REFERENCE 5

APPENDIX E

STANDARD OPERATING PROCEDURE TO DETERMINE SITE LATITUDE AND LONGITUDE COORDINATES

HAZARDOUS SITE EVALUATION DIVISION
SITE ASSESSMENT BRANCH
U.S ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C.

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1. STATEMENT OF PROBLEM

Location information is critical to the site investigation process. This Standard Operating Procedure (SOP) describes the minimum standard to which latitudinal and longitudinal measurements should be recorded and how to obtain measurements from topographic maps. The investigator should complete a worksheet and attach supporting documentation, which record measurements and provide computations for review.

The purpose of this SOP is to provide a method to measure latitude and longitude which is accurate and practical. The procedure uses linear measurement and interpolation, referred to as Linear Interpolation (LI) to measure latitude and longitude. Compared to other techniques, LI:

- Requires only a single ruler or scale
- Requires no extrapolation of tangents or perpendiculars
- Requires no conversions or calculations, when using a scale graduated in seconds
- Is easy to learn
- Can be easily reviewed
- Is accurate to 1 second (± 0.5)

2. SITE REFERENCE POINT

The investigator should determine the site's geographic coordinates of a specified reference point. EPA's June 1989 draft policy simply requires describing the reference point for a site (e.g., northeast corner of site, entrance to facility, point of discharge). The January 1990 revision states: " ... latitude and longitude coordinates may be made in reference to **any convenient aspect of a site**..." The language was intentionally vague due to the potentially infinite range of site spatial characteristics.

Latitude and longitude determination relies on 7.5-minute topographic maps published by the U.S. Geological Survey (USGS). At the scale of these maps (1:24,000), the small black square used to identify a single family dwelling is a little less in width than 1 second of latitude; the latitude and longitude of a house can be accurately determined to 1 second. When the building, facility, site, etc., is larger in width than 1 second, the question becomes, "From where should I take the measurement?" In some cases, the site could encompass hundreds of square miles, and several degrees or minutes of latitude. To specify a pair of geographic coordinates for the site location, a reference point must be determined for each site on a map for the official record.

To specify a single point location, remember that both natural and man-made features can change with time, and contamination can be documented outside a facility boundary. Property lines, water bodies, and buildings are particularly vulnerable to change. Give priority to the following situations when determining site reference points:

- Point representing the approximate center of the area of greatest concern or a major source as chosen by the project officer in the Region most familiar with the site; or
- Location of largest permanent structure, identified to the corner being measured.

On a 7.5-minute topographic map, mark the boundaries of the site, the area encompassing waste sources, with a very sharp pencil. If the site is a single point or building, use that point. If the building is large, select a corner and describe it for later worksheets. If the site is larger than a single building, draw a center line along the long axis (longest part) of the site (curving or segmenting the line so the line is always centered within the site), and designate the midpoint of the line as the center of the site. Mark this spot in pencil keeping the dot or cross-hair as fine as possible.

Choose a permanent site reference point that is accessible to field verification. During the site reconnaissance, verify the point location relative to topographic and physical structures on the map. Coordinates of known point locations (e.g., landfills, impoundments, wells) can also be calculated and recorded.

3. EQUIPMENT

The only equipment required for LI is an original version of the scale template, the Coordinator™ (see attached page), a fine mechanical pencil (0.3 or 0. 5 mm) , a large flat work surface, and the topographic map (s) containing the site. Mylar films of maps are preferable. Do not use folded or wrinkled field maps.

The accuracy of LI depends on several factors, specifically the accuracy of the map and measuring device, the width of the pencil, and the cartographic ability of the person making the measurements.

The accuracy of maps printed on paper is approximately 50 feet (1 millimeter map distance) due to paper shrinking or swelling in varying humidity, or by creases in the map. This error can be considerable at the 1:24,000 scale, but these problems can be overcome by using Mylar film versions of the USGS maps. Similarly, measuring tools can have different levels of precision. Do not use the Topo-Aid™, a map aid used in the past, which does not provide the 1-second precision now required by EPA.

A second area where precision can be lost is the pencil used to mark reference lines. The smaller the width of the scribe (or line drawn by the pencil), the greater the ability to align measurements to the ruler. If the width of the scribe is broader than the graduation marks on the ruler, precision cannot be greater than the width of the scribe or ruler calibration.

A third critical factor of accuracy is the cartographic ability of the measurer. There are basically two ways to measure latitude and longitude on maps. The first requires extrapolating data from the site reference point out to the map boundaries. This method requires moderate cartographic skill and accurate drafting supplies, and can magnify resulting errors in proportion to the map edge distance from the reference point. The second requires measuring data interpolated within known map reference points, thereby reducing drafting errors.

Methodologies that required drawing tangents from an unknown point on a map to the map boundary using straight-edges or right-triangles are no longer supported by EPA. The ability to align edges parallel to the map boundaries while extrapolating the tangent line is critical to the accuracy of the calculation. A difference of only a few millimeters will create coordinate errors of 1 or more seconds. Error will result from aligning the straight edge directly over the unknown point and not allowing for the width of the scribe while drawing the tangent line. Another way that locational error is introduced is by relying on other features inside the map -- such as straight roads, apparently straight survey lines, and section lines -- to extrapolate tangents.

4. PROCEDURE

4.1 DEFINING THE GRID

Nine 2.5-minute map grid cells make up a USGS 7.5-minute topographic map (scale 1:24,000). These nine grid cells are defined by 2.5-minute tic marks at the edges of the map and 2.5-minute cross-hairs within the map. Determine which of the nine 2.5-minute grid cells contains the site center or reference point. Depending on the location of the grid, you will be required to draw two, three, or four framing lines. All measurements will be made within this grid. To draw the lines, align a straight edge so the point of the pencil will intersect two of the 2.5-minute cross-hairs. Be sure that the edge is not directly over the cross-hairs or the width of the pencil will be offset and the framing line will not exactly intersect the two cross-hairs (see Figure 4-1).

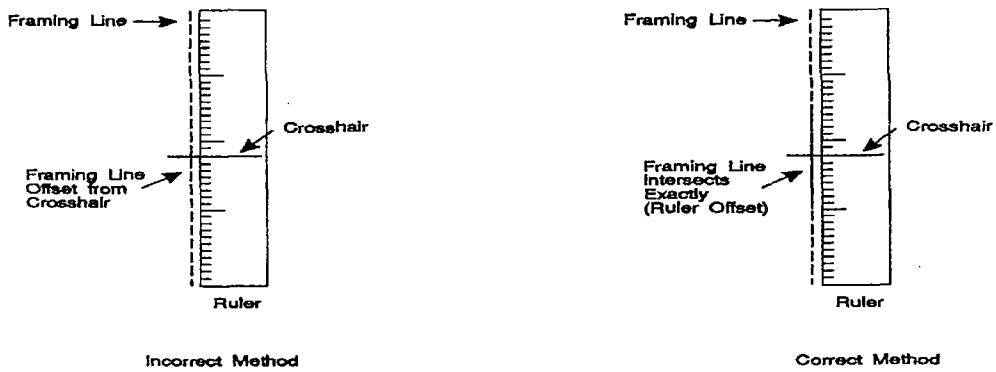


Figure 4-1. Aligning Framing Lines

Lightly draw the framing line, being careful to keep the pencil at an angle less than vertical, between 60 and 80 degrees. Strive to keep the pencil point against the straight edge at all times (see Figure 4-2).

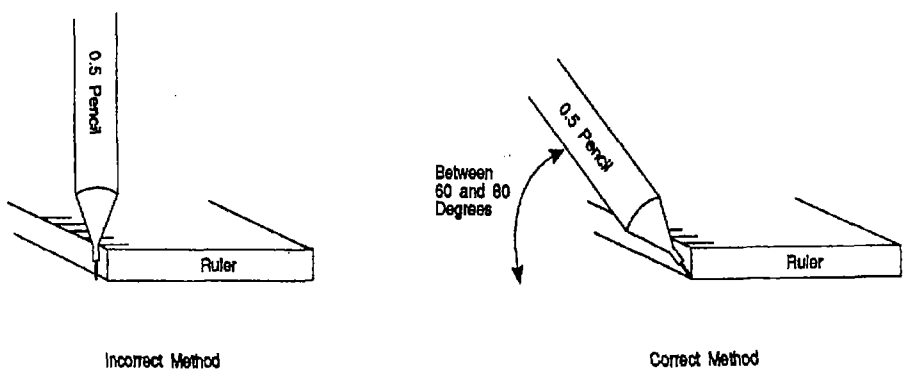


Figure 4-2. Scribing Framing Lines

After completing one of the lines, remove the straight edge and examine the line. If it does not intersect the center of the cross-hairs exactly on each end, erase the line completely and repeat the process.

NOTE: The corners of more recent 7.5 minute topographic maps may have dashed cross-hairs that differ slightly from the corners of the map. Measure from the corners of the map and not the dashed corner cross-hairs a USGS correction for the 1983 datum. Most maps still rely on the 1927 datum. Consult the lower left legend of the map for more information on geodetic datum.

4.2 LI USING RULER GRADUATED IN SECONDS

The Coordinator ™ is a clear template that is essentially eight custom rulers corresponding to the most common map scales. (The Coordinator™ can be obtained from drafting supply stores or 145 Cedar Hill Road, Bedford, NY 10506.) Other custom rulers can be used if the 1-second (or better) level of precision is maintained and documented.

Custom rulers are directly graduated in seconds of latitude. This is possible because map representations of latitude are essentially constant. One scale on the Coordinator™ fits precisely within a 2.5 minute arc of latitude on a 7.5 minute quadrangle map. By laying the scale over the site location precisely between the scribed latitude lines, latitude is read directly off the scale and added to the latitude of the lower line. With scale graduations in seconds, the accuracy of latitude to 1.0 second is ensured through direct measurement and interpolation. Directly measuring seconds prevents errors caused by conversion and ratio calculations.

Measuring Latitude Using a Custom Ruler (Coordinator™)

1. Set out Coordinator ™ 1:24,000 scale and map with the site center or reference point identified.

2. Draw 2.5-minute framing lines around the grid with the site center or reference point (see Section 4.1).

3. Fill out background information on latitude/longitude worksheet.

4. Lay the scale on the map so that the bottom of the scale coincides with the bottom framing line and the top of the scale coincides with the top framing line (see Figure 4-3).

5. Move the scale laterally until it intersects the point to be measured. Be very careful to keep the top and bottom edges of the scale on the framing lines.

6. The scale has two sets of incremental designations; the left set begins at 30 seconds and the right set begins at 0 seconds. Use the scale that corresponds to the latitude number of the lower framing line. If it ends in 30 seconds, read along the left side. If it ends in 0 seconds, read along the right side.

7. Read up the scale from the lower framing line to the point to be measured. Note at each 00 second reading on the Coordinator Scale, add 1 minute to the beginning latitude number of the lower framing line. Record that number on the worksheet.

Measuring Longitude Using a Custom Ruler (Coordinator™)

Longitude is calculated using the same principle and scale as for latitude. The difference is that the ground distances of 2.5 minutes of latitude and longitude are not the same. If, however, you use the same scale and align your

divisions to those of the known longitude lines, the ratios and conversions become a linear measurement. Since the scale is exactly 2.5 minutes long, place each end of the scale on one of the longitude lines. Next, slide the scale up or down until it intersects the reference point. When the edges of the scale are precisely touching the longitude lines and the scale intersects the unknown point, read up the scale from right to left to measure the longitude.

1. Set up longitude framing lines as described in Section 4.1.

2. Lay the 1:24,000 scale on the map so that the bottom of the scale coincides with the right framing line and the top of the scale coincides with the left framing line (see Figure 4-3).

3. Move the scale up or down until it intersects the point to be measured. Be very careful to keep the top and bottom edges of the scale on the framing lines.

4. The scale has two sets of increments: the left set begins at 30 seconds and the right set begins at 0 seconds. Use the scale that corresponds to the longitude number of the right framing line. If it ends in 30 seconds, read along the left side. If it ends in 0 seconds, read along the right side.

5. Read the scale up from the right framing line to the point to be measured. Note at each 00" on the Coordinator™ scale, add 1 minute to the beginning longitude number of the lower framing line. Record that number on the worksheet.

Note: Be sure to identify starting latitude and longitude from the lower right-hand corner of the 2.5 minute grid. If it ends in 30 seconds (30"), read off the 30-second side on the scale; if it ends in 00 seconds (00"), read off the 00 side.

4.3 LI USING AN ENGINEER'S SCALE

Alternative equipment to determine latitude and longitude coordinates is an "engineer's scale." An engineer's scale is a multi-sided ruler containing series of graduations per inch corresponding to map scales. For the 1:24,000 topographic maps, use the 60 divisions per inch scale; on this scale 454 divisions equal to 2.5 minutes. Use the 0 as 00" and 454 as 2'30" and follow the alignment process of Section 4.2. Record the number of divisions on the ruler, divide by 454 and multiply the resultant by 150. The number is now in seconds and can be added to the starting latitude or longitude to get the coordinates of the site.

Measuring Latitude and Longitude using an Engineer's Scale

1. Display the 1/60 engineer's scale and map with the site center or reference point site identified.

2. Draw 2.5-minute framing lines on the grid with the site center or reference point (see Section 4.1).

3. Fill out background information on the latitude/longitude worksheet.

4. For latitude: place the 1/60 scale on the map so that the bottom of the ruler coincides with the bottom framing line and 454 coincides with the top framing line (see Figure 4-3).

   For longitude: place the scale on the map so that the bottom of the ruler coincides with the right framing line and 454 coincides with the left framing line (see Figure 4-3).

5. Move the scale laterally (for latitude) or vertically (for longitude) until the scale intersects the point to be measured. Be very careful to keep the 0 and 454 edges of the scale on the framing lines.

6. Record the number on the ruler where it intersects the point to be measured on the appropriate worksheet. Divide that number by 454 and multiply the resultant by 150. **OR** multiply the number by 0.3304. The number is now in seconds and can be added to the starting latitude or longitude of the grid to get the latitude or longitude coordinates of the site. Complete the worksheet.

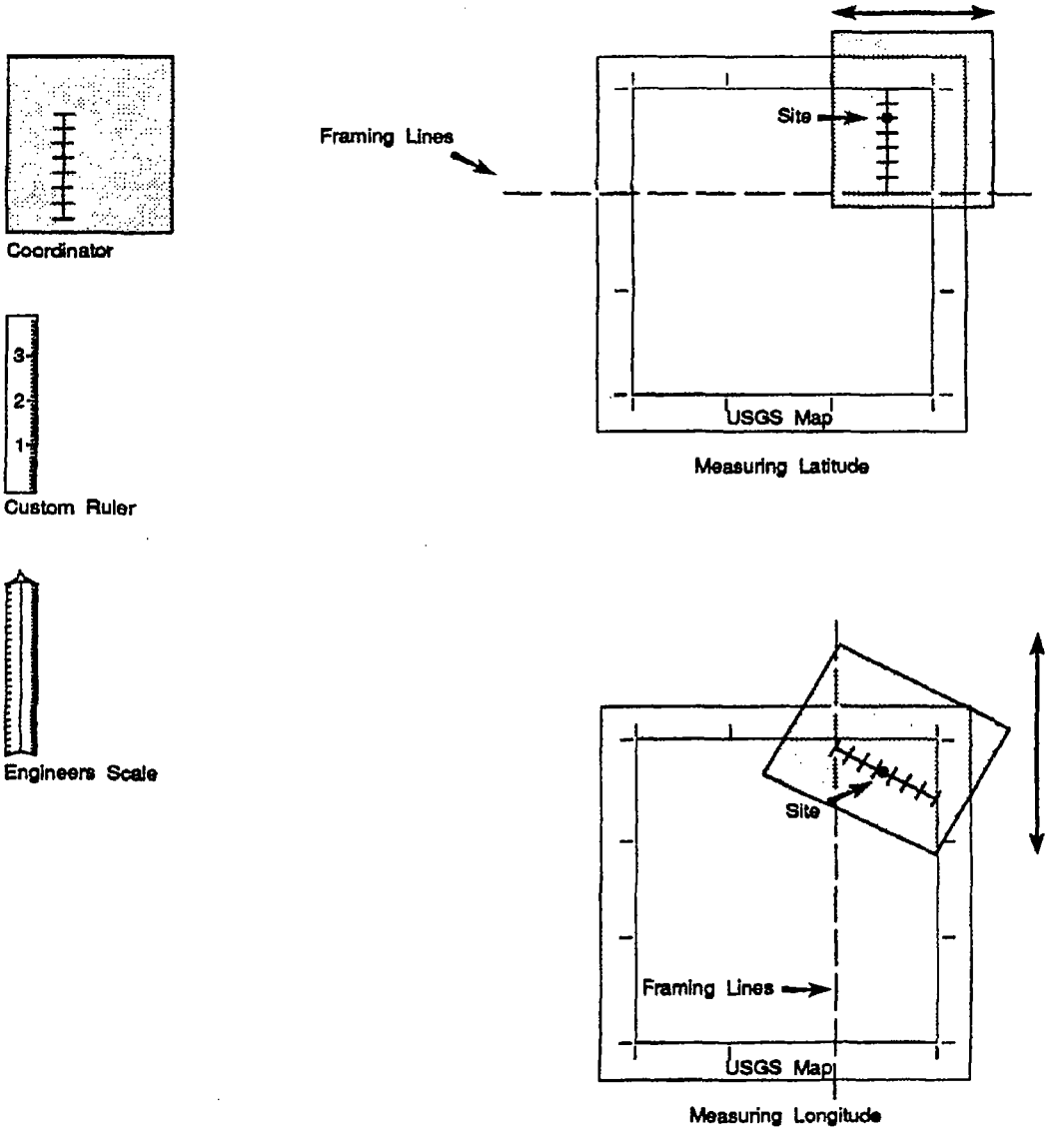


Figure 4-3. Determining Latitude and Longitude Using Linear Interpolation

5. QUALITY ASSURANCE

For QA purposes, a method must be developed to track how latitude and longitude coordinates have been verified and calculated. A datasheet (worksheet) is part of the required documentation for each PA. A completed worksheet allows a reviewer to follow the original steps and check the calculations. Completing each form is estimated to take approximately 10 minutes. Attach a complete 2.5-minute grid on a separate page with the site center or reference point clearly marked. All four corners of the grid must be clearly visible.

LATITUDE AND LONGITUDE CALCULATION WORKSHEET #1
LI USING CUSTOM RULER OR COORDINATOR™

SITE NAME:_____ CERCLIS #:_____

AKA:_____ SSID:_____

ADDRESS:_____

CITY:_____ STATE:_____ ZIP CODE:_____

SITE REFERENCE POINT:_____

USGS QUAD MAP NAME:_____ TOWNSHIP: ____ N/S RANGE: ____ E/W

SCALE: 1:24,000 MAP DATE:_____ SECTION: _____1/4 _____1/4 _____1/4

MAP DATUM: 1927 1983 (CIRCLE ONE) MERIDIAN:_____

COORDINATES FROM LOWER RIGHT (SOUTHEAST) CORNER OF 7.5' MAP (attach photocopy):

LONGITUDE: ____° ____' ____" LATITUDE: ____° ____' ____"

COORDINATES FROM LOWER RIGHT (SOUTHEAST) CORNER OF 2.5' GRID CELL:

LONGITUDE: ____° ____' ____" LATITUDE: ____° ____' ____"

CALCULATIONS: LATITUDE (7.5' QUADRANGLE MAP)

A) ALIGN THE BOTTOM OF THE SCALE WITH BOTTOM OF GRID. ALIGN THE TOP OF THE SCALE WITH THE TOP OF GRID. POSITION EDGE OF RULER OVER SITE REFERENCE POINT WHILE KEEPING TOP AND BOTTOM ALIGNED.

B) READ TICS ON RULER AT 1- OR 0.5-SECOND INTERVALS (INTERPOLATE).

C) EXPRESS IN MINUTES AND SECONDS (1'= 60"): ____'____.____"

D) ADD TO STARTING LATITUDE: ____°____'____.____" + ____'____.____ =

SITE LATITUDE: ____°____'____.____"

CALCULATIONS: LONGITUDE (7.5' QUADRANGLE MAP)

A) ALIGN THE BOTTOM OF THE SCALE WITH RIGHT SIDE OF GRID. ALIGN THE TOP OF THE SCALE WITH THE LEFT SIDE OF GRID. POSITION EDGE OF RULER OVER SITE REFERENCE POINT WHILE KEEPING TOP AND BOTTOM ALIGNED.

B) READ TICS ON RULER AT 1- or 0.5-SECOND INTERVALS. (INTERPOLATE)

C) EXPRESS IN MINUTES AND SECONDS (1'= 60"): ____'____.____"

D) ADD TO STARTING LONGITUDE: ____°____'____.____" + ____'____.____ =

SITE LONGITUDE: ____°____'____.____"

INVESTIGATOR:_____ DATE: _____

LATITUDE AND LONGITUDE CALCULATION WORKSHEET #2
LI USING ENGINEER'S SCALE (1/60)

SITE NAME: Little Scioto River CERCLIS #: OHN000509950

AKA: — SSID: —

ADDRESS: Holland Road

CITY: Marion STATE: OH ZIP CODE: 43301

SITE REFERENCE POINT: Little Scioto River at Holland Road Bridge

USGS QUAD MAP NAME: Marion West, OH TOWNSHIP: ___ N/S RANGE: ___ E/W

SCALE: 1:24,000 MAP DATE: 1961 SECTION: ___1/4 ___1/4 ___1/4

MAP DATUM: (1927) 1983 (CIRCLE ONE) MERIDIAN: ___

COORDINATES FROM LOWER RIGHT (SOUTHEAST) CORNER OF 7.5' MAP (attach photocopy):

LONGITUDE: 83 ° 07 ' 30 " LATITUDE: 40 ° 30 ' 00 "

COORDINATES FROM LOWER RIGHT (SOUTHEAST) CORNER OF 2.5' GRID CELL:

LONGITUDE: 83 ° 10 ' 0 " LATITUDE: 40 ° 35 ' 00 "

CALCULATIONS: LATITUDE (7.5' QUADRANGLE MAP)

A) NUMBER OF RULER GRADUATIONS FROM LATITUDE GRID LINE TO SITE REF POINT: 106

B) MULTIPLY (A) BY 0.3304 TO CONVERT TO SECONDS:

A x 0.3304 = 35.02 "

C) EXPRESS IN MINUTES AND SECONDS (1'= 60"): 0 ' 35.02 "

D) ADD TO STARTING LATITUDE: 40 ° 35 ' 0.0 " + 0 ' 35.02 =

SITE LATITUDE: 40 ° 35 ' 35.02 "

CALCULATIONS: LONGITUDE (7.5' QUADRANGLE MAP)

A) NUMBER OF RULER GRADUATIONS FROM RIGHT LONGITUDE LINE TO SITE REF POINT: 183

B) MULTIPLY (A) BY 0.3304 TO CONVERT TO SECONDS:

A x 0.3304 = 60.46 "

C) EXPRESS IN MINUTES AND SECONDS (1'= 60"): 1 ' 0.46 "

D) ADD TO STARTING LONGITUDE: 83 ° 10 ' 0.0 " + 1 ' 0.46 =

SITE LONGITUDE: 83 ° 11 ' 0.46 "

INVESTIGATOR: Dan McA DATE: 2/10/09

SITE NAME: Little Scioto River NUMBER: OHN000509950

AFFIX MAP GRID CELL HERE

Map must have a minimum of ¼ inch
around the 2.5′ grid cell and show all four grid tic marks.

- Indicate permanent site reference point
- Indicate boundary of site/sources

See Attached

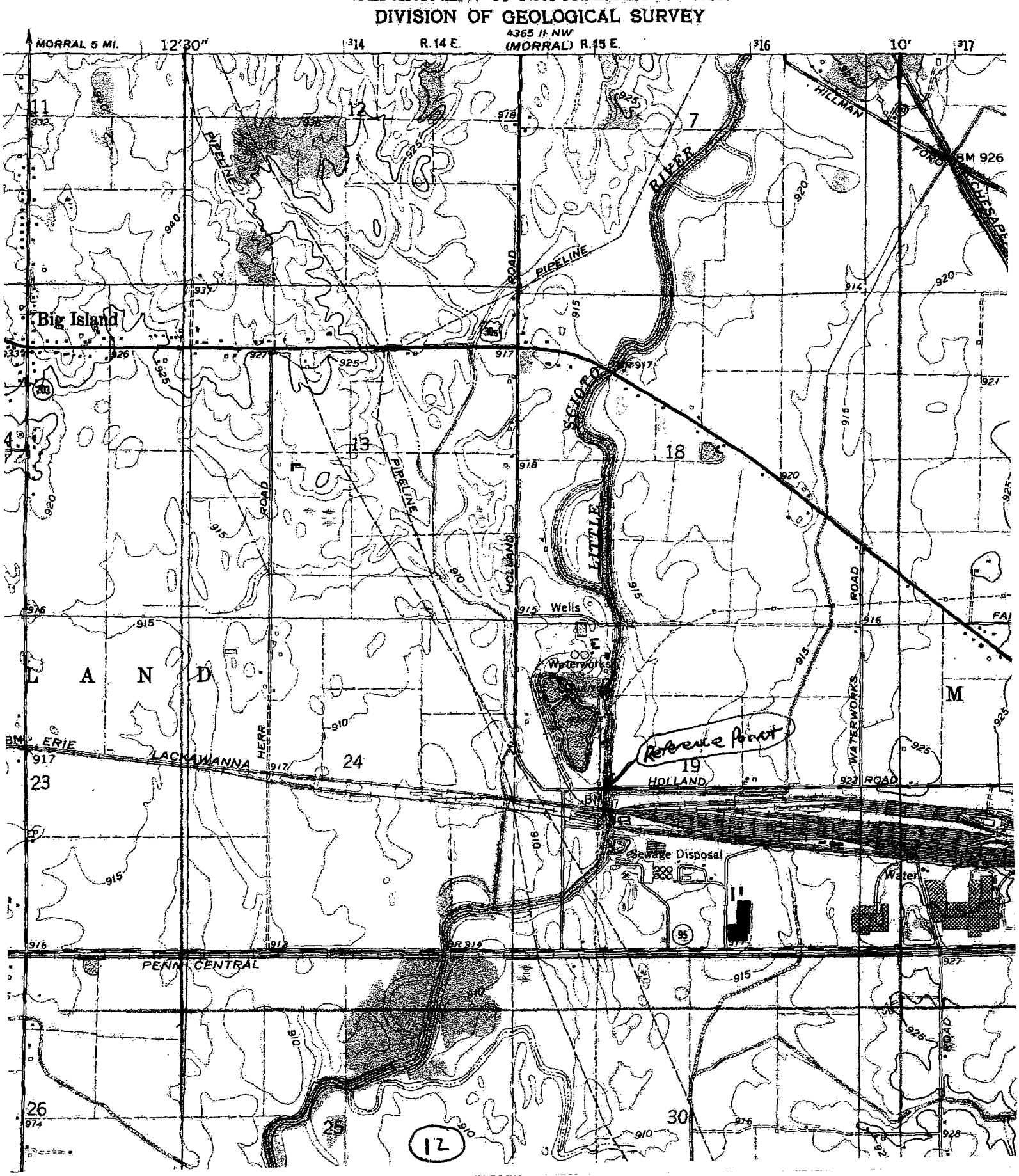
TOPOGRAPHIC MAP QUADRANGLE NAME: Marion West SCALE: 1:24,000

COORDINATES OF LOWER RIGHT-HAND CORNER OF 2.5-MINUTE GRID:

LATITUDE: 40° 35' 0.0" LONGITUDE: 83° 10' 0.0"

*U.S GOVERNMENT PRINTING OFFICE: 1991-548-187/40605 E-11

STATE OF OHIO
DEPARTMENT OF HIGHWAYS
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGICAL SURVEY



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