The MIT Geodetic Observatory

In the Middlesex Fells

This sketch of the observatory is believed to be by Charles H. Woodbury

"[The MIT Geodetic Observatory in the Middlesex Fells] is intended primarily to be used in giving instruction in the most refined methods of determining latitude and longitude and secondarily to be used in magnetic and gravity observations."

MIT Professor George L. Hosmer, "The Geodetic Observatory at Middlesex Fells," in
The Technology Quarterly, Vol. 12, No. 2 of June 1899

By Brian DeLacey and Bill Ricker
Published by www.DigitalTrailGuides.com, Draft: January 20, 2017
Questions or corrections welcomed to DigitalTrailGuides@gmail.com

“Geodesy is the science of where things are, where they have been and where they are going.”

From “Looking Down a Well: A Brief History of Geodesy” NASA Goddard Media Studies, on February 23, 2012, http://svs.gsfc.nasa.gov/vis/a010000/a010900/a010910/

Special thanks to

Sean M. Fisher, Archivist
DCR Archives, Office of Cultural Resources
Bureau of Planning, Design and Resource Protection
MA Department of Conservation and Recreation

Capt. Mike Nelson, Park Ranger
MA Department of Conservation and Recreation

Russell Blood
Eagle Scout

Cover Sketch is of the MIT Geodetic Observatory believed to be by Charles H. Woodbury
The image provided courtesy of Capt. Mike Nelson and DCR from documents on display at the site.

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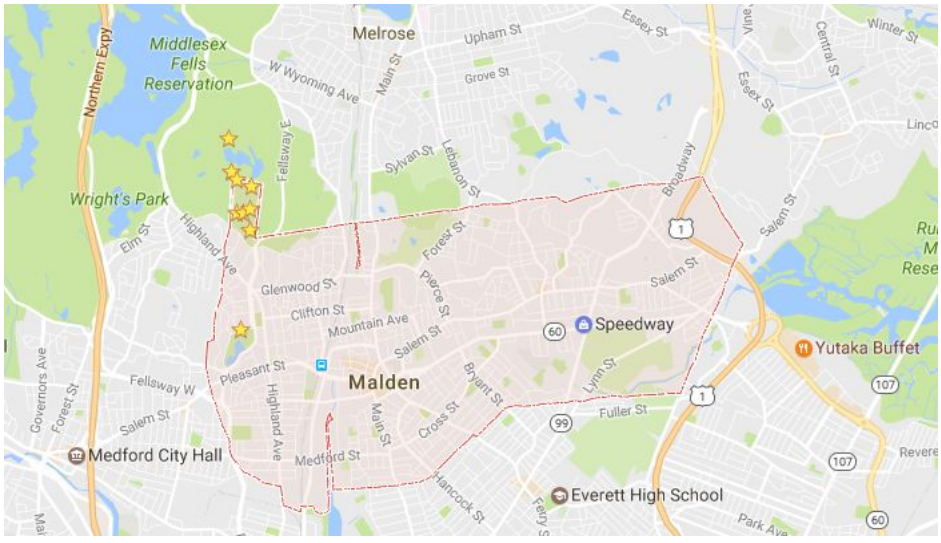
11. “Missing Rocks” and unanswered questions



City of Malden Map, sources: maps.google.com

1. Introduction

My family noticed these signs on a number of visits to the Middlesex Fells. They stand near a public parking area of the Middlesex Fells on Fellsway East. The signs are an open invitation. We had heard about Boojum Rock before, but never the “1899 MIT Observatory”. This is where our search began.

Finally, late one afternoon, my wife and I followed our curiosity, to search for the ancient observatory.

We started to follow the “Rock Circuit Trail.” We dodged puddles, climbed (and descended) steep rocks. After a while - with no signs pointing to Boojum or the Observatory, we wondered where we made a wrong turn. A spry hiker, with gear and no pause in his gait, sailed over the stones in a hilly area.

As he raced by us, he kindly offered some helpful hints suggesting headings for the general direction to the Observatory. We kept moving.

As time and travel passed, we came across other walkers enjoying their stroll along a gentle path. We learned this was Jerry Jingle Road. They seemed very familiar with that particular path, but told us they had never visited the Observatory. Indeed, they suggested it might be on the other side of Route 93!

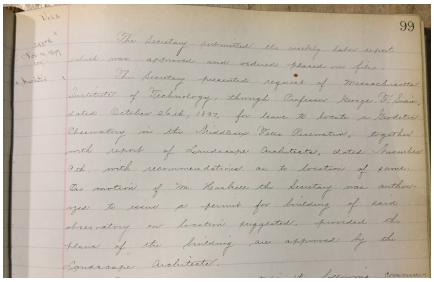
Shouldn't it be easy to locate the MIT Geodetic Observatory? After all, this historic site was created for education in "the most refined methods of determining latitude and longitude"? At that, we brought our impromptu hike to a halt and headed home determined to return. After a computer search, I was surprised to find a lack of information about the site with conflicting reports as to its location.

I shared my navigational curiosity with some MIT-savvy friends. Fortunately, Bill Ricker was ready to hike. He also happens to be expert and knowledgeable about modern-day geo-locating systems built atop the foundations of Geodesy. He had never been to the MIT Geodetic Observatory either, but we were both determined to find it. This pamphlet is the result.

2. The MIT Geodetic Observatory

In early antiquity, civilizations wanted to determine the shape and size of the earth. Some thinkers thought it was flat, while others thought it was rectangular. Over time, through observation and study, a greater understanding developed about the true shape of the earth. Leading thinkers like Pythagoras, Aristotle, Plato and Eratosthenes applied math, science, and time. The engineering, science and practice of Geodesy was born. As this was formalized in later centuries, the Massachusetts Institute of Technology (MIT) introduced a number of related educational programs - in Geodesy - for the classroom and the field.

The November 10, 1897 Metropolitan Parks Commission (MPC) minutes document MIT's desire to build a Geodetic Observatory in the Middlesex Fells Reservation. The MPC - as precursor to the Massachusetts Department of Conservation and Recreation (DCR) . MIT's request was approved.

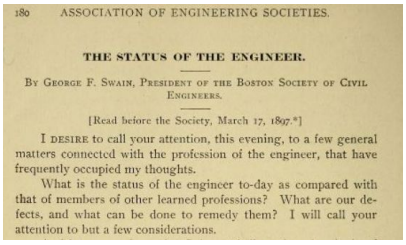

99

The Secretary presented the weekly labor report which was approved and ordered placed on file.

The Secretary presented request of Massachusetts Institute of Technology, through Professor George F. Swain, dated October 26th, 1897, for leave to locate a Geodetic Observatory in the Middlesex Fells Reservation, together with report of Landscape Architects, dated November 9th, with recommendations as to location of same.

On motion of Mr. Haskell the Secretary was authorized to issue a permit for building of said observatory on location suggested, provided the plans of the building are approved by the Landscape Architects.

"The Secretary presented request of Massachusetts Institute of Technology, through Professor George F. Swain, dated October 26th, 1897, for leave to locate a Geodetic Observatory in the Middlesex Fells Reservation, together with report of Landscape Architects, dated November 9th, with recommendations as to location of same. On motion of Mr. Haskell the Secretary was authorized to issue a permit for building of said observatory on location suggested, provided the plans of the building are approved by the Landscape Architects."


180 ASSOCIATION OF ENGINEERING SOCIETIES.

THE STATUS OF THE ENGINEER.

By George F. Swain, President of the Boston Society of Civil Engineers.

[Read before the Society, March 17, 1897.*]

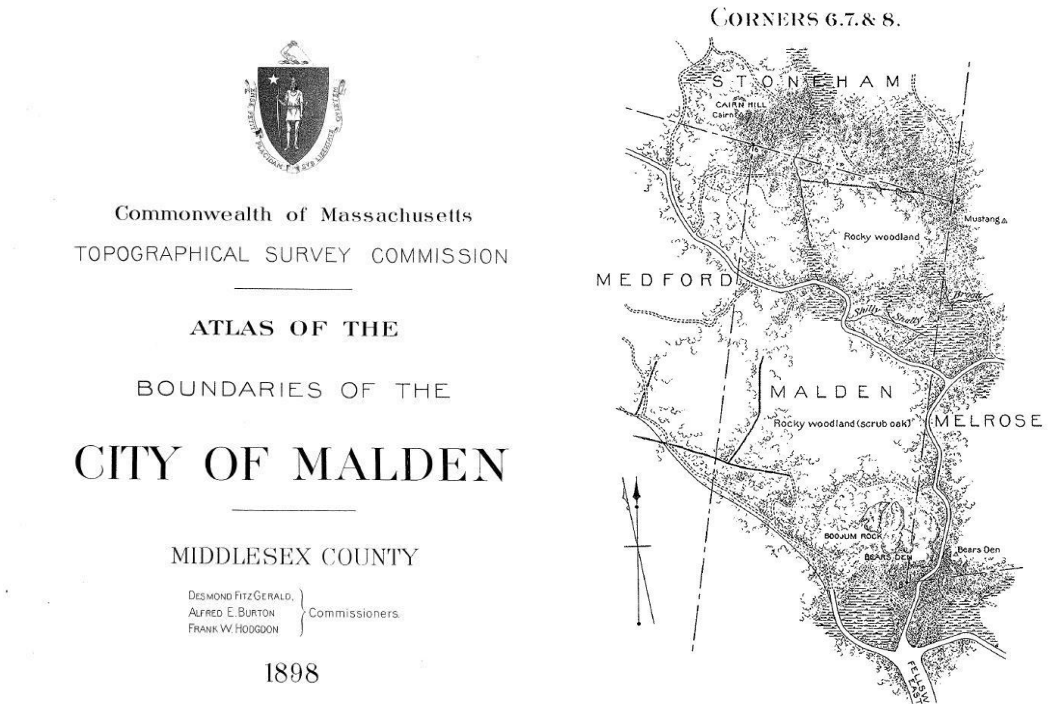
I desire to call your attention, this evening, to a few general matters connected with the profession of the engineer, that have frequently occupied my thoughts.

What is the status of the engineer to-day as compared with that of members of other learned professions? What are our defects, and what can be done to remedy them? I will call your attention to but a few considerations.

MIT's request carried the added authority of Professor Swain who also served as the President of the Boston Society of Civil Engineer around this time. The MIT Geodetic Observatory was established by the MIT Civil Engineering Department in 1898 to incorporate a real-world experience into their Geodesy curriculum. For reasons that were scientifically driven, the Middlesex Fells location proved ideal for this use. A small structure was built on conservation land that lies within the Middlesex Fells, just

inside the northern border of the City of Malden. (Image of the 1987 minutes of the MPC provided courtesy Sean Fisher and Massachusetts Department of Conservation and Recreation.)

Around this same time, Massachusetts published the 1898 “Atlas of the Boundaries of the City of Malden”. There was a tremendous amount of “surveying” and landscape mapping work taking place around that time. A few images from the 1898 Atlas convey the layout of the land at that time.



Commonwealth of Massachusetts

TOPOGRAPHICAL SURVEY COMMISSION

ATLAS OF THE

BOUNDARIES OF THE

CITY OF MALDEN

MIDDLESEX COUNTY

DESMOND FITZGERALD,
ALFRED E. BURTON
FRANK W. HODGDON
} Commissioners.

1898

CORNERS 6.7.& 8.

STONEHAM

CAIRN HILL
Cairn

Rocky woodland

Mustang

MEDFORD

Spring

Spring

MALDEN

Rocky woodland (scrub oak)

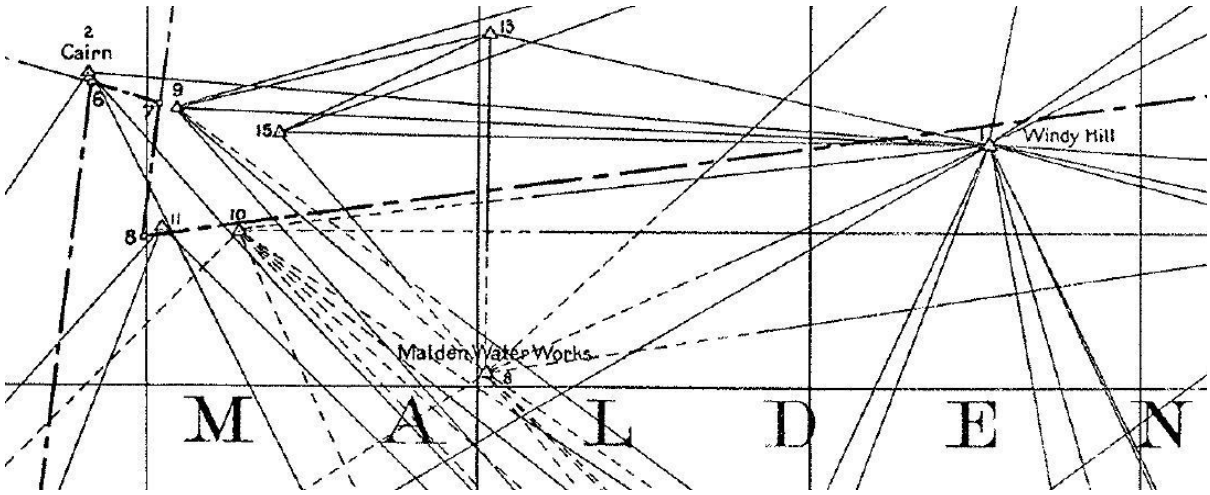
MELROSE

BOGUM ROCK

BEARS DEN

Bears Den

FELSEN



See the 1898 “Atlas of the Boundaries of the City of Malden”:
http://gis.massdot.state.ma.us/Images/Survey/AllAtlases//Book%2008%20complete.pdf

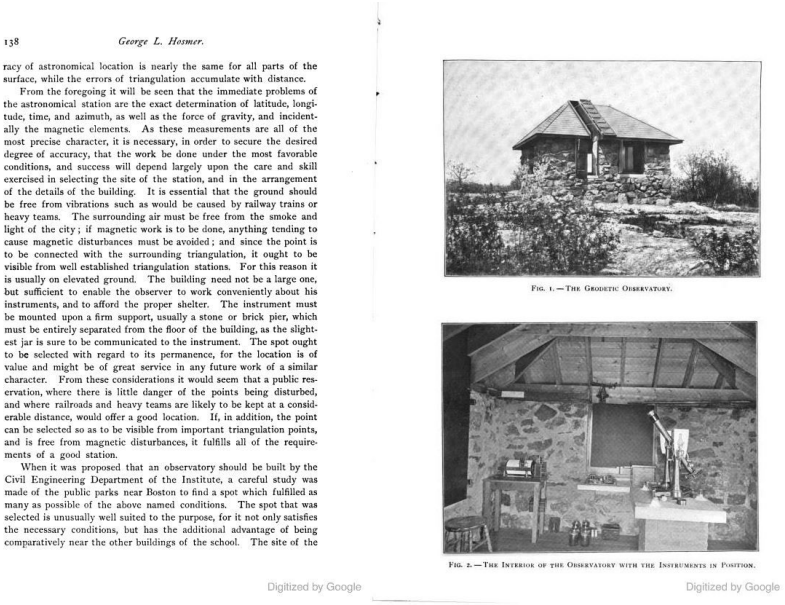
3. Why Geodesy in the Middlesex Fells?

An article written by MIT Professor Hosmer explained why this location was ideal for MIT. You can find a scanned copy of the full article at http://www.digitaltrailguides.com/Observatory/hosmer.html and numerous book-length references listed in Section 9 of this document.

From the foregoing it will be seen that the immediate problems of the astronomical station are the exact determination of latitude, longitude, time, and azimuth, as well as the force of gravity, and incidentally the magnetic elements. As these measurements are all of the most precise character, it is necessary, in order to secure the desired degree of accuracy, that the work be done under the most favorable conditions, and success will depend largely upon the care and skill exercised in selecting the site of the station, and in the arrangement of the details of the building. It is essential that the ground should be free from vibrations such as would be caused by railway trains or heavy teams. The surrounding air must be free from the smoke and light of the city; if magnetic work is to be done, anything tending to cause magnetic disturbances must be avoided; and since the point is to be connected with the surrounding triangulation, it ought to be visible from well established triangulation stations. For this reason it is usually on elevated ground. The building need not be a large one, but sufficient to enable the observer to work conveniently about his instruments, and to afford the proper shelter. The instrument must be mounted upon a firm support, usually a stone or brick pier, which

Hosmer noted, "Observations have been made during the past term for the determination of time and on latitude by Talcott's method. Arrangements have been made for the determination of longitude by telegraph connection with the Harvard observatory. The freedom of the observatory from vibrations and its distance from magnetic disturbances permits of much work that could not before be performed at any of the Institute buildings. A discussion followed and the meeting then adjourned."

See: George L. Hosmer, “The Geodetic Observatory at Middlesex Fells,” in The Technology Quarterly, Vol. 12, No. 2 of June 1899, on pages 135 - 144
You can find that issue of The Technology Quarterly at https://goo.gl/oXzf0o



138 George L. Hosmer.

racy of astronomical location is nearly the same for all parts of the surface, while the errors of triangulation accumulate with distance.

From the foregoing it will be seen that the immediate problems of the astronomical station are the exact determination of latitude, longitude, time, and azimuth, as well as the force of gravity, and incidentally the magnetic elements. As these measurements are all of the most precise character, it is necessary, in order to secure the desired degree of accuracy, that the work be done under the most favorable conditions, and success will depend largely upon the care and skill exercised in selecting the site of the station, and in the arrangement of the details of the building. It is essential that the ground should be free from vibrations such as would be caused by railway trains or heavy teams. The surrounding air must be free from the smoke and light of the city; if magnetic work is to be done, anything tending to cause magnetic disturbances must be avoided; and since the point is to be connected with the surrounding triangulation, it ought to be visible from well established triangulation stations. For this reason it is usually on elevated ground. The building need not be a large one, but sufficient to enable the observer to work conveniently about his instruments, and to afford the proper shelter. The instrument must be mounted upon a firm support, usually a stone or brick pier, which must be entirely separated from the floor of the building, as the slightest jar is sure to be communicated to the instrument. The spot ought to be selected with regard to its permanence, for the location is of value and might be of great service in any future work of a similar character. From these considerations it would seem that a public reservation, where there is little danger of the points being disturbed, and where railroads and heavy teams are likely to be kept at a considerable distance, would offer a good location. If, in addition, the point can be selected so as to be visible from important triangulation points, and is free from magnetic disturbances, it fulfills all of the requirements of a good station.

When it was proposed that an observatory should be built by the Civil Engineering Department of the Institute, a careful study was made of the public parks near Boston to find a spot which fulfilled as many as possible of the above named conditions. The spot that was selected is unusually well suited to the purpose, for it not only satisfies the necessary conditions, but has the additional advantage of being comparatively near the other buildings of the school. The site of the

Fig. 1. — The Geodetic Observatory.

Fig. 2. — The Interior of the Observatory with the Instruments in Position.

MIT, as a leader educating students and professionals in crucial technical and engineering skills, invested heavily. This early activity led to sophisticated geodetic techniques used to precisely locate resources in our three-dimension world - especially in the earth's environment. NASA summarized it this way: "Geodesy is the science of where things are, where they have been and where they are going."

You can read more about the science, practice and history of geodesy on Wikipedia:

https://en.wikipedia.org/wiki/Geodesy
https://en.wikipedia.org/wiki/History_of_geodesy

Geodesy is utilized today in real-world applications. It's likely leaders in the field included students who learned about this through the MIT Geodetic Observatory. According to the National Ocean Service:

> "Geodesists assign coordinates to points all over the Earth. Using the Global Positioning System (GPS), geodesists can accurately define the coordinates of points on the surface of the Earth in a consistent manner. This set of accurately measured points is called the National Spatial Reference System (NSRS), which allows different kinds of maps to be consistent with one another.
>
> Developers, local officials, city planners, and many others use the National Spatial Reference System to determine land boundaries for development or conservation efforts. Government agencies also rely on the NSRS to update maps of the U.S. shoreline.
>
> Geodesy is also critical to the transportation industry. Surveyors use the National Spatial Reference System as one of their tools to develop nautical charts. Mariners use these nautical charts and GPS to accurately position their ships. This technology, accurate down to a centimeter scale, allows mariners and commercial vessels to assess where the bottoms of their ships are relative to the bottom of the ocean. With this information, a ship can hold extra cargo, sinking deeper into the water, and still safely navigate through a channel. The ability to move more cargo at a time is direct economic benefit to the shipping industries and ultimately to the consumer.
>
> In addition, geodetic data, specifically datum information, and water level data are critical for agency officials to properly plan, design, and engineer coastal restoration projects. These data provide baseline information that assist in the construction of phases of marsh restoration projects, for example.
>
> Geodesy is the science of measuring and monitoring the size and shape of the Earth, including its gravity field, and determining the location of points on the Earth's surface."
> Source: http://oceanservice.noaa.gov/facts/geobenefits.html

4. Finding the MIT Geodetic Observatory

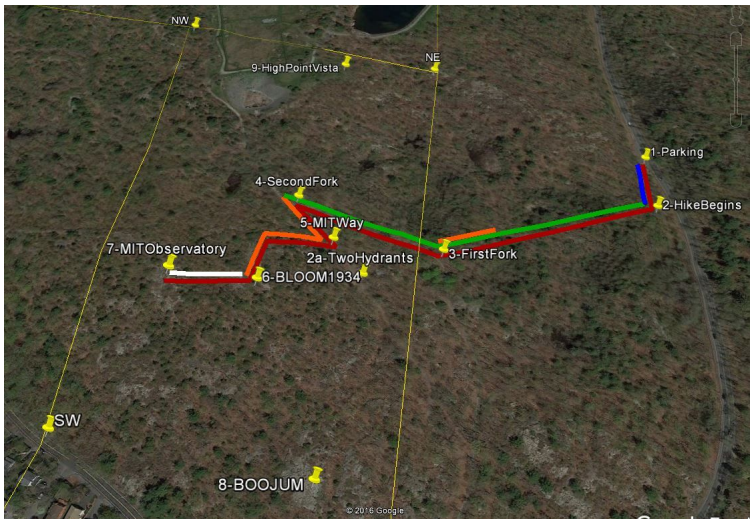
Some maps (such as the excellent http://www.mass.gov/eea/docs/dcr/parks/trails/fells.pdf) show the location of the MIT Geodetic Observatory, but provide little guidance on how to get there. As of December 2016, the main sign designating the MIT Observatory leads to the “Rock Circuit Trail” which is a strenuous and sometimes difficult hike.

This section provides a clear, detailed path of GPS waypoints to find the MIT Observatory along a relatively relaxed path. (CAUTION: These paths include rocky, slippery points. Good hiking shoes and taking appropriate safety precautions highly recommended!) We are calling this the “MIT Trail”, which we’ve drawn in a hue of red to approximate MIT’s colors, and it crosses several existing well known trails. Here’s our summary of relevant trail names:

Blue = Cross Fells Trail
White = Rock Circuit Trail
Orange = Rock Circuit Connector
Green = Forest Way
Red = MIT Trail

We also provide the “MIT Trail” placemarkers and waypoints online as a digital file. You can use this with widely available mapping software to easily find and follow a trail to the MIT Geodetic Observatory:
http://www.digitaltrailguides.com/Observatory/MIT-Trail.kml

Digital Trail Guide for the MIT Geodetic Observatory



The first three waypoints (1. Parking, 2. Hike Begins, and 3. First Fork) are in Melrose. The remainder of the hike is in the City of Malden. The rough rectangular area of Malden shown in this TRAIL IMAGE covers approximately 40-acres of the Middlesex Fells Reservation. (The perimeter of this land is over 1,800 yards.) The walking distance from the parking area to the MIT Geodetic Observatory, is about a half-mile. There is some climbing up and down rocky, steep inclines. Sharp, poky branches line the path.

Waypoint 1: "Parking" (image) (map)
42° 26' 33.990" N, 71° 04' 45.830" W (42.44277° , -71.0794)

Waypoint 2: "Hike Begins" (image) (map)
42° 26' 31.640" N, 71° 04' 46.150" W (42.44212° , -71.07949)

Waypoint 3: "First Fork" (image) (map)
42° 26' 30.080" N, 71° 04' 55.770" W (42.44169° , -71.08216)

Waypoint 4: "Second Fork" (image) (map)
42° 26' 31.860" N, 71° 05' 1.840" W (42.44218° , -71.08384)

Waypoint 5: "MIT Way" (image) (map)
42° 26' 29.960" N, 71° 05' 0.210" W (42.44166° , -71.08339)

Waypoint 6: "BLOOM 1934" (image) (map)
42° 26' 28.500" N, 71° 05' 3.600" W (42.44125° , -71.08433)

Waypoint 7 - "MIT Geodetic Observatory" (image) (map) (video)
42° 26' 28.590" N, 71° 05' 6.480" W (42.44127° , -71.08513)

While you are in the area, here are two additional locations well worth visiting and close by:

Waypoint 8: "Boojum Rock" (image) (map)
This provides a great view of Boston, looking over East Border Road

42° 26' 22.860" N, 71° 05' 0.480" W (42.43968° , -71.08347)

Waypoint 9: "High Point Vista" (image) (map) *The Northeast Tip of Malden panhandle*
42° 26' 37.910" N, 71° 04' 59.970" W (42.44386° , -71.08333)

Boojum Rock and "High Point Vista" are at lower elevations than BLOOM1934 and the MIT Geodetic Observatory,however, they generally offer better unobstructed views of the distant skyline. Harsher terrain below may have limited tree growth. (It's unclear if controlled removal of shrub brush has taken place.)

Alternate Routes to the MIT Geodetic Observatory

There are many alternate routes to find the MIT Geodetic Observatory. Here is one alternate route that is particularly convenient for pedestrians visiting by walking from the City of Malden:

Waypoint 1a: "Jerry Jingle Gate" (image) (map)
42° 26' 16.830" N, 71° 04' 58.960" W (42.43801° , -71.08304)
Start from East Border Road, at the corner of Fellsway East near McCormack Street.
Enter the Middlesex Fells Reservation at the well-marked **Middlesex Fells Gate 55**

Waypoint 2a: "M-M Monument" (image1) (image2) (map) (video) (detail)
N 42 26.331,W071 04.976

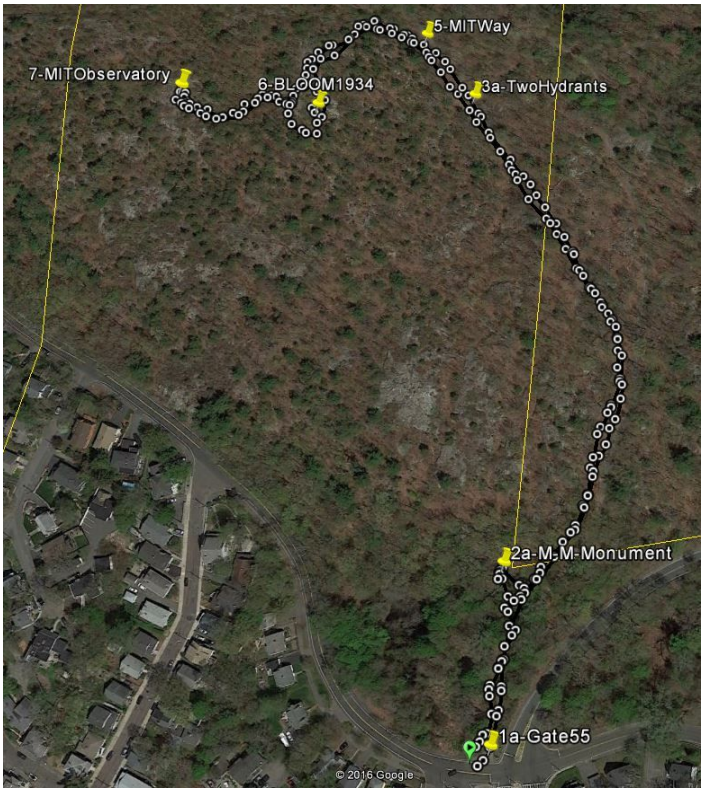
Shortly after you pass through "Jerry Jingle Gate", also known as DCR gate 55, on the left of the path you'll see a stone monument. The letter M indicates this is a corner point for Malden and Melrose.

About a quarter mile away from Gate 55, you arrive at two fire hydrants on Jerry Jingle Road.

Waypoint 3a: “Two Hydrants” (image) (map)
42° 26' 29.000" N, 71° 04' 59.000" W (42.44139° , -71.08306)

Continue past these two fire hydrants, and soon you’ll be on the main “MIT Trail”, which you can join at

Waypoint 5: “MIT Way” (image) (map) *Final ascent to the MIT Geodetic Observatory*
42° 26' 29.960" N, 71° 05' 0.210" W (42.44166° , -71.08339)
After 3a, your next destination is Waypoint 5 - “MIT Way” - described above. If you were to trace your steps along this alternate path, it might look something like this:



CAUTION: If you cross the road - especially at the busy roadways of Fellsway East or East Border Road - please do so carefully. With this document, we are asking for the DCR to include the placement of improved pedestrian and hiker crosswalk road painting near this location.

5. Images and Narrative from the MIT Trail

Photographic images can vary greatly depending on the season, time of day and weather, so you'll have to keep that in mind when viewing images in this document or online. It will look different during your hike!

As your hike begins at **Waypoint 1**, you'll be on the Blue Trail for a very short time. Paths are marked by paint or plastic markers, referred to as a "blaze".

Waypoint 2 is marked **"Hike Begins" (image) (map)**
42° 26' 31.640" N, 71° 04' 46.150" W
(42.44212° , -71.07949)

However, the WHITE Rock Circuit Trail is challenging so we devised an alternative route which we have named the "MIT Trail". Instead of heading for the Rock Circuit Trail, look for this nice path nearby. You'll be following a tree lined, dirt trail for a relaxed casual hike.

Eventually you'll make it to "MIT Way" where you will see an orange blaze on the tree.

Waypoint 5 - "MIT Way" (image) (map)
Ascent to the 1899 MIT Geodetic Observatory
42° 26' 29.960" N, 71° 05' 0.210" W (42.44166° , -71.08339)

Waypoint 6 - "BLOOM 1934" (image) (map)
42° 26' 28.500" N, 71° 05' 3.600" W (42.44125° , -71.08433)

This is the location where a bronze disk has been secured into the rock as an official "geodetic" location station. It's also sometimes known as a benchmark. However, this one seems to be lost-from-records even though some believe the BLOOM 1934 benchmark is one of the highest points in Malden.

http://www.massdot.state.ma.us/highway/Departments/Survey/GeodeticControlData.aspx

See also https://www.flickr.com/photos/not_on_display/9233439267 for a clearer image of the BLOOM1934 engraving. The B and the 34 have really faded in the last 3.5 years it was quite legible in Summer 2013. (The Bloom1934 location is also significant as a location with a Pokemon Go Gym!)

A personal nickname for the BLOOM1934 benchmark spot is “Trail Mix” - because it’s an easy place to get “mixed” up! It’s a key juncture and a place where the new detoured white ROCK CIRCUIT TRAIL and the orange ROCK CIRCUIT CONNECTOR meet. (New route is not shown on above map; see OSM for current white detour MIT Observatory - BLOOM - BOOJUM.) It’s easy to get mixed up on which direction to head. OSM.ORG lists the location of the Observatory as 42.4412948, -71.0851152 http://www.openstreetmap.org/node/944663159. It is just a short distance away, but it is largely hidden from site. You need to head northwest for the observatory. If you head southeast, you can follow the trail to Boojum Rock. (Maybe we can get some trail signs added in the future!)

Waypoint 7 - “MIT Geodetic Observatory” (image) (map) (video)
42° 26' 28.590" N, 71° 05' 6.480" W (42.44127° , -71.08513)

You can find a short video, of an aerial flyover with quadcopter drone posted to YouTube:
https://youtu.be/H1-mO6QhgUQ

See Technology Quarterly and Proceedings of the Society of Arts, Volume 12 pp.135-144
& p.186 with reference at pp.135-144:

"The Middlesex Fells Geodetic Observatory [1: p.135-144] This observatory is intended primarily to be used in giving instruction in the most refined methods of determining latitude and longitude and secondarily to be used in magnetic and gravity observations. A description was given of the building and instruments which include a transit of 2 inches aperture 27 inches focus, a sidereal chronometer, chronograph, alt azimuth etc.

"Observations have been made during the past term for the determination of time and on latitude by Talcott's method. Arrangements have been made for the determination of longitude by telegraph connection with the Harvard observatory. The freedom of the observatory from vibrations and its distance from magnetic disturbances permits of much work that could not before be performed at any of the Institute buildings. A discussion followed and the meeting then adjourned."

Thursday, April 13. Meeting of the Society of Arts, 8 P. M., Huntington Hall, Mr. Geo. L. Hosmer to speak on "The Middlesex Fells Geodetic Observatory." Smoke talk of the Architectural Society, at the Technology Club, 7.30 P. M.

MIT Tech - http://tech.mit.edu/V18/PDF/V18-N23.pdf, page 11 "Smoke Talk" on the Observatory

A wooden structure at the site displays a variety of historical documents related to MIT's early establishment of the site. The installation of the interpretive bulletin board was done by Eagle Scout Russell Blood in 2010 - it served multiple purposes preserving the history and also encouraging appropriate use of the space. (Prior to the installation of this bulletin board, vandalism and littering were common problems. This improved greatly with the historical respect shown by the displays.)

You can find copies of the documents included in the display as Appendices to this document - see Appendix 1 - Appendix 5 for copies of the historic documents pinned to the bulletin board when established at the MIT Observatory site in 2010. Appendix 6 is a contour map from 1895.

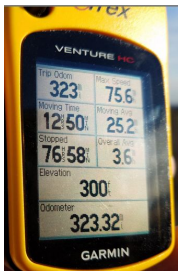
The research and documentary materials for the display were gathered by DCR Park Ranger Capt. Mike Nelson and he provided them to Russell Blood, an Eagle Scout, who was working on this project.

A short aerial video of the MIT Geodetic Observatory site in January 2017 can be found here:
https://youtu.be/H1-mO6QhgUQ

Waypoint 8: “Boojum Rock” (image) (map) *Boston skyline, viewing over East Border Road*
42° 26' 22.860" N, 71° 05' 0.480" W (42.43968° , -71.08347)

Waypoint 9: “High Point Vista” (image) (map) - *View from Northeast Tip of Malden Panhandle*
42° 26' 37.910" N, 71° 04' 59.970" W (42.44386° , -71.08333)

Despite being at a lower elevation than BLOOM and the MIT Geodetic Observatory, this “High Point Vista” offer better views, because harsher terrain below limits tree growth.



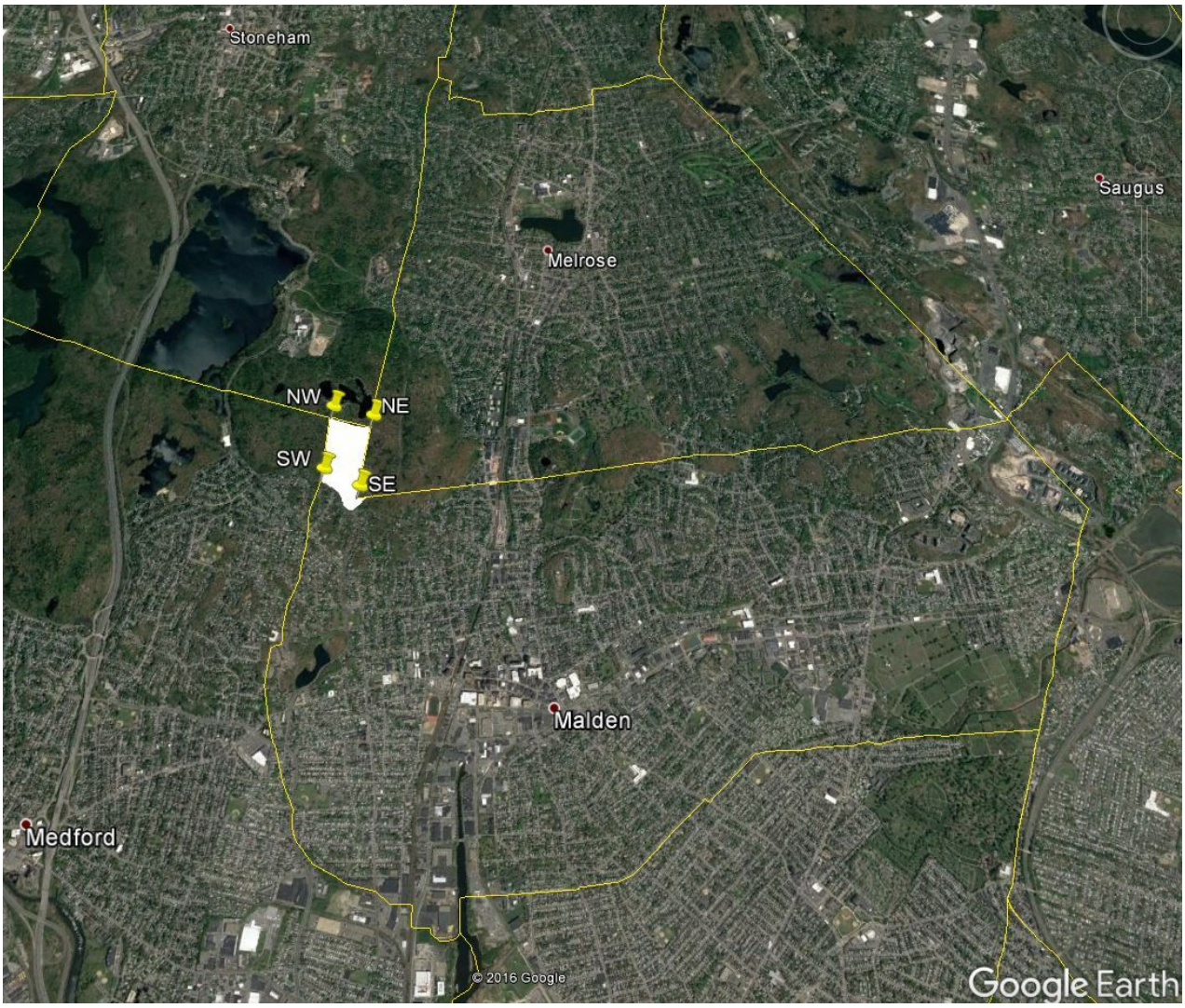
Places of Interest
in the “Malden Panhandle”

The northwest corner of Malden is a parcel of conservation land in the Middlesex Fells Reservation. It is approximately 40 acres in size, bounded by a perimeter traversing a little over 1 mile. This conservation land, within the borders of Malden and the Middlesex Fells Reservation, has trails through rocky, scenic landscapes and offers majestic views of the Boston skyline. This informal name of this area is given as the “Malden Panhandle”, since it is in a shape similar to the “Texas Panhandle”

Place of Interest 1: Boundary Markers

The “Malden Panhandle” maps an area where four neighboring cities come together.

The NW corner is a meeting point for Malden, Medford and Stoneham.
The NE corner is a meeting point for Malden, Melrose and Stoneham.
The SE corner marks a border between Malden and Melrose.
The SW corner marks a border between Malden and Medford.



Land framed in YELLOW border is Middlesex Fells Reservation land, which is consdervation land sitting within the borders of Malden.

This image is sourced from Malden GIS Parcel Viewer https://maldenma.mapgeo.io/

The boundary points of the Malden Panhandle correspond to the following approximate GPS Coordinates:

NorthWest Marker - NW - is at 42°26'40.63"N, 71° 5'8.23"W
NorthEast Marker - NE - is at 42°26'38.21"N, 71° 4'55.45"W
SouthEast Marker - SE - is at 42°26'19.93"N, 71° 4'58.30"W
SouthWest Marker - SW - is at 42°26'24.34"N, 71° 5'9.81"W

Three of the four boundary markers are clearly carved with letters for the adjacent cities. There is a large rock near the Southeast corner of the “Malden Panhandle” but it’s unclear if that is an official border marker.

Place of Interest 2: Jerry Jingle Road

Approximate gps coordinates: N42 26.371' W71 05.001'

Jerry Jingle Road is the main pedestrian entrance to the “Malden Panhandle”

Nearby the woodpecker’s tree is a traditional handpainted wooden sign for Jerry Jingle Road

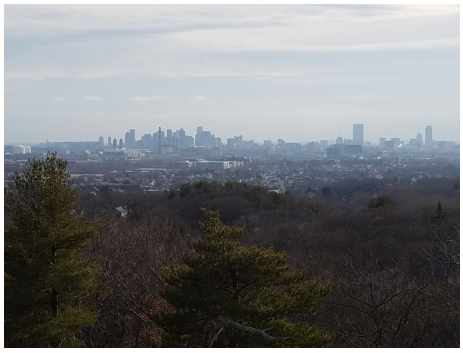
As you walk a bit further down Jerry Jingle Road, look to the tree on your left for a trail sign. Can you spot the woodpecker in this tree-lined walk?

Here’s a short video clip to help you find the woodpecker at work:

http://www.digitaltrailguides.com/Observatory/video/woodpecker-vid.mp4

Place of Interest 3: Boojum Rock

Approximate gps coordinates: 42° 26' 22.86" N, 71° 05' 00.48" W



Place of Interest 4: MIT Geodetic Observatory

Approximate gps coordinates: : 42°26'28.59"N 71° 5'6.48"W

Place of Interest 5: MUSTANG survey station

Middlesex Fells Reservation has a number of survey markers. These are fun to find! As described by Wikipedia, “Survey markers, also called survey marks, survey monuments, or geodetic marks, are objects placed to mark key survey points on the Earth's surface. They are used in geodetic and land surveying. Informally, such marks are referred to as benchmarks,[1] although strictly speaking the term "benchmark" is reserved for marks that indicate elevation. Horizontal position markers used for triangulation are also known as triangulation stations.” https://en.wikipedia.org/wiki/Survey_marker

Approximate location of Mustang Triangulation Station is N42 26.622, W071 04.873. This was a carefully determined and measured reference point used in creating survey records and maps. (A description of survey markers is at https://en.wikipedia.org/wiki/Survey_marker)

EDITOR’s NOTE: We have reached out to DCR to see if we can help get this graffiti removed.

Malden’s border with Melrose and Stoneham is located nearby at N42 26.637, W071 04.927

6. Trail Guides, Maps, and Databases: Getting Around

To make it easier for you to find your way to the MIT Geodetic Observatory, we've created a "***digital trail guide"***. You can download your very own digital trail guide from THIS LINK and then open it and use it with Windows, Android and other types of software.

This "***digital trail guide"*** utilizes a format known as KML - "keyhole markup language" - which has been established as an industry standard thanks to widespread use of the excellent (and free) Google Earth application.

The MIT Geodetic Observatory Trail Guide is at
http://www.digitaltrailguides.com/Observatory/MIT-Trail.kml

You can learn more about KML at the following tutorial:
https://developers.google.com/kml/documentation/kml_tut

Google Earth runs on Windows, Android tablets and phones, as well as possibly other types of computing devices.) The KML file format simply identifies locations of interest using GPS coordinates, and allows you to attach additional descriptive information to each waypoint (or PlaceMark.) When a software application with mapping capabilities, such as Google Earth, reads the file it is able to display the desired locations on a map.

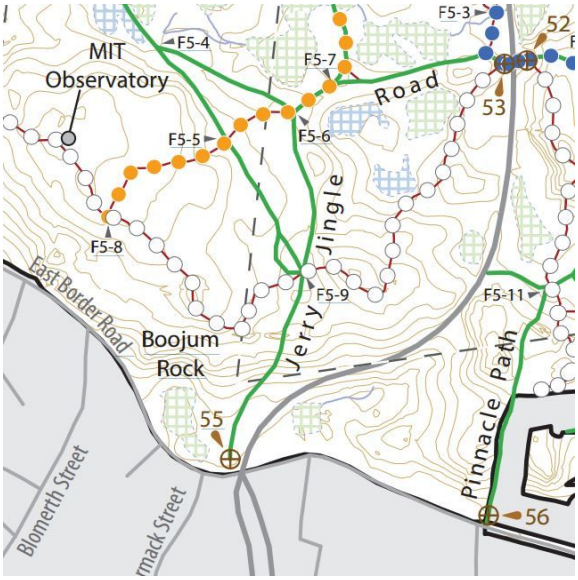
For key "waypoints" and areas of interest, we've included GPS coordinates. These are approximate, but useful. Just copy the coordinate and paste them into Google Maps or Google Earth or some other mapping software and you'll be teleported to that location! Here's a coordinate for the MIT Geodetic Observatory: 42° 26' 29.960" N, 71° 05' 0.210" W

You can use the KML file mentioned earlier (link here) or simply copy and paste these "waypoints" into mapping software (e.g. maps.google.com or www.openstreetmap.org) or other "geo" software (e.g. Google Earth) to produce your own guide.

The official DCR map of the Middlesex Fells hiking trails is available online at the following link:

http://www.mass.gov/eea/docs/dcr/parks/trails/fells.pdf

Here is a small corner of that map, focused on the area and trails around the MIT Geodetic Observatory:



Because this specific location had a lot to do with the history of surveying and locating land features, it seems appropriate to take a bit of a side adventure into how that corner of engineering works today.

Key survey control points are listed in the Massachusetts Geodetic databases, such as this one:

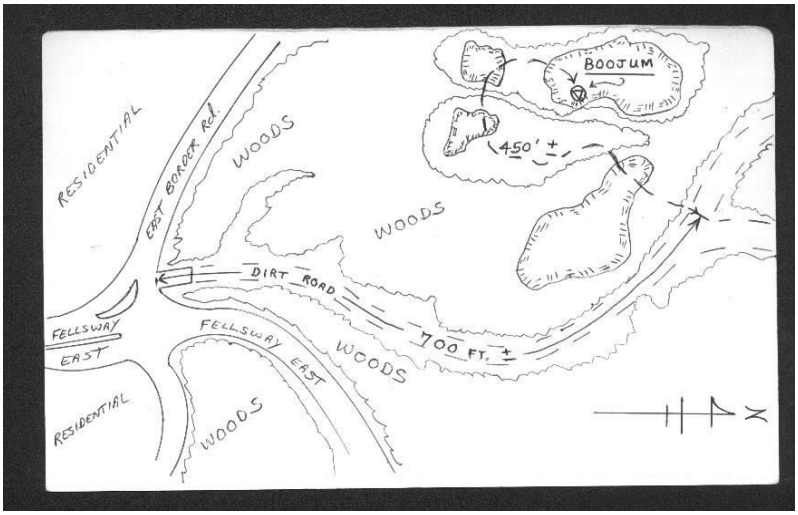
http://gis.massdot.state.ma.us/maptemplate/geodeticcontrol

Here is the available information for Boojum Rock (it appears there is no entry in this database for station marker BLOOM1934 - though it would seem there should be)

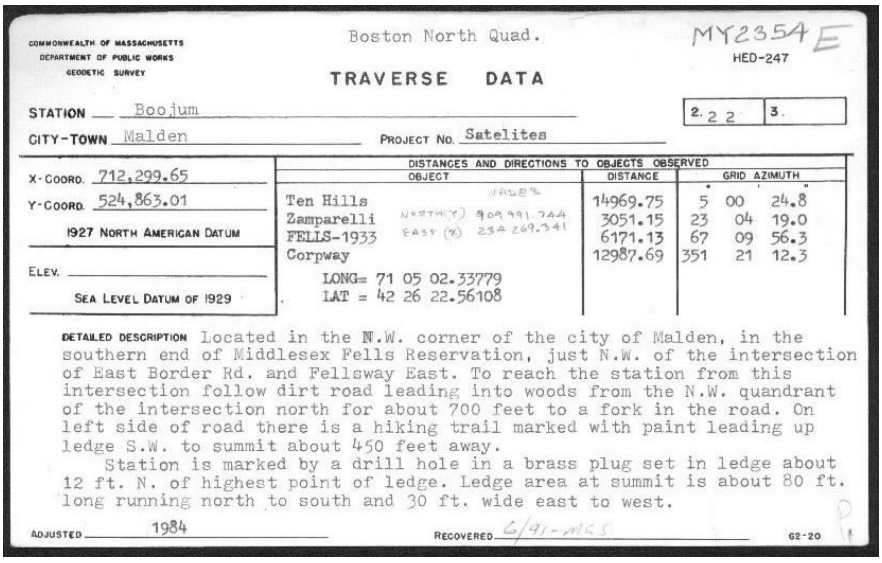
MassDOT - http://www.massdot.state.ma.us/highway/Departments/Survey/GeodeticControlData.aspx

4915	BOOJUM	MassDOT Sheet 4915	MY2354	NGS Sheet 4915	BOSTON NORTH	Scan 4915	Sketch 4915

The MassDOT sketch: http://gis.massdot.state.ma.us/images/survey/4915_B.jpg



The linked state datasheet: http://gis.massdot.state.ma.us/images/survey/4915_F.jpg



COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS
GEODETIC SURVEY

Boston North Quad.

MY2354 E

HED-247

TRAVERSE DATA

STATION Boojum

2. 2 2 | 3.

CITY-TOWN Malden

PROJECT NO. Satelites

X-COORD. 712,299.65

Y-COORD. 524,863.01

1927 NORTH AMERICAN DATUM

ELEV.

SEA LEVEL DATUM OF 1929

DISTANCES AND DIRECTIONS TO OBJECTS OBSERVED

OBJECT	DISTANCE	GRID AZIMUTH
Ten Hills	14969.75	5 00 24.8
Zamparelli	3051.15	23 04 19.0
FELLS-1933	6171.13	67 09 56.3
Corpway	12987.69	351 21 12.3

VALUES
NORTH (Y) 909 991.744
EAST (X) 234 269.341

LONG= 71 05 02.33779
LAT = 42 26 22.56108

DETAILED DESCRIPTION Located in the N.W. corner of the city of Malden, in the southern end of Middlesex Fells Reservation, just N.W. of the intersection of East Border Rd. and Fellsway East. To reach the station from this intersection follow dirt road leading into woods from the N.W. quandrant of the intersection north for about 700 feet to a fork in the road. On left side of road there is a hiking trail marked with paint leading up ledge S.W. to summit about 450 feet away.

Station is marked by a drill hole in a brass plug set in ledge about 12 ft. N. of highest point of ledge. Ledge area at summit is about 80 ft. long running north to south and 30 ft. wide east to west.

ADJUSTED 1984

RECOVERED 6/91-MCS

62-20

The linked US Data sheet: https://www.ngs.noaa.gov/cgi-bin/ds_mark.prl?PidBox=MY2354

The NGS Data Sheet

See file dsdata.txt for more information about the datasheet.

```
PROGRAM = datasheet95, VERSION = 8.11
1        National Geodetic Survey,   Retrieval Date = JANUARY 10, 2017
 MY2354 ***********************************************************************
 MY2354  DESIGNATION -  BOOJUM
 MY2354  PID         -  MY2354
 MY2354  STATE/COUNTY-  MA/MIDDLESEX
 MY2354  COUNTRY     -  US
 MY2354  USGS QUAD   -
 MY2354
 MY2354                        *CURRENT SURVEY CONTROL
 MY2354 ______________________________________________________________________
 MY2354* NAD 83(1996) POSITION- 42 26 22.90561(N) 071 05 00.52999(W)   ADJUSTED
 MY2354* NAVD 88 ORTHO HEIGHT -    82.3   (meters)      270.    (feet) VERTCON
 MY2354 ______________________________________________________________________
 MY2354  GEOID HEIGHT    -        -27.547 (meters)                    GEOID12B
 MY2354  LAPLACE CORR    -          2.52  (seconds)                   DEFLEC12B
 MY2354  HORZ ORDER      -  SECOND
 MY2354
 MY2354.The horizontal coordinates were established by classical geodetic methods
 MY2354.and adjusted by the National Geodetic Survey in June 1998.
 MY2354.
 MY2354.The NAVD 88 height was computed by applying the VERTCON shift value to
 MY2354.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)
 MY2354
 MY2354.Significant digits in the geoid height do not necessarily reflect accuracy.
 MY2354.GEOID12B height accuracy estimate available here.
 MY2354
 MY2354.The Laplace correction was computed from DEFLEC12B derived deflections.
 MY2354
```

MassDOT Geodetic Data Sheet:
http://services.massdot.state.ma.us/surveypdf/inline.aspx?mhdid=4915

massDOT Massachusetts Department of Transportation Highway Division

Geodetic Data Sheet

MassDOT Point ID: 4915
NGS Point ID: MY2354
Station Name: BOOJUM
Town: MALDEN
Quadrangle: BOSTON NORTH

Published Values

Horizontal

NAD83/96 (Meters):	Northing:	909991.703	Easting:	234269.314
NAD83/86 (Meters):	Northing:	909991.744	Easting:	234269.341
Data Source NAD83:	NGS-ADJ			
NAD27 (U.S. Feet):	Northing:	524863.01	Easting:	712299.65
Data Source NAD27:	NGS-ADJ			

Horizontal Order: 2nd **State Plane Coordinate Zone:** 2001

Vertical

Feature Name	ID	Class	County	State	Latitude	Longitude	Ele(ft)	Map	BGN Date	Entry Date
Boojum Rock	612710	Summit	Middlesex	MA	422629N	0710503W	279	Boston North	-	24-FEB-197

Here is the USGS, Geographic Names Information System (GNIS)
https://geonames.usgs.gov/apex/f?p=138:3:0::NO:3:P3_FID%2CP3_TITLE:612710%2CBoojum+Rock

USGS
Geographic Names Information System (GNIS)

Stop! Do not bookmark or copy/paste this URL before reading FAQs.

Feature Detail Report for: Boojum Rock

ID: 612710
Name: Boojum Rock
Class: Summit (Definitions)
Description: 1.2 mi SW of Melrose C.H.; Cities of Malden, Medford and Melrose.
Citation: U.S. Geological Survey. Geographic Names Phase I data compilation (1976-1981). 31-Dec-1981. Primarily from U.S. Geological Survey 1:24,000-scale topographic maps (or 1:25K, Puerto Rico 1:20K) and from U.S. Board on Geographic Names files. In some instances, from 1:62,500 scale or 1:250,000 scale maps.
Entry Date: 24-Feb-1974
*Elevation: 279/85

*Elevations in feet/meters from the National Elevation Dataset

Counties

Sequence	County	Code	State	Code	Country
1	Middlesex	017	Massachusetts	25	US

Coordinates (One point per USGS topographic map containing the feature, NAD83)

Sequence	Latitude(DEC)	Longitude(DEC)	Latitude(DMS)	Longitude(DMS)	Map Name
1	42.4414849	-71.0842191	422629N	0710503W	Boston North

CURIOSITY OF NOTE: the Lat / Long of 42.4414849, -71.0842191 is listed on the Boojum Rock Feature Detail Report, but it appears to correspond more closely to the location of BLOOM1934! So this information seems to be in error.

Oliver Map: http://maps.massgis.state.ma.us/map_ol/oliver.php

Official DCR Middlesex Fells Trail Map - http://www.mass.gov/eea/docs/dcr/parks/trails/fells.pdf

Spot Pond Brook Archaeological District Self-Guided Trail describes a trail marked beginning at 1 Woodland Road (approximately 42°27'22.22"N, 71° 5'12.90"W) which is the site of the MDC Recreation Department from many years ago. (There are actually markings throughout the trail area, and multiple locations where you can pick this trail up. The trail is relatively well traveled

> "Visitors can walk the trail while referencing the self-guided trail brochure, describing 150 years of water-powered industry. An easy trail."

The following image is a 40 acre part of conservation land, including the area known as Virgina Wood which was perhaps the first parcel of private land in the United States donated to public conservation.- thus becoming a cornerstone of the Middlesex Fells. There is a nice "Spot Pond Brook" trail.

Spot_Pond_Brook_Guide
http://www.friendsofthefells.org/wp-content/uploads/2014/04/Spot_Pond_Brook_Pamphlet_-_Final.pdf

You can find a number of photos of the Virginia Wood, including the dedication tablet, as part of the Olmsted #1513 project - see 1513: Metropolitan Park Commission, Middlesex Fells Reservation (3 albums) https://www.flickr.com/photos/olmsted_archives/sets/72157646786913248/
o 1513-114 (Virginia Wood tablet)

There are a number of state and federal databases of key locations, such as those “geodetic controls” which would have been the area of interest of the 1899 MIT Observatory.

Other Trail Blogs:

https://liveandlethike.com/2013/08/21/rock-circuit-trail-middlesex-fells-reservation-ma/

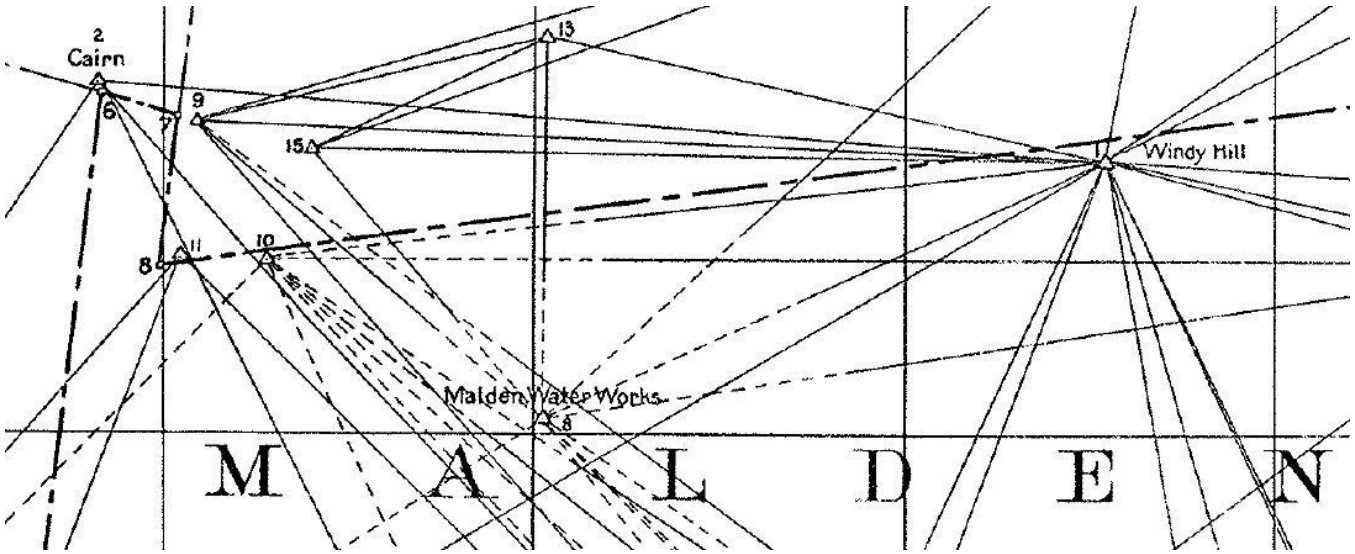
Friends of Fells map -
http://www.friendsofthefells.org/wp-content/uploads/2014/04/Fells_Reservation_Map.pdf and available for purchase thru http://www.friendsofthefells.org/maps/
Friends of Fells Trails - http://www.friendsofthefells.org/trails/

https://ngmdb.usgs.gov/maps/TopoView/
https://www.usgs.gov/media/videos/exploring-us-topo-geopdfs
https://nationalmap.gov/ustopo/

Lists and data sheets of marker disks etc across Massachusetts.
http://www.massdot.state.ma.us/highway/Departments/Survey/GeodeticControlData.aspx

7. Modern day GPS and navigating the future

TBD: More work being done on this section



Would you like to learn everything you can about our Global Positioning System - also known as GPS? A good place to start is with this Wikipedia article on the topic!

https://en.wikipedia.org/wiki/Global_Positioning_System

As a beginning point for comparison, we first take a look at the 1898 “Atlas of the Boundaries of the City of Malden”: http://gis.massdot.state.ma.us/Images/Survey/AllAtlases//Book%2008%20complete.pdf . From this, we proceed and take a look at the current day, and how these historical locations can be found.

In addition to some kind of coordinate location, important placemarks need to be described with words, maps and photographs.

Descriptions of Triangulation Stations (from 1898 Atlas Sheet 3)

6. MUSTANG - This station is situated on a ledge on high land in Middlesex Fells, Metropolitan Park System. It is 258.38 feet easterly from Malden corner 6, and can be easily found by the sketch of the same. (Marked with a triangle)

DESCRIPTIONS OF TOWN CORNERS (from 1898 Atlas Sheet 5)

CORNER 6

LOCATION - The corner is situated on very high land in Middlesex Fells, about 600 feet north of Spot Pond road, at a point about 1,300 feet westerly from its junction with Fells Parkway east. About 200 feet northerly from the corner is a large pile of stones about 8 feet high, known ad “the Monument” or “Cairn,” located upon a ledge. The corner is also about 250 feet southwesterly from the cart path which passes to the north of the “Cairn”.

MARK - The corner mark is a granite monument (apparently new) 3 feet in height and 6 1-2 x 8 inces in section. The letter S is cut on the northeast face, M on the northwest and southeast faces, and 7 on the southeast face.

DIRECTIONS - Follow the roadway which leads northerly from the end of tFells Parkway east about 1,600 feet to a branch road leading westerly, hence by this latter road about 1,600 feet to a cart path leading northerly, thence northerly along the cart path 300 feet and easterly by the same path about 200 feet, thence northerly through the woods about 150 feet to the bound.

CORNER 7

LOCATION - The corner is situated in Middlesex Fells on rough and rocky ground, in a growth of oaks containing a few scattering pines.

MARK - The corner mark is an irregular bowlder about 18 inches square and 2.2 feet high. It rests on a pile of stones and is marked M M S I.

DIRECTIONS - Follow Fells Parkway East about 160 feet northeasterly from Spot Pond Road to a flat rock; thence follow a cart path which leads northerly from this rock about 865 feet up a sharp incline to a large rock; thence 74 feet northeasterly from the cart path to the bound.

CORNER 8

LOCATION - The corner is situated in the woods in Middlesex Fells, at an intersection of stone walls, about 75 feet southerly from the “Bear’s den,” so called.

MARK - The corner mark is a rough granite monument 4 feet in height and 6 1-2 x 9 inces in section. The letters M M M are cut on the north, east, and west faces.

DIRECTIONS - Follow Fells Parkway East about 517 feet, northerly from the point where it intersects the street which leads westerly from the Summer Street known as the South Boundary road of the east section of the Middlesex Fells Reservation; thence westerly about 45.5 feet to the bound.

Technical Notes on GPS Math

Over time, methods have changed for recording coordinates and location.

The coordinates provided in the 1898 “Atlas of the Boundaries of the City of Malden” (which is available http://gis.massdot.state.ma.us/Images/Survey/AllAtlases//Book%2008%20complete.pdf) are not directly usable in a modern day GPS. The coordinates from the 1898 Atlas make reference to an older Geoid (presuming a Clarke ellipsoid but antedating 1901 datum that precedes NAD27.)

The coordinates listed on SHEET 2 of the 1898 survey, and shown below, would get you into a close proximity of designated destinations (e.g. within about 50 yards) but they are far from exact.

GEOGRAPHICAL POSITIONS OF TOWN CORNERS.

	CORNER	LATITUDE	LONGITUDE	TO COR.	AZIMUTH	BACK AZIMUTH	TRUE BEARING	DISTANCE METERS	DISTANCE FEET
1	Everett – Malden – Medford			2	Follows the	thread of Mal-	den river (old	channel).	
2	Malden – Medford 4			3	Follows the	thread of Little	Creek.		
3	Malden – Medford 3			4	Follows the	old thread of	Little Creek.		
*W. M. 3	Malden – Medford 3 (W. M.)	42° 24′ 54.64″	71° 04′ 47.70″						
4	Malden – Medford 2	42 25 04.69	71 05 10.95	5	168° 25′ 12″	343° 25′ 05″	N. 16° 35′ W.	810.0	2658
5	Malden – Medford 1	42 25 29.85	71 05 21.06	6	186 30 28	6 30 35	N. 6 30 E.	2212.0	7257
6	Malden – Medford – Stoneham	42 26 41.08	71 05 10.09	7	285 58 55	105 59 04	S. 74 01 E.	301.4	989
7	Malden – Melrose – Stoneham	42 26 38.39	71 04 57.41	8	6 39 02	186 39 00	S. 6 39 W.	570.4	1871
8	Malden – Melrose 1	42 26 20.03	71 05 00.30	9	262 04 25	82 06 44	N. 82 04 E.	4741.6	15556
9	Malden – Melrose – Revere – Saugus	42 26 41.17	71 01 34.81	10	327 57 04	147 57 17	S. 32 03 E.	846.4	2777
10	Malden – Revere 1	42 26 17.92	71 01 15.16	11	22 16 53	202 16 48	S. 22 17 W.	426.8	1400
11	Malden – Revere 2	42 26 05.12	71 01 22.24	12	22 32 50	202 32 36	S. 22 33 W.	1262.2	4141

GEOGRAPHICAL POSITIONS OF TRIANGULATION STATIONS.

	NAME OF STATION	LATITUDE	LONGITUDE	AZIMUTH	BACK AZIMUTH	TO STATION	DISTANCE METERS	DISTANCE LOGARITHMS
1	Windy Hill	42° 26′ 32.812″	71° 02′ 27.572″	278° 47′ 17″	93° 51′ 44″	Little Nahant 2	9055.4	3.956906
				349 55 51	169 56 15	Powderhorn 2	4646.1	3.667084
2	Cairn	42 26 42.53	71 05 11.01	333 23 47	153 25 18	Naval Hospital	6899.4	3.83881
				33 55 27	213 54 04	Tufts College Flag Pole	5044.1	3.70278
3	East End	42 26 20.556	71 01 13.393	11 53 56	191 53 30	Powderhorn 2	4288.3	3.632288
				102 35 08	282 34 18	Windy Hill	1737.1	3.239815
4	Powderhorn 2	42 24 04.564	71 01 52.055	18 10 42.7	198 07 20.4	Blue Hill	22100.3	4.344397
				85 40 59.6	265 31 58.0	Prospect, Waltham	18426.6	4.265445
				244 12 16	64 15 19	Little Nahant 2	9134.5	3.960685
5	Tufts College Flag Pole	42 24 26.870	71 07 14.112	319 38 24.8	139 40 41.7	Boston State House	7176.4	3.855904
				25 12 22.4	205 11 24.2	Mount Auburn Tower	4634.8	3.666035
6	Mustang	42 26 37.494	71 04 54.183	272 27 10	92 28 49	Windy Hill	3353.8	3.525536
				318 33 31	138 35 34	Powderhorn 2	6293.3	3.798875
7	Malden W. W.	42 26 01.681	71 03 58.264	245 07 41	65 08 42	Windy Hill	2284.6	3.358813
				321 22 55	141 24 20	Powderhorn 2	4624.7	3.665079
8	Dutton's N. Summer House	42 26 20.985	71 04 43.354	263 16 48	83 18 20	Windy Hill	3124.7	3.494806
				335 56 42	155 57 54	Naval Hospital	6027.6	3.780146

This Technical Note is provides a bit of background on this, including specific details which you could use to compare the “old” and the “new” coordinate systems by yourself.

You can begin reading about more of the evolutionary background of these navigational systems and the modern foundations of GPS at https://en.wikipedia.org/wiki/World_Geodetic_System#WGS84:

> “The World Geodetic System (WGS) is a standard for use in cartography, geodesy, and navigation including GPS. It comprises a standard coordinate system for the Earth, a standard spheroidal reference surface (the datum or reference ellipsoid) for raw altitude data, and a gravitational equipotential surface (the geoid) that defines the nominal sea level.

> The latest revision is WGS 84 (a.k.a. WGS 1984, EPSG:4326), established in 1984 and last revised in 2004.[1] Earlier schemes included WGS 72, WGS 66, and WGS 60. WGS 84 is the reference coordinate system used by the Global Positioning System."

A question arises - what happens to all those "old coordinates" that might be lying around, such as the ones used in the City of Malden Survey, documented in the 1898 Atlas?

If you have coordinates that are NAD27 based , you can convert them with

https://www.ngs.noaa.gov/cgi-bin/nadcon.prl

Converting from USD01/NAD13/C1866 is an inexact science.

But more to the point of the City of Malden survey history, there is a relevant discussion of coordinate conversations related to Massachusetts Atlases and USSD coordinates at this link:

https://rplstoday.com/community/threads/converting-from-lat-long-clarke-spheroid-to-spc.326148/

One commenter wrote, "This thread is the clearest, simplest explanation of conversions, and locations, that has ever been posted on this site. Thanks to all for keeping it simple!" It is well worth reading if you are interested in delving into this further. In the following write-up, we'll convert some of the "old" coordinates into the new, modern coordinate system!

According to 1898 Atlas

Geographical Positions of Town Corners (according to sheet 2 of 1898 Atlas)

6. Malden-Medford-Stoneham Lat: 42 26 41.08 Lon: 71 05 10.09 - 42 26 41.08N,71 05 10.09W
7. Malden-Melrose-Stoneham Lat: 42 26 38.39 Lon: 71 04 57.41 - 42 26 38.39N, 71 04 57.41W
8. Malden - Melrose Lat: 42 26 20.03 Lon: 71 05 00.30 - 42 26 20.03N, 71 05 00.30W

NOTE: Corners 6, 7, 8 in the Atlas are approx 40 - 50 yards off Google Earth, etrex, and camera phone

Geographical Positions of Triangulation Stations (according to sheet 2 of 1898 Atlas)

2. Cairn Station Lat: 42 26 42.58 Lon: 71 05 11.01
6. Mustang Station Lat: 42 26 87.494 Lon: 71 04 54.183

According to Google Earth (in 2017)

Estimates (by placing pushpins along borders drawn by Google Earth)

6. Malden-Medford-Stoneham (40 yards off Atlas?) 42°26'40.86"N 71° 5'8.50"W
7. Malden-Melrose-Stoneham (50 yards off Atlas) 42°26'38.37"N 71° 4'55.21"W
8. Malden - Melrose (50 yards off Atlas) 42°26'19.93"N 71° 4'58.30"W

According to site visit GPS measures (in 2017)

Camera phone GPS measurement

6. Malden-Medford-Stoneham (Monument near Cairn) 42 26 37.6N, 71 5 8.22W
7. Malden-Melrose-Stoneham (Funny Rock) 42 26 28 4N, 71 5 5.61W
8. Malden - Melrose (Jerry Jingle Monument) 42 26 16.2N, 71 4 58.6W
** READING from Camera Phone GPS off substantially relative to Google Earth and etrex
Cairn Station 42 26 32.3N, 71 4 57W
Mustang Station 42 26 37.3N, 71 4 53W

Garmin etrex GPS measurement

6. Malden-Medford-Stoneham (Monument near Cairn) N42 26.681, W071 05.140
7. Malden-Melrose-Stoneham (Funny Rock) N42 26.637, W071 04.927
8. Malden - Melrose (Jerry Jingle Monument) N42 26.331,W071 04.976
Cairn Station N42 26.706, W071 5.154
Mustang Station N42 26.622, W071 04.873

Modern systems document town corners and are available online:

- http://www.massdot.state.ma.us/highway/Departments/Survey/TownCornersData.aspx
- http://gis.massdot.state.ma.us/maptemplate/towncorners

Trans-Calculating from OLD to NEW coordinate

The following summarizes multiple points from the 1898 ATLAS translated and trans-calculated into modern coordinates programatically. This involves applying USSD1901 ->WGS84 MA offsets to atlas points

Transcribed points

Waypoint WindyHill
42 26 32.812, 71 02 27.572 USSD
42° 26' 32.668" N, 71° 02' 25.980" W (42.44241° , -71.04055)

Waypoint Cairn
42 26 42.53, 71 05 11.01 USSD
42° 26' 42.386" N, 71° 05' 9.418" W (42.44511° , -71.08595)

Waypoint Mustang

42 26 37.494 , 71 04 54.183 USSD
42° 26' 37.350" N, 71° 04' 52.591" W (42.44371° , -71.08128)

Waypoint Dutton's N Summer House
42 26 20.985, 71 04 43.354 USSD
42° 26' 20.841" N, 71° 04' 41.762" W (42.43912° , -71.07827)

Waypoint Corner 6 MMS
42 26 41.08, 71 05 10.09 USSD
42° 26' 40.936" N, 71° 05' 8.498" W (42.44470° , -71.08569)

Waypoint Corner 7 MMS (aka FUNNY ROCK)
42 26 38.39 , 71 04 57.41 USSD
42° 26' 38.246" N, 71° 04' 55.818" W (42.44396° , -71.08217)

Waypoint Malden Melrose 1 Corner 8
42 26 20.03 , 71 05 00.30 USSD
42° 26' 19.886" N, 71° 05' -1.292" W (42.43886° , -71.08297)

Points approx from map interpolation

procedure:

1. screen-shot one minute grid square of 1898 atlas map
2. rescale One Minute gridsquare to 600x600.
3. Coord from upper left x,y=(0,0) = (42 27', 71 05')
4. is tenths-of-seconds to subtract from NW corner,
5. or from 60" to add to SE corner (42 26', 71 04')

Waypoint Bears Den #11 interp (x=030, y=380)
USSD 42° 26' (60.0-38.0)", 71° 04' (60.0 - 0.30)"
USSD 42° 26' 22.0", 71° 04' 59.7"
WGS84 42° 26' 21.856" N, 71° 04' 58.108" W (42.43940° , -71.08281)

Waypoint Fells Bluff #15 interp (x=240 , y=256)
USSD 42° 26' (60.0 - 25.6)", 71° 04' (60.0 - 24.0)"
USSD 42° 26' 34.4", 71° 04' 36.0"
WGS84 42° 26' 34.256" N, 71° 04' 34.408" W (42.44285° , -71.07622)

FELLS BLUFF looks like very challenging rocks - and attempting a visit there not recommended excerpt for expert hikers and climbers with suitable safety precautions and plans in place.

check of procedure, test interpolating from map points also given in text

Waypoint Duttons North #10 interp (x=167 y=388)
USSD 42° 26' (60.0 - 38.8)", 71° 04' (60.0 -16.7)"
USSD 42° 26' 21.2", 71° 04' 43.3"
WGS84 42° 26' 21.056" N, 71° 04' 41.708" W (42.43918° , -71.07825)
CHECK FROM TABLE:
USSD 42 26 20.985, 71 04 43.354 *given in table ... just a few pixels !*
Within 30' of DUTTONS MAGS 1934, which is rounding error level

Waypoint Mustang #9 interp (x=056, y=222)
USSD 42° 26' (60.0 - 22.2)", 71° 04' (60.0 - 05.6)"
USSD 42° 26' 37.8", 71° 04' 54.4"
WGS84 42° 26' 37.656" N, 71° 04' 52.808" W (42.44379° , -71.08134)
CHECK FROM TABLE:
USSD 42 26 37.494 , 71 04 54.183 *given in table ... just a few pixels*

For our research on this, we used a number of pieces of hardware and software, most of which are readily available online or from online marketplaces (like Amazon.com) or “big box” stores..

HARDWARE

Garmin eTrex Venture HC
Garmin GPSMAP 78sc
Future hardware? A GPSMAP 76CSx or greater! (These include sd-card and altimeter)

SOFTWARE

Google Earth
http://wiki.openstreetmap.org/wiki/OSM_Map_On_Garmin/Download
http://www.gpsvisualizer.com/elevation
https://www.youtube.com/watch?v=237pVwC3fNk
PRUNE - edit GPS tracks and synchronize GPS and Camera post facto

Websites

We’ve established the following website in an effort to better create, document and share common tools and techniques for navigating trails: www.DigitalTrailGuides.com

8. The Math and Science of Geodesy: Educational Programs

TBD: More work being done on this section

NASA described Geodesy succinctly:

> "Geodesy is the science of where things are, where they have been and where they are going."
>
> From "Looking Down a Well: A Brief History of Geodesy" NASA Goddard Media Studies, on February 23, 2012, http://svs.gsfc.nasa.gov/vis/a010000/a010900/a010910/

Wikipedia provides a few more background details:

> "Geodesy … also known as geodetics, geodetic engineering or geodetics engineering — a branch of applied mathematics [2] and earth sciences, is the scientific discipline that deals with the measurement and representation of the Earth (or any planet), including its gravitational field, in a three-dimensional time-varying space. Geodesists also study geodynamical phenomena such as crustal motion, tides, and polar motion. For this they design global and national control networks, using space and terrestrial techniques while relying on datums and coordinate systems."
> (https://en.wikipedia.org/wiki/Geodesy)

Geodesy has advanced tremendously since the historic - and now technologically ancient - turn-of-the-century installation at Middlesex Fells. MIT's established the Haystack Observatory (http://www.haystack.mit.edu/) in 1970 addresses similar science and research issues. The technology has advanced and the landscape footprint has expanded tremendously. MIT's Geodetic research operations are now part of 1,300 acres of related research activities in Groton, Tyngsborough, and Westford.

There has been a remarkable progression in the technology employed by Geodesy - and in many cases it has been a confluence of multiple techniques and technologies which has led to great advance:

In a History of Geodesy, Wikipedia notes: "The invention of the telescope and the theodolite and the development of logarithm tables allowed exact triangulation and grade measurement."

You can read more:

Telescopes - https://en.wikipedia.org/wiki/Telescope
Theodolite - https://en.wikipedia.org/wiki/Theodolite
Log tables - https://en.wikipedia.org/wiki/Common_logarithm

You can get a taste of the scientific advances underway through some of the published journal articles:

> "High-precision global reference frames are needed for precise positioning in geodesy, for navigation on the Earth and in space, for Earth and space research, and for applications in precision surveying. This is particularly true if satellite-based navigation systems such as GPS and GLONASS (or the future GALILEO) are employed. An inertial reference frame that is fixed in space is needed for orbit determination of space vehicles, of the moon and the planets, and for the description of the positions of stars and extragalactic sources. An Earth-fixed reference frame, i.e. a frame rotating with the Earth, is required for point positioning on the Earth. These two reference frames are connected through the dynamic motions of the Earth in space, including rotation, polar motion, nutation, and precession." See "IVS High Accurate Products for the Maintenance of the Global Reference Frames as Contribution to GGOS" by Schluter, W.; Behrend, D.; Himwich, E.; Nothnagel, A.; Niell, A.; Whitney, A. 2006, "IVS high accuracy products for the maintenance of the global reference frames as a contribution to GGOS," Proceedings, International Association of Geodesy General Assembly 2005
> Source:
> http://www.haystack.mit.edu/geo/pubs/schlueter_IAG2005_IVS_GGOS%20after%20review%20paper_clean.pdf

Here are some ideas:

Malden 7 - 12 Youth Program (proposed)
Team projects and afterschool activities.
"Observatory Revitalization" project (to update the DCR kiosk with information on the site

The authors would like to see elements of this document aligned with
http://www.doe.mass.edu/frameworks/current.html

And

http://www.doe.mass.edu/frameworks/math/0311.pdf

Trail Detectives' Club
Looking for a new afterschool activity? Drop-in anytime to this fun and hands-on nature club. We will...
http://boston.eventful.com/events/trail-detectives-club-/E0-001-033717844-0
Boston Nature Center and Wildlife Sanctuary
500 Walk Hill Street, Mattapan, MA 02126, 617-983-8500
bnc@massaudubon.org

MIT's Survey Camp
Survey Held a "Survey Camp" - and there's vintage video of the camp held in Maine:

MIT's "Camp Technology" - vintage video from 1936: https://www.youtube.com/watch?v=rRtOGgQHZkY

We will learn more about this.

http://www.learningace.com/doc/82347/d342cc2d0c5b64e3ad6596a197a4a00d/tech_v042_s0105_p001

CAMBRIDGE, MASS., MONDAY, OCTOBER 2, 1922

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IBS HOLD
EDNESDAY

Glee, Banjo
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club try-outs on
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ent will be start-

SURVEYING GAMP AT EAST MACHIAS CLOSES

Prof. Hosmer in Charge of Instruction—Course for Advanced Students

94 MEN ENCAMPED

The Surveying Camp maintained by the Institute each summer near East Machias, Maine, ended this year's session Friday, September 22. Its 94 campers arrived in Boston the next morning after their seven weeks' stay on the shore of Gardners Lake.

The courses this year were under the supervision of Professor G. L. Hosmer, Associate Professor of Geodesy at the Institute, and were made up almost entirely of outdoor work, with rainy days reserved for the drafting room and problems.

Miners Left Early in Summer

The regular course in connection with Course I at the Institute consisted of 60 hours Stream Gaging and Hydrographic Surveying, 75 hours Railway Curves and Field Work, 100 hours Plane Surveying and 100 hours

GREETINGS FROM T

To the Class of 1
those who come to u
sister institutions,
those from many
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a cordial welcome.
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H. P. TAL

TRACK MANAGE
CANDIDATES

Freshman Competit
Eligible for C
Country Pos

THREE TO BE RET

This is a notice from 1922 that camp was closed (for the summer!)

GIS tends to view the Geomatics data as an input to a communications process on another topic, not an end in and of itself. Geodesy is a component, predecessor, or prerequisite for Geomatics, depending on how broad or narrow the definitions.

http://gisgeography.com/geomatics-gis-difference/

9. References and Terminology

TBD: More work being done on this section

The sign appears to have been created in MIT's official color scheme, with the paint approximating

MIT's official colors are described here: http://web.mit.edu/graphicidentity/colors.html -

Pantone 101-C translates to RGB of 157, 34, 53
http://rgb.to/pantone/201-c

The official MIT color is somewhere between maroon and dark candy apple red.

http://www.workwithcolor.com/red-color-hue-range-01.htm

Malden 1898 atlas, shows the survey triangulation.

Official / Atlas Surveys

NOTE: CAIRN station used in surveying the Malden... along with Bears Den and Dutton and other points in the FELLS but not BLOOM or BOOJUM.
Note there is a typo giving the distance from C.6 to Mustang, but means C.7 ...

See the 1898 survey report on Malden:
http://gis.massdot.state.ma.us/Images/Survey/AllAtlases//Book%2008%20complete.pdf

(Points on Everett line apparently in book 11)

Can get a modern table of corners via
http://www.massdot.state.ma.us/highway/Departments/Survey/TownCornersData.aspx

The MIT Geodetic Observatory was established in the Middlesex Fells Reservation in 1898 by the MIT Civil Engineering Department.

You can find a background article by George L. Hosmer, "The Geodetic Observatory at Middlesex Fells," in The technology Quarterly, Vol. 12, No. 2 of June 1899, on pages 135 - 144. You can find Hosmer's essential article at https://goo.gl/oXzf0o

You can also find a reference to this in the "Massachusetts Institute of Technology," publication Engineering, Vol. 67, May 26, 1899 on page 685.

Additionally, "The Geodetic Observatory" was featured in The Technology Review, Vol. 1, no. 2 (April 1899), pages 170 - 171, with illustration of the observatory by Charles H. Woodbury (1864 - 1940). The building was designed by architect Eleazer b. Homer (1864 - 1929). Permission was granted by the MPC, and the structure was required to be built of local field rock.

Geodesy including Astronomical Observations, Gravity Measurements, and Method of Least Squares, by George L. Hosmer, Associate Professor of Topographical Engineering, Massachusetts Insitutute of Techonlogy, First Edition, New York, New York, 1919, a digitized version by Google and uploaded to https://archive.org/details/geodesyincludin00hosmgoog

Navigation, First Edition, By George L. Hosmer, Text-Book on Practical Astronomy (214 pages), a digitized version by Google and uploaded to https://archive.org/details/navigation00hosmgoog

Azimuth, Second Edition (78 pages), 1916, by George L. Hosmer, a digitized version by Google and uploaded to https://archive.org/details/azimuthhosmergeo00hosmrich

Text-book on practical astronomy, by Hosmer, George L. (George Leonard), 1874-1935, Published 1910, a digitized version by Google and uploaded to https://archive.org/details/textbookonpract01hosmgoog

The Principles and Practices of Surveying, By Charles B. Breed and George L. Hosmer
Vol I, Elementary Surveying, Fourth Edition (610 pages)
Vol II, Higher Surveying, second edition (460 pages)
a digitized version by Google and uploaded to https://archive.org/details/principlesandpr00bonegoog

“Geodesy for the Layman” was originally published by the United States Air Force in 1959. Last revised in 1984, it is now maintained by the National Imagery and Mapping ...
See www.ngs.noaa.govngs.noaa.gov/PUBS_LIB/Geodesy4Layman/TR80003A.HTM (obsolete)

Additional References and Links

Malden GIS Parcel Viewer
https://maldenma.mapgeo.io/

Guides
http://adventure.howstuffworks.com/destinations/trail-guides/appalachian-trail-hiking-guide.htm
http://www.appalachiantrail.org/about-the-trail/history

US Geological Survey - https://www.usgs.gov/

Trail Terms
http://www.rmghadventures.com/trailterms.htm

Thru-hiking the Appalachian Trail
http://www.appalachiantrail.org/home/explore-the-trail/thru-hiking
http://www.appalachiantrail.org/docs/default-source/default-document-library/stepbystep.pdf?sfvrsn=26

Recommended Standardized Trail Terminology for Use in Colorado
http://www.americantrails.org/resources/info/TrailTermCOTI.html

Hiking Glossary - http://www.davidalbeck.com/hiking/glossary.html#h

http://earth-info.nga.mil/GandG/publications/geolay/toc.html
Search domain www.dtic.mildtic.mil/dtic/tr/fulltext/u2/a142764.pdf

1. http://gisgeography.com/geomatics-gis-difference/
2. https://www.ngs.noaa.gov/PUBS_LIB/Geodesy4Layman/TR80003A.HTM
3. http://earth-info.nga.mil/GandG/publications/index.html
4. http://earth-info.nga.mil/GandG/publications/geolay/toc.html

USGS SDTS format Digital Elevation Model data (DEM)
http://data.geocomm.com/dem/ and https://en.wikipedia.org/wiki/Digital_elevation_model

You can find a few introductory details in "A Guide to Related Archival Collections Outside of the DCR Archives pertaining to the Metropolitan Parks System, the Metropolitan Water Works System, and the State Forests and Parks System" compiled by Sean M. Fisher, Archivist, DCR Archives, Office of Cultural

DCR Files and References

"Resources, Bureau of Planning, Design and Resource Protection, Massachusetts Department of Conservation and Recreation" (April 8, 2009, First Release with a June 9, 2015 Update)
http://www.mass.gov/eea/docs/dcr/stewardship/cultural-resource/guidetorelatedarchivalcollections.pdf

> This DCR guide refers to the following articles (with photos and illustration):
> George L. Hosmer, "The Geodetic Observatory at Middlesex Fells," The Technology Quarterly, Vol. 12, No. 2 (June 1899), pp. 135-144
>
> "Massachusetts Institute of Technology," Engineering, Vol. 67 (May 26, 1899), p. 685, c. 1 "The Geodetic Observatory," The Technology Review, Vol. 1, No. 2 (April 1899), pp. 170-171 with illustration of observatory by Charles H. Woodbury (1864-1940).
>
> The Observatory building was designed by architect Eleazer B. Homer (1864-1929)

Henry F. Bryant, "Topographical Surveys of the Metropolitan Park Reservations of Massachusetts,"*Journal of the Association of Engineering Societies* 18 (April 1897): 252-264.
is https://archive.org/stream/journalofassoci181897asso#page/n7/mode/2up

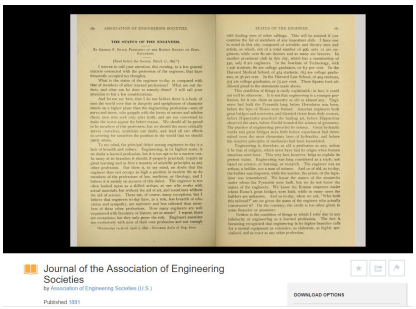
Full text of "Journal of the Association of Engineering Societies" can be found online at the following link: https://archive.org/details/journalofassoci181897asso - - see especially pages 180 ff and 252 ff

DCR provided us with pointers to fascinating journal articles about the state of Engineering and also surveying of the Middlesex Fells in the late 1890s. You can find reprints and a description of those at

> http://www.publicactionnetwork.com/Observatory/DCR/DCR-Reference.html

A description of some key related documents DCR has on file are described at:

http://www.publicactionnetwork.com/Observatory/DCR/MPC-topographicalsurveyrecords.pdf



10. Community Goals for The MIT Geodetic Observatory

The MIT Observatory has fallen into disuse and disrepair over the years but it is a scientific and historic treasure. In approximately 2010, a number of enhancements were made to the site with an excellent interpretive bulletin board and information kiosk. This provided recognition of the significance of this site, and the added attention and respect helped to cut down on previously observed instances of littering.

Geodesy has grown larger and more pervasive and expanded into different academic disciplines. This is a crucial academic arena and technology critical to modern life. You can learn more about MIT's current activities (in Geodesy and Geodynamics) at http://geoweb.mit.edu/.

The area is very deserving of added, ongoing attention to protect and preserve the significance of this site and the community benefits it offers. As of January 2017, the following actions are proposed:

- Enhance trail markings (e.g. "MIT Trail)
    - The signpost near the public parking area on Fellsway East displays an invitation to visit the "1899 MIT Observatory Rock Circuit Trail.' Apart from that sign, there are guides or specially blazed trails to find your way to the Observatory markers.
- Create an official "MIT Geodetic Observatory Trail"
    - include station markers such as BLOOM1934 and BOOJUM
- Revitalize interpretive bulletin board / kiosk at the Observatory site
    - Upkeep
    - Fresh paint, replace broken - general maintenance and upkeep
    - Plexiglass replacement
    - Replace missing research pages / Laminate pages with more comprehensive history and science poster
    - Consider providing "digital URL" at sign to supplemental printed information source
- Repair / Repaint Boojum Rock signpost, located at DCR Gate 55
- Request DCR paint crosswalk over East Border, near McCormack
    - make site access safer and more accessible / walkable
- Implement Prototype Educational Program
    - Malden Summer Youth Program

    - School Based Science / Math Field Trip
- Schedule “Earth Day” or “May Day” Volunteer Clean-up of “MIT Geodetic Trail”

Community Goal Images

Boojum Rock signpost near DCR gate 55

General (lowcost) upkeep needed: Paint, repaired plexiglass,

and replaced information sheets

Improved signage / trail blazing needed - “MIT Trail” alternatives needed for easier access

Crosswalk needed across DCR-maintained East Border Road, Malden, to provide pedestrian access to Jerry Jingle Road, at DCR gate 55.

10. “Missing Rocks” and unanswered questions

This quest began as a search to answer our curiosity about the MIT Geodetic Observatory. Once we found the Observatory, there was an immediate sense that it was even more historically significant and visually impressive than we had originally anticipated.

Along the way, we also found a few other things that were unexpected.

As ironic as it seems - most of the other discoveries involve missing or incorrect measures related to well-known locations. Somehow, these measures had either been forgotten or mis-located in increasingly complex and interdependent information systems! Here’s a short summary:

A summary of “missing rocks” and unanswered questions

1. Wikipedia has geography details for the City of Malden that are wrong (Wait's Mount can NOT be taller than MIT Observatory peak) https://en.wikipedia.org/wiki/Malden,_Massachusetts
2. Friends of the Fells Map doesn't list the MIT Observatory (even though the DCR Map does - weve reached out to FriendsOfFells on this) See the map at this link: http://www.friendsofthefells.org/wp-content/uploads/2014/04/Fells_Reservation_Map.pdf
3. MassGIS/MassDOT is missing BLOOM1934 entirely - at this link http://www.massdot.state.ma.us/highway/Departments/Survey/GeodeticControlData.aspx
4. GNIS is missing BLOOM1934 entirely - https://geonames.usgs.gov
5. GNIS lists Boojum in the wrong place - https://geonames.usgs.gov/apex/f?p=138:3:0::NO:3:P3_FID,P3_TITLE:612710,Boojum%20Rock
6. Google Earth is excellent and free. But it lists Boojum Rock in the vicinity of where BLOOM1934 is located. This suggests Google Earth may be using the same bad data found in GNIS - it’s a good example of how bad data percolates through systems reliant on location information.
7. Topozone is wrong (which is a good example of how bad data can be fed downstream into other systems - the "fake news" problem of the dot-com era - since they likely get their data from GNIS)
8. The Massachusetts State-based "Oliver" system is "wrong" - it places Boojum in Medford - perhaps attempting to make an aesthetic adjustment, however, it makes it impossible to accurately locate where Boojum rock actually is - http://maps.massgis.state.ma.us/map_ol/oliver.php
9. Do we need additional names summit/s looming above Boojum Rock?
    a. Possibly: GNIS name needed for the MIT Observatory site? for BLOOM1934?
10. There appears to be a typo in the 1898 Atlas, Sheet 3, description of the MUSTANG Triangulation Station, where it states “This station is situated on a ledge on high land in Middlesex Fells, Metropolitan Park System. It is 258.38 feet easterly from Malden corner 6, and can be easily found by the sketch of the same. (Marked with a triangle)” The description appears to INCORRECTLY locate the MUSTANG station in close proximity to CORNER 6 - it is NOT close to CORNER 6 as defined by the Atlas. The description on Sheet 3 accurately approximates distance between the MUSTANG station and Malden-Melrose-Stoneham City Corner (which is CORNER 7) - see 1898 “Atlas of the Boundaries of the City of Malden”: http://gis.massdot.state.ma.us/Images/Survey/AllAtlases//Book%2008%20complete.pdf .
11. other related mysteries ?...

Some of this gets a bit technical, and relates to information that is getting incorrectly added in one place, and then flowing into other systems. These changes, and errors, are subtle, but they are deeply interesting to study and decipher, because it forces you to develop a deeper understanding of the math, science of the past that created and recorded this datum. In addition, though, it brings this historic data into the modern era of the information age and you begin to see how local, state, and federal information systems are closely coupled and dependent on each other.

The following Appendices have been provided courtesy of the Massachusetts Department of Conservation and Recreation

Appendix 1

THE GEODETIC OBSERVATORY AT MIDDLESEX FELLS.
By GEORGE L. HOSMER.
(from "The Technology Quarterly", Vol. XII, MIT 1899)
Read April 13, 1899.

The present year marks a radical change in the course of instruction in geodesy at the Institute. The occasion is the completion of a geodetic observatory at Middlesex Fells, where instruction is now given in astronomical observations such as will prepare students for the career of observer in geodetic work. This new feature of the course is the result of the efforts of Professor A. E. Burton to establish a laboratory where geodetic measurements may be made. The introduction of work of this character into the course gives the student an insight into the practical side of geodetic operations, and it creates an interest in the subject and gives a reality to it which class work alone could never do. It will enable the Institute to send out men who have that confidence in their own power which laboratory work of the right kind is able to give.

This observatory is not so general in character as an "astronomical observatory," but confines itself to such observations as have a direct bearing on geodetic work. It corresponds very nearly to the regular astronomical station of the Coast and Geodetic Survey, the chief difference being that it is of a more permanent character. An astronomical station may be defined as a point whose exact position on the earth's surface has been determined (astronomically), and where any data needed in geodetic operations have been obtained. These stations serve two purposes: First, they are of primary importance in the solution of the problems of geodesy, and have, therefore, a use of a purely scientific nature. Second, they have a practical application in geodetic surveying. The character of the observations is in either case the same, namely, the location of the point upon the earth's surface, and finding the direction of some line of the survey. At this observatory all of the observations are of this character, and all are concerned with geodetic operations.

The part which the astronomical station plays in these problems may be better understood if we inquire a little more closely into the nature of the problems themselves. In the first case before mentioned, observatory is in the southeastern portion of Middlesex Fells, about one mile from the city of Malden. The nearest point on the railroad is at a distance of two-thirds of a mile, and the nearest highway is over a quarter of a mile away. The nearest park road (where only light travel is allowed) is 460 feet distant. There is little danger under these circumstances that much trouble will be caused by vibrations. The atmosphere is very clear, on account of the elevation of the point and its distance from all settled districts; this is a condition which could not be reached near a city. In regard to magnetic

disturbances the spot is well chosen. The nearest electric current is one-quarter of a mile away, and moving masses of iron such as carriages and bicycles cannot approach nearer than about 460 feet. This is a condition not easy to obtain in combination with so many other advantages. The number of triangulation points visible is quite large, including Blue Hill, Prospect Hill, State House, Nahant, Powderhorn, Tufts College, and Bear Hill. These are all important points in the Massachusetts system of triangulation, and make it easy to determine the position of the observatory very accurately. The building itself is about 15 feet square, and is built of the field stone found in the vicinity. It is set upon an outcropping ledge whose elevation is about 290 feet above mean tide. There is a clear horizon in nearly all directions. In the roof of the building is a slit about 14 inches wide extending in the north and south direction. The pier on which the instrument is mounted is placed directly underneath this opening. It is set directly upon the ledge, and built up to a height of about 3 feet above the floor. It is made of brick, and is capped with a stone about 2| feet square and 4 inches thick. The instrument is mounted so as to swing in the plane of the meridian. The opening in the roof is extended down the walls to about the level of the top of the pier, so that any portion of the meridian (above the horizon) may be seen. By placing the pier a little out of the central position, it was found possible to see Blue Hill and Prospect, through the windows from the pier, thus avoiding an eccentric station in locating the point by triangulation.

The instrumental outfit consists of a 2-inch portable transit instrument provided with a micrometer and a level for latitude observations, a chronometer and a chronograph. With these instruments latitude, time, and longitude observations may be made. Beside these there is a complete magnetic outfit («. *e.,* a magnetometer and a dip circle), and an alt-azimuth instrument with circles reading to seconds by means of microscopes. A pendulum apparatus es now being made for this observatory. These instruments, together with several smaller ones, make up an outfit with which all of the observations necessary in geodetic work can be made. With this equipment the students of geodesy have been carrying on a regular series of observations for latitude, time, and longitude. The latitude observations have been made both with the zenith telescope and the vertical circle. The two sets of results show a close agreement. In the longitude work the method of moon culminations has been used chiefly. A little later this observatory will have a wire from one of the telegraph offices, so that it may be connected with other observatories, and its longitude very accurately found by the "telegraphic method."

A brief description of the method of making and recording these observations may not be out of place here. The transit instrument, with which the time observations are made, is mounted so as to revolve in the plane of the meridian. In the "field" of the telescope are five vertical threads (spider threads stretched across a metal ring). These are spaced so that a star at the equator travels from one thread to the next in about twelve seconds. The observation consists in noting the time that the star crosses each thread and recording it. After the proper instrumental corrections are applied to these times the result is a measurement of the local sidereal time at the instant of the observations, and shows the error of the chronometer. The method of recording is that known as the "American method," *i.e.,* by chronograph. The essential parts of the instrument are a revolving cylinder carrying a sheet of paper, and a pen,

in contact with the paper, moving along an element of the cylinder. The two motions cause a spiral line to be traced on the sheet. The pen is attached to the armature of an electro-magnet, the coils of which are connected with a chronometer, a key, and a battery. This chronometer is arranged to break the circuit at regular intervals (two seconds), thus causing the pen to move sidewise and make a notch on the sheet. In this way the sheet is graduated into minutes and seconds of the chronometer time. When the observer wishes to record the instant that a star crosses a thread, he presses the key, and makes a notch on the paper between two of those made by the chronometer. The position of this notch is easily measured, and the corresponding time known within about a hundredth of a second. If the transit of the moon be included in the set of observations on stars, its position at the instant can be found; a comparison with the (known) Greenwich time when it had the same position gives the longitude of the place of observation. But a far more accurate way of finding longitude is by telegraph. The main line is so connected that records can be made at the same instant on chronographs at each end of the line. In this way the local times of the two places are directly compared so that the difference of longitude becomes known. Observations for latitude are most accurately made by the zenith telescope. The accuracy of the method depends upon the fact that the measurements are all differential. Such measurements are more easily and more accurately made than absolute values. Stars are selected in pairs, one north and one south of the zenith, and at nearly equal distance from it. A micrometer serves to measure the small difference of the zenith distances, while a spirit level shows the amount the telescope has moved between the two measurements. From these measures the latitude is easily deduced. The latitude of the observatory has also been found by measuring altitudes of the pole star, by means of an alt-azimuth instrument and a basis of mercury. These two independent determinations check each other very closely. These descriptions merely serve to show what kind of observations are being made and do not go into details. All of these methods are very fully explained in various reports and text-books. Examples of time and latitude observations are given at the end of this paper.

A considerable amount of work has been done here this year which has never before been possible at any of the Institute buildings, such, for example, as tests of delicate spirit levels, tests of pivots, etc. This is also quite true of the magnetic work. None of the observations previously made could be regarded as really valuable; all that was attempted was to teach the methods. At this place there is practically no local disturbance, and the observations ought to be trustworthy. In all of this work it is the aim to get reliable results, so that the student is actually observing, and not merely going through the manipulation in order to learn it. The work offers a large variety of problems, and the student is continually working at something new. He is thrown upon his own resources and held responsible for his results, just as he will be in his later experience. In this way he is trained to attack new problems, and is kept constantly on the watch for causes tending to affect the accuracy of his results.

The work that has been done this year is only a beginning, but it is a beginning under favorable conditions. When the latitude and longitude have been accurately determined and the position connected with the neighboring survey points, this observatory will become an important station in the Massachusetts system of triangulation. The location is an excellent one, and has everything in its favor for accurate work, so that the outlook for the future is very encouraging.

Following are the records of two sets of observations made at the observatory, given in order to show the kind of observations and the method of working them up. These are very nearly the same as those of the Coast Survey and other similar surveys, so that no special explanation will be necessary.

Appendix 2

THE GEODETIC OBSERVATORY

(from “Technology Review”, Vol. 1, No. 1, pp. 170-171, 1899)

“A Geodetic observatory is a necessary part of the equipment of an institution giving instruction in geodetic methods of surveying. The plans for the erection of such an observatory near Boston have been under discussion ever since the adoption of what is known as the Geodetic Option of the course in Civil Engineering, but it was not until May of 1898 that the observatory became an established fact.

This observatory is intended primarily to be used in giving instruction in the most refined methods of determining latitude and longitude, and secondarily to be used in magnetic and gravity observations.

A hill in the southeastern part of Middlesex Fells was chosen for the site. Here was found a firm foundation for the most delicate instruments, free from the vibrations caused by railroad and highway traffic, and not too far from Boston. There is an unobstructed view of the heavens and the horizon, with the two United States Coast Geodetic Survey triangulation stations at Blue Hill in Milton, and Prospect Hill in Waltham, in plain sight.

The park commissioners kindly granted permission to the Institute for the erection of the building, with the provision that it should be built of field rock, and with pleasing proportions. The exterior was designed by Professor Homer. The building is of stone; it is fifteen feet square, and contains the following apparatus, namely: a transit instrument of two and one-half inches aperture, twenty-seven inches focus, with a delicate level and micrometer eye-piece for latitude observations; a sidereal chronometer; a chronograph; a magnetometer; a dip circle; an altazimuth instrument, and various other smaller appliances, such as a heliotrope, a self-recording barometer, etc. During the present year it will be further equipped with a one-half second pendulum for determining the force of gravity.

Observations have been made during the past term for the determination of time, and on latitude by Talcott's method. Arrangements have been made for the determination of longitude by telegraph connection with the Cambridge observatory.

Much work has been done at the observatory that could not be performed before at any of the Institute buildings. This is especially true of the tests on delicate spirit levels, and the

determinations of constants depending on such observations. The freedom of the observatory from vibrations permits of such work, while its distance from all magnetic disturbances renders it especially favorable for observations with the magnetometer and dip circle.
It has been attempted to give the students in geodesy such practice as will not only illustrate the theory, but enable them at the end of their work to make satisfactory observations of permanent value with all the various instruments mentioned. The observatory will also be used by all civil engineering students in connection with their fourth year astronomy.

The observatory, on account of its unique position, will be a valuable magnetic station, and its observations will probably be incorporated in the general magnetic work of the United States government.

The sketch of the observatory… is by Charles H. Woodbury, [1886] *."

Editorial Note * The Observatory was not constructed in 1886. The source of this image is being researched.

Appendix 3

MIT's Middlesex Fells Geodetic Observatory

"The present year (1899) marks a radical change in the course of instruction in geodesy (the study of the shape, size, and gravity of the earth) at the (Massachusetts Institute of Technology). The occasion is the completion of a geodetic observatory at Middlesex Fells, where instruction is now given in astronomical observations such as will prepare students for the career of observer in geodetic work. . ." *The Geodetic Observatory at Middlesex Fells* by George L. Hosmer, read April 13, 1899; published in "The Technology Quarterly" Vol. XII, MIT 1899.

"This observatory is intended primarily to be used in giving instruction in the most refined methods in determining latitude and longitude, and secondarily to be used in magnetic and gravity observations. . . A hill in the southeastern part of the Middlesex Fells was chosen for the site (intersection of the Rock Circuit Trail and Rock Circuit Connector). Here was found a firm foundation for the most delicate instruments, free from the vibrations caused by railroad and highway traffic and not too far from Boston. . . The park commissioners kindly granted permission for the erection of the building, with the provision that it should be of field rock, and with pleasing proportions." "Technology Review," Vol., 1, No. 1, p.170, 1899.

FIG. 1. — THE GEODETIC OBSERVATORY.

FIG. 2. — THE INTERIOR OF THE OBSERVATORY WITH THE INSTRUMENTS IN POSITION.

Appendix 4

What You Will See in Boston: Scientific Observatories

By Frederick W. Coburn

The School Journal, Vol. 67, No. 1 (July 4, 1903): pp. 7-8

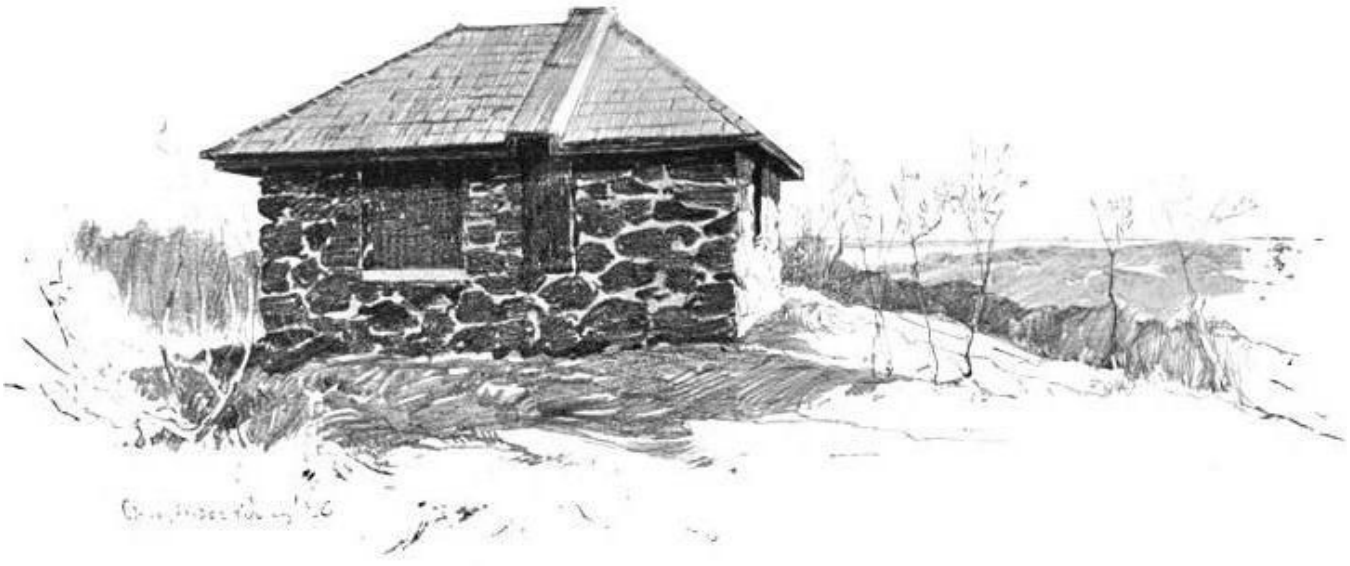
[An] observatory, one of unique interest, is the little Geodetic Observatory, maintained by the Massachusetts Institute of Technology in the Middlesex Fells. That the Institute should take a live interest in geodesy is natural enough when you remember that its president, Dr. Henry S. Pritchett, was formerly at the head of the United States Survey.

The location chosen for this observatory is ideal for its purposes, being quite free from the possibilities of hindrance, for it is a fact that geodetic work must be carried on where the instruments will not feel the vibrations caused by the steam cars, street cars, heavy teams, or any of the magnetic disturbances due to the activities of a great city. The Institute Observatory, situated in the wild Fells country, is constructed of field rock and has an aperture thru which the meridian can be followed from one side of the horizon to the other.

The astronomical transit that is used in this observatory is one that saw service in Sumatra during the celebrated expedition of the Technology astronomers in 1901 and is one of the two which were used in driving the center line of the famous Hoosac Tunnel in western Massachusetts.

This observatory, on account of its isolated position, has proved itself one of the most important in the country, and its magnetic work is being incorporated within the more general work carried on by the United States government—another instance of the modern methods of co-operation by means of which the limits of scientific knowledge are being so widely and rapidly extended.

Appendix 5



Sketch believed to be by Charles H. Woodbury. We are attempting to locate the original.

Appendix 6

MPC 1895 Topographical Map of the Middlesex Fells Reservation

Quad section map, Section B4

Exhibit - Malden Station Names

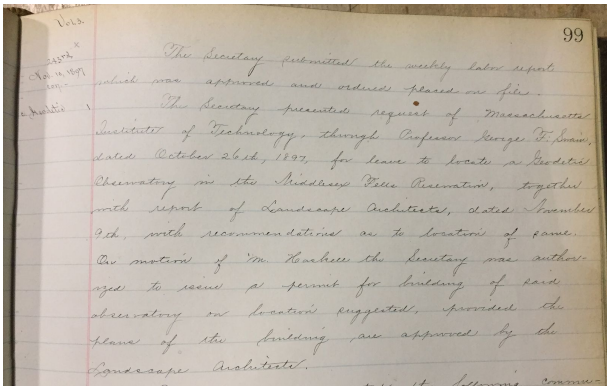
Source: http://www.massdot.state.ma.us/highway/Departments/Survey/GeodeticControlData.aspx

MassDOT ID	Station Name	MassDOT Datasheet	NGS PID	NGS Datasheet	USGS Quadrangle	Benchmark Card Scan	Tie Card Sketch
1355	DUTTON 1934	MassDOT Sheet 1355	MY2792	NGS Sheet 1355	BOSTON NORTH	Scan 1355	Sketch 1355
1367	HANCOCK 1934	MassDOT Sheet 1367	MY2782	NGS Sheet 1367	BOSTON NORTH	Scan 1367	Sketch 1367
1371	JOSLYN 1940	MassDOT Sheet 1371	MY2779	NGS Sheet 1371	BOSTON NORTH	Scan 1371	Sketch 1371
1377	MALDEN 1940 1941	MassDOT Sheet 1377	MY2772	NGS Sheet 1377	BOSTON NORTH	Scan 1377	Sketch 1377
1433	WALNUT 1940 1941	MassDOT Sheet 1433	MY2740	NGS Sheet 1433	BOSTON NORTH	Scan 1433	Sketch 1433
1434	WAYTES RESET 2011	MassDOT Sheet 1434	MY2749	NGS Sheet 1434	BOSTON NORTH	Scan 1434	Sketch 1434
1436	WINDY 1934	MassDOT Sheet 1436	MY2745	NGS Sheet 1436	BOSTON NORTH	Scan 1436	Sketch 1436
4809	4 9	MassDOT Sheet 4809		Datasheet not available	BOSTON NORTH	Scan 4809	Sketch 4809
4863	43 E	MassDOT Sheet 4863		Datasheet not available	BOSTON NORTH	Scan 4863	Sketch 4863
4864	43 F	MassDOT Sheet 4864		Datasheet not available	BOSTON NORTH	Scan 4864	Sketch 4864
4865	43 GA	MassDOT Sheet 4865		Datasheet not available	BOSTON NORTH	Scan 4865	Sketch 4865
4915	BOOJUM	MassDOT Sheet 4915	MY2354	NGS Sheet 4915	BOSTON NORTH	Scan 4915	Sketch 4915
4927	EDGEWORTH	MassDOT Sheet 4927	MY2376	NGS Sheet 4927	BOSTON NORTH	Scan 4927	Sketch 4927
4938	MAPLEVIEW	MassDOT Sheet 4938	MY2402	NGS Sheet 4938	BOSTON NORTH	Scan 4938	Sketch 4938
4945	OAK GROVE	MassDOT Sheet 4945	MY2416	NGS Sheet 4945	BOSTON NORTH	Scan 4945	Sketch 4945
4970	WINTER	MassDOT Sheet 4970	MY2472	NGS Sheet 4970	BOSTON NORTH	Scan 4970	Sketch 4970
12539	40 A	MassDOT Sheet 12539		Datasheet not available	BOSTON NORTH	Scan 12539	Sketch 12539
12540	40 B	MassDOT Sheet 12540		Datasheet not available	BOSTON NORTH	Scan 12540	Sketch 12540
12555	TBM 606	MassDOT Sheet 12555		Datasheet not available	BOSTON NORTH	Scan 12555	Sketch 12555
12557	2023	MassDOT Sheet 12557		Datasheet not available	BOSTON NORTH	Scan 12557	Sketch 12557
12579	2787	MassDOT Sheet 12579		Datasheet not available	BOSTON NORTH	Scan 12579	Sketch 12579
12594	3587	MassDOT Sheet 12594		Datasheet not available	BOSTON NORTH	Scan 12594	Sketch 12594
12601	4101	MassDOT Sheet 12601		Datasheet not available	BOSTON NORTH	Scan 12601	Sketch 12601
12602	4102	MassDOT Sheet 12602		Datasheet not available	BOSTON NORTH	Scan 12602	Sketch 12602
12603	4103	MassDOT Sheet 12603		Datasheet not available	BOSTON NORTH	Scan 12603	Sketch 12603
12637	AC 52	MassDOT Sheet 12637		Datasheet not available	BOSTON NORTH	Scan 12637	Sketch 12637
23164	COMMERCIAL	MassDOT Sheet 23164	MY2363	NGS Sheet 23164	BOSTON NORTH	Scan 23164	Sketch 23164
23241	PINE BANKS	MassDOT Sheet 23241	MY2420	NGS Sheet 23241	BOSTON NORTH	Scan 23241	Sketch 23241
25470	800 F RESET	MassDOT Sheet 25470		Datasheet not available	BOSTON NORTH	Scan 25470	Sketch 25470
25612	WAYTES RESET 2011	MassDOT Sheet 25612		Datasheet not available	BOSTON NORTH	Scan 25612	Sketch 25612
25613	WAYTES RESET 2011 RM 4	MassDOT Sheet 25613		Datasheet not available	BOSTON NORTH	Scan 25613	Sketch 25613
25614	WAYTES RESET 2011 RM 5	MassDOT Sheet 25614		Datasheet not available	BOSTON NORTH	Scan 25614	Sketch 25614

The MIT Geodetic Observatory - An Overview

In early antiquity, civilizations wanted to determine the shape and size of the earth. Some thinkers thought it was flat, while others thought it was rectangular. Over time, through observation and study, a greater understanding developed about the true shape of the earth. Leading thinkers like Pythagoras, Aristotle, Plato and Eratosthenes applied math, science, and time. The engineering, science and practice of Geodesy was born. As this was formalized in later centuries, the Massachusetts Institute of Technology (MIT) introduced a number of related educational programs - in Geodesy - for the classroom and the field.

The November 10, 1897 Metropolitan Parks Commission (MPC) minutes document MIT's desire to build a Geodetic Observatory in the Middlesex Fells Reservation. The MPC - as precursor to the Massachusetts Department of Conservation and Recreation (DCR) . MIT's request was approved.


99

The Secretary presented the weekly labor report which was approved and ordered placed on file.

The Secretary presented request of Massachusetts Institute of Technology, through Professor George F. Swain, dated October 26th, 1897, for leave to locate a Geodetic Observatory in the Middlesex Fells Reservation, together with report of Landscape Architects, dated November 9th, with recommendations as to location of same. On motion of Mr. Haskell the Secretary was authorized to issue a permit for building of said observatory on location suggested, provided the plans of the building are approved by the Landscape Architects.

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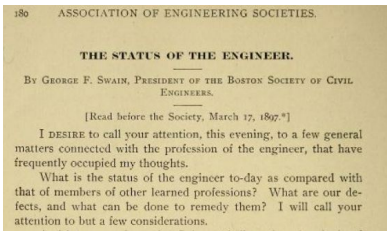

180 ASSOCIATION OF ENGINEERING SOCIETIES.

THE STATUS OF THE ENGINEER.

By George F. Swain, President of the Boston Society of Civil Engineers.

[Read before the Society, March 17, 1897.*]

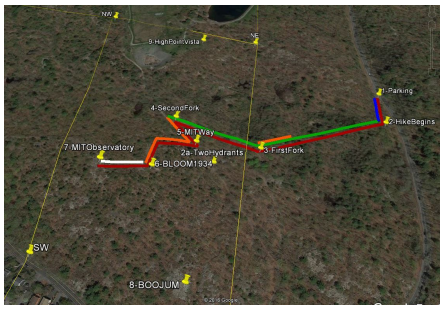
I desire to call your attention, this evening, to a few general matters connected with the profession of the engineer, that have frequently occupied my thoughts.

What is the status of the engineer to-day as compared with that of members of other learned professions? What are our defects, and what can be done to remedy them? I will call your attention to but a few considerations.

.

MIT's request carried the added authority of Professor Swain who also served as the President of the Boston Society of Civil Engineer around this time. The MIT Geodetic Observatory was established by the MIT Civil Engineering Department in 1898 to incorporate a real-world experience into their Geodesy curriculum. For reasons that were purely scientifically driven, the Middlesex Fells location proved ideal for this use. A small structure was built on conservation land that lies within the Middlesex Fells, just inside the northern border of the City of Malden. (Image of the 1987 minutes of the MPC provided courtesy Sean Fisher and Massachusetts Department of Conservation and Recreation.)

Digital Trail Guide for the MIT Geodetic Observatory



The first three waypoints (1. Parking, 2. Hike Begins, and 3. First Fork) are in Melrose. The remainder of the hike is in the City of Malden. The rough rectangular area of Malden shown in this TRAIL IMAGE covers approximately 40-acres of the Middlesex Fells Reservation. (The perimeter of this land is over 1,800 yards.) The walking distance from the parking area to the MIT Geodetic Observatory, is about a half-mile. There is some climbing up and down rocky, steep inclines. Sharp, poky branches line the path.

Waypoint 1: "Parking" (image) (map)
42° 26' 33.990" N, 71° 04' 45.830" W (42.44277° , -71.0794)

Waypoint 2: "Hike Begins" (image) (map)
42° 26' 31.640" N, 71° 04' 46.150" W (42.44212° , -71.07949)

Waypoint 3: "First Fork" (image) (map)
42° 26' 30.080" N, 71° 04' 55.770" W (42.44169° , -71.08216)

Waypoint 4: "Second Fork" (image) (map)
42° 26' 31.860" N, 71° 05' 1.840" W (42.44218° , -71.08384)

Waypoint 5: "MIT Way" (image) (map)
42° 26' 29.960" N, 71° 05' 0.210" W (42.44166° , -71.08339)

Waypoint 6: "BLOOM 1934" (image) (map)
42° 26' 28.500" N, 71° 05' 3.600" W (42.44125° , -71.08433)

Waypoint 7 - "MIT Geodetic Observatory" (image) (map) (video)
42° 26' 28.590" N, 71° 05' 6.480" W (42.44127° , -71.08513)

Alternate route, convenient to pedestrians visiting this site from the City of Malden, could begin as follows:
Waypoint 1a: "Jerry Jingle Gate" (image) (map)
42° 26' 16.830" N, 71° 04' 58.960" W (42.43801° , -71.08304)
Enter the Middlesex Fells Reservation at the well-marked **Middlesex Fells Gate 55**

Waypoint 2a: "M-M Monument" (image1) (image2) (map) (video) (detail)
N 42 26.331,W071 04.976

Waypoint 3a: "Two Hydrants" (image) (map)
42° 26' 29.000" N, 71° 04' 59.000" W (42.44139° , -71.08306)
After Waypoint 3a, your next destination is Waypoint 5 - "MIT Way" - described above.