Course 4: Restoration of Lost Corners Study Guide

COURSE DESCRIPTION:	This course consists of four videos, some reading, and three exercises, on the "Restoration of Lost Corners". The legal, mathematical, and practical applications of the methods of proportioning, as found in the Manual of Surveying Instructions, are presented. Students will be able to address what corners control in most situations, how to proportion properly, what legal principles are involved when proportioning, and how to deal with the latitudinal curve. A lengthy discussion of convergence and curvature in the PLSS is also included.
COURSE OBJECTIVES:	Upon completion of this course, students will be able to: • Define the three corner conditions listed in the Manual of Surveying Instructions • Describe, identify applicability, and compute proportions using all methods • Demonstrate an understanding of curvature in the PLSS
COURSE INSTRUCTOR(S):	Dennis Mouland, Bureau of Land Management Ron Scherler, Bureau of Land Management
VIDEO LECTURE TITLE:	Restoration of Lost Corners – Part 1 (40 minutes)

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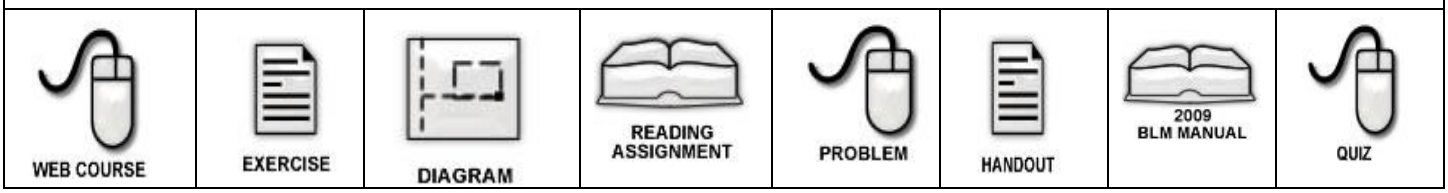


RESTORATION OF LOST CORNERS – PART 1

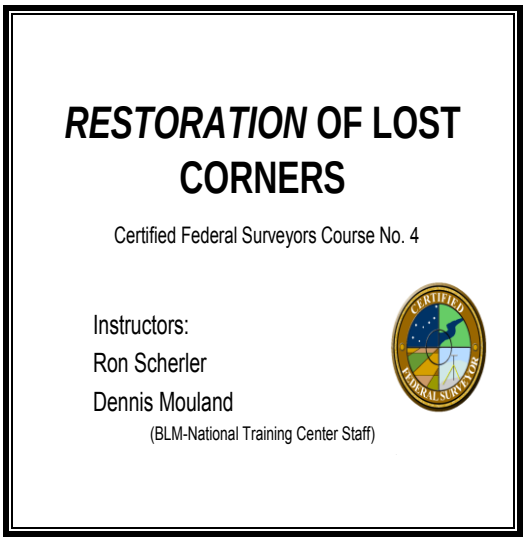
Before you begin the course, read Chapter 2, Section 2-9 to 2-43 and Chapter 7 of the 2009 BLM Manual

New to Restoration of Lost Corners? There is an optional web course available, which is accessible from the course description page.

Introduction

Well hello everyone this is Dennis Mouland once again and the infamous Mr. Scherler. Well, I don't know if I am infamous. We are here to give you course number four of the CFedS Program and it is on Restoration of Lost Corners.

A very important subject and one that we've even had difficulty explaining it and going through it here and this is actually our 3rd iteration of this course because for various technical reasons and other things; but it is a complex subject in spite of what some folks may think they already know about it we personally know and many of you will discover if you don't already know this, that an awful lot of the proper methods as described in the 2009 Manual for the proportioning of lost corners are not well known and there is not really any software that does most of it correctly. So that is why we are going to spend some time on this and we are glad to have you here.



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Objectives

I think the first thing that we will do is take a look at our objectives for this course. Given a lost corner situation, whatever type of corner it is, you will be able to: (1) select the correct method for restoring lost corners based on the 2009 Manual; (2) properly compute any lost corner position that is the math itself based on the 2009 Manual, and (3) you will be able to identify some special cases where proportioning rules may need to be modified.

Restoration of Lost Corners
Course Objectives

- Given a lost corner situation, you will be able to:
  1. Select the correct method for restoring lost corners based on the 2009 Manual
  2. Properly compute any lost corner position based on the 2009 Manual
  3. Identify some "special cases" where proportioning rules may need to be modified

We will tackle those things in the order that we move along, but leaving special cases at the end … one thing that I am a big believer in you cannot know or understand when you have an exception to the rules unless you know the rules like the back of your hand.

Is it Really Lost?

So we are going to go through the rules first and then talk about those pretty rare occasions where some situation comes up and we need to figure out what we are gong to do with it.

Is it ***REALLY*** lost?

- "Proportioning is an admission that our profession has failed." - Ken Witt, BLM, Retired
- We should learn to *hate* proportioning
- What does it take to be lost?
  (We do not proportion lost monuments)
- What do we do with coordinates?

Now before we go into this subject we need to ask an important question and of course this goes back to the things that you heard from Stand French, myself and Bob Dahl in course 3 and that was really asking yourself, " Is it really lost?"

Is the corner really lost? Ken Witt, who passed away a few years ago but who was the Cadastral Chief in Colorado for the BLM, he once said, and it stuck with me every since, he said "when we proportion it is an admission that our profession has failed" meaning that we either haven't found the evidence that is there or the evidence that was left there wasn't substantial enough to remain to our time and so his point being that either way the surveying profession hasn't fulfilled it most basic duty.

So I know I kind of start with that when I have to proportion that I am admitting that my own profession has failed. We should learn to really hate proportioning. That is almost a terrible thing to say anymore because it we are in the big high-tech world where we compute everything and math is easy and technical easy with the

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devices and software that we have, but we should learn to hate proportioning. Then another issue here is what does it take for something to be lost? Let's remember that for something to be lost, the evidence has to be gone, there is a little sub comment there we do not proportion lost monuments.

Let's go back and review that for a moment. You will recall that there is a difference between those two terms, **corner** and **monument**. A corner is a place, a position, its a location on the surface of the earth. Whereas a monument is a physical object marking that position or al least claiming to mark that position. And here's my point I've been to an awful lot of places where the monument for one reason on another is gone, is lost, but the corner isn't lost but somebody went and proportioned it in anyway, they didn't realize there were bearing trees there, didn't realize there were accessories, other types of evidence, things we discussed in the previous course. So we don't proportion lost monuments. You want to make sure it is really lost that you've really looked for all of the evidence.

Then we have another question that I am gong to ask Ron to address and that is just generically, "What do we do with coordinates?" **Coordinates** are another form of evidence, but what do we do with those. Ron, you have any comments on that.

Well, I think that you are exactly right, coordinates are another form of evidence. They are measurements. Therefore, we need to evaluate that evidence, the coordinates, and use them accordingly. Sometimes those coordinates are going to be very accurate. Sometimes they are going to be coordinates on the controlling corner plus the lost corner which means it is basically a different measurement of the line. Other times those coordinates are going to be on different positions. They may be coordinates from a position far, far away, or they may be some kind of a local coordinate base that we can't figure out and get on to.

The point is they are evidence and when we are trying to reestablish a lost corner, we want to use the best evidence. So just because it is lost, doesn't mean that we are immediately going to go to proportioning between the nearest found corners. If we have some evidence in the form of coordinates, we may use that. It is evidence that needs to be evaluated. And that's really all it is. I

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think that one of the dangers that we have seen, I know I have seen and you probably have too, is that just because people have some kind of coordinates in there they jump on that real quick and don't even consider the evidence, And you know that may be there.

Three Corner Conditions

I want to remind you of the three corner conditions which we also reviewed and discussed in course number 3. There are three basically in the Manual and they are listed here on this slide, the **Existent Corners**, you find that at 6-11 in the Manual, the **Obliterated Corners** at 6-17 and then the **Lost Corner** at 7-2. And what I to remind you is that we when we are talking about proportioning, we are only dealing with the latter of those three. And it takes a lot of effort and energy to get down to the point where it is a lost corner.

The Three Corner Conditions

- Existent Corners (BLM 6-11)
- Obliterated Corners (BLM 6-17)
- Lost Corners (BLM 7-2)

Just because it isn't evident the first time you walk up, or whatever, doesn't mean that it is lost and just because someone else didn't find it, doesn't mean that it is lost. What it means is that you still need to do a job to your personal professional satisfaction as to what the evidence situation is there and then therefore which of the three corner conditions you are actually dealing with. So all of that under that question that we asked, "Is it really lost?" So moving on to proportioning itself.

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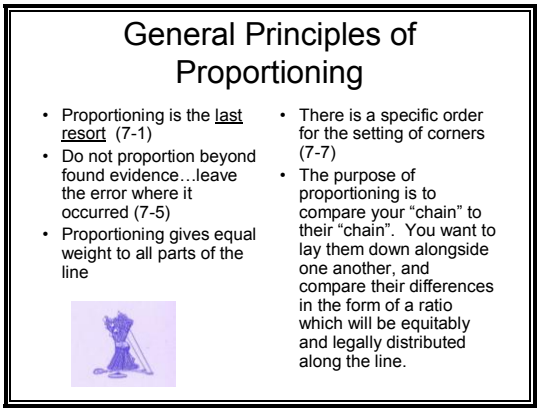
General Principles of Proportioning

We have several general principles of proportioning that we want to take a look at. The first one is that proportioning is the last resort. You may have heard people say that and that is true, but the Manual says it too. It doesn't use quick those words, but let's talk a look at it. In 7-1, I am just going to read to you, the rules for the restoration of lost corners should not be applied until all original and collateral evidence has been developed. That goes back with what we just talked about. And when these means have been exhausted.



You might want to underline that word there that is a powerful word, "**exhausted**", when these means have been exhausted, the surveyor will turn to proportionate measurements. You see, the Manual in its own way is saying that proportioning is the last resort and we need to recognize that and be in harmony with that.

Another principal that you find in 7-5 of the Manual, you don't proportion beyond found evidence. **Leave the error where it occurred.** Let me read just a couple of sentences here in 7-5. Existing original corners may not be disturbed. Hopefully, we know that.

Consequently, discrepancies between the new measurements and the measurements shown on the record have no effect beyond the identified corners. Now, let's understand something what that means first of all there is really two ways we can look at this.

One is if you've got a record measured relationship between these two existent monuments, anything in between there, that is how you will use that proportioning with the correct method of course, between those two monuments, but if you go on past those to another monument, the difference between those two monuments may be the opposite, it may be longer than the record whereas the first one was shorter than the record. You just leave your proportioning between found existent controlling corners.

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Now the other way I want to look at this is I have know people who for convenience sake have not searched for intervening evidence. In other words, there is a case in California where they found a corner, real rugged country, and the next place that a road crossed that township line was four miles away. So they drove all the way down there; went out there four miles hunted for a day or two; found another corner, real rugged brush country and then used it to do some proportioning in there, but they never looked for the corners in between. So that is another way to look at this.

You can't proportion beyond found evidence. Well you need to look for all the intervening evidence to know what is the found evidence. Because just one corner in between those four miles that comes up and it completely changes the proportion on both sides. So we want to make sure that we are not short changing the process. You know it is not correct to go down to the most convenient next corner and use it to proportion. We need to look at every piece of evidence because the first one you find that's where this "leave the error where it occurred" principal which you see a lot in the court cases comes in.

Another principal here, proportioning gives **equal weight to all parts of the line**, you'll read that in 7-17. I won't read it to you, it just says that equal relative weight it says and we will see how that plays out here. But one of the things that we want to remember here is that you have to be very cautious and we'll show you a couple of these as we go along where and maybe even unconsciously you find yourself preferring one set of corners over another and a lot of that is just by mistake it's not paying attention to the fact that we need to weigh all parts of the line in a relative way, equally, not picking one set of corners, and saying I am going to force this to be straight, even though other evidence makes it otherwise. And I'll show you some other examples of that as we go along.

Also in 7-7 you will find that there is a specific order for the setting of lost corners. They are listed actually on the top of the next page in Italics. That is another general principal for you. And then finally, one that you don't find in the Manual directly. But I want you to understand the purpose. The whole purpose for proportioning is to **compare your chain** or whatever your measurement device is, **your chain to their chain**.

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Here is what you are doing, you are laying them alongside one another. And you are going to find out that your chain is a couple of hundredths of a foot longer than their chain and then you are going to take that difference and apply that in a ratio to everything that is in between those two corners. That's really what proportioning is.

We also need since we are talking about that, we need to maybe think about the mathematical assumption that proportioning makes. In most cases, proportioning assumes that whatever the difference is, the difference is between the record and your measured, that difference is equally distributed along that line. And if you really think about that, that is not always true. That is not always true. I can think of a lot of situations where that is not true.

For instance, maybe you've got a quarter corner lost and you are going to single proportion it in and the east half mile us down in the flats and the west half mile goes up the face of a mountain range, and to say that the difference between the chain and the measurements that they took are equitably or equally distributed along that line is not necessarily true.

Now I am not disagreeing with that principal because that is the foundation of the math in proportioning, but what they should do is scare you a little bit and help you understand why proportioning is the last resort because it is relying on assumptions that are not all that realistic, but that is what happens when you don't have any evidence and you are left with the math and that's all you are left with.

So that is a good reason for us to understand why that is so critical to make sure that it really is lost first of all and that we use the correct method and that we pay close attention to what you are doing when you are comparing those two chains.

Case Law

Now I just want to mention that we have had some discussion already in the CFedS courses about case law and there is some

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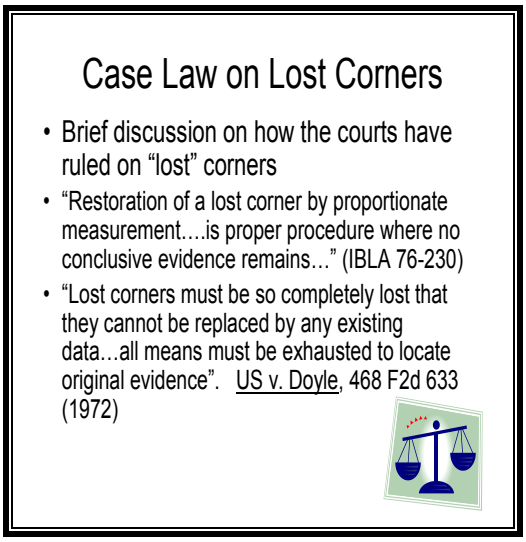
case law on this subject, and actually there is quite a bit, we just wanted to throw a couple of things out here for, a brief discussion, if you will, on how the courts have ruled on lost corners.

We have just pulled two cases in here, the first one is an IBLA decision, which you are familiar with now, and there is the number 76-230. It says, "Restoration of a lost corner by proportionate measurement is the proper procedure where no conclusive evidence remains." So you know we have Federal courts and here the IBLA telling us that that is the proper method when no conclusive evidence remains and we have a lot of other cases like that or that say this one as well.



But another one I think is interesting is US versus Doyle, which is a Federal case, and it says and I quote, "Lost corners must be so completely lost that they cannot be replaced by any existing data, all means must be exhausted" and that is probably where the Manual got that term, "to locate original evidence." So hopefully those two just help emphasize what we have been saying in this introductory portion of the course.

Now, you know, in proportioning, I know that when I took my state Land Surveying exams and I ended up, well I was licensed in 4 states, but I took 5 exams, because the first time I took the opportunity in Arizona, it didn't work out that well, so I got to take their state test twice. But you know in most states and in most surveyor's minds, there is really only two methods of proportioning in the public land system. We all understand single proportion and double proportion.

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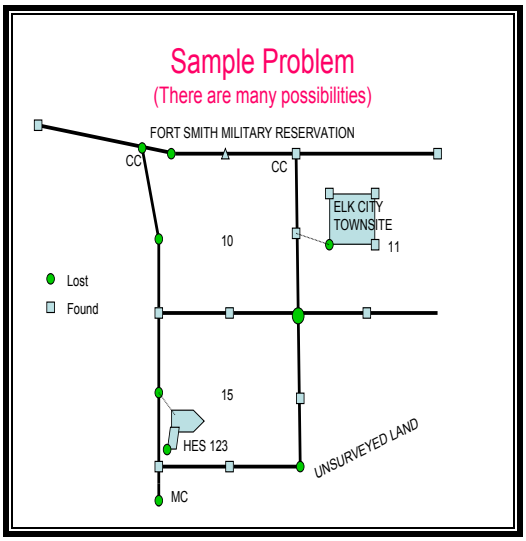
If you take a look at this slide here for a moment, this is something that we kind of drew up just to kind of show you a sample of what types of things are out there, but notice that we not only have a quarter corner that is on a straight line which we are all familiar with but we have a lost section corner at the intersection of 4 lines, which those are the two we are familiar with, but notice that there are a whole lot of other possibilities.



What about a quarter corner with a bearing break on it? What about a lost closing corner up where this section line intersects this military reservation? And what about a lost corner along that military reservation? Also we have a non-rectangular entity, the Elk City townsite and it has a lost corner. What is the proper method for that? And more interestingly, we have a section corner out here where the survey did not continue out this way or this way. In other words all we have are these two lines coming together yet it is a section corner. How do we deal with that? And then finally, down here we have a meander corner which is a snubbed out corner. They stopped the survey there and claimed they stopped it there.

So what do we do with that? So you see there are a lot of different possibilities, a lot of different things that we are going to be looking at in the subject of proportioning lost corners. So we are ready to go with the first subject area and that is talking about these different methods.

Single Proportion

Let's talk about single proportions. Now within the subject of single proportions you might think that this will go fast but no its not going to go very fast because we have 4 different sub methods or categories, not categories really, but 4 different ways to look at single proportions.

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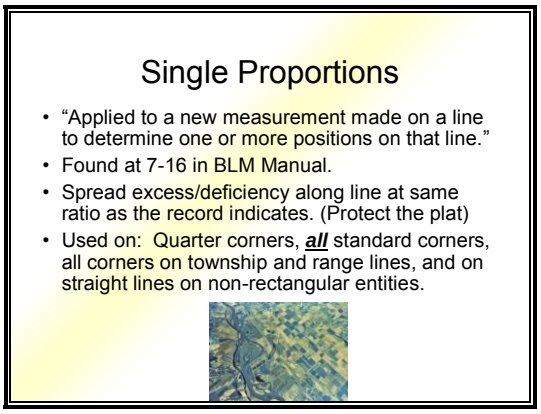
A single proportion is as the Manual talks about is applied to a new measurement made on a line to determine one or more positions on that line, so this is on a line. We find this at 7-16 in the Manual and that was a quote from the Manual so I won't read that one and what it is going to do is it is going to spread the excess or deficiency between the record and the measure along that line at the same ratio all the way across there as the record would indicate and this comes up with a term that I gave you in course number 3, protect the plat meaning we go to the plat and the notes by default and we look at what the record is, what they said they did and then deal with lost corners along the way and those same mathematical ratios.



So a single proportion is simply going to spread out whatever the record measure is, so in other words if you have an extra foot and a half a mile and you are going to put a sixteenth corner in, frankly it will work the same way it goes at midpoint and except in closing sections. Why? Because well first of all it is aliquot on both sides, it is a midpoint corner, so each side of that is going to get an extra half foot. Same thing with a lost quarter corner. So single proportions, at least we start that way with something simple.

Single proportioning is applied to all quarter corners, standard corners, every corner on a standard parallel or correction line, all corners on township and range lines and on straight lines of non-rectangular entities so even an Indian Reservation boundary that is straight in the record for you know eight miles and you've got two or three of the mile corners missing in there the way to properly proportion those is a single proportion.

Well, single proportioning is the only proportionate method that we use to establish corners for the first time. $1/16^{th}$ corners, $1/256^{th}$ corners, $1/64^{th}$ corners, corners along the line, we use a proportionate method, single proportion for and it is the only one that we use that way. Double proportioning we are reestablishing corners, grant boundaries, we are reestablishing corners, but single proportion we actually use to establish corners for the first time. Interesting point.

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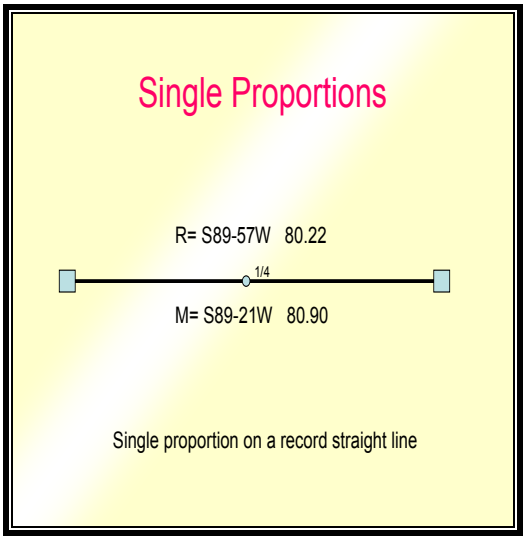
Single Proportion - Midpoint

Let's take a look at a simple single proportion, all right, on your screen we have a quarter corner that is lost on a straight section line. Notice that the bearing of the, the record bearing 89.57 SW – 80.22. Now you could verify this in the notes but that quarter corner was probably set at 40.11, okay, midpoint in other words. And it is not the 40.11 that we are going to hold, it is the midpoint relationship that we are going to hold because the record said that it was midpoint that both sides of that line was the same length either side of that quarter corner, therefore, we come in we have different measurement.



Notice that our bearing is different. Does that matter? No it doesn't because a line, just a single line, that is all we are talking about was a single proportion, a line is determined by the two points or corners in our case on either end. So the fact that we have a different bearing doesn't change this here. But we do have a different distance. We are at 80.90. But we know that if you are going to protect the plat and the notes which means that the record says that that was the midpoint and if that quarter corner is truly lost then you are going to set it at 40.45 because that's midpoint based on your measurements. And that is the simplest, that's a midpoint single proportion, those are the simplest ones to do and that is usually what people think about with single proportions.

Single Proportion – Closing Section

Now let's stay with a quarter corner on a straight line but let's show that we have a slightly different situation when what we call or some of us call closing sections and that is here is a situation where the quarter corner is not at midpoint in the record as many of you know and you should know from what we went through in course 2, this distance here in a closing section, what is this section six and seven, yeah, this distance here is 40 chains in the record and if it is something different just by chance and I have seen that once in my career, well then fine, just do whatever they indicate.

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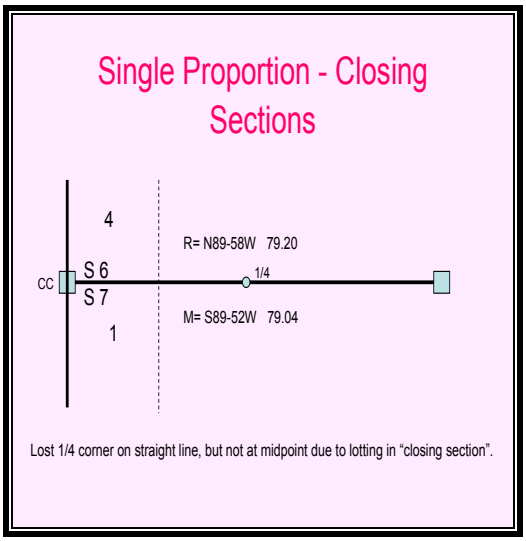
I saw one here in Arizona where they midpointed the quarter corner where they weren't supposed to, but that is what they said they did. So that is where we put it back, but that is not normally where that would go. That's 40 and the record here is 79.20 so that means that this is 39 if I can point, 20, right, 20? So we have 40 chains on one side and 39.20 (that's a 9 there) on that side, so we are not at midpoint.



So in order to compute this, we are going to have to set up the actual proportion. Now this is where that analogy of compare your chain to their chain comes in handy. There's what their chain said it was in the record and here is what you say, there's your ratio right there 79.20 is to 79.04 as and you know we could solve for this side, okay, so 79.20 is to 79.04 as 40 is to "X".

So using that mathematical relationship we solve for "X" and it is just a simple computation solving for one variable, "X" = 39.92 chains, so what that means is that you would, your distance when your survey is done, you would have 39.92 in this distance and of course, you could compute for this one too, that's a different formula, not a formula, but different numbers that you would put into the computation.

And notice, one of the things that I always try to do to make sure that I did it right, notice that the record is 79.20 and the measure is 79.04 so the measured is shorter so my 40 chains here should be shorter, which it was, 39.92. So you know that is one of the ways to make sure that you didn't do this backwards with the measured over the record or something like that.

And if you wanted to solve this other side, you can actually one of the best ways to do this is a double check and surveyors should be the kings and queens of double checking is I compute what this one is and then I should compute what this one is which is 39.12 and then add them together and it should equal 79.04. So that is one of the ways to always make sure of what you have done, that you did it correctly. So what we have seen so far with single proportions is that both on a straight line, we did the midpoint then we did a non-midpoint.

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Now this leads us into another situation as we pointed out earlier and if you look on this plat. Now if you looked at the original survey of this township, the surveyor said that he was running straight lines down here. But when we get out on the ground, this was done back probably in the '70s or so, we get on the ground we find that he falsified his documents basically. He came from a section corner and went down to his quarter corner and then faked in the notes for the last part.

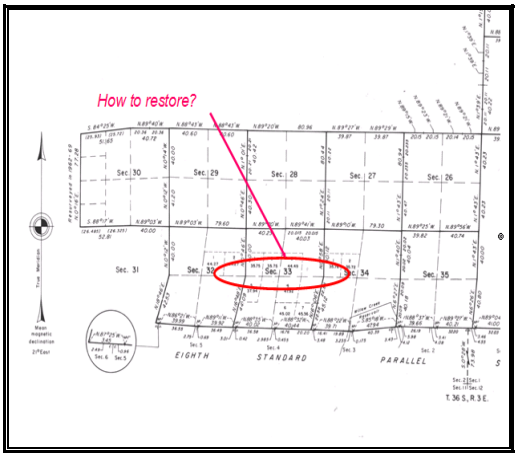

DIAGRAM **A full size version can be found in the Diagram section at the end of this study guide.**

So when we get on the ground we find that in reality there is these big angle breaks in these quarter corners. Now let's just assume that in 1970 or something, the BLM came in and this is this plat is their survey and you come back in whatever, this is 2007 when we are taping this, and that has become lost. How are you going to put it in knowing that there is an angle break? You know obviously, the last thing you want to do is do a single proportion on a straight line.

You are going to set that corner you know maybe five, six, seven chains away from where it was and our goal is not to put it where is should have been but rather to put it where it was. So you know that is the question, how do we restore those types of situations? So when we look in the Manual and this is at 7-50 and 7-51 in your Manual and you've already been, you've already read chapter 5 at least you were supposed to in preparation for this particular course.

I am just going to read you a little bit here. Sections 7-50 and 7-51. Some township boundaries not established as straight lines are termed as irregular exteriors. Parts were surveyed from opposite directions and the intermediate portion was completed later by a random and true, leaving a fractional distance. What they are saying is that the township line came in and they stopped and then a couple of years later they came in here and it was over here and so the last half mile has got this angle point in it. So the township line is a single proportion but it's got these two angle points in it. But let's read on.

Such irregularity follows some material departure from the basic rules for establishment of original survey. Sure it does, it was supposed to be a straight line all the way, but now it has a break. But then they say, a **modified form of single proportionate**

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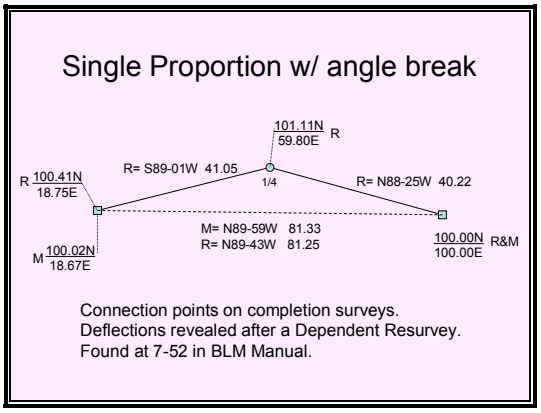
measurement is used in restoring lost corners on such boundaries. Then this last sentence in the paragraph is really the key because that is the situation we were just looking at and it is actually more likely for you and I and that is this is also applicable to a section line or a township line which has been shown to be irregular by a previous retracement and that is the scenario that we laid out.

In 1970, the BLM came in and found that the quarter corners had that big bearing break at them now that quarter corner is lost and our question is, "How do we restore that quarter corner knowing that in reality it was not on a straight line?

Single Proportion – Angle Break

So if we take a look at this problem that we have here on the screen, we see the situation ere that we have a section corner here and a section corner here, where we have found, all right? And the quarter corner is lost.



Now once again, why would you ever, and believe me I have seen this done quite a few times, the quarter corner was lost and a surveyor comes in and he goes and puts this thing out here. Why would you run this line and put it out here? When we have evidence that that says it was there. Yet that is with blinders on. People aren't realizing that there is a modified form of single proportion when you have an angle break in the record. Now if you were to read the next two or three paragraphs in 7-52 you will be absolutely boggled by what the Manual attempts to tell you to do and I am not going to waste the time to read it you have already read it but I want to explain what it really means.

Understand first of all I call this one of the secret decoder rings of the Manual especially Chapter 7. Understand that most of these methods are written as if you were running record bearing and distance and setting a temporary stake, not something that a lot of modern surveyors do, even in the government. So let's understand that you and I can do that mathematically, going back to the screen, we just made up small numbers here but we have 100 and 100 over here and we just said that's our record and our measured for this example.

Here is the record bearing and distance; here is the record bearing

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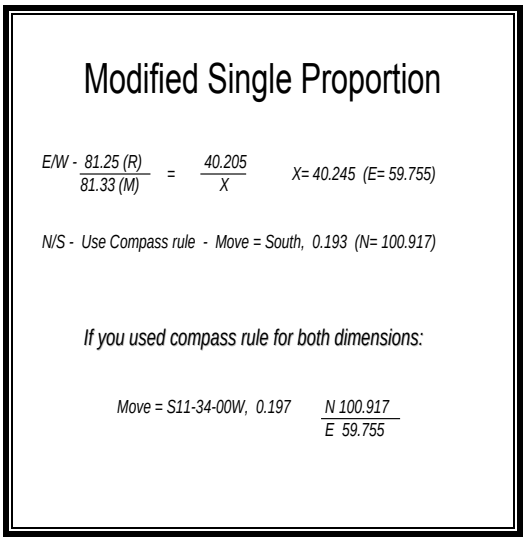
and distance. So f you enter those into a COGO program, it is going to give you a record coordinate. A record coordinate over here. And so there's my record and I compare that to my measured. Now if the record and the measured coordinates are the same, that means that you have found the two existent corners in exactly the same relationship in the record as the record said you found them to be in that same relationship. So but that is not likely. They are going to differ. And so this is where we make our adjustment.

Now the way the Manual says to do this if you decode 7-52 (the second half of it), you will find that what it is really saying is that in the direction that the line goes okay so in this case it is an east west one, in the direction that the line goes, we are going to do a single proportion okay which means that we are only going to be using the eastings to help compute that. But for the opposite direction okay, in this case its east west, so for the north south, we are going to use the compass rule. Now that is a bizarre mixture of two different methods and I am not sure that I understand all of the reasoning behind that but the bottom line is that is what the Manual says to do, so we do a single proportion this way to come up with an easting, all right. We will compute an easting off of that but we are going to do a compass rule adjustment for the northing.

Modified Single Proportion

Now let's take a look at this and solve it then. Let's do the east west first which is a single proportion. If you go back to that page and I'll assume you can do that easier than I can. I've got two dimensions here for the total dimensions between the two points. I have a 81.25 and an 81.33. So there is my record measured. So what I have done is set up 81.25 is to 81.33 okay there is the ratio. There is laying the two chains down next to each other. And then I am going to go 40.205. Now where did I get that distance from? 40.205? Was that it? I'm sorry, let me look again, yes 40.205. That number comes from the departure of this.

You see if you went north 88° 25' west for 40.22 what that does is it gives you an easting difference here that matches that number. So you see how we are only letting the eastings control this single proportion? So that is where the 40.205 came from. "X" =



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40.245. So you would subtract that from the 100 here, the easting 100, so what that does gives me a easting of 58.756. Now that is our east west position for this corner. Now we want to do the north south of it. And that is where we use the compass rule.

Now I am not going to go through the math of a **compass rule** but you should know how to do that you all being licensed surveyors. The compass rule is a basic adjustment method for a lot of different things. In this case we are only going to deal with the north south so if you use the compass rule you are going to move due south .193 that is the southerly move in a compass rule. So that gives us a northing of 100.917. Now how did I get that? Well because I took the northing in the record and subtracted from it because our move over here is to the south, okay and I subtracted from it the .193 southerly move so that is where I get the 100.917.

Now here is an interesting thing to look at though, as you see at the bottom of the screen there it says if you used the compass rule for both dimensions, in other words if you didn't do it the way the Manual said but you actually used the compass rule you find out that at least in this case it is the exact same answer. It actually comes out just two or three thousandths of a chain which is not worth worrying about for our survey so it's very interesting that the compass rule comes out so much the same. Now I am just going to tell you what we have shown you here is exactly how to do it by the book. And that doesn't take much time to do and if you are going to use the compass rule instead, in other words you use the compass rule for both dimensions rather than just the opposite dimension.

Recognize that in most cases it comes up the same place or if I could put within a very small amount of difference now what I have found personally and I have kind of played with it over the years is the more the quarter corner is away from midpoint and the more severe that break is, that angular break, the further these two solutions might get. So you know my recommendation is you know if it is relatively flat, which most of them are, relatively flat situation you would probably use the compass rule any way, but you know the only way you are going to know for sure is to do it the correct method and then you will know that you are right on the money.

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Now if somebody else did it previous to you and they used the compass rule, you're probably going to be on their cap anyway but recognize that there are two differences. So that is the modified single proportion and that's for where we have an angle break in the record, all right, for something that would normally have been single proportioned.

EXERCISE **Before moving on, complete the "Irregular Boundary Exercise" which can be found in the Exercise section at the end of this study guide.**

Now we have one more category of single proportions and this one is going to take a while and I want to remind you of something in course number 2 which I discussed and I believe may have been mentioned by one of the other speakers too, if you remember a discussion we had in course 2 here with the sample plat about basis of bearings in the Public Land System, and you will recall that the bearing of this west line of the township is north and the bearing of the east line of the township is north and you will recall that in reality those lines are not parallel to each other but because we are on an astronomic basis of bearings, a geodetic system, then what we actually have I exaggerate here but those lines are converging towards each other, right?

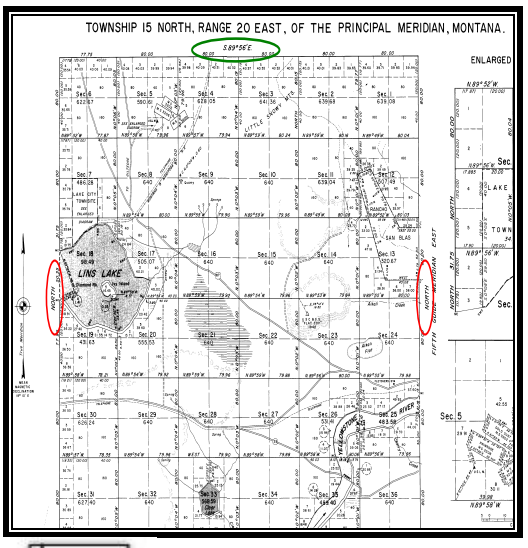

DIAGRAM **A full size version can be found in the Diagram section at the end of this study guide.**

And with that in mind then we have to remember that even though we have a bearing here and us regular surveyors are used to working on a rectangular grid, a plane coordinate system, we have to realize that that bearing south 89°56' east, if it is a continuing bearing that entire six miles than that line is curved. And you will recall discussions in the earlier class that the law said that the north south lines were going to be on the true line, the true meridian, so I'm exaggerating that those are there, and that the east west lines would be 90 degrees to them. So here is exactly what is happening, we got 90 degrees here and we got 90 degrees there and this line has to curve. That is the only way that it can maintain that kind of bearing.

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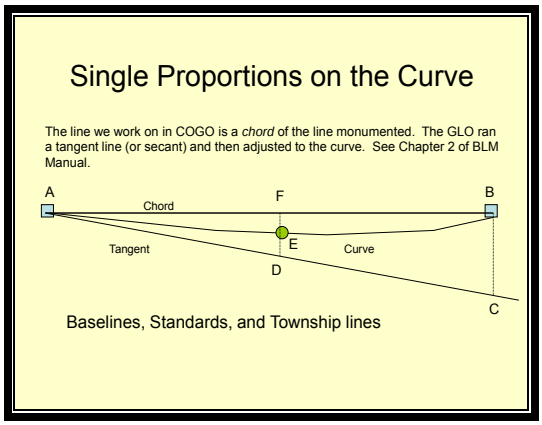
Single Proportions on the Curve

Now I am showing you that to remind you of something we discussed in course 2 because it now affects us in the proportioning of another type of single proportion. So what is happening here and the discussion we are about to have is about single proportions on one of the lines that are curved. Now in the Public Land System there are some folks who might argue a little bit about this, they might expand this list a bit, but the lines that were run as curves in the original survey were the base lines, the standard parallels or correction lines and the north and south boundaries of the township exteriors. They were actually run on a curve.

If you look at this slide, you will see here is the problem. You and I have found point A on the township line and point B which is over here on the township line. All right? And maybe they are four miles apart or whatever. Here's the problem that we have, when you and I are working in this sort of a situation, we are not remembering what the GLO actually did, the General Land Office actually ran this line a tangent to the curve, they may have done it the other way depending upon which way the survey was going, but they actually ran the tangent, that is the line they ran on the ground, but then they computed using the Red Book, they didn't have to compute, they just looked up for what latitude they were at and that told them how far to move each of these corners up to get it on the latitudinal curve.



So in other words the GLO ran the tangent but what they left on the ground is this curve, all right, through here. But here is the issue, when you and I are surveying and we have a coordinate at A and a coordinate at B over here, you and I are in coordinate geometry working on a cord of the curve. In other words, you are not actually on the curve that they ran and that is because you are trying to apply a rectilinear coordinate system to a geodetic coordinate system, and so where we are going with this is Ron is going to discuss and this is where we are really going to get into the discussion on geodesy and basic convergence and curvature in the Public Land System.

Well, next we would like to just take a few minutes and talk about

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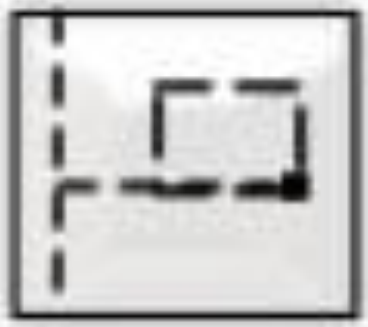
the geodesy of boundary surveys. And we are not going to get into anything heavy duty but some basic geodesy that affects the boundary surveys. You know in the original surveys, in the oldest ones, they were surveyed with a compass which means they were surveyed as a curved line on the ground because a compass continually is finding the true bearing. The same thing later when they used the solar compass, those were surveyed as a curved line so any east west line was surveyed as a cured line.

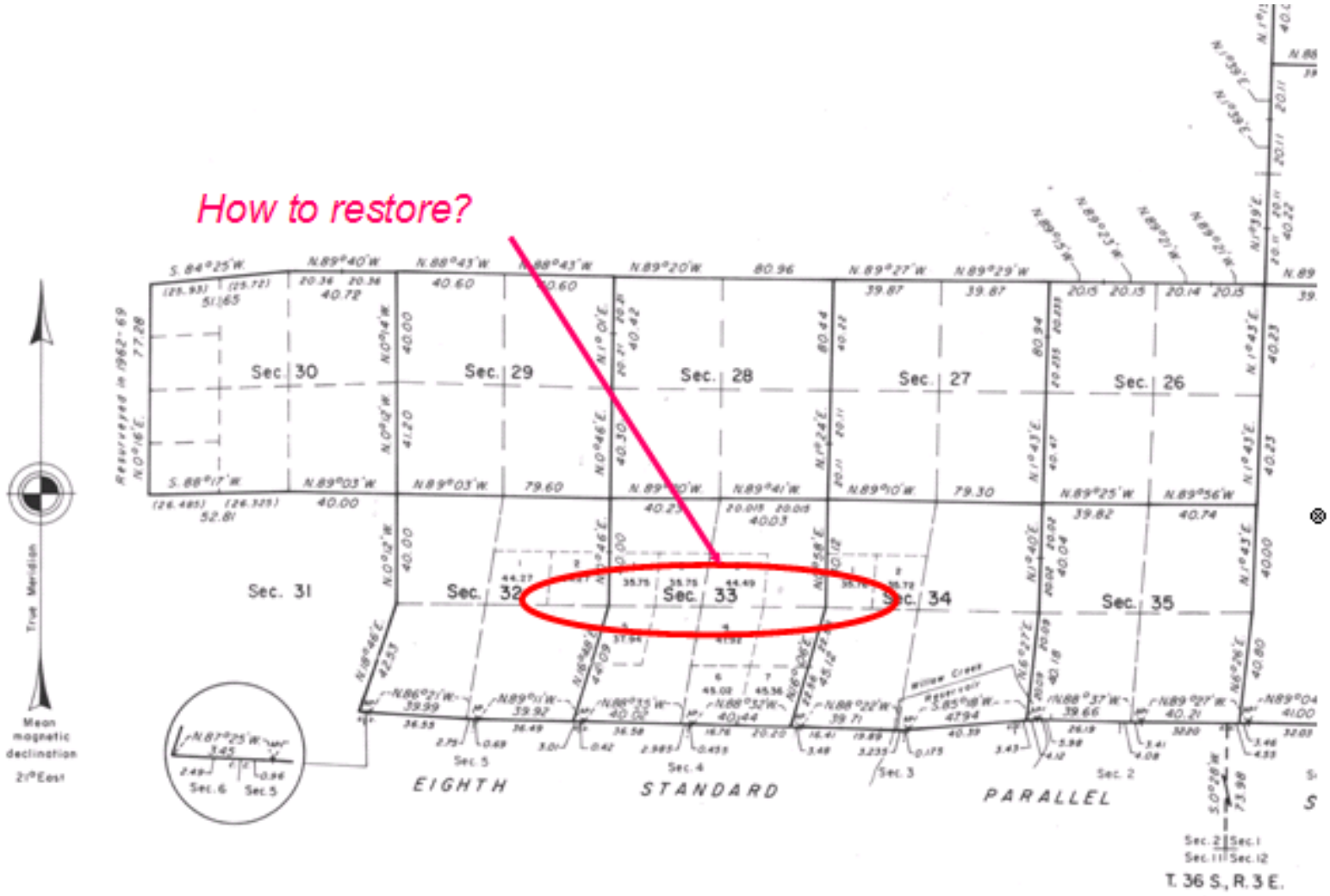
Later then we began using tangents and secant lines to deal with that. So what we are going to do is that we are going to take a short break now. When we come back we are going to look at some of the computations, some of the tables, how we can go about dealing with this convergency and the curvature that is involved in a boundary survey on the surface of a curved earth.

So let's take a short break now and when we come back we will deal with that.

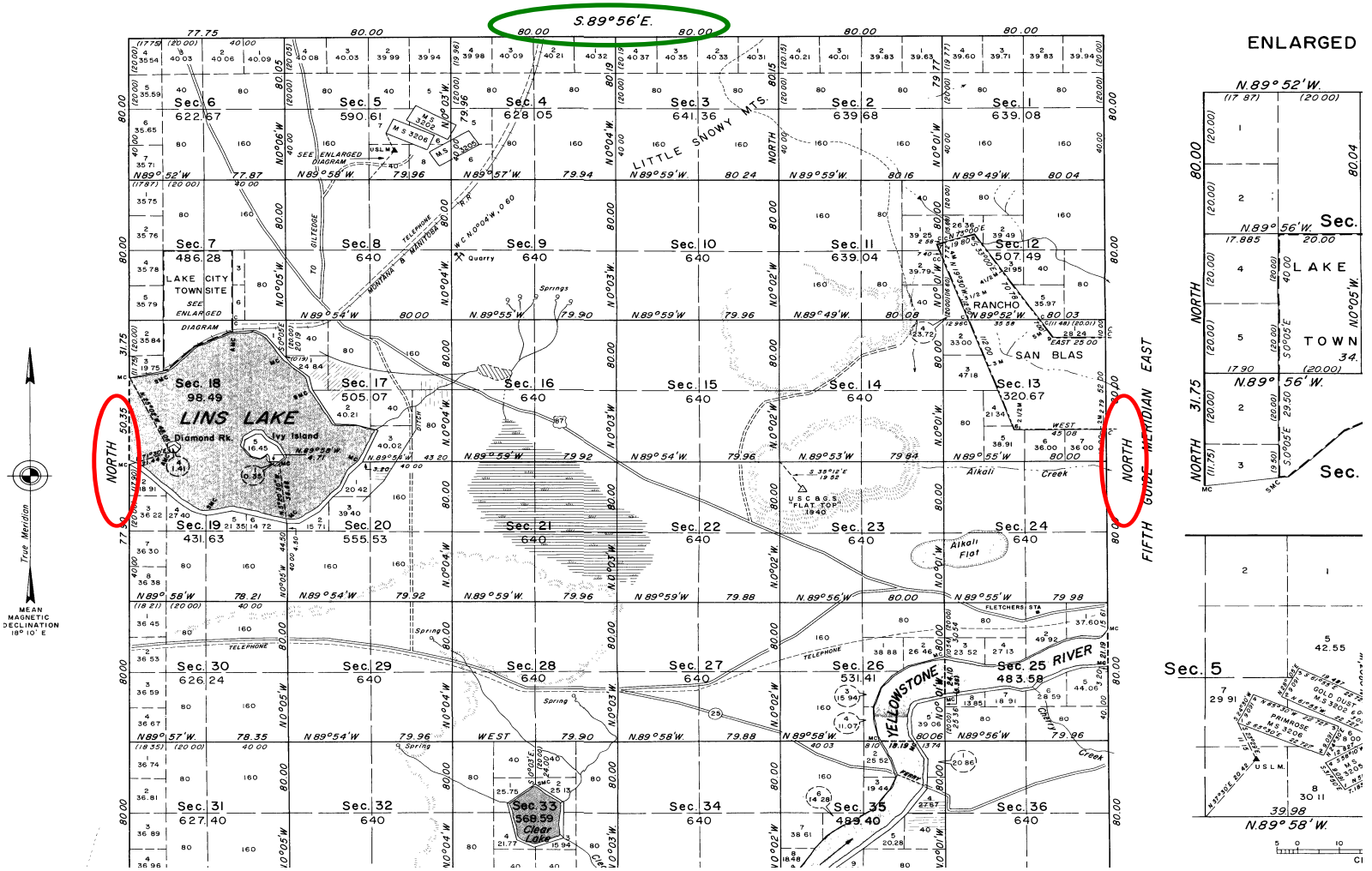
EXERCISE **Before moving on to the next topic, complete the "Single Proportion Exercise" which can be found in the Exercise section at the end of this study guide.**



DIAGRAM

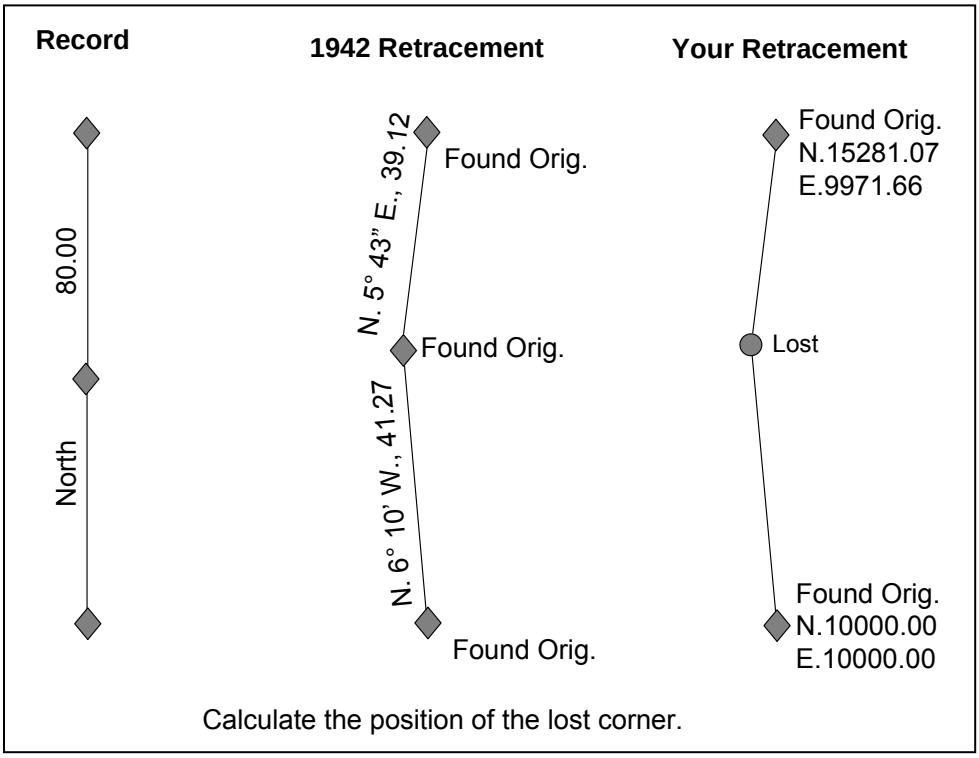

How to restore?
Sec. 30
Sec. 29
Sec. 28
Sec. 27
Sec. 26
Sec. 31
Sec. 32
Sec. 33
Sec. 34
Sec. 35
EIGHTH STANDARD PARALLEL
T. 36 S., R. 3 E.
True Meridian
Mean magnetic declination 21° East

TOWNSHIP 15 NORTH, RANGE 20 EAST, OF THE PRINCIPAL MERIDIAN, MONTANA.



EXERCISE

Irregular Boundary (Manual Sec. 7-52)



Calculate N-S
(single proportion for latitude on N-S lines)

1942 latitude S1/2: N.2708.06
1942 latitude N1/2: N2569.08
1942 total latitude: N.5277.14
Your retracement latitude: N.5281.07

Latitude of the S1/2
N.2708.06 (1942 lat. S1/2) ÷ 5277.14 (1942 total lat.) = 0.513168
0.513168 x 5281.07 (your retracement lat.) = **N.2710.08 Ft**.

Latitude of the N1/2
N.2569.08 (1942 lat. N1/2) ÷ 5277.14 (1942 total lat.) = 0.486832
0.486832 x 5281.07 (your retracement lat.) = **N.2571.01 Ft**.

Calculate E-W
(compass rule for departure on N-S lines)

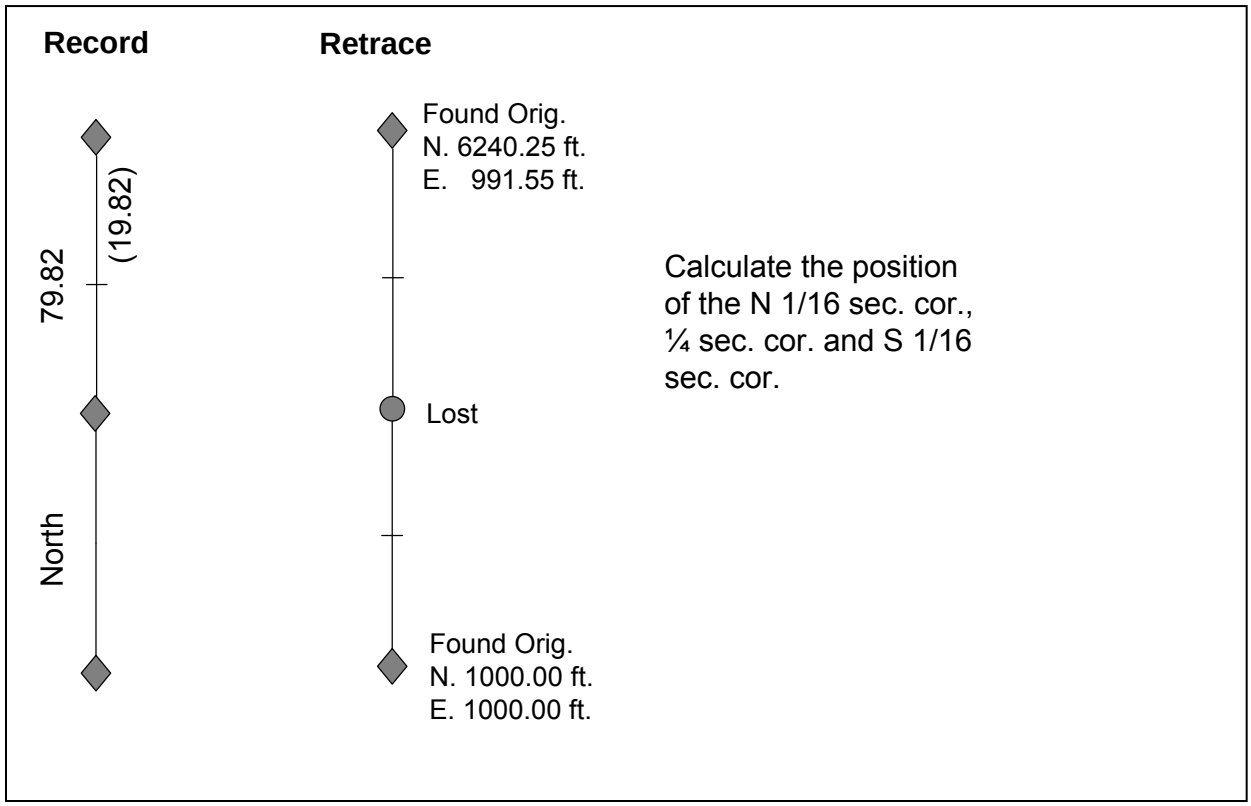
1942 dist. of S1/2: 2723.82 ft.
1942 dist. of N1/2: 2581.92 ft.
1942 total dist.: 5305.74 ft.
Difference in departure: 7.08 ft.

Departure of S1/2
2723.82 (1942 dist. S1/2) ÷ 5305.74 (total dist.) = 0.513372
0.513372 x 7.08 (diff. in departure) = E.3.63 ft.(correction)
E.-292.60 (1942 departure of S1/2) + 3.63 (correction) = **E.-288.97 ft**.
(departure of this course is minus because it is a NW bearing, the correction is + because it is E.)

Departure of N1/2
2581.92 (1942 dist. N1/2) ÷ 5305.74 (total dist.) = 0.486628
0.486628 x 7.08 (diff. in departure) = 3.46 ft.
E.257.18 (1942 departure of N1/2) + 3.45 (correction) = **E.260.63 ft**
(the correction is + because it is E.)

Coordinates of the proportioned point: N.12710.10, E.9711.03
Bearing and distance of S1/2: N. 6° 05' 11" W., 2725.46 ft. (41.295 chs.)
Bearing and distance of N1/2: N. 5° 47' 19" E., 2584.16 ft. (39.154 chs.)

SINGLE PROPORTION EXERCISE



Record: North, 79.82

Retrace: N. 5240.25 ft.
W. 8.45 ft.

Calculate True Bearing and Distance

Dep. ÷ Lat. = Tan of the bearing

8.45 ÷ 5240.25 = 0.001613

ArcTan of 0.001613 = 0° 05' 33" = Retrace bearing: N. 0° 05' 33" W.

Dep. ÷ sin of the bearing = Dist.

8.45 ÷ 0.001613 = 5240.26

Calculate Proportion

Retrace distance ÷ Record distance = K

5240.26 ÷ 5268.12 = 0.994712

K x record dist. = Proportionate dist.

0.994712 x 1320.00 = 1313.02
" x 1320.00 = 1313.02
" x 1320.00 = 1313.02
" x 1308.12 = 1301.20
5240.26

Proportionate Position of the Corners

Sin 0° 05' 33" x 1313.02 = 2.12
" x 1313.02 = 2.12
" x 1313.02 = 2.12
" x 1301.20 = 2.10

Cos 0° 05' 33 " x 1313.02 = 1313.02
" x 1313.02 = 1313.02
" x 1313.02 = 1313.02
" x 1301.20 = 1301.20

S 1/16: N. 1000.00 + 1313.02 = **N. 2313.02**
E. 1000.00 - 2.12 = **E. 997.88**

¼ Sec. Cor.: N.2313.02 + 1313.02 = **N. 3626.04**
E. 997.88 - 2.12 = **E. 995.76**

N. 1/16: N. 3626.04 + 1313.02 = **N. 4939.06**
E. 995.76 - 2.12 = **E. 993.64**

Sec. Cor.: N. 4939.06 + 1301.20 = **N. 6240.26**
E. 993.64 - 2.10 = **E. 991.54**