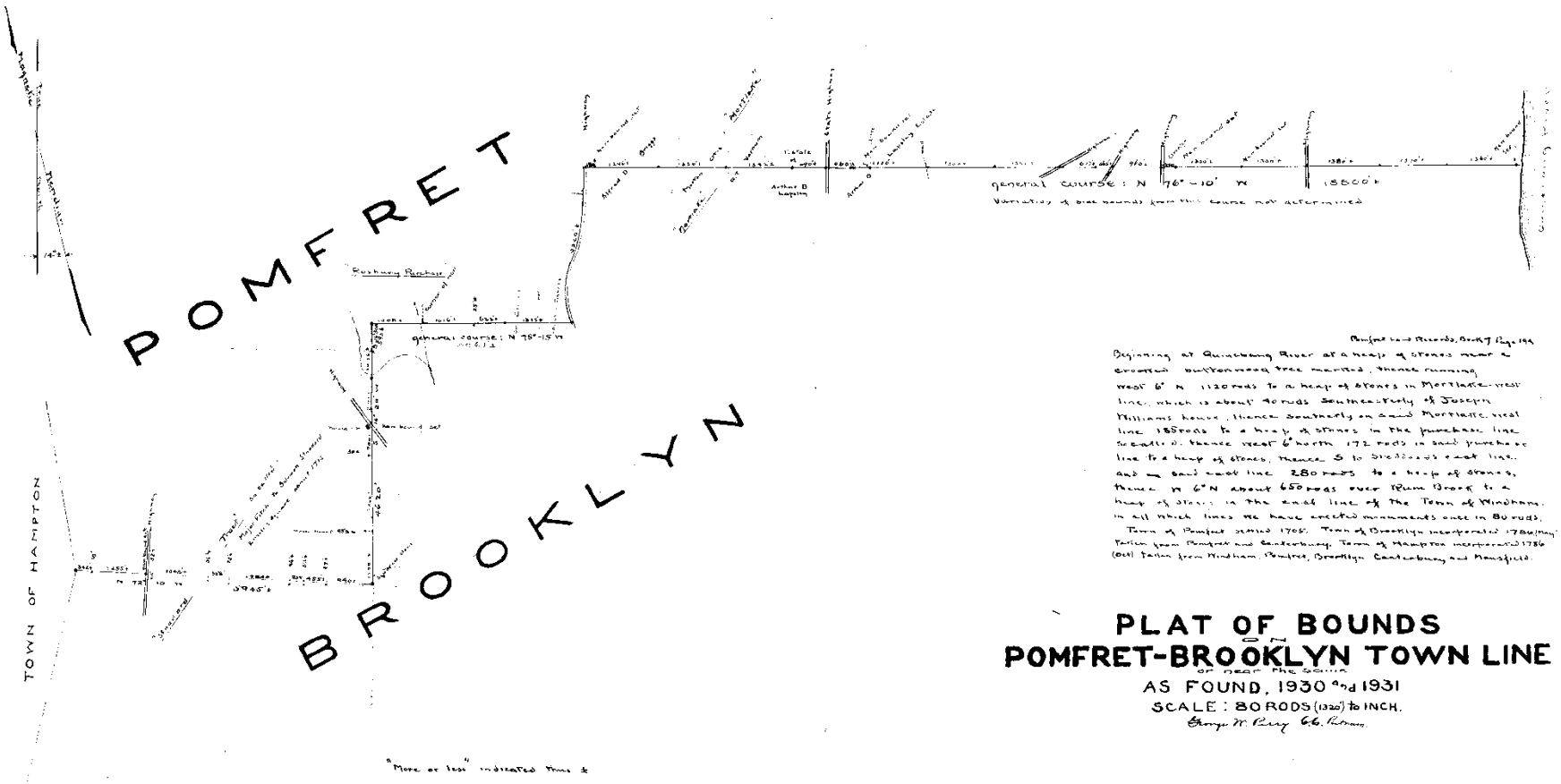
Selectmen in Brooklyn

Seth Paine
Andrew Murdock
Asa Pike
Daniel Tyler Jr.
Joseph Scarborough

Selectmen in Pomfret

Eben. Kingsbury
Zebariah Ingalls
Stephen Williams
Stephen Avery
Joseph Trowbridge





Pomfret Land Records, Book 7, Page 194

Beginning at Quinebaug River at a heap of stones near a crooked southern wood tree marked, thence running west 6° N 1120 rods to a heap of stones in Mortlake-west line, which is about 40 rods southeasterly of Joseph Williams house, thence southerly on said Mortlake-west line 188 rods to a heap of stones in the purchase line so called, thence west 6° north 172 rods in said purchase line to a heap of stones, thence S 10 Sixteenths east line, and on said east line 280 rods to a heap of stones, thence N 6° N about 650 rods over Plum Brook to a heap of stones in the east line of the Town of Windham, in all which lines we have erected monuments once in 80 rods.

Town of Pomfret settled 1705. Town of Brooklyn incorporated 1786 (May) Parties from Pomfret and Canterbury. Town of Hampton incorporated 1786 (Oct) Parties from Windham, Pomfret, Brooklyn, Canterbury and Hampfield.

PLAT OF BOUNDS ON POMFRET-BROOKLYN TOWN LINE or near the same

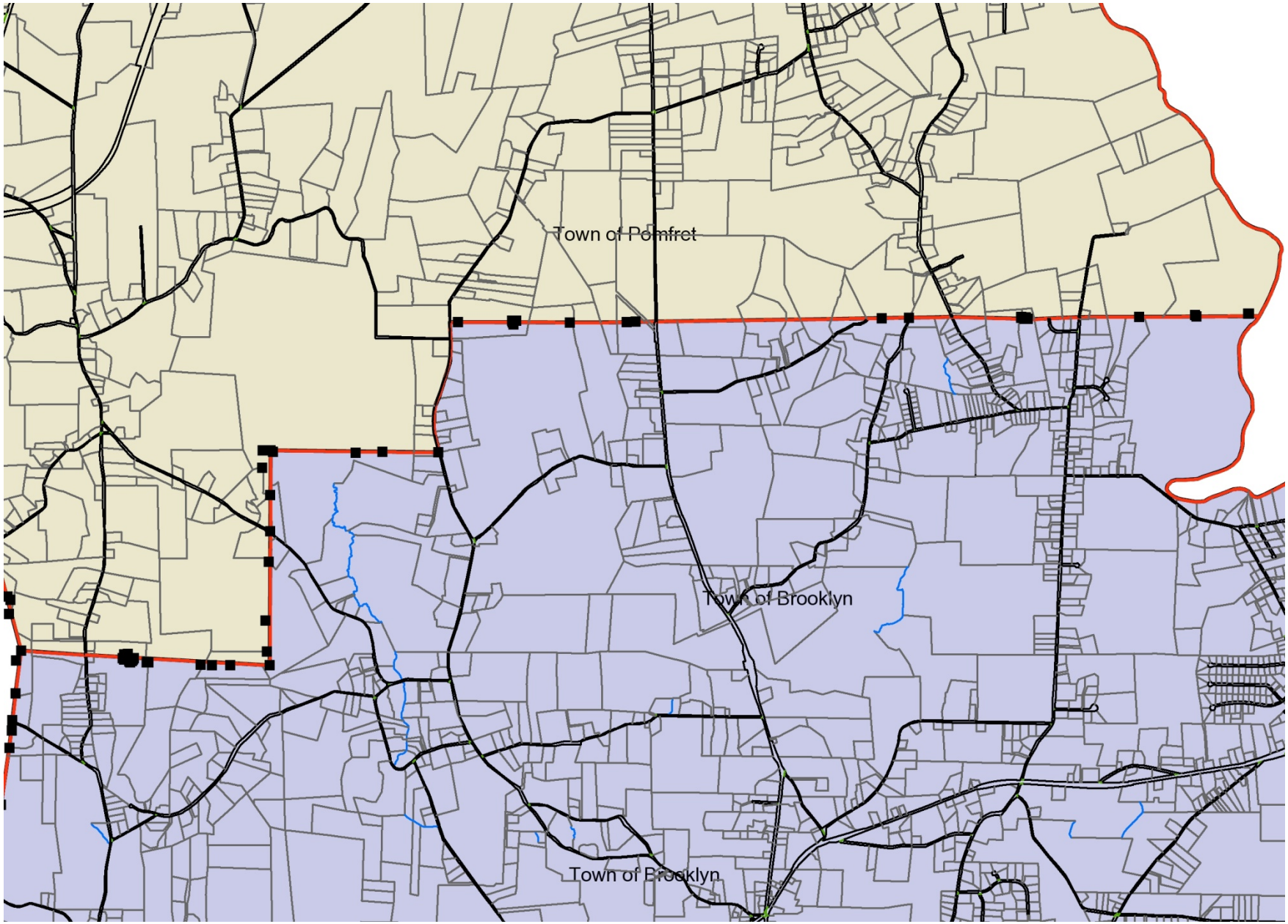
AS FOUND, 1930 and 1931

SCALE: 80 RODS (1320') to INCH.

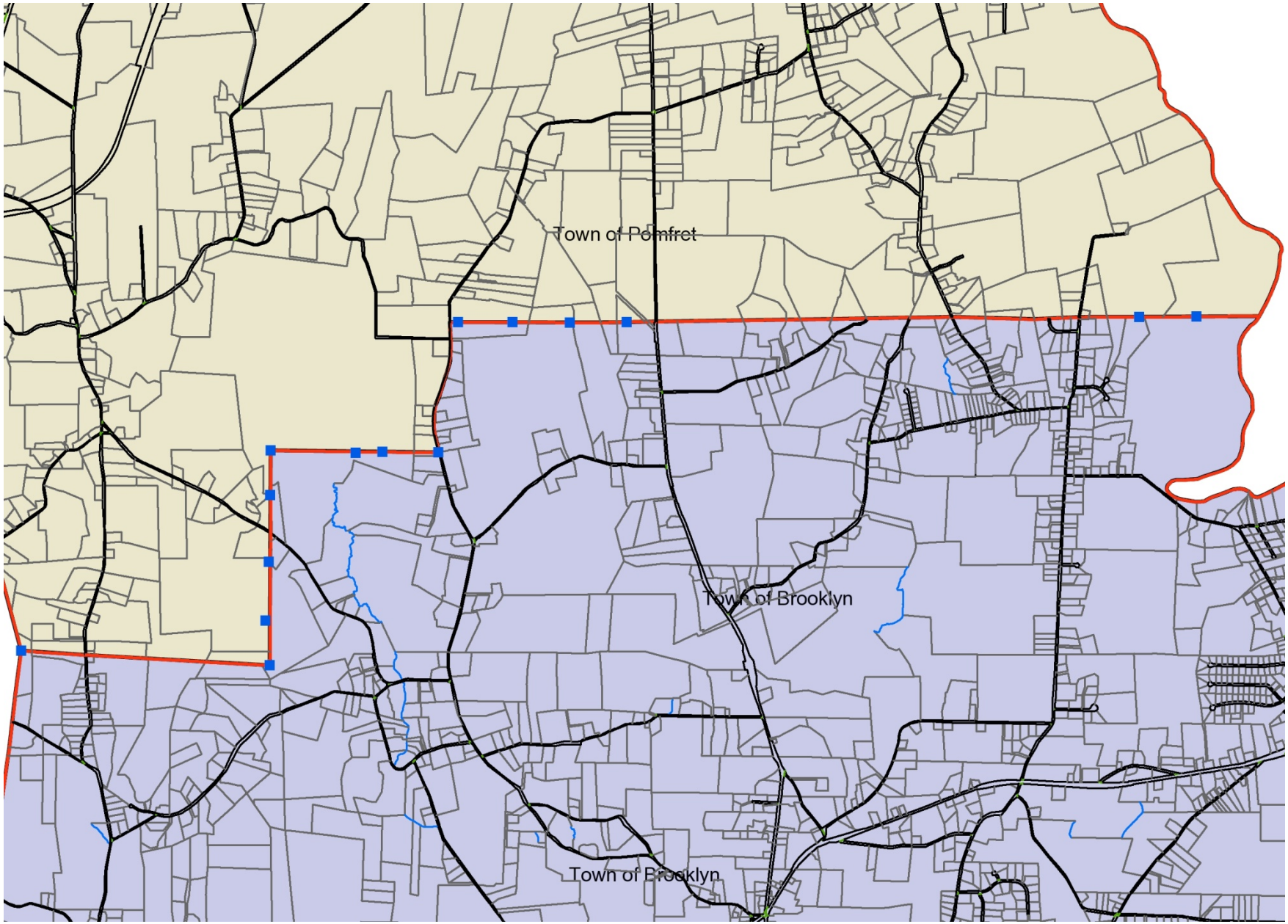
George M. Berry C.E. Draftsman


Trimble
Lufkin
25'
Trimble

Raw GPS Points

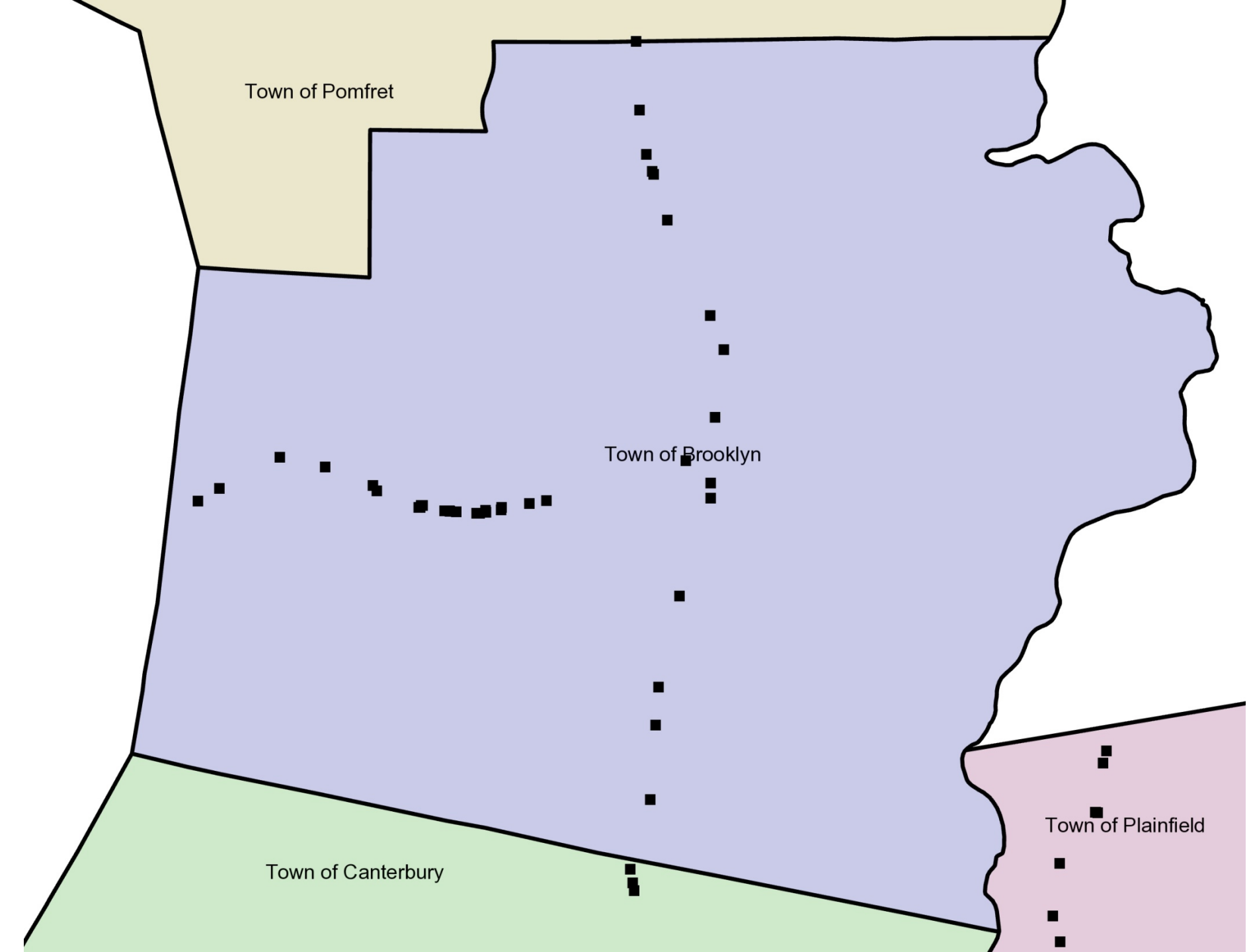


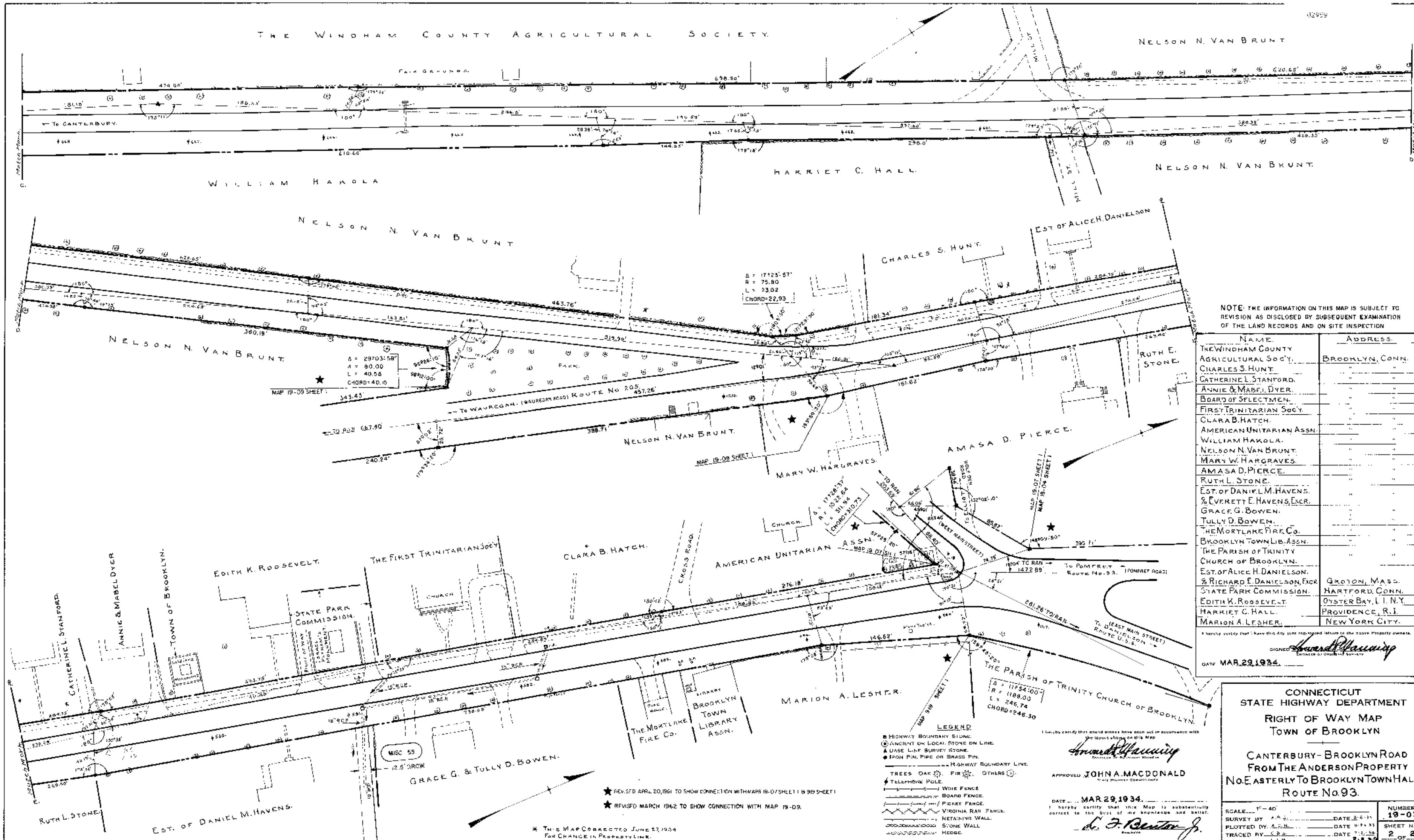
Filtered GPS Points



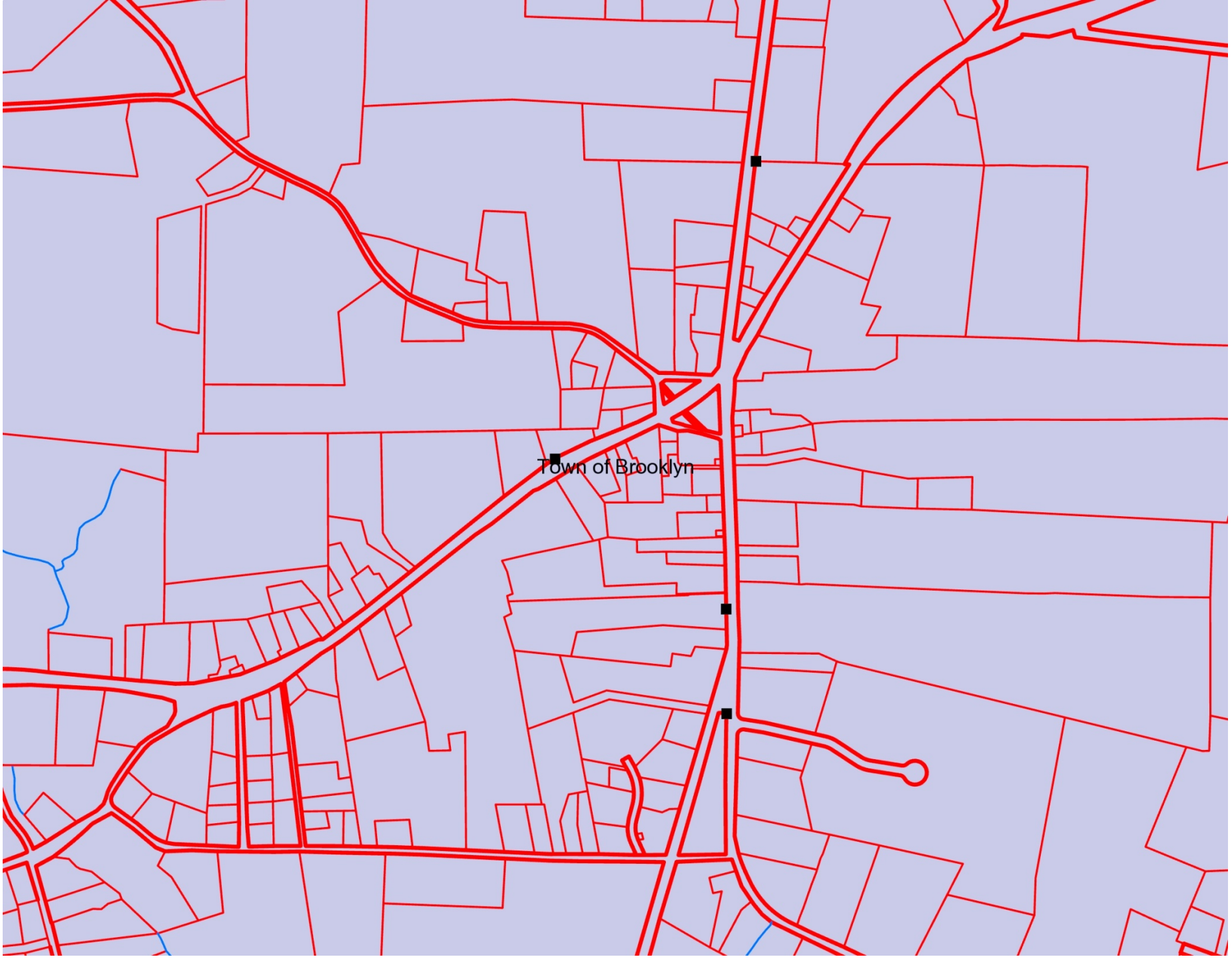
CT DOT ROW's

- Use CAD if exists
- Scanned ROW maps otherwise
  - Coordinated maps – COGO'ed with ROW XY coordinates
  - Non-coordinated - COGO'ed with GPS coordinate
- Same GPS process as town boundaries
- ROW lines "snapped" to selected GPS CHD locations


Town of Pomfret
Town of Brooklyn
Town of Canterbury
Town of Plainfield



THE WINDHAM COUNTY AGRICULTURAL SOCIETY
NELSON N. VAN BRUNT
WILLIAM HAKOLA
HARRIET C. HALL
To CANTERBURY
NELSON N. VAN BRUNT
EST. OF ALICE H. DANIELSON
CHARLES S. HUNT
RUTH E. STONE
AMASA D. PIERCE
MARY W. HARGRAVES
To WAUREGAN (WAUREGAN ROAD) ROUTE No. 205.
MAP 19-09 SHEET 1
NOTE: THE INFORMATION ON THIS MAP IS SUBJECT TO REVISION AS DISCLOSED BY SUBSEQUENT EXAMINATION OF THE LAND RECORDS AND ON SITE INSPECTION
NAME. | ADDRESS.
THE WINDHAM COUNTY AGRICULTURAL SOC'Y. | BROOKLYN, CONN.
CHARLES S. HUNT.
CATHERINE L. STANFORD.
ANNIE & MABEL DYER.
BOARD OF SELECTMEN.
FIRST TRINITARIAN SOC'Y.
CLARA B. HATCH.
AMERICAN UNITARIAN ASSN.
WILLIAM HAKOLA.
NELSON N. VAN BRUNT.
MARY W. HARGRAVES.
AMASA D. PIERCE.
RUTH L. STONE.
EST. OF DANIEL M. HAVENS. % EVERETT E. HAVENS, EXCR.
GRACE G. BOWEN.
TULLY D. BOWEN.
THE MORTLAKE FIRE CO.
BROOKLYN TOWN LIB. ASSN.
THE PARISH OF TRINITY CHURCH OF BROOKLYN.
EST. OF ALICE H. DANIELSON, % RICHARD E. DANIELSON, EXCR. | GROTON, MASS.
STATE PARK COMMISSION. | HARTFORD, CONN.
EDITH K. ROOSEVELT. | OYSTER BAY, L. I. N.Y.
HARRIET C. HALL. | PROVIDENCE, R.I.
MARION A. LESHER. | NEW YORK CITY.
DATE MAR. 29, 1934.
EDITH K. ROOSEVELT
THE FIRST TRINITARIAN SOC'Y
CLARA B. HATCH
AMERICAN UNITARIAN ASSN.
CHURCH
STATE PARK COMMISSION
CATHERINE L. STANFORD
ANNIE & MABEL DYER
TOWN OF BROOKLYN
CROSS ROAD
To POMFRET ROUTE No. 93. (POMFRET ROAD)
(EAST MAIN STREET) To DANIELSON ROUTE U.S. 6
(WEST MAIN STREET)
THE PARISH OF TRINITY CHURCH OF BROOKLYN.
MARION A. LESHER
THE MORTLAKE FIRE CO.
BROOKLYN TOWN LIBRARY ASSN.
GRACE G. & TULLY D. BOWEN.
RUTH L. STONE
EST. OF DANIEL M. HAVENS.
MISC 55
★ REVISED APRIL 20, 1961 TO SHOW CONNECTION WITH MAPS 19-07 SHEET 1 & 919 SHEET 1
★ REVISED MARCH 1962 TO SHOW CONNECTION WITH MAP 19-09.
* THIS MAP CORRECTED JUNE 27, 1934 FOR CHANGE IN PROPERTY LINE.
LEGEND
HIGHWAY BOUNDARY STONE.
ANCIENT OR LOCAL STONE ON LINE.
BASE LINE SURVEY STONE.
IRON PIN, PIPE OR BRASS PIN.
HIGHWAY BOUNDARY LINE.
TREES OAK FIR OTHERS
TELEPHONE POLE.
WIRE FENCE.
BOARD FENCE.
PICKET FENCE.
VIRGINIA RAIL FENCE.
RETAINING WALL.
STONE WALL.
HEDGE.
APPROVED JOHN A. MACDONALD
DATE MAR. 29, 1934.
I hereby certify that this Map is substantially correct to the best of my knowledge and belief.
CONNECTICUT STATE HIGHWAY DEPARTMENT
RIGHT OF WAY MAP
TOWN OF BROOKLYN
CANTERBURY-BROOKLYN ROAD FROM THE ANDERSON PROPERTY NO. EASTERLY TO BROOKLYN TOWN HALL.
ROUTE No. 93.
SCALE 1"=40'
NUMBER 19-03
SHEET NO. 2 OF 2


Town of Brooklyn

Conclusions

- Using GPS technology as an aid in creating local/regional level Cadastral Data
- Local/regional Cadastral Data to flow up to State/Federal government
- Intergovernmental cooperation
  - Local, regional, state and federal
  - Data and resource sharing
- Derivatives coming soon.
  - Example: Address points

Thanks

Mark Goetz, GISP

GIS Director

NECCOG

860-779-1443

mark.goetz@neccog.org