PLS Lost Corner Methods

WESTERN REGIONAL SURVEY CONFERENCE
MARCH 18 - 21, 2026

Presented by
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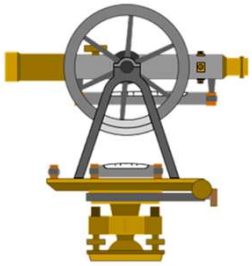
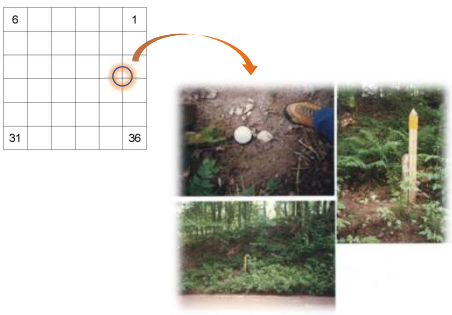
I. Overview

A. General Observations
B. Will-Be-Was
C. Corner Type





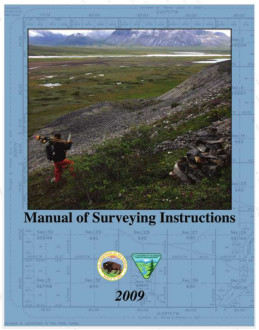
A. Introduction

Most PLS states have statutes or code that require a surveyor dividing a Section or re-establishing a government corner to:

> "... proceed according to the statutes of the United States and the rules and regulations made by the secretary of the interior in conformity to the federal statutes...." Wis Stat 59.73

These are in the *Manual of Surveying Instructions 2009.*

- Chapters on corner re-establishment:
  - V. Principles of Resurveys
  - VI. Resurveys and Evidence
  - VII. Resurveys and Restoration
  - VIII. Resurveys and Water Boundaries



B. Will-Be-Was

1. PLSS Corner Rule-of-Three

Surveying has a number of *Rules-of-Three* (R3)[1]

- e.g.: monument control, agreed boundary, common report corner, etc

PLSS corner location R3, where the surveyor:

- was *supposed* to set it (Instructions, *Manuals*)
- *said* he placed it (notes, plat)
- actually *did* place it (original physical evidence)

Re-establishment order is reversed

- Acceptable evidence of original corner monument
- Written evidence to reconstruct; secondary evidence related to position
- No evidence, follow *Manual* restoration methods

[1]You won't see this in any textbooks, it's just a pattern I've noticed.

B. Will-Be-Was

2. Applicable Instructions

Instructions:

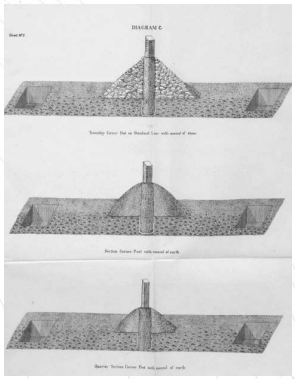
Procedures, monuments & marking, accessories, note forms, accuracies

Manual of Surveying Instructions to the Surveyor General of Oregon – 1851

"First " *Manual*

Manual of Surveying Instructions, 1855

First *Manual*



Post, mound, and pit examples, 1881 *Manual*

I. Overview

B. Will-Be-Was

2. Applicable Instructions

BUREAU OF LAND MANAGEMENT
KNOWLEDGE RESOURCE CENTER

1851-2009 Manuals online at:

BLM Knowledge Resource Center

Arizona BLM Library

CLSA Education Foundation

(links in handout)

CLSA EDUCATION FOUNDATION

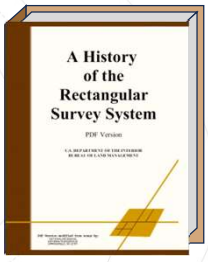
A History of the Rectangular Survey System,

C.A. White

From Colonial tenure system through 1979 *Manual*

Includes summary of pre-Manual Instructions

pdf at BLM KRC



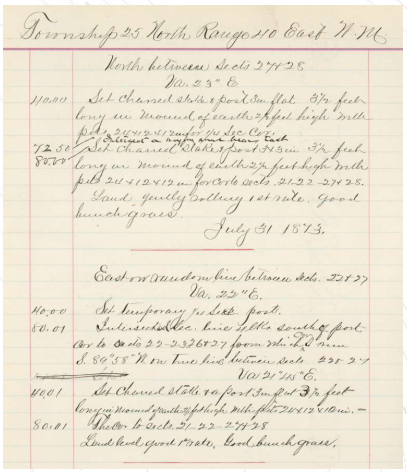
B. Will-Be-Was

3. Notes; Plat
   - Copies of both
     - Originals - turned over to State
     - Duplicates: retained by GLO/BLM
     - Triplicates: National Archive

GLO Records website: https://glorecords.blm.gov/default.aspx

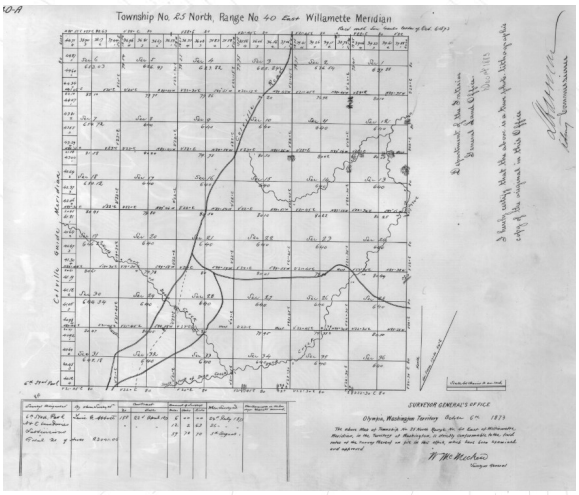
B. Will-Be-Was

3. Notes; Plat
   - Field Notes
     - What was done in the field
     - Type of monument
     - Accessories
     - Memorials
     - Topo calls
     - Corrective action on random and true
     - Distances to Closing Corners
     - Other evidence for line or corner location
     - etc



B. Will-Be-Was

3. Notes; Plat
   - Plat
     - Graphic representation of field notes
     - Protractions
     - Gov't lots
     - Off-line features
     - Other information depicted



I. Overview

B. Will-Be-Was

4. A Package Deal
   - Why bother with original notes, plat, Instructions?
   - All that stuff is 150+ years old
   - We can measure *much* better today.

   - Where the corner was originally est'd is where it belongs today.
     - ➔ attempt to recreate the original situation.

B. Will-Be-Was

5. Monument Records

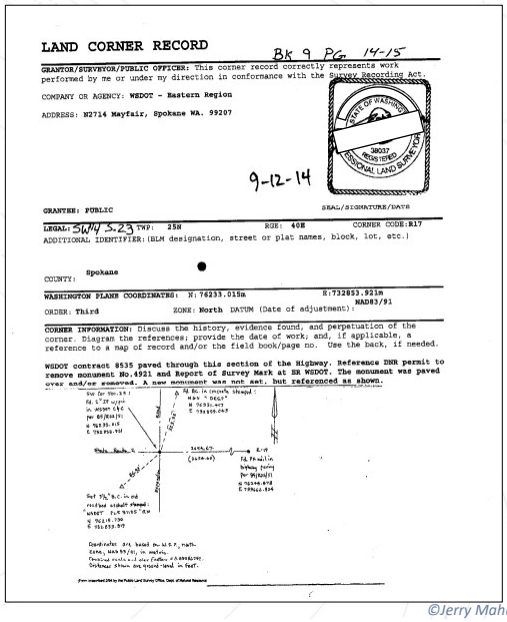
Previous re-establishment(s)

The record should include sufficient information to explain why the surveyor re-established the corner where he/she did.

Maintaining Monument Records can help:

- establish corner location credibility
- understand what was used as the corner over time

"Commencing at the southeast corner of Section 27; thence...."



LAND CORNER RECORD Bk 9 Pg. 14-15

GRANTOR/SURVEYOR/PUBLIC OFFICER: This corner record correctly represents work performed by me or under my direction in conformance with the Survey Recording Act.

COMPANY OR AGENCY: WSDOT - Eastern Region

ADDRESS: N2714 Mayfair, Spokane WA. 99207

9-12-14

SEAL/SIGNATURE/DATE

GRANTEE: PUBLIC

LEGAL: SW¼ S.23 TWP: 25N RGE: 40E CORNER CODE:R17

ADDITIONAL IDENTIFIER: (BLM designation, street or plat names, block, lot, etc.)

COUNTY: Spokane

WASHINGTON PLANE COORDINATES: N: 76233.015m E:732853.921m

ORDER: Third ZONE: North DATUM (Date of adjustment): NAD83/91

CORNER INFORMATION: Discuss the history, evidence found, and perpetuation of the corner. Diagram the references; provide the date of work; and, if applicable, a reference to a map of record and/or the field book/page no. Use the back, if needed.

WSDOT contract 8535 paved through this section of the Highway. Reference DNR permit to remove monument No.4921 and Report of Survey Mark at RR WSDOT. The monument was paved over and/or removed. A new monument was not set, but referenced as shown.

B. Will-Be-Was

6. Other Resources

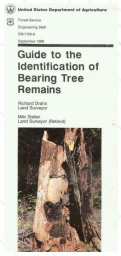
Guide to the Identification of Bearing Tree Remains, Drahn and Stefan, U.S. Forest Service.

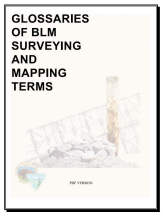
Durability of Bearing Trees training manual by BLM Cadastral Survey Training Staff.

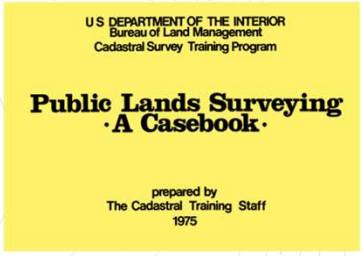
BLM Glossary: dated, but useful

Legal Reference Library: *Word* .doc of a collection of case law excerpts

BLM Casebook, 1975 collection of actual interesting and unique resurvey situations used for Cadastral Training.

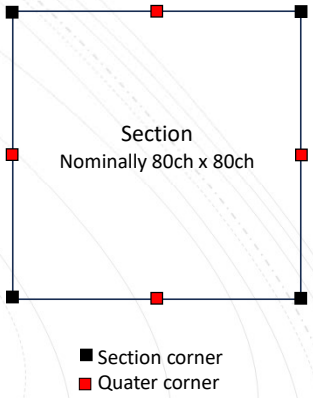






C. Corner Types

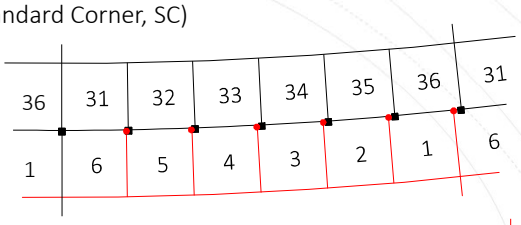
1. Regular
   - Primary corners defining smallest PLS unit
     - Section
       - at each corner
     - Quarter Section
       - at each Section side midpoint
     - Nominal 40 ch spacing
     - Can be used for
       - Distance
       - Direction
     - control



C. Corner Types

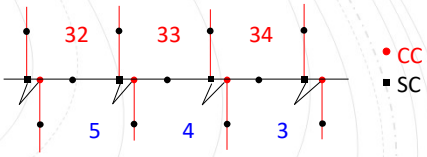
2. Special Corners
   - a. Closing Corners (CC)
     - (1) What and Where

Section line from south intersects closing line on PM side of Section corner (aka Standard Corner, SC)



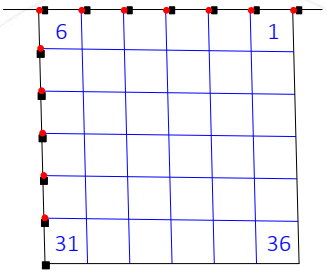
CC was intended to be on the closing line.

Surveyor recorded distance to corresponding SC.

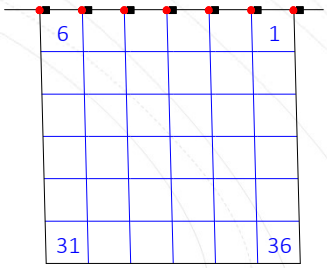


C. Corner Types

2. Special Corners
   a. Closing Corners (CC)
      (2) Evolution



CC on West and North Township lines up through 1833 Instructions



CC only on North Township lines, 1833-1840 Instructions

- Closing Corner
- Standard Corner

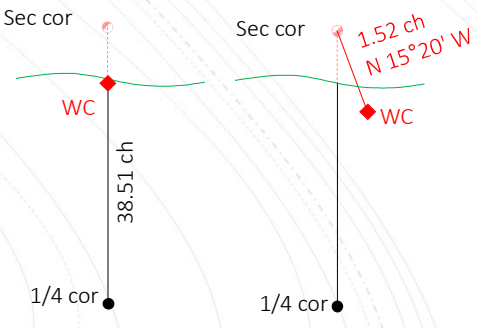
After 1840, CC only set on Standard Parallel.

I. Overview

C. Corner Types

2. Special Corners
   b. Witness Corner (WC)
      Set when regular corner couldn't be set or was subject to destruction
      Two kinds
      - on line: takes place of Regular cor
        Generally only one per corner, on line coming in.
        Running distance recorded
      - off line: is an accessory

      Marking & accessory req same as for a Regular corner.



C. Corner Types

2. Special Corners

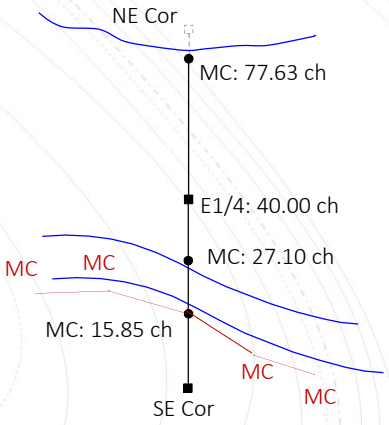
c. Meander Corners

Two types of Meander Corners (MC):

- set where a PLS line intersected or a regular corner fell in a meanderable body of water
- used to map meanderable bodies of water.

Dist to a MC along the line was recorded;

Marking & accessories req same as for a regular corner.

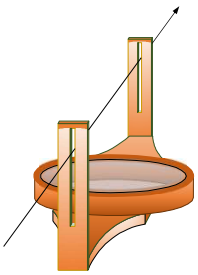


II. Principles of Corner Re-Establishment

A. Corner Disposition

B. Lost Corner Restoration Methods

C. PLS Direction Reference



A. Corner Disposition

Definitions

Existent Corner – There it is

Obliterated – uh...

Lost – Oh, well 

1973 Manual to *2009 Manual* change

6-17. An obliterated corner is an existent corner where, at the corner's original position, there are no remaining traces of the monument or its accessories but whose position has been perpetuated...

"beyond a reasonable doubt" not used for obliterated & lost

II. Principles of Corner Re-Establishment

A. Corner Disposition

Definitions

Existent Corner – There it is

Obliterated – uh...

Lost – Oh, well 

Gray area between

Degree of evidence.

Can't be "lost" for one surveyor and "obliterated for another.

At any given time, a corner's disposition is only one of the three conditions.

B. Lost Corner Restoration Methods

Restoration Methods - *2009 Manual*

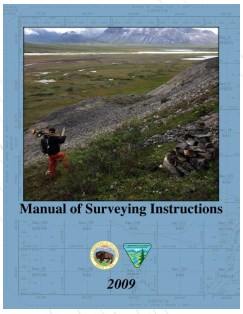
1. Primary; Manual page 166

Double Proportionate Measurement (DPM)	Sec 7-8
Single Proportionate Measurement (SPM)	Sec 7-16
3 Point Control (3PC)	Sec 7-13
2 Point Control (2PC)	Sec 7-14
Modified SPM (MSPM)	Sec 7-44

2. Secondary Methods; Manual page 173

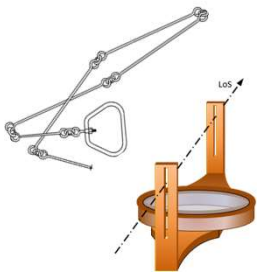
Irregular Boundary Adjustment (IRR)	Sec 7-51
Grant Boundary (GB)	Sec 7-54
One Point Control (1PC)	Sec 7.58
Mixed & Miscellaneous	Sec 7-58 & 59

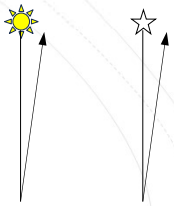
An index correction might also be applicable.



C. PLS Direction Reference

1. PLSS Direction Reference
   - PLSS lines run in True directions
     - Astro observations to determine True N
     - Variation – angle from True N to Magnetic N



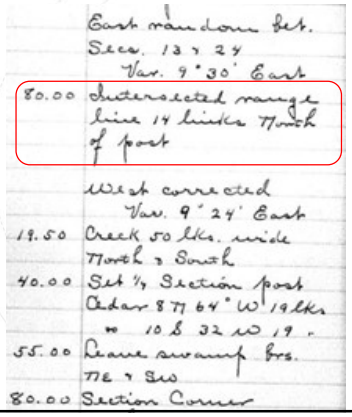


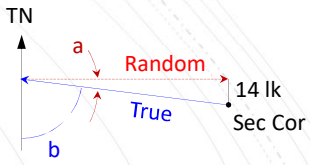
C. PLS Direction Reference

1. PLSS Direction Reference

Before *1864 Manual* E/W random & true lines did not show true directions in the notes or on plat.

1864 Manual: required surveyor to compute true bearing of corrected line based on miss at closing corner.


East random line.
Secs. 13 & 24
Var. 9° 30' East
80.00 Intersected range line 14 links North of post
West corrected
Var. 9° 24' East
19.50 Creek 50 lks. wide North & South
40.00 Set ¼ Section post Cedar 8 11 64° W 19 lks to 10 B 32 W 19
55.00 Leave swamp bro. NE & SW
80.00 Section Corner



$$a = \tan^{-1}\left[\frac{0.14}{80.00}\right] = 0°06'01''$$

$$b = 90°00'00'' - 0°06'01'' = 89°53'59''$$

True Brg = S86°54'E

C. PLS Direction Reference

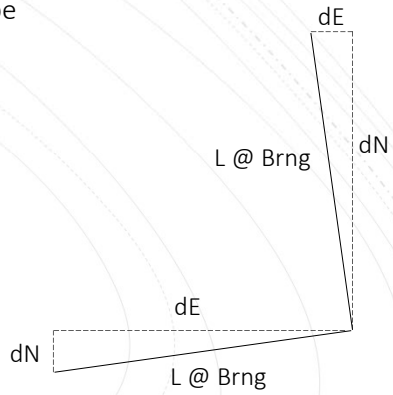
2. Cardinal Equivalents

Most re-establishment methods require original and contemporary measurements be reduced to N/S and/or E/W components.

Computed with respect to True North

$$dN = Lat = L \times \cos(Brng)$$

$$dE = Dep = L \times \sin(Brng)$$



C. PLS Direction Reference

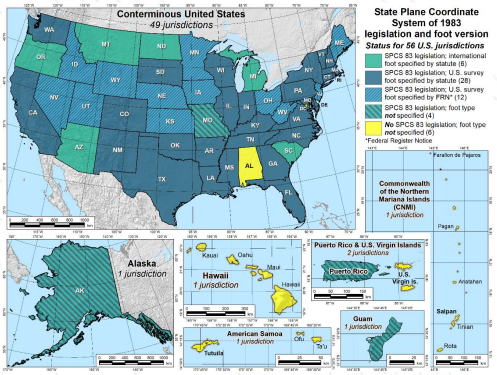
3. Grid Systems

Each state has one or more State Plane Coordinate (SPC) System zone.

Each is centered on a specific Central Meridian (CM)

If starting with grid coordinates, must compensate Grid to Ground:

- Direction
- Distance



II. Principles of Corner Re-Establishment

C. PLS Direction Reference

3. Grid Systems

a. Direction

PLSS lines ref'd to True meridians; converge

Grid north lines are parallel

γ, Convergence, angle Geodetic to Grid N.

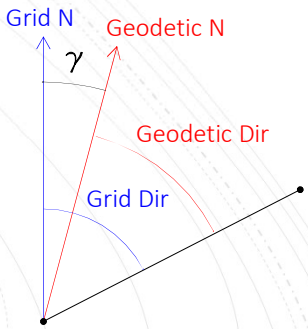
Grid Az = Geodetic Az - γ

Technically, Geodetic & True N not the same

slight separation between the two: <15-20"

can usually treat *Geodetic* & *True* same

Grid Az = True Az - γ

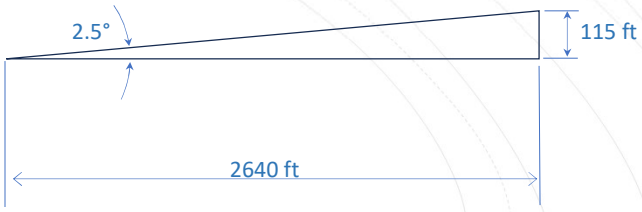


C. PLS Direction Reference

3. Grid Systems

Conv generally <2.5°

2.5° angle in one-half mile is 115 ft offset



II. Principles of Corner Re-Establishment

C. PLS Direction Reference

3. Grid Systems

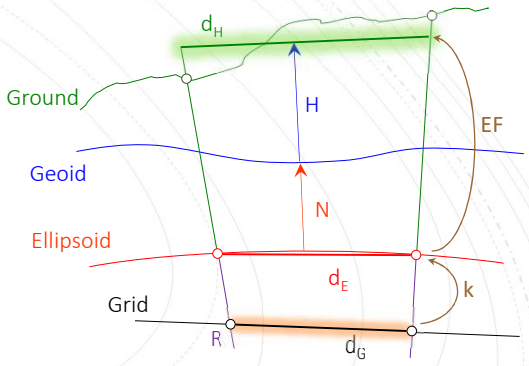
b. Distance

If using grid distance, must convert to ground.

$$Ground = \frac{Grid}{k \times EF}$$

$$EF = \frac{R}{R + H + N}$$

k: Grid scale factor
R: Mean Earth radius
H: Average endpoint elev
N: Geoid height



C. PLS Direction Reference

4. What About Assumed Systems

Do not use an assumed system.

An assumed system has no angular relationship to True meridians.

Correct contemporary cardinal equivalents can not be determined.

III. Lost Corner Re-Establishment

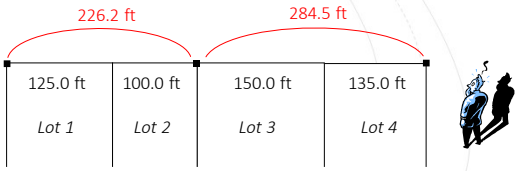
A. When All is Lost
B. A Matter of Proportions
C. Limited Control
D. Other Methods
E. Curved Lines

A. When All Is Lost

1. The Island of Lost Corners

Basic rules for lost PLSS corners re-establishment are same as for a subdivision lot resurvey:

- One or more accepted original corner locations are needed
- Original corners cannot be disturbed.
- Any discrepancies between original corner positions must be managed between those positions and cannot extend beyond them.



III. Lost Corner Re-Establishment

A. When All Is Lost

1. The Island of Lost Corners

Lost - means there is *no credible evidence* of original location.

Must relate contemporary to record distances
Depends on disposition of controlling corners
Are they found or re-established obliterated or lost corners? Combination?

Also depends on original procedure presumption:
By the book, modified procedure, creative approach

Original survey had distance and direction criteria
Most lost corner procedures are distance-biased

So we know re-establishing lost corner doesn't guarantee it will be in original location.

A. When All Is Lost

2. Line Hierarchy

PLS used a control framework

Hierarchy based on order theoretically run

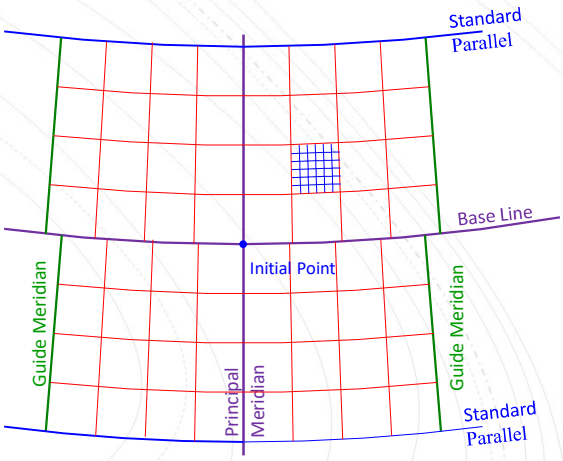
Highest to lowest:

Principal Meridian and Base Line

Standard Parallels and Guide Meridians

Township Lines

Section Lines



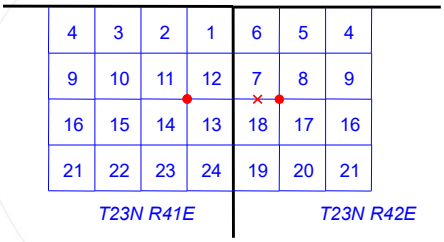
III. Lost Corner Re-Establishment

A. When All Is Lost

3. Corner Dependency

Control point must have equal or greater standing

There must be a dependency connection a lost corner and the control points.



Ex: SW S12 can't directly control location of S1/4 Sec 7. They are in different Townships.

4. It's a Guess at Best

Because of distance bias, no guarantee re-established position will match original.

Absolute LAST RESORT!!

B. A Matter of Proportions

1. Distance Based

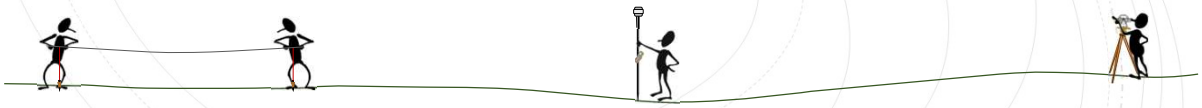
Original surveyor had specific distance *and* direction criteria to follow.

Because proportionate measurement uses only distances, original directions may not be met.

Current technology make proportionate measurement quick and easy than in the past.

Speed doesn't replace research.

Can use proportionate measurement as another piece of evidence for an obliterated corner.



III. Lost Corner Re-Establishment

B. A Matter of Proportions

2. Single Proportionate Method (SPM)

Used to restore corner that is

on a single line

at intersection of two lines, along the higher weighted line

Re-Establishment Steps

Step (1) Compute appropriate record cardinal equivalents

Step (2) Compute measured cardinal equivalents

Step (3) Set up and solve proportion(s)

Step (4) Use proportion(s) to determine lost corner location

B. A Matter of Proportions

2. Single Proportionate Method (SPM)

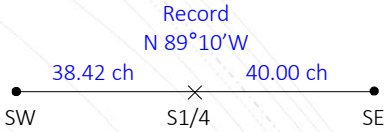
Cor must be online so cardinal equivalents not necessary.

(1) Set up proportion.

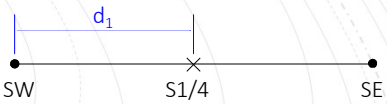
$$\frac{5183.60\ ft}{(38.42\ ch + 40.00\ ch)} = \frac{5183.60\ ft}{78.42\ ch}$$

(2) Compute dist from SW cor

$$d_1 = 38.42\ ch \times \frac{5183.60\ ft}{78.42\ ch} = 2539.581\ ft$$



5183.60 ft N 87°30'10"W
Measured



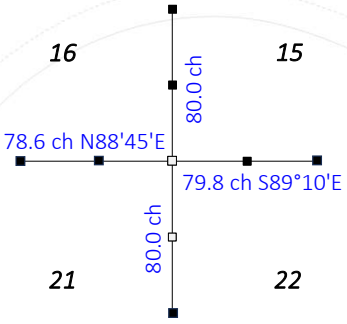
Measure 2539.58 ft from SW in direction of SE

III. Lost Corner Re-Establishment

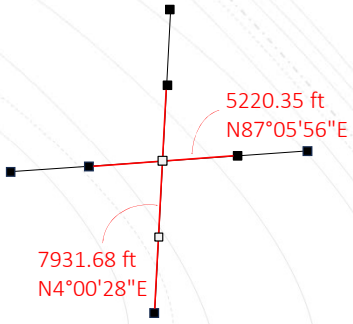
B. A Matter of Proportions

3. Double Proportionate Method (DPM)

Corner is at intersection of two equal weight lines.



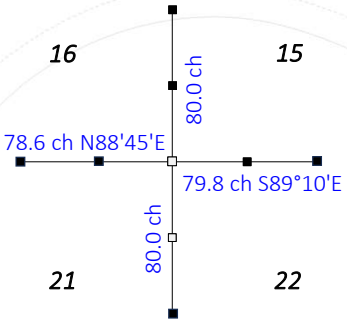
Record Dimensions



Resurvey Measurements

B. A Matter of Proportions

3. Double Proportionate Method (DPM)



Record Dimensions

(1) Cardinal equivalents

Record

N-S

$80.0\ ch\ +\ 40.0\ ch = 120.0\ ch$

E-W

$\left(78.6\ ch/2\right) \times \sin(88°45') = 39.29\ ch$

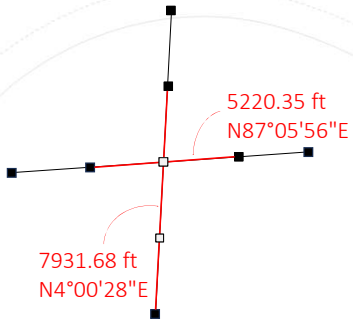
$\left(79.8\ ch/2\right) \times \sin(89°10') = 39.90\ ch$

$39.29\ ch + 39.90\ ch = 79.19\ ch$

III. Lost Corner Re-Establishment

B. A Matter of Proportions

3. Double Proportionate Method (DPM)



Resurvey Measurements

(1) Cardinal equivalents

Resurvey

N-S

$7931.68\ ft \times \cos(4°00'28'') = 7912.284\ ft$

E-W

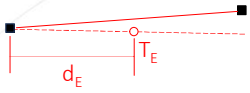
$5220.35\ ft \times \sin(87°05'56'') = 5213.659\ ft$

B. A Matter of Proportions

3. Double Proportionate Method (DPM)

(2) SPM E-W

Set temp point T_E



$$\frac{d_E}{39.29\ ch} = \frac{5213.659\ ft}{79.19\ ch}$$

$$d_E = 39.29\ ch \times \frac{5213.659\ ft}{79.19\ ch}$$

$$d_E = 2586.764\ ft$$

(3) SPM N-S

Set temp point T_S

$$\frac{d_S}{40.0\ ch} = \frac{7912.284\ ft}{120.0\ ch}$$

$$d_E = 80.0\ ch \times \frac{7912.284\ ft}{120.0\ ch}$$

$$d_E = 5274.856\ ft$$

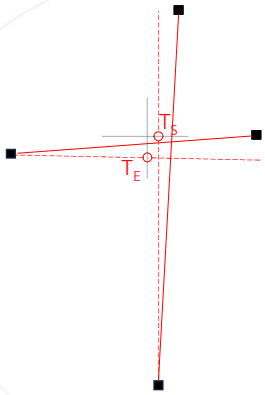
III. Lost Corner Re-Establishment

B. A Matter of Proportions

3. Double Proportionate Method (DPM)

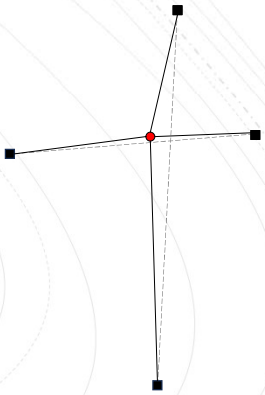
(4) SPM E-W

Cardinal lines through temp points



Corner is pulled off line.

Final distances not in original proportions

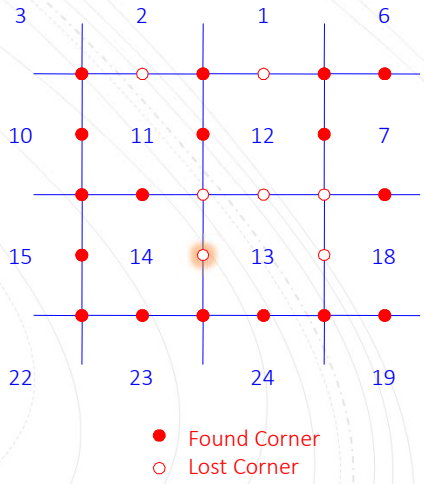


B. A Matter of Proportions

4. Which Way When?

To re-establish one corner may require re-establishing others first.

W1/4 Sec 13?



III. Lost Corner Re-Establishment

B. A Matter of Proportions

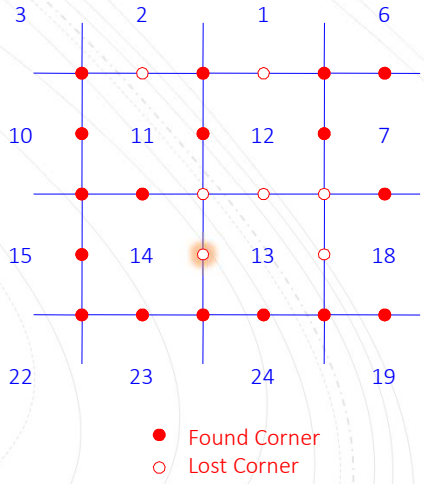
4. Which Way When?

To re-establish one corner may require re-establishing others first.

W1/4 Sec 13?

SPM SW Sec 13 and...

Must use NW Sec 13.



B. A Matter of Proportions

4. Which Way When?

To re-establish one corner may require re-establishing others first.

W1/4 Sec 13?

SPM SW Sec 13 and...

Must use NW Sec 13

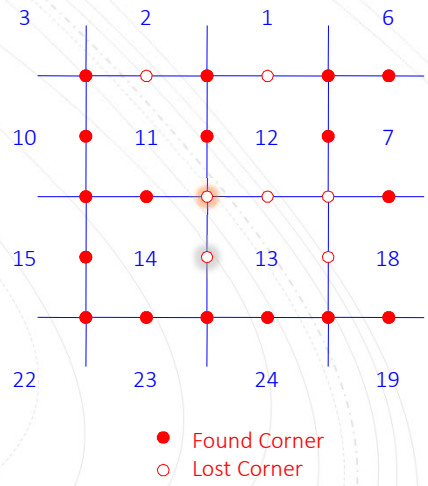
NW Sec 13: DPM

N-S: W1/4 Sec 12 and SW Sec 13

W-E: S1/4 Sec 11 and....

S1/4 Sec 7 is in a different Township

Must use SE Sec 12



III. Lost Corner Re-Establishment

B. A Matter of Proportions

4. Which Way When?

To re-establish one corner may require re-establishing others first.

W1/4 Sec 13?

SPM SW Sec 13 and...

Must use NW Sec 13

NW Sec 13: DPM

N-S: W1/4 Sec 12 and SW Sec 13

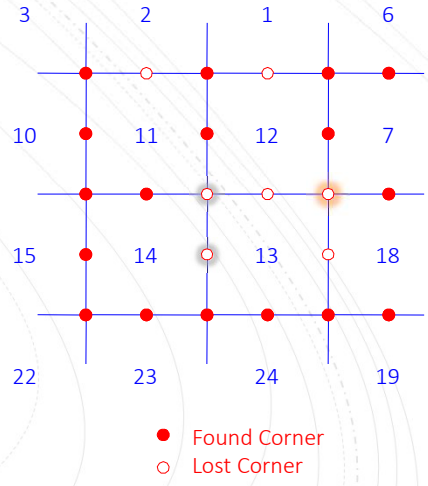
W-E: S1/4 Sec 11 and....

S1/4 Sec 7 is in a different Township

Must use SE Sec 12

SE Sec 12

SPM: SE 1/4 Sec 13 and E1/4 Sec 13



B. A Matter of Proportions

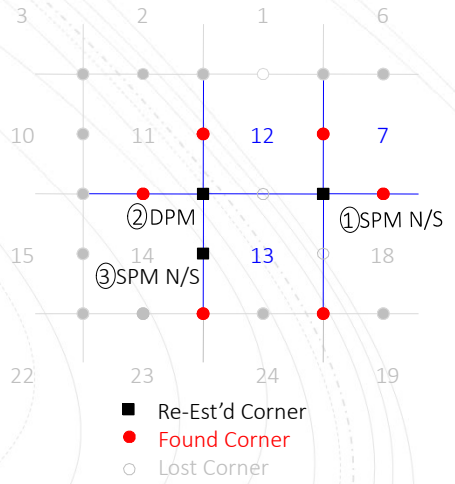
4. Which Way When?

To re-establish one corner may require re-establishing others first.

Step 3 W1/4 Sec 13?
- SPM SW Sec 13 and...
- Must use NW Sec 13

Step 2 NW Sec 13: DPM
- N-S: W1/4 Sec 12 and SW Sec 13
- W-E: S1/4 Sec 11 and....
- S1/4 Sec 7 is in a different Township
- Must use SE Sec 12

Step 1 SE Sec 12
- SPM: SE 1/4 Sec 13 and E1/4 Sec 13



III. Lost Corner Re-Establishment

B. A Matter of Proportions

5. Modified SPM (MSPM)

Section line originally bent at a quarter corner

Usually because township subdivided partially by two different surveyors at different times.

Second survey may have bent lines to fit

MSPM re-est's lost corner keeping the line bent.

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

B. A Matter of Proportions

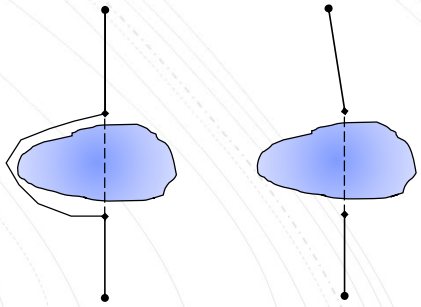
5. Modified SPM (MSPM)

2009 Manual Sec 7-34:

"There may be persuasive proof of a deflection in the alinement of the exterior, though the record shows the line to be straight...This condition, when supported by substantial evidence, would warrant an exception to the straight-line or two-way adjustment because under the rules for the acceptance of evidence, the evidence out-weighs the record."

Ex: Surveyor traversed around large water body.

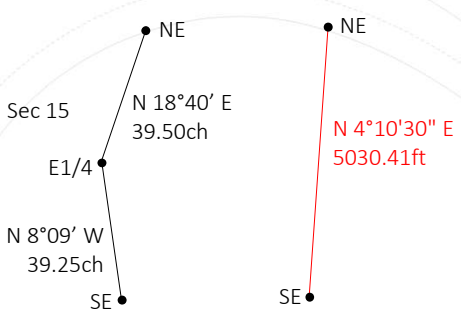
Error could cause Sec line bend despite being shown on the plat as straight.



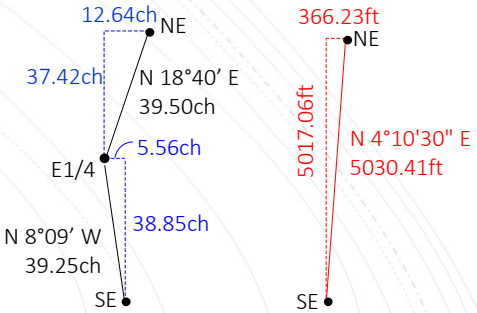
III. Lost Corner Re-Establishment

B. A Matter of Proportions

5. Modified SPM (MSPM)



Record and Contemporary Measurements



Record and Contemporary Cardinal Equivalents

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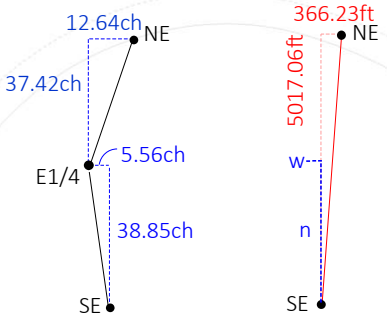
B. A Matter of Proportions

5. Modified SPM (MSPM)



Record and Contemporary Cardinal Equivalents

SPM N/S

$$n = 5017.06ft \times \left[\frac{38.85ch}{(38.85ch + 37.42ch)}\right]$$

$$= 2555.56ft$$

Compute E/W offset

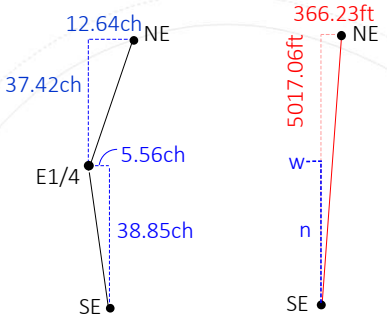
$$w = 2555.56ft \times \left[\frac{5.56ch}{38.85ch}\right]$$

$$= 365.74ft$$

III. Lost Corner Re-Establishment

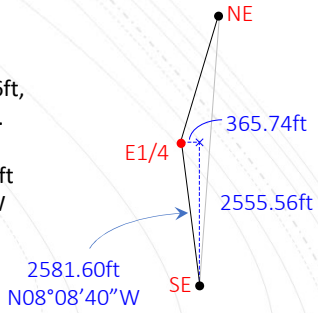
B. A Matter of Proportions

5. Modified SPM (MSPM)



Record and Contemporary Cardinal Equivalents

Measure N 2555.56ft,
then W 365.74ft.
or
Measure 2581.60ft
at N 08°08’40” W



B. A Matter of Proportions

6. Index Correction

2009 Manual Sec 7-57:

"In cases where a retracement has been made of many miles of the original lines, between identified original corners, and there has been developed a definite and consistent surplus or deficiency in distance, or a definite and consistent angle from cardinal that characterizes the original survey, it is proper to make allowance for the average difference(s). Such adjustment will be incorporated automatically in all cases where there exists a suitable basis for proportional measurement."

Index error - systematic causing measurements to be consistently too large or small.

Examples

Worn links causing chain length to increase - distances are all too long

Incorrect variation making line deviate from true direction

Proportional methods generally, but not always, compensate index errors

C. Control Corners

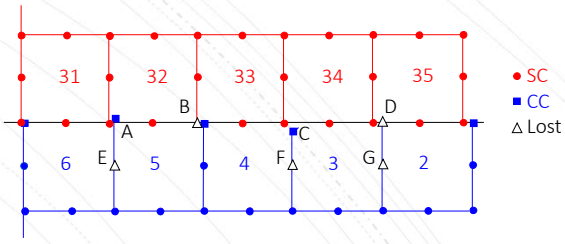
1. Closing Corners (CC)

Controls:

dir for setting Sec cor on closing line

dist and dir for proportioning

does not control along closing line



How to est:

A	NW S5
B	SE S32
C	NW S3
D	NW S2
E	W1/4 S5
F	W1/4 S3
G	W1/4 S2

C. Control Corners

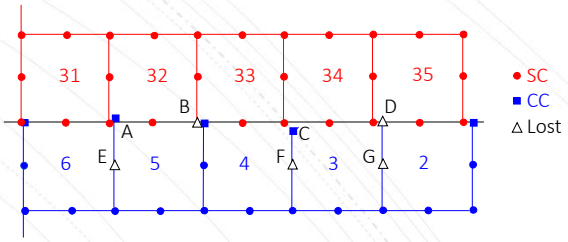
1. Closing Corners (CC)

Controls:

dir for setting Sec cor on closing line

dist and dir for proportioning

does not control along closing line



How to est:

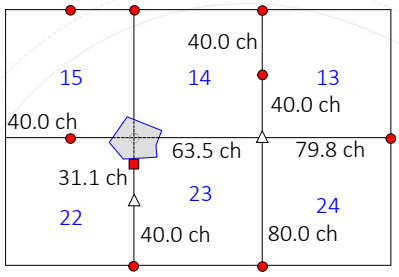
A	NW S5	Intersect SW S5 to CC A with SW S32 to S1/4 S32
B	SE S32	SPM S1/4 32 to S1/4 33
C	NW S3	Intersect SW3 thru CC C with SW34 to S1/4 34
D	NW S2	SPM SW35 to S1/4 35
E	W1/4 S5	SPM SW5 and CC A
F	W1/4 S3	SPM SW3 and CC C
G	W1/4 S2	SPM SW2 and Re-est NW S2 (D)

III. Lost Corner Re-Establishment

C. Control Corners

2. Witness Corners (WC)

Must be on the Sec line: can stand in place of or define a regular corner



How to est:

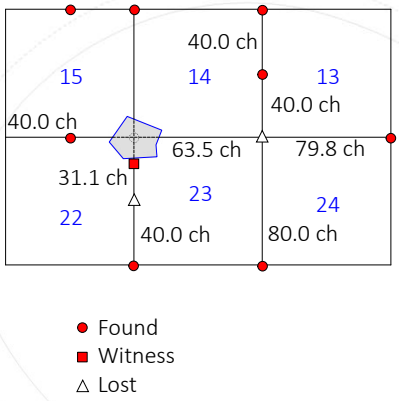
W1/4 S23

NE S23

C. Control Corners

2. Witness Corners (WC)

Must be on the Sec line: can stand in place of or define a regular corner



How to est:

W1/4 S23	SPM between SW S23 & WC
NE S23	Compute NW S23 by continuing 8.9 ch past the WC
	Re-set NE S23 by DPM
	EW: NW S23 to NE S24
	N/S: SE S23 to E1/4 S14

III. Lost Corner Re-Establishment

C. Control Corners

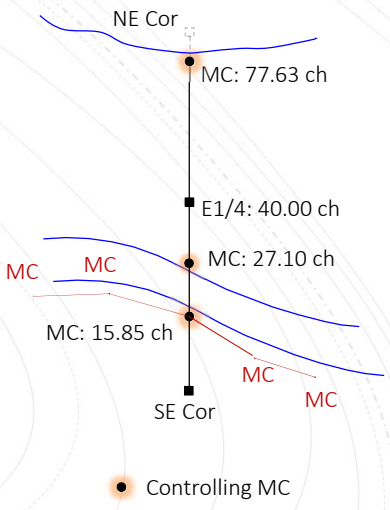
3. Meander Corner (MC)

Section 6-30 of the 2009 Manual:

> "When recovered, meander corners normally control both alinement and proportionate measurement along the line, as any corner of first order."

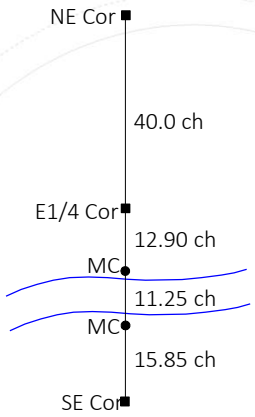
Only MC on the Sec line can control corner re-est.

MC used to map waterways do not.

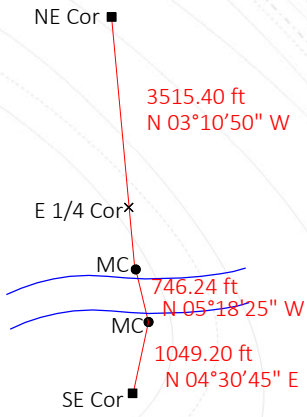


C. Control Corners

3. Meander Corner (MC)



Record

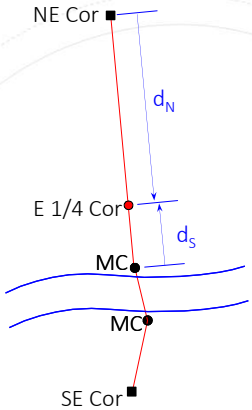


Resurvey

III. Lost Corner Re-Establishment

C. Control Corners

3. Meander Corner (MC)



Compute proportion from N

$$\frac{d_N}{40.0\ ch} = \frac{3515.40\ ft}{(40.0\ ch + 12.90\ ch)}$$

$$d_N = 40.0\ ch \times \frac{3515.40\ ft}{52.90\ ch}$$

$$= 2658.147 ft$$

Can check from S

$$\frac{d_S}{12.9\ ch} = \frac{3515.40\ ft}{(40.0\ ch + 12.90\ ch)}$$

$$d_N = 12.9\ ch \times \frac{3515.40\ ft}{52.90\ ch}$$

$$= 857.253 ft$$

D. Limited Control

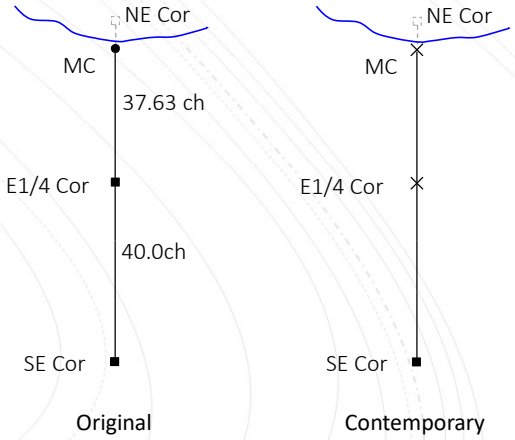
Limited Control?

- Lost corner originally tied to fewer corners than needed to re-est it by SPM or DPM
  - or
- All controlling corners are lost on one side of needed control.

Record measurements are used for missing connections

Three limited control conditions

- Three-point control (3PC)
- Two-point control (2PC)
- One-point control (1PC)



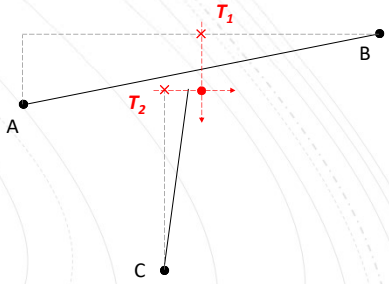
III. Lost Corner Re-Establishment

D. Limited Control

1. Three-Point Control (3PC)

DPM situation; control lacking to one side

- SPM in direction of sufficient control, set temp pt
- In other direction use cardinal record to set second temp pt
- Re-est corner at intersection of True E/W & N/S lines thru temp pts.



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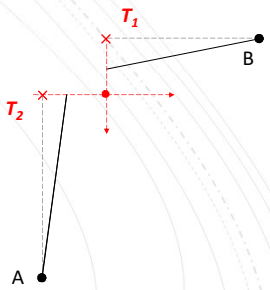
D. Limited Control

2. Two-Point Control (2PC)

DPM situation; control lacking on one N/S and one E/W side

In both directions use cardinal record to set temp pts.

Re-est corner at intersection of True E/W & N/S lines thru temp pts.



D. Limited Control

3. One-Point Control (1PC)

Lost corner only connected to one control corner.

Lacks control on other three sides.

Re-est at record distance and direction.

D. Limited Control

4. Examples

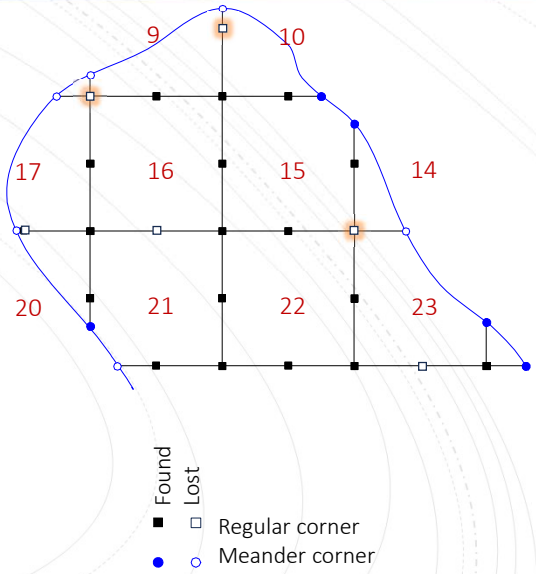
Fractional Township surrounded by water.

Re-establish

a. E1/4 cor Sec 9

b. SE cor Sec 15

c. NW cor Sec 16



III. Lost Corner Re-Establishment

D. Limited Control

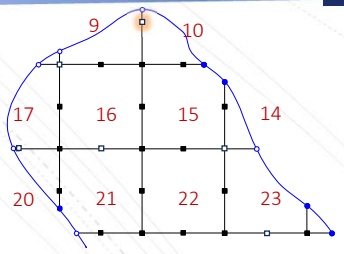
4. Examples

a. E1/4 cor Sec 9

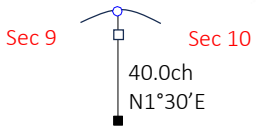
Quarter cor usually by SPM

But only one control point: SE cor Sec 9

Must use 1PC

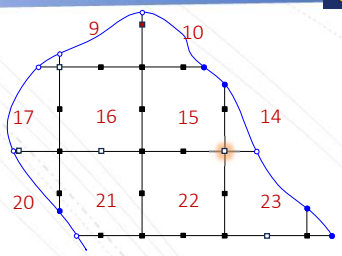


Record data:



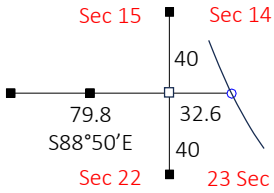
Set E1/4 at N1°30'E, 40.0 ch from SE cor

D. Limited Control



4. Examples
   b. SE cor Sec 15
      Interior sec corner set by DPM
      Missing one E/W control cor; OK N/S
      Use 3PC

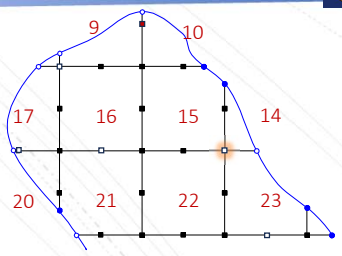
Record:



Meas E1/4 cor S22 to E1/4 cor S15
5212.36 ft , N 3°10'20"W

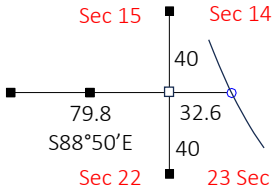
III. Lost Corner Re-Establishment

D. Limited Control



4. Examples
   b. SE cor Sec 15
      Interior sec corner set by DPM
      Missing one E/W control cor; OK N/S
      Use 3PC

Record:



Meas E1/4 cor S22 to E1/4 cor S15
5212.36 ft , N 3°10'20"W

E/W cardinal

$$Dep = (79.8ch/2) \times sin(88°50') = 39.89ch$$

N/S cardinal

$$Lat = 5212.36ft \times cos(3°10'20'') = 2504.37ft$$

N/S proportion

$$\frac{dN}{40ch} = \frac{2504.37ft}{40ch + 40ch}$$

$$dN = \frac{40ch \times 2504.37ft}{40ch + 40ch} = 1252.18ft$$

D. Limited Control

4. Examples

b. SE cor Sec 15

Interior sec corner set by DPM

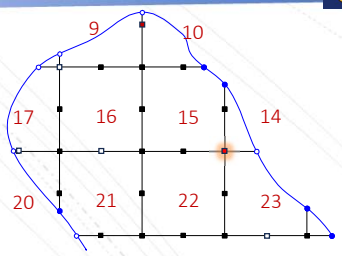
Missing one E/W control cor; OK N/S

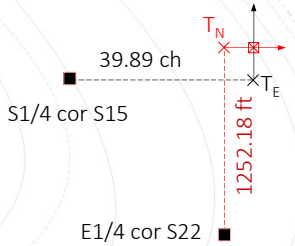
Use 3PC

Set T_E east of S1/4 S15 at 39.89 ch

Set T_N north of E1/4 S22 at 1252.18 ft

Set SE S15 at intersection of cardinal lines through T_E and T_N





III. Lost Corner Re-Establishment

D. Limited Control

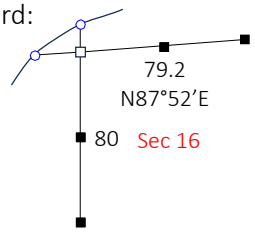
4. Examples

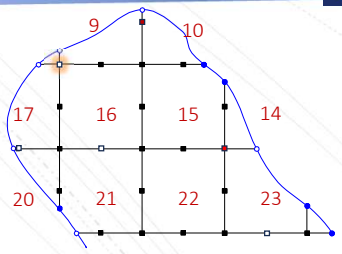
c. NW Cor Sec 16

Can't use DPM: missing an N/S and an E/W control corner.

Use 2PC

Record:





Record E/W

$$Dep = \left(79.2ch/2\right) \times sin\left(87°52'\right) = 39.57ch$$

Record N/S

Bearings not given so assume direction is cardinal

Use 80/2 = 40ch

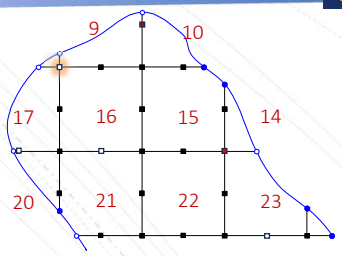
D. Limited Control

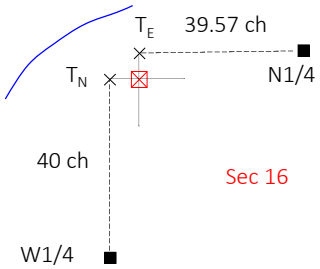
4. Examples

c. NW Cor Sec 16

Can't use DPM: missing an N/S and an E/W control corner.

Use 2PC





Set T_N 40 ch north of W1/4 cor S16

Set T_E 39.57 ch west of W1/4 cor S16

Set NW cor Sec 16 at intersection of cardinal lines through T_N and T_E.

E. Other Methods

1. Irregular Boundary Adjustment

Township boundaries that are not straight in record. why?

Multiple partial surveys

Modified methods

Erroneous procedures

etc

Try to recreate segment configuration.

Run traverse from one control point using record data

Measure closure error at second control point.

SPM each angle point in traverse direction

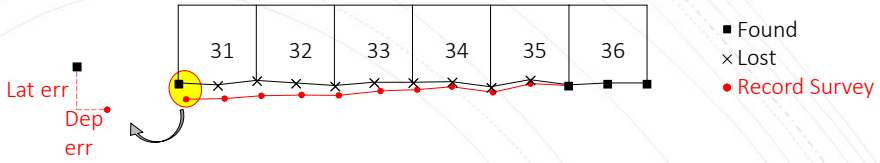
Use Compass Rule to compute offsets at each angle point

Use SPM and offsets to compute corner locations,

E. Other Methods

1. Irregular Boundary Adjustment

Complete numeric example in Appendix A.



SPM E/W

Record cardinal E/W =Σ(Dep)

Contemporary cardinal E/W =Σ(Dep) +(Dep err)

Multiply each segment Dep by ratio

$$ratio = \frac{\Sigma(Dep)}{\Sigma(Dep) + (Dep\ err)}$$

Compass Rule at each point

Total dist = Σ(segment lengths, L)

Offset at each point is:

$$(Lat\ corr'n) = L \times \left[\frac{-Lat\ err}{Total\ Dist}\right]$$

III. Lost Corner Re-Establishment

E. Other Methods

1. Irregular Boundary Adjustment

Complete numeric example in Appendix A.

SPM N/S

Record cardinal N/S =Σ(Lat)

Contemporary cardinal N/S =Σ(Lat) +(Lat err)

Multiply each segment Lat by ratio

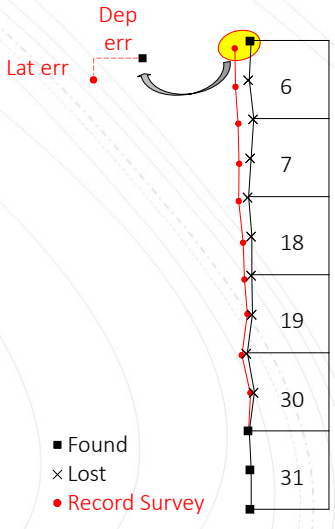
$$ratio = \frac{\Sigma(Lat)}{\Sigma(Lat) + (Lat\ err)}$$

Compass Rule E/W

Total dist = Σ(segment lengths, L)

Offset at each point is:

$$(Dep\ corr'n) = L \times \left[\frac{-Dep\ err}{Total\ Dist}\right]$$



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E. Other Methods

2. Grant Boundary

PLS had to stop at boundaries of existing grants, reservations, and other lands not included in the Public Domain.

Grant boundary similar to Correction Line:

Corner placed where Section line intersected boundary, like a CC

Different from Correction Line:

No Standard Corners along boundary: Section lines just ended

Boundary is not oriented in cardinal directions

Grant boundary (GB) is senior line so must be located first.

III. Lost Corner Re-Establishment

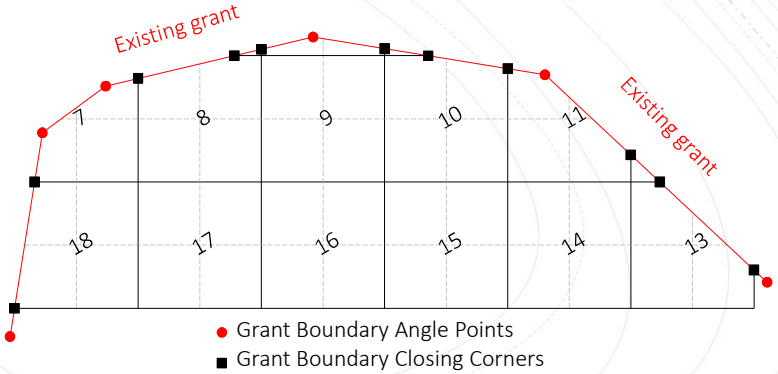
E. Other Methods

2. Grant Boundary

GB is not a PLS line so the same restoration rules do not apply to it.

Often described by metes and bounds and not limited to cardinal orientation.

Re-establishment process maintains GB shape and proportions between original corners.



E. Other Methods

2. Grant Boundary

Procedure:

Step 1. Two existent or otherwise re-established GB corners are located.

Step 2. Angle point locations are computed starting at one corner using record GB description data

III. Lost Corner Re-Establishment

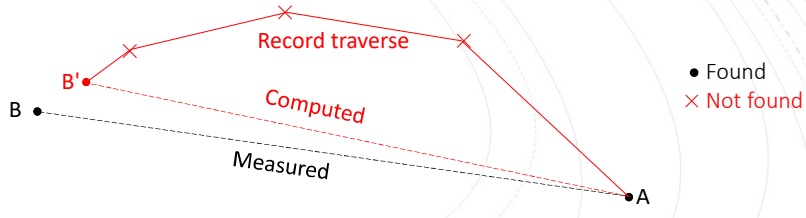
E. Other Methods

2. Grant Boundary

Procedure:

Step 3. Length and direction of line connecting end points (AB') computed from record data.

Step 4. Length and direction of the line connecting endpoints (AB) is measured.



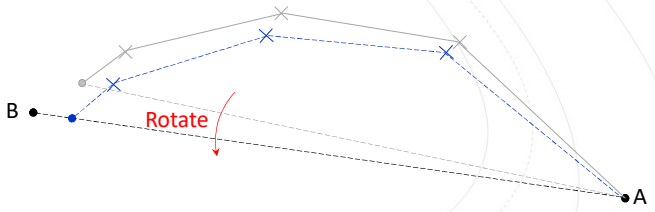
E. Other Methods

2. Grant Boundary

Procedure:

Step 5. Rotate record traverse into the measured line

Use directions computed in steps 3 & 4
Each line direction changes the same amount.



III. Lost Corner Re-Establishment

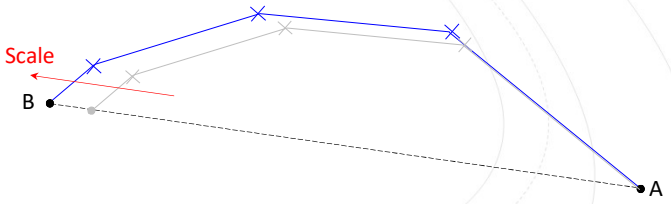
E. Other Methods

2. Grant Boundary

Procedure:

Step 6. Scale the record traverse so it matches found corners

Use distances computed in steps 3 & 4
Each line increase/decreases proportionately



Sidebar:

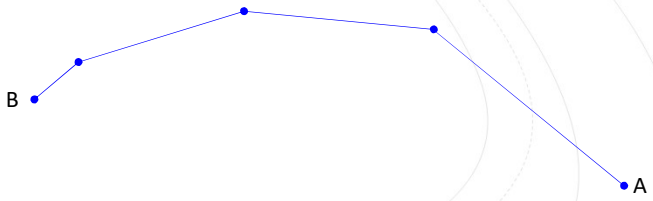
Basically, it's a simple 2D transformation

E. Other Methods

2. Grant Boundary

Procedure:

Step 7. Locate the GB corners on the ground using the updated directions and distances.



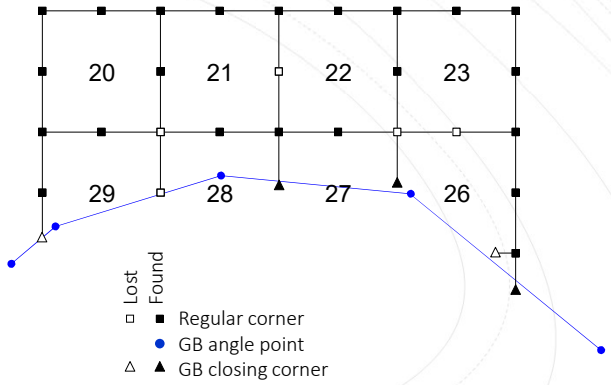
III. Lost Corner Re-Establishment

E. Other Methods

2. Grant Boundary

Once established on the ground, the Section lines must terminate on the GB.

Found "closing" corners are used to control direction.



E. Other Methods

3. Mixed and Miscellaneous

Last method defined in *Manual* is surveyor's discretion.

That does not mean to use an incorrect method because it's less work.

If original surveyor used a different approach, or did poor quality work, or worked under extreme conditions, etc, SPM, DPM, MSPM, 3PC, 2PC, 1PC, may not give reasonable results.

Can consider combining or modifying methods to better represent original intent.

Judgement call on corner-by-corner basis.

F. Curved Lines

True Line of Latitude

Many E/W PLS lines were curved latitudinal lines, down to Township boundaries

Lost corner re-est'd by SPM on curved line must be offset to south.

2009 Manual Section 7-17.

> In order to restore a lost corner on a line by single proportionate measurement, a retracement is made connecting the nearest identified corners on the line. These corners control the position of the lost corner. The lost corner is then reestablished at proportionate distance on the line connecting the recovered corners. Proper adjustment is made on an east and west line to secure the latitudinal curve. Any number of intermediate lost corners may be located on the same plan.

1973 Manual explained how to determine offsets using the *Standard Field Tables and Trigonometric Formulas.*

2009 Manual briefly describes offsets but does not explain how to compute them.

F. Curved Lines

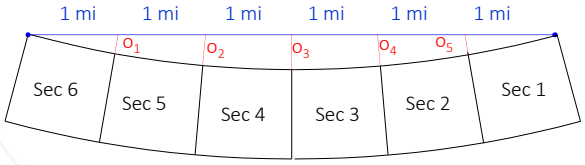
True Line of Latitude

How large is an offset?

Depends on:

- latitude
- control corner spacing
- lost corner distance along the line

Example: N line of T25N R42E Willamette Mer ~47°42' Lat



- Existent
- Re-est'd online

Offset	Dist, ft	Ang err
o_1	3.7	0°02'24"
o_2	5.9	0°01'55'
o_3	6.6	0°01'26"
o_4	5.9	0°00'58"
o_5	3.7	0°00'29"

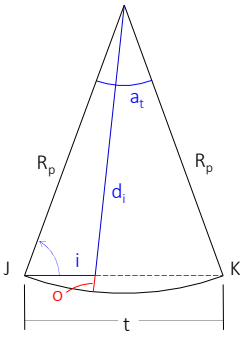
III. Lost Corner Re-Establishment

F. Curved Lines

True Line of Latitude

Math Explained in Appendix C of handout.

Latitude_Offset.xlsx, Excel spreadsheet at jerrymahun.com.



$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

$$R_p = \frac{a}{\tan(\phi)\sqrt{1 - e^2 \sin^2(\phi)}}$$

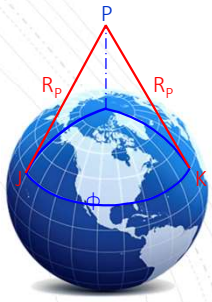
$$a_t = 2 \times \sin^{-1}\left[\frac{t}{2 \times R_p}\right]$$

$$J = 90° - \frac{a_t}{2}$$

$$d_i = \sqrt{i^2 + R_p^2 - 2(i)(R_p) \times \cos(J)}$$

$$o = R_p - d_i$$

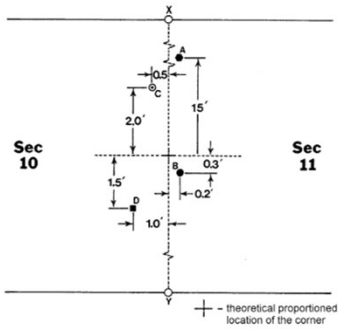
a: semi-major axis
b: semi-minor axis
φ: Latitude
Rp: Radius of latitude parallel

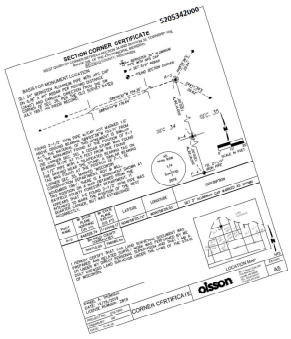


IV. Perpetuation

A. Monumentation

B. Documentation





A. Monumentation

Physical evidence

Once corner location determined it must be monumented and witnessed.

Many of the decisions about the type of monument are left to the surveyor

More typical are state or local requirements:

- Monument
  - Material
  - Size
  - Markings
- Accessories ties
  - Number and proximity depends on corner location

B. Documentation

Written evidence

- Most states requires a PLS Monument Record for a corner when a surveyor alters something, good or bad

- Should contain sufficient information for subsequent user to:
  - locate it (or recreate from accessories)
  - understand how location was determined
  - see the relationship with surrounding monuments which purported to be the corner
  - what the location lineage is

- Monument Records are retained as new ones are added
  - Form the corner's history over time; could be important for early surveys

IV. Perpetuation

B. Documentation

Written evidence

- Rules of Construction
  - For monument to control, it must be:
    - called for
    - found
    - undisturbed

- Original monument: wooden post
- Today: capped iron pipe

- Are they in the same position?
  - To be "found" or existent the monuments must be connected.

- Is the contemporary monument a replacement for a perpetuated known position?
  - Is lineage provided?

- If re-established as a lost corner, does documentation include:
  - sufficient info to understand why?
  - description of method used?

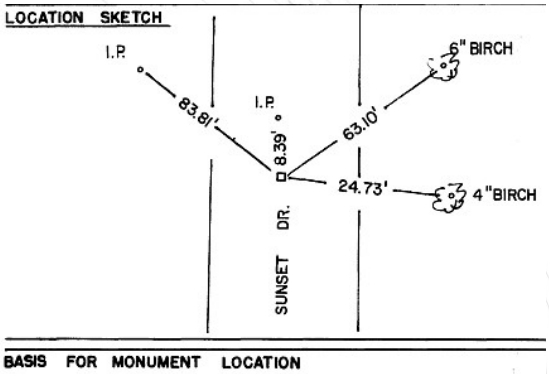
B. Documentation

Written evidence

How much confidence in the corner location does this Monument Record instill?

Except for the Surveyor's name and seal, no other corner information was provided.

Re-establishing a "lost" S1/4 corner



V. Summing It All Up?

Research

Locate

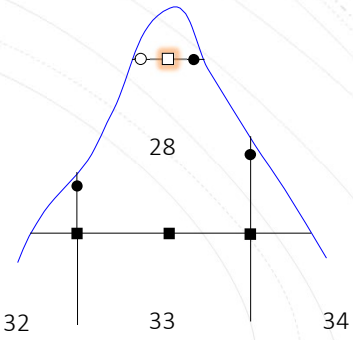
Document

VI. Exercises

Exercise 1

How would you re-establish the lost N1/4 of Sec 28?

Lost	Existent	
□	■	Corner
○	●	Regular
		Meander



Exercise 2

From original notes:

The witness corner near the NE cor Sec 21 was on the Section line.
The witness corner near the NE cor Sec 14 was not on the Section line.
Distance and direction was measured from each witness corner to the respective regular corner

Explain the procedure to re-establish the indicated corner.

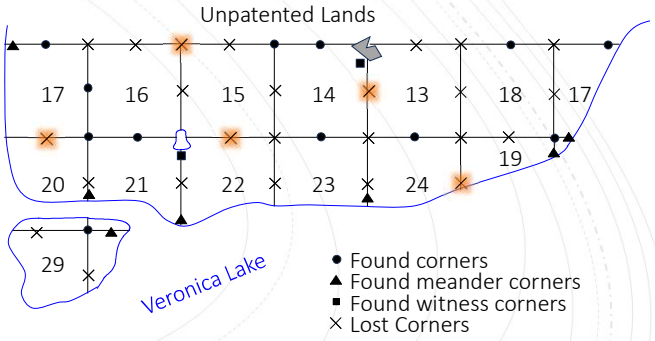
(a) N1/4 Sec 20

(b) NE Sec 16

(c) W1/4 Sec 13

(d) E1/4 Sec 24

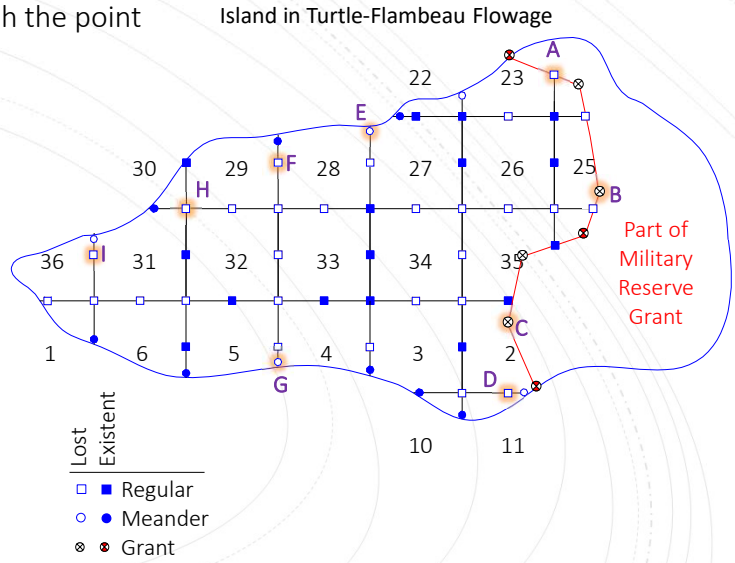
(e) N1/4 Sec 22



Exercise 3

Explain procedure to re-establish the point labeled:

A.
B.
C.
D.
E.
F.
G.
H.
I.



I've run out of things to say.
Good-bye.