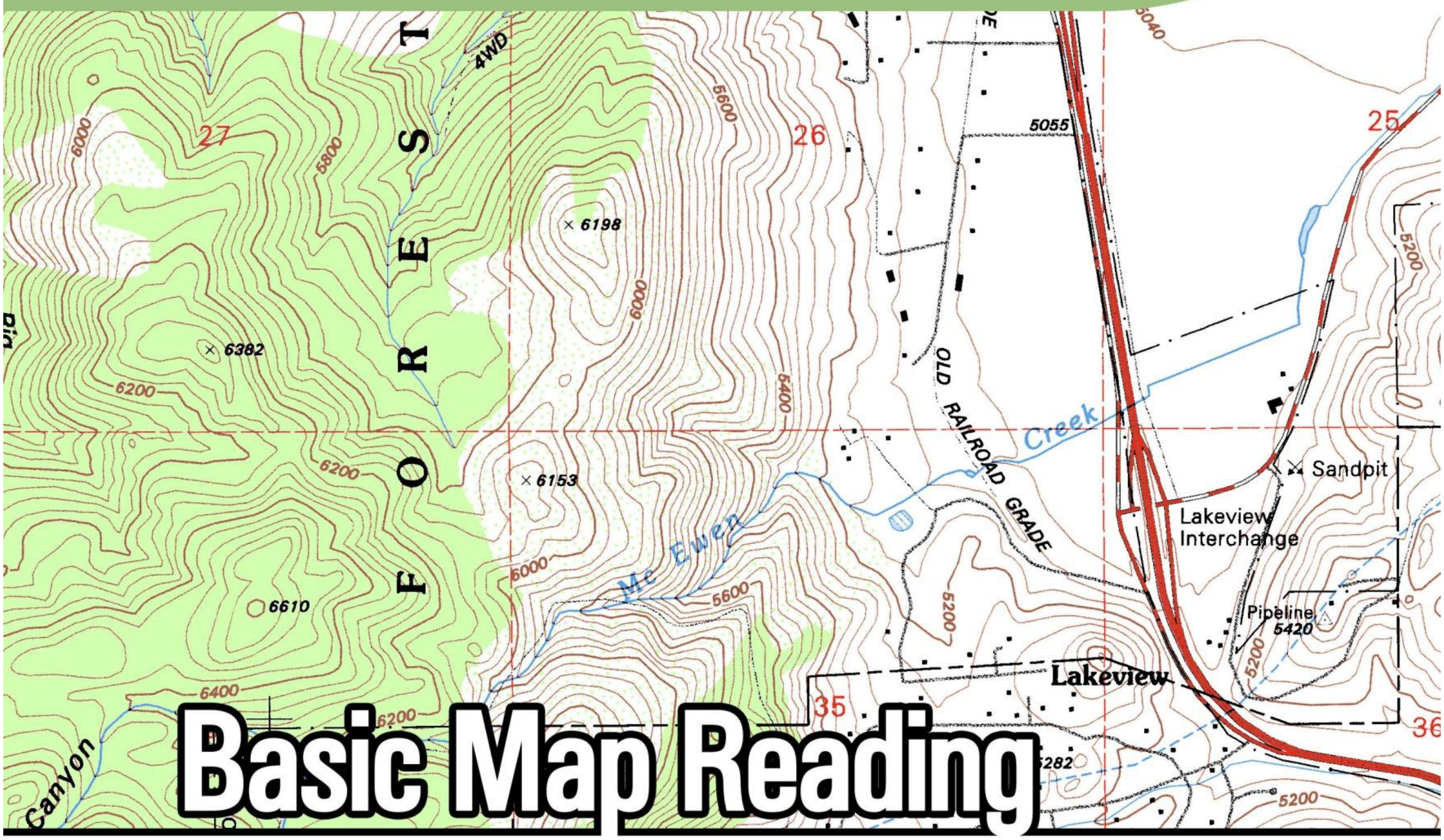



# Basic Map Reading

## v.1 2010

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT

NATIONAL SYSTEM OF PUBLIC LANDS

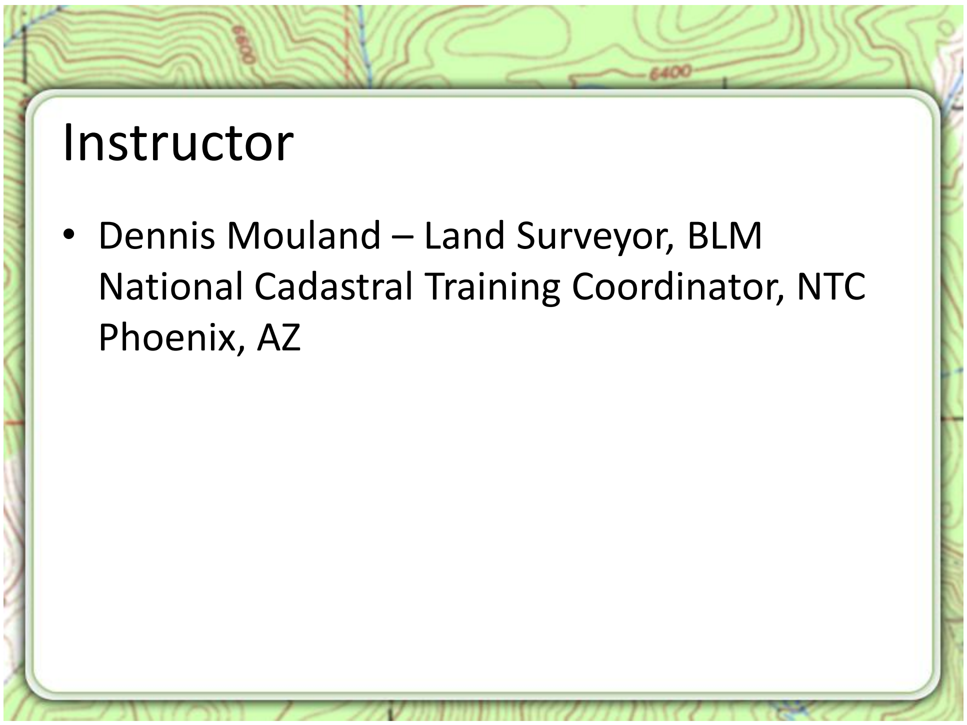
STUDY GUIDE

# Table of Contents

# Course Introduction

## Instructor Introduction

Hello and welcome to the Basic Map Reading course.  This is being produced by the Bureau of Land Management here at their National Training Center in Phoenix, Arizona for use by BLM and other users of topographic and planimetric maps.




My name is Dennis Mouland and I will be your instructor in this course.  I am a land surveyor with the BLM, I'm their National Cadastral Training Coordinator stationed here at the National Training Center in Phoenix, Arizona.  And we are glad to have you here in this course.

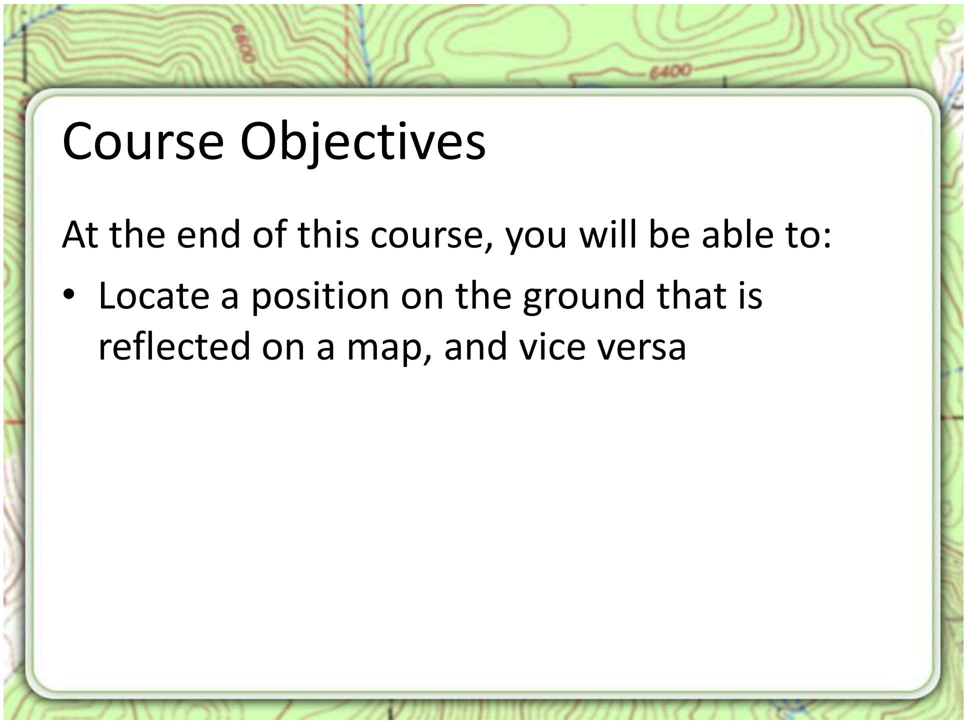
We have some really important and interesting things to discuss in this course and that's because many people have come to believe that mapping and map reading is a skill that is no longer needed because we have GPS.  And as we'll see thru this course that map reading skills are absolutely vital even with a good GPS unit.

Because a GPS unit simply tells you where you are. It doesn't tell you the route to get to or figure out the best way for you to get to another place, an event or situation that you are trying to get to, or to report about something that you see, maybe a fire but how do you relate that to someone else who is not there.

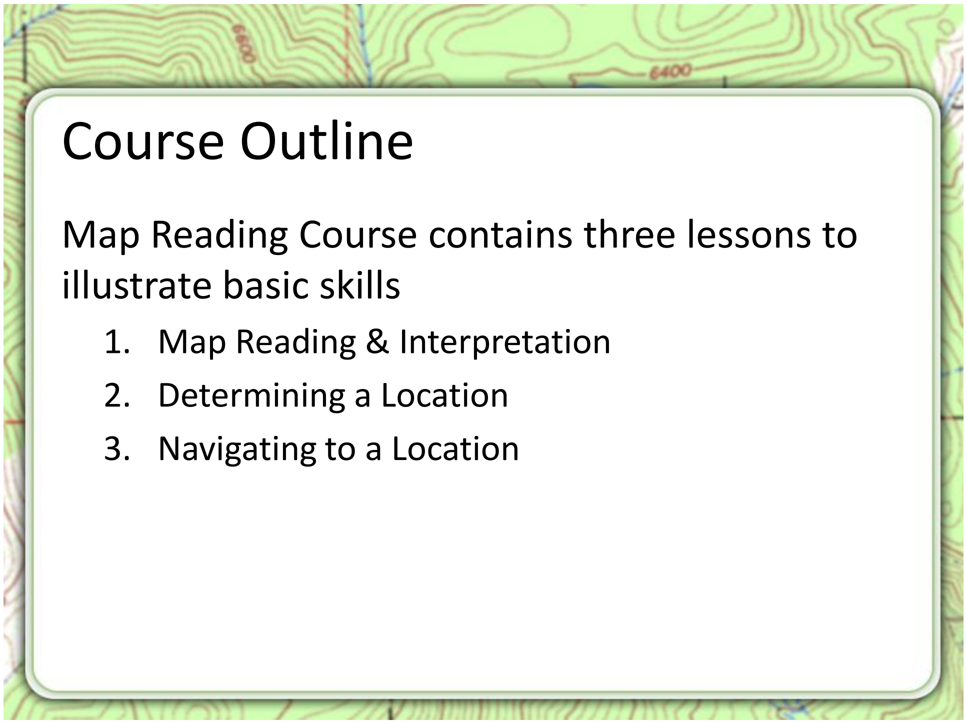
Map reading is one of those basic skills that allows us to communicate with other people, give them a better idea of what it is we are looking at on the ground, where we are, where we want to go, and how we got there.  So map reading is a good skill and glad that you are joining us for this.  Here's our objective for this course.

## Course Objective

At the end of this course, you will be able to locate a position on the ground that is reflected on a map, and vice versa.




In other words you will be able to go from a map back to on the ground. That's a very simple sounding objective, but that is exactly what we'll be doing when learning how to read these maps and understand these processes. We are basically going to break it down into three basic lessons.




We are going to learn how to read and interpret maps, in particular topographic maps. We are going to learn how to determine our location and that is with or without GPS, and we are going to learn how to navigate to a location, with or without GPS.

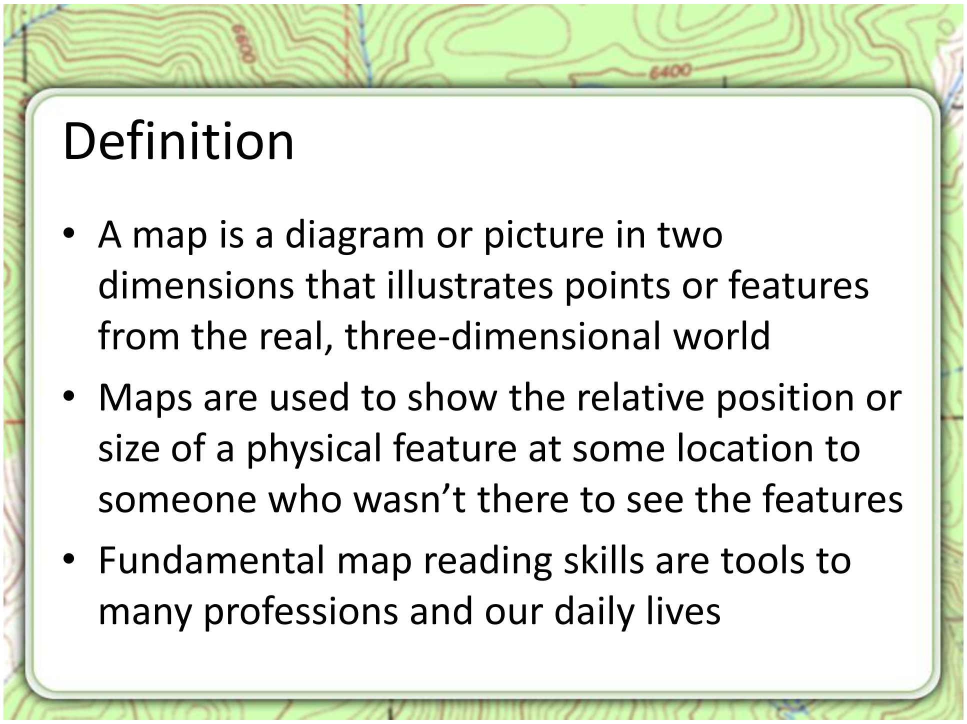
So these are valuable skills, and we all need them. I wonder if you have thought much about the reality of how much you use maps, and how many times we refer to them? As we'll see here in a few minutes we are able to bring up maps using different mapping software on the computer and the Internet like Google maps or some other map software that's out there.

Mapping is used by all government agencies and entities even down to your city's sewer departments. The sewer department has maps of where their sewers are and their manholes. The water department knows where their valves are and the meters. All these things have been mapped to one accuracy or another, one degree or another. That is how we figure out where things are in relation to other things. An awful lot of mapping is done, millions of dollars are spent on mapping every year by the private sector as well as the government.

So maps are a fundamental part of everything that we do, and it's important that we learn to look at a map, and understand what it's telling us, understand some of the basic terms and processes that we use to figure out what's going on.

## Maps Defined

Let me give you a definition here. A map is a diagram or picture in two dimensions because it's on a flat piece of paper, that illustrates points or features from the real, three-dimensional world.




Maps are used to show the relative position or size of a physical feature at some location to someone who was not there to see the features themselves. Fundamental map reading skills are tools to many professions and to our daily lives.

## Google Maps Example

Now with those basic definitions of a map in mind, and helping us to understand that it's important to us. I mentioned just a minute ago about a mapping software that's on the Internet. I want to take you to Google's map site. It is actually http://maps.google.com/ which you can get there directly or you can go www.Googlemaps.com and it will take you to this site. This is their standard mapping software. I've already typed in Phoenix, Arizona, and so there's Phoenix and I'm going to zoom in a little bit, and you know it's great software, you can zoom way in, and I'll even drag it over here to where we are at.

Here's the metro center mall and the training center is just west of that and so tremendous mapping capability. We can even zoom in so close, we can get all the street names and figure out how to get from here to there. Where is it we are going to go, or where we are now. If you aren't really familiar with Phoenix, but you are looking at the street signs, it says that you are at the corner of Thirty-Fifth Avenue and Dunlap and you can look here and realize I need to go so far north or so far east or whatever to get to where it is that I am wanting to go. This fits exactly what our definitions were that we were looking at a few minutes ago and so that is two dimensional representation.

Now one of the features this mapping software has and many others do too, is a terrain feature and I'm going to show that to you. I'm going to drag this in, here's some mountains that are just east of where we are sitting here. And you can see, by relief, and by shading in color, they are able to show us those mountains.

So there's an attempt there to give us a three-dimensional appearance but we really don't know the relative elevation differences. We just know that there's some mountains that are kind of shaped like this. What we are going to see as we go into the course is that with topographic maps we are able to get a very clear picture of elevation differences of shapes of mountains of where the water's going to flow and where it won't flow, and that sort of thing. We will be able to find out all sorts of information that you really want. It is really amazing with mapping, you can take maps like this and you can bring in other layers, either that you and or your profession created, or someone else has created for you.

But think about all of the applications. You can go to your county's website and most county's now have a geographic information system, or GIS. You can go in there and you can look up every single parcel of land, and see who owns it. See how much they paid for taxes last year, see if they are behind on their taxes. You can get all kinds of information in there with maps which we call parcel based that are based on the individual parcels of land ownership.

There are other maps that different professions use including geologists, they use soil maps, it uses the same basic map but then it brings in colors and layers that show, you know, this is the type of soil here but it changes there. Foresters and wildlife biologist and others, they use the same base maps if you want to call it that, and bring in colors and layers that show them where the different types of vegetation are. Or where the bug kill is or where this or that or the other activity has gone on. Where a fire has been, exactly where it went and where it didn't, so they can plan reseeding and figuring out how much a work it's going to take to do this, that or the other.

So there's all sorts of applications, so being able to read a map is pretty critical, even to the person who is in the office and answering the phone. What if you were in the office and you answer the phone and somebody says there is a fire and they give you the latitude and longitude. They give you the section, township, range or they give you some other location identifier like that, which we will be learning in this course. Do you know what to do with those things? Do you know how to find those? Do you know what questions you need to ask to verify those things?

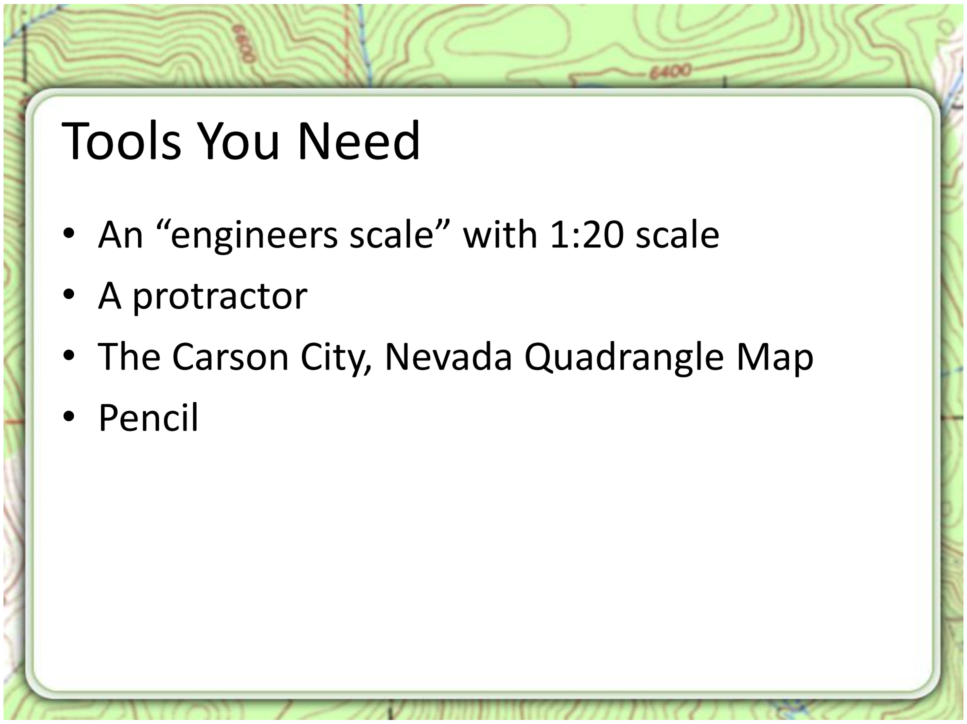
These are important because before you send fire trucks, helicopters or whatever it is that's going to be sent out to whatever this disaster is, this example a fire, or maybe just somebody injured. You really want to know how to read a map, how to direct others there and how to explain what's going on. On the other hand, you could be out hiking, and the person hiking with you, you could be way out in the boonies somewhere, the person hiking with you trips, falls and breaks their leg. So you want to call for help. You need help to get this person out of there, they might have to be airlifted out of there, and so you pull your GPS unit out, and guess what, the batteries dead.

Do you know how to pull out a topo map, topographic map, and look at it and figure out where you are, with enough accuracy that you could get a helicopter or an ambulance or a fire truck, that would be able to get within vision of you, within sight of you so they could find you and could solve the problem. And so if you get the impression I'm trying to sell to you on map reading, I am.

Because it is a fundamental basic skill, especially for those of us in government. Especially in BLM, some of the other agencies in the interior, because we deal with land. We deal with our own land ownership but we also deal with the management of the resources, we deal with responding to accidents or emergencies, all sorts of situations so that's why it's very important that we all have these basic map reading skills.

## Basic Tools

Now there are some basic tools that you are going to need in order for you to successfully complete this course, they are listed on the screen in front of you. I'm going to talk about these one at a time.




### Engineer's Scale

The first one is an engineer's scale with a 1 to 20 scale. Let me talk about that for a few minutes. First of all we call them engineers scales because there's really two basic types of scales that we use in mapping or plans, drawing plans, these are either engineer's scales or architectural scales. Architectural scales are a very different in they function differently, because architectural drawings are drawn paying attention to inches which in mapping we are mostly paying attention to feet and tenths of a foot, hundredths of a foot, more of a metric system if you will within using the foot and the mile.

So architect's scales are a little different, you don't want to be using one of those, but the engineering scale but when we talk about it the most common ones kind of a three sided device here with six different scales. We are going to learn later when we get to the scale discussion, scales are about how much of an inch and how you are going to divide that inch up so that you can read what a distance is on a map.

Let me give you an example of this, and let's just take a look here on the Elmo, I'm just going to set this scale down there, and here you see I've got the 30 scale. We just call it that. It takes an inch and divides it into a certain number of parcels or portions, based on 30 scale. We'll talk about that, you will learn more about that, so don't worry about that now. Just to show you as you flip this, you get other scales, there is the 10 scale, and of course what we're really interested in is the 20 scale.

And the reason for that is because that is the scale that this map, these U.S.G.S., the United States Geological Survey maps, the standard topographic maps that are used throughout the United States, that is what scale they are set up at. And so what that means is that I can actually look at the scale without having to do any computations and just read exactly what I want.

For instance, from this line here to this hilltop here, we will learn more about that, it's about 2400 feet. I can tell that just by reading the scale correctly, I don't have to do any computations. That makes it a very, very useful tool and that's why we are interested in the engineer's scale, in particular, 1 to 20 scale. If you do not have one of these triangular scales, for instance you have a flat scale, usually you see some of those that are slightly beveled but they have but they have four different scales on them, that's fine as long as one of them is a 20 scale. If not, you are going to have to learn to do some computations to adjust for that and we are not going to go into that in this course, I urge you to get that.

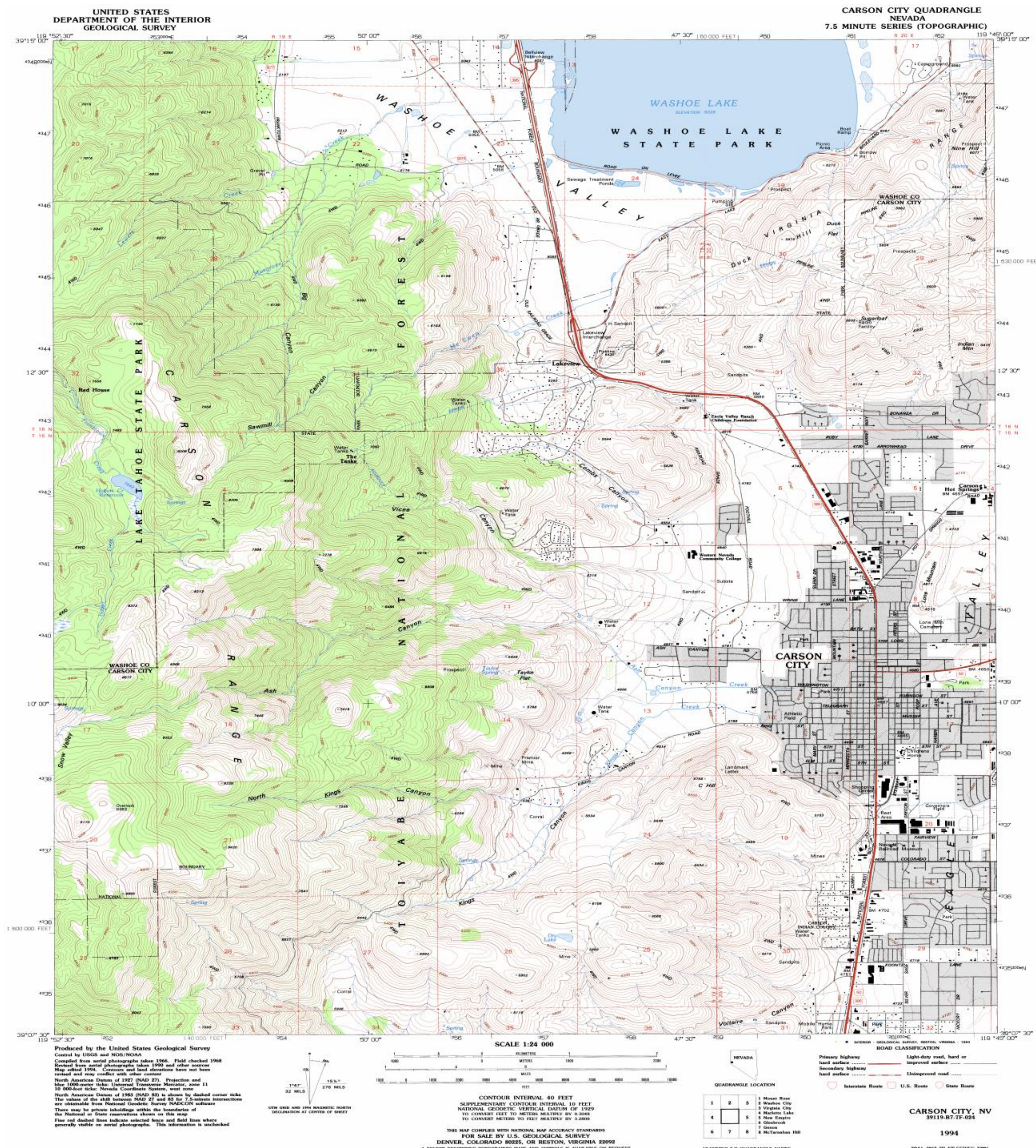
### Protractor

The second item that you need is a protractor. And you are used to protractors, you used them back in grade school and this a very simple protractor that we are using, at least the model that was provided with the materials in the course and again I'm going to go over here to the Elmo and put that protractor up here and as you can see this is a simple protractor, some are full circles, this one is simply half a circle, it has what we call an index point which we will discuss later, and it has degrees from 0 up to 90 and then back down to 0 or going the other way it goes from 0 to 90 and all the way down to 180.

So depending on what we are using degrees or azimuths, we will be able to figure it out. We will talk about all of that stuff here in the course. But you need some kind of a scale that does show a full half circle. And I'll mention also notice that, and we will discuss these divisions later, notice that this scale has, here is 10 degrees here from 90 to 100 is 10 degrees of angle, and notice that each degree has a tick mark but they also have half degree tick marks. See they are shorter and those, so those we can measure bearings and directions to the nearest ½ degree. And so the reason I'm mentioning that cause if you don't have either the scale end or the protractor that we intended for you to have in this course for some reason, then you need to go down to Wal-Mart or somewhere and buy these and make sure that you get that capability there.

## Carson City, Nevada Quad

Now, we are also using a particular map, when we designed the course here we decided that it would be best if everybody, everything that we talk about here and the lessons that we learn about maps as well as the exercises that we do with the maps, all of them be based on one particular map.  And because the majority of this course is based on topographic maps and the U.S.G.S. type in particular, we are going to be looking at one of their quadrangle maps, and we will explain what that means.



The map that we use is called the Carson City map. It's from Carson City, Nevada and if you take a look here at the Elmo you can see up here in the upper right corner of the map, there's the name of the topographic map, and also in the lower right hand corner of the map, is the same name. It also has a code number for this map, and it gives you the date on it and that sort of thing, but this is the map that you will be using and if you don't have this one, for some reason you didn't get it with this course, then you are going to want to purchase that map, you don't want to do it with any other map because nothing that we talk about will directly make sense.

So be sure that you find the Carson City map, that's easily bought online, or at a lot of different outlets who sell quadrangle maps, USGS maps. I believe ordering it online is probably the easiest thing for you if you are not in the general area of Carson City, Nevada where you can purchase this map. You know also there is software available out there and that is where we printed this map from where you can buy all of the topo maps for an entire state and you might even have something like that in your office, or if you have paper copies you may have this there too.

### Pencil

But you want one that is your copy for use in this course because we are going to be drawing on it and that is why you need the other item on the list, and that is a pencil, mechanical pencil or just a regular pencil but something that you can draw with and we might add, you can erase also since we occasionally make mistakes when we are drawing things, and scaling things out, but those are the tools you are going to need.

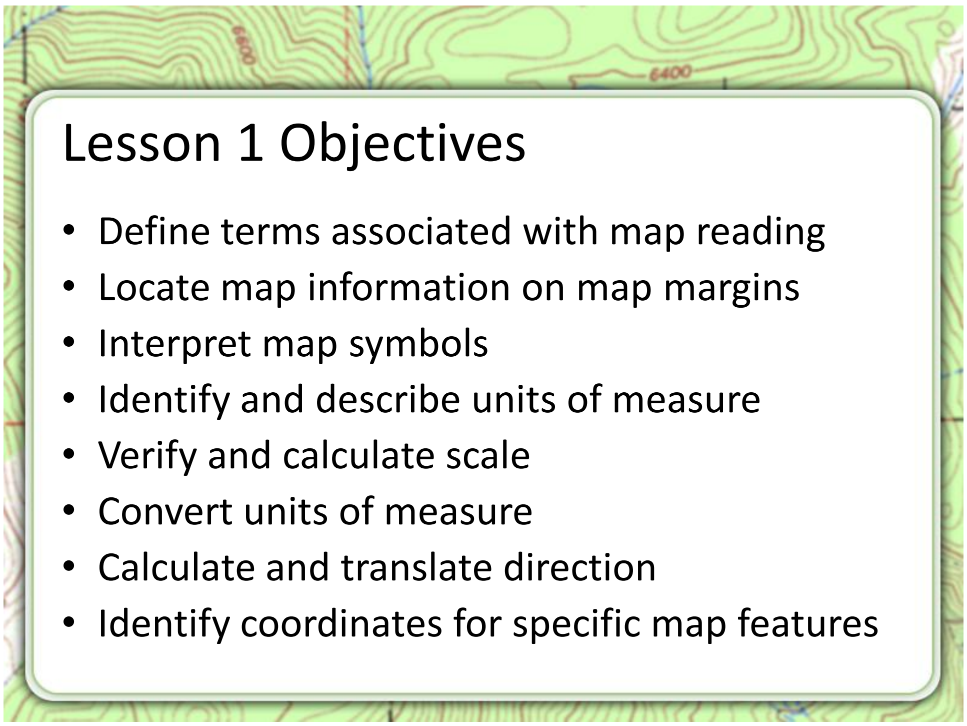
And so, I'm going to end this introduction here with just this thought. I've given you an idea of what it is you need, the tools you need here, I've given you some ideas of some of the applications to just how important map reading is to us, regardless of who we are, or where we are, what we do in our office or our organization, wherever it is that we work, and we've given you some objectives or the objective of this course to enable you to understand maps, and we gave you a little bit of a definition of a map and that was, and it's a two dimensional drawing that's at a scale that you can look at and figure out what the real world looks like out there on the ground without ever being there.

So, hopefully you are excited about this, and you want to take a look at and learn a lot about map reading . I'll see you in the next lesson where we will begin to discuss the terms and symbols that are used on maps.

## Lesson 1 Map Reading & Interpretation, Part 1

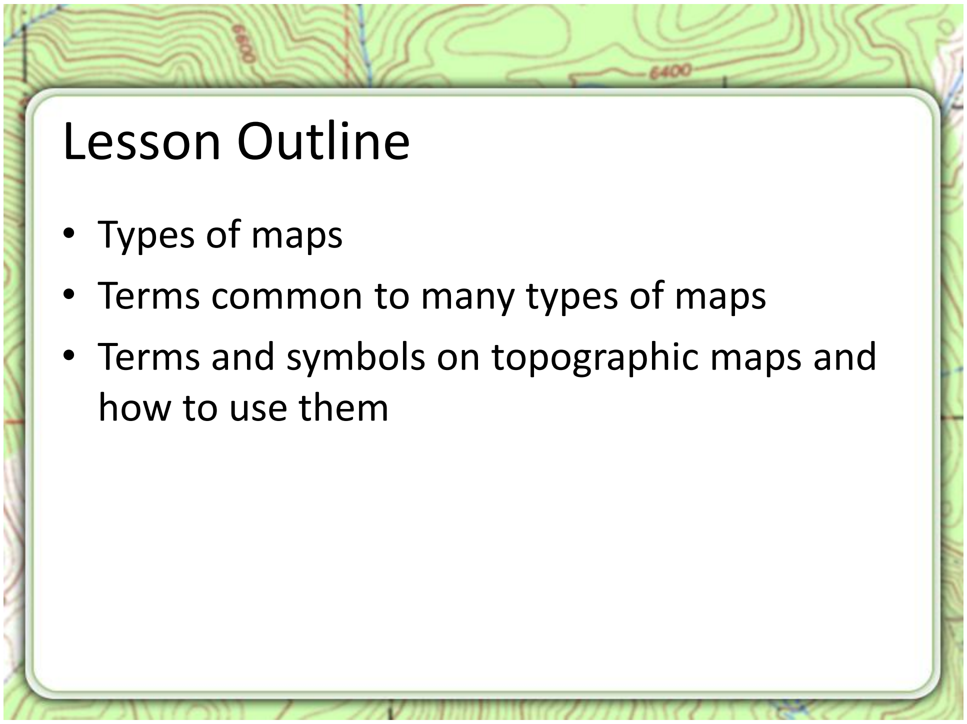
### Lesson Objectives

Well, here we are, Lesson 1 of our basic map reading course. This is called map reading and interpretation. I want to set some objectives, we have several for this first lesson, it's all about getting to know maps.




We are going to define terms that are associated with map reading. We are going to find out about marginal notations, or map information that's on the margins of a map, we will learn to interpret various map symbols. We are going to identify and describe units of measure, because there are many different units of measurement in both the distance and direction areas as well. We will learn how to verify and calculate scale on a map, we will learn how to convert units of measure back and forth.

We are going to learn how to calculate and translate direction and understand how it is that we measure direction, and then we are going to identify the different coordinate systems that are used on maps so that we can use them to help figure out where we are and what it is that we are doing.




## Types of Maps

First thing I want to do though is talk about the different types of maps that are out there and see what those, some of those terms are, and then we will move on from there. There are really two basic types of maps I suppose that we could define and equate differently if we wanted to go down into more detail as to the different types of maps, there's really two basic types of maps.

### Planimetric Maps

One is what we call planimetric. Now a planimetric map is one that does not show elevation information. In the introduction we looked at that and I'm going to back to Google, back to the map of the Phoenix area and just remind you of that. This is a planimetric map, your highway department maps, your highway maps , road maps, this of course being a road map on the Internet. A paper road map, your cities map of all of the streets that they have there, whether it's digital originally or just on paper, those are all planimetric maps.

They do not show elevation information. Sometimes you may have a planimetric map that tells you an elevation, but it doesn't have detailed elevation information on it. That's why we call it planimetric. Planimetric means, you know really it's a plan of something, it's just showing you the two dimensional layout of something, usually to scale and does not relate to you the third dimension, up and down, the elevations there. And so that's really a planimetric map and you are used to using those all the time.

Most people are relatively familiar with them as far as you know you find the north arrow, you kind of orient yourself to it and figure out which way you are looking and that sort of thing. And some people have trouble with that we call that rotating. Rotating a map, some people that are very used to maps, you know they can pick up a map they can look at it, and north may be that way in real life, but north is this way on the map. But they can rotate that in their mind. Other people have trouble with that, and that's no problem, and they kind of have to lay the map out and kind of eyeball it and something like that, hey that's fine too, if that's what you need to do to get oriented on a map, Planimetric maps are what most people are used to. You know there are other types of maps and things that people use that don't really fall in either of these categories.

I'll mention one in particular and that's a survey map, either a cadastral survey map that BLM does or some other kind of a boundary map that's sort of a parcel map. Again these don't show elevation information so I suppose you could say they are planimetric. But they have very different purposes. A cadastral survey map or a property survey map are you know, it's showing specific information about parcels of land, but perhaps not in relationship to streets and roads and other things, it's just showing that boundary survey. So that's sort of a specialized if you will planimetric map. But again this is what most people are used to, planimetric.

### Topographic Maps

Now the other, the second type of map that, you know in this general description that I'm giving, is a topographic map. Let's understand that that is referring to the topography of the land, which means the lay of the land, the elevations and the changes in it and that sort of thing.

Let's go over here to the Elmo and we'll take a look at a topographic map. Again this is the Carson City map that we had already referred to earlier. I just want you to notice some things. It has some of the same things on it, a topographic map does, some of the same things shown, such as roads, there's a freeway there, it has some other roads, it has these little dots or buildings, there's various things, a highway number, that sort of thing.

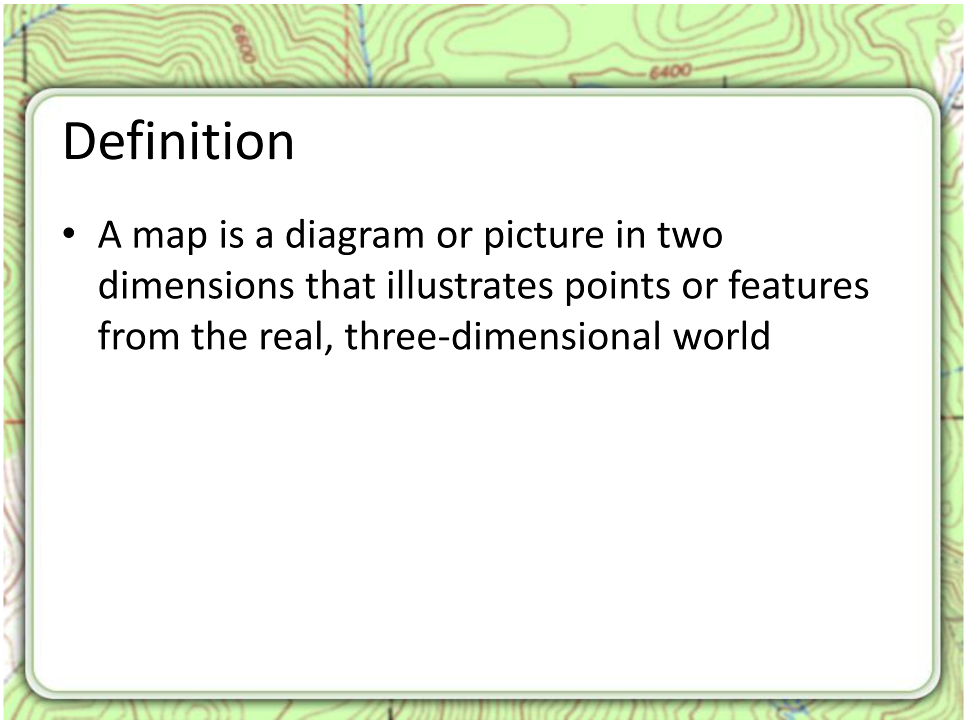
But it has other information on it that a planimetric map does not have and those in particular are these. What you notice is what appear to be squiggly lines, I will zoom in on them a little bit here, these are what you call contours. We are going to learn about those, this is elevation information. Once you learn how to read these contours you'll know how to understand the shape of the land, the elevation of the land, the slope that the land is at.

You'll be able to look at this and you'll know that if you were walking down here that this is not as steep of a route as this is. That is simply because of how close the contours are together, it tells me that. We are going to learn those sorts of things.

So you see a planimetric map may have these roads and two dimensional information on it, but a topographic map brings in the topography in great detail. It not only shows where the creek is, you know this blue line, where the creek is, but it also shows the lay of the land, how the contours are coming here. So we can understand, is that creek running thru a steep canyon or is it a wide valley that is just you know a wandering creek there. We can tell those things from the map without ever going there, we can tell those things about it. So we learn a lot about the land based on, what we see on that map.

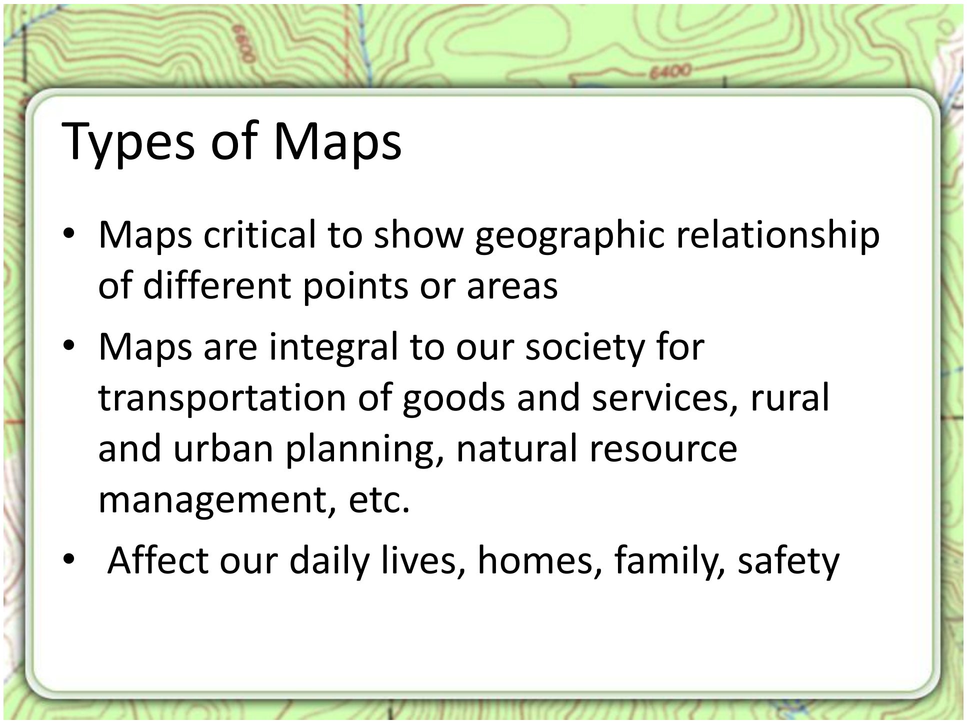
We have these two basic types, planimetric which we are all used to, and then topographic which really is a planimetric but with all that elevation information added in. And that's what's important for us to recognize, those two basic types of maps.

Now, in the introduction, we gave you this definition and we are going to look at it again.




A map is a diagram or a picture in two dimensions, even though a topographic map is in two dimensions, that illustrates points or features from the real, three-dimensional world. So, whether you are looking at a planimetric or topographic maps, you know it's still, the map itself, the sheet of paper or your computer screen, if you are looking at a digital map, is two dimensional. But if it's a topographic map it's going to provide you some of the other information that you need.

Now, we use maps for a lot of different things in life, and I mentioned some of that in the introduction as well, here's a couple things to think about.



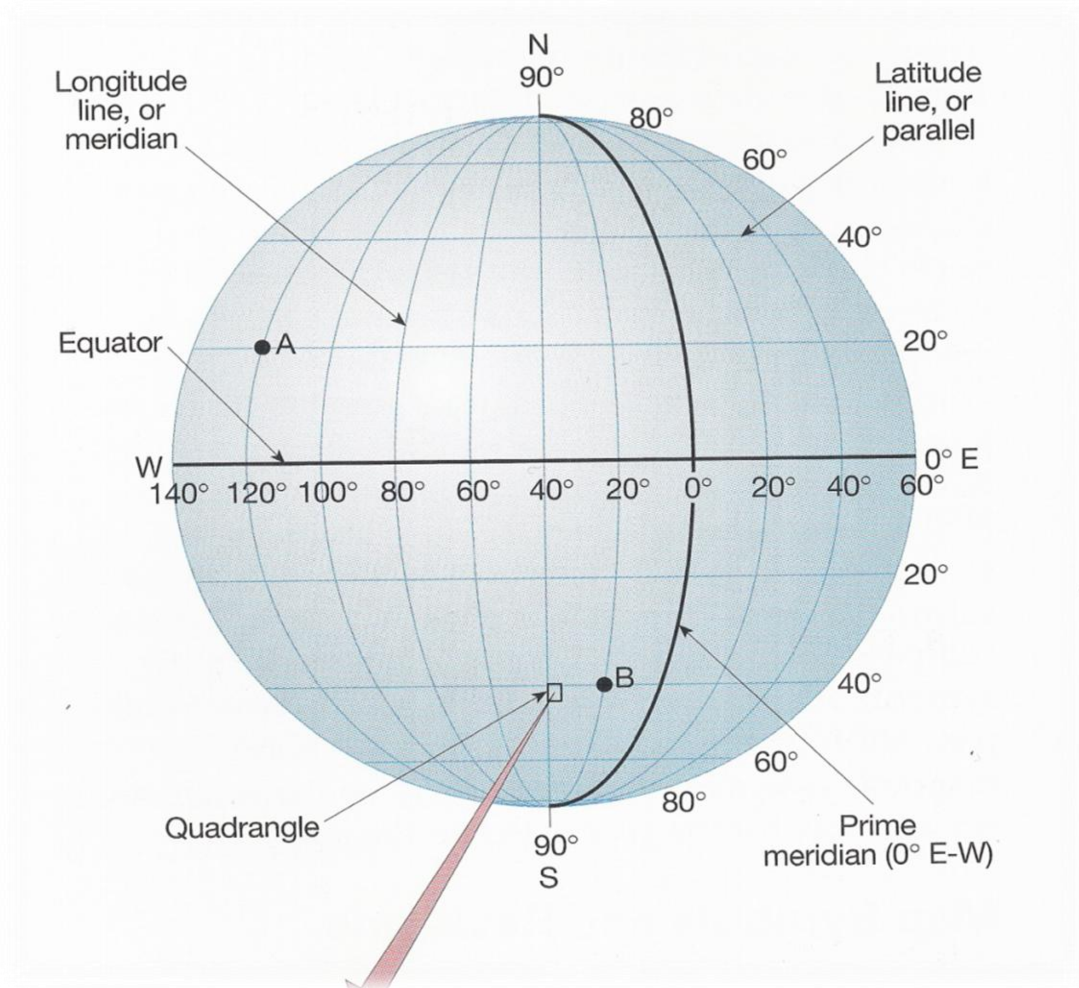

Maps are critical to show geographic relationships of different points or different areas. It is how we figure out what am I close to? What kind of things might affect this? You know, when we do Natural Resource Management of some sort, we can use maps, whether they are digital, or on paper. But we can use those maps to understand the relationships of things.

Such as, if I were to cut timber here or to build a road thru here or whatever, what else does it affect? The map helps you understand it. You look at it and you realize downstream there's some private property there and if we a muddy up the water and it's going to go thru there, and that's where he gets his drinking water. If we a cut timber here it's going to allow a more run-off of the soil into the creek. You know, we can look at different things, we can study things, we can, you know, even a planimetric map that shows property ownership, you could plan how you are going to run a road into somewhere and who you are going to have to buy right-of-way from.

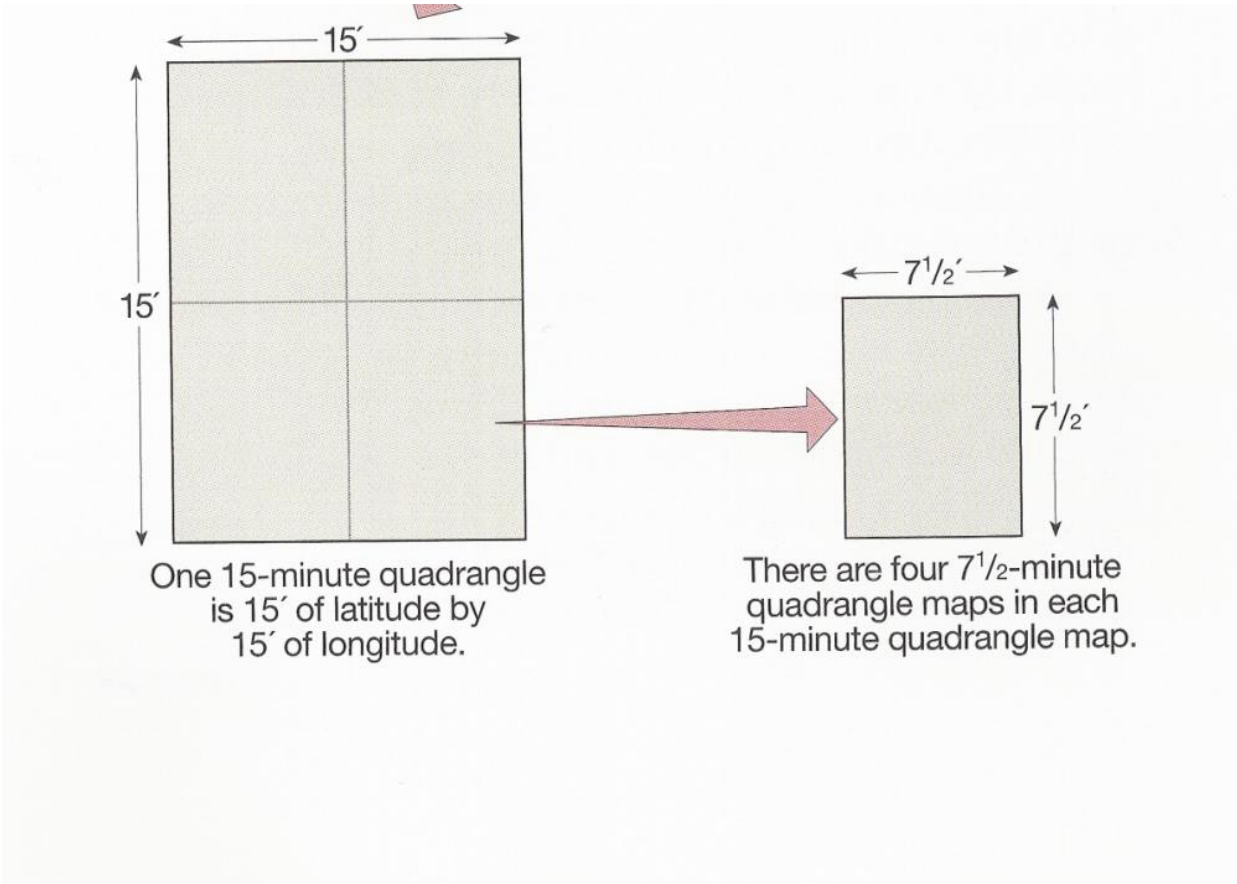
There's all of these different things of the relationships of things geographically to one another. And again, whether it's on paper or in a GIS, that same information's there, the same use of a map. A second one here to understand is maps are integral to our society. We use them for transportation of goods and services, all of our planning of cities or rural areas. We do it for natural resource management as I just mentioned. It affects our daily lives, it affects your homes, your family, your safety.

All of these things are there because maps are being used all the time by different government entities, even your emergency services, your fire departments and police. They identify certain addresses. When you call in your address or even if you don't give them your address, but if you call in from a land line phone, most of those with the 911 service, it gives an address, they are able to identify where that address is, they can figure which fire station is closest to that. All of these things and it's all because of geographic relationships that are displayed on maps. And that's what they are doing.

Now, let's take care of another definition here, as we have spoken already about the USGS topographic map, you may have noticed that I called it a quadrangle map or for short, many people call it a quad.



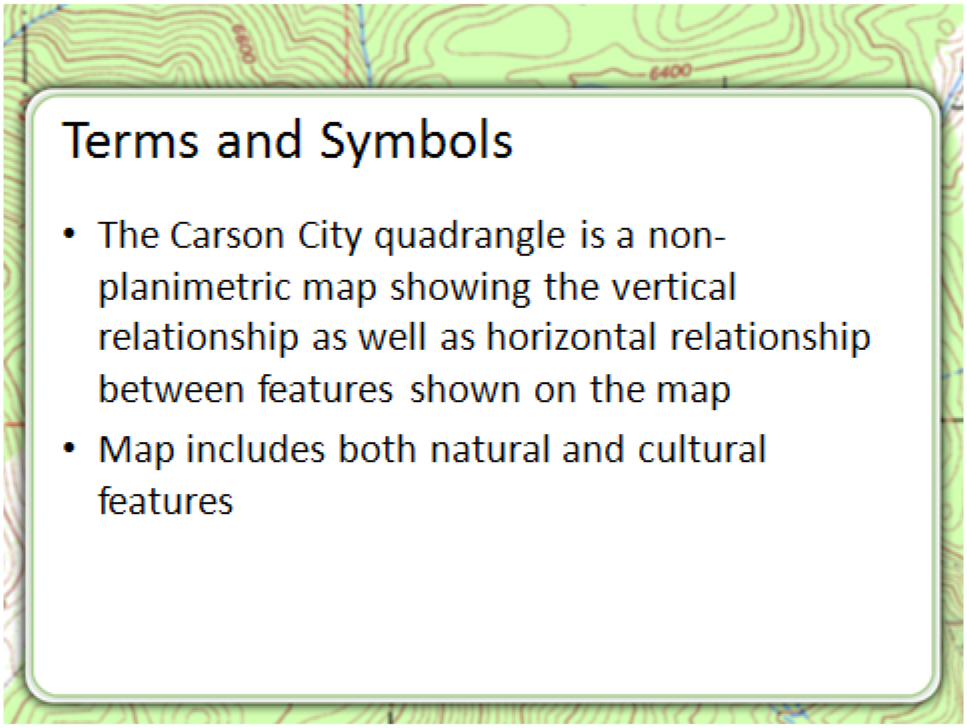

I want you to understand what that is and why that is. What we see here on the screen, don't let this scare you, we are going to learn a little about latitude and longitude later, but we see the whole earth here, and we need to understand that it's all divided up in latitude and longitude and that's by degrees. We'll understand all of that soon.



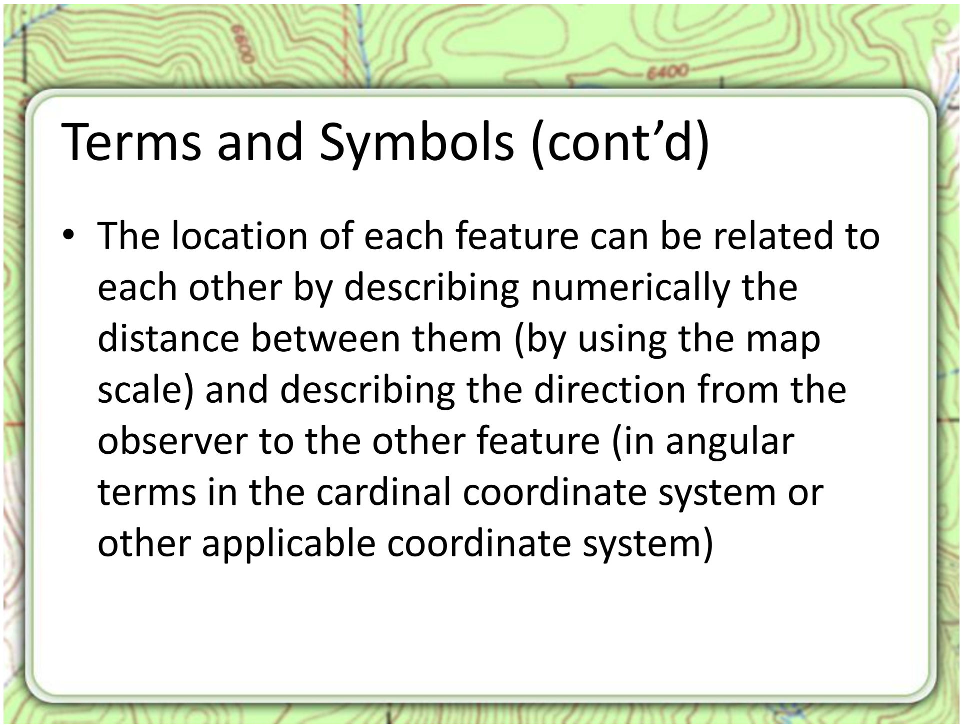

But understand that a quadrangle, is actually this little tiny area here, they got it circled, I know a square there, you probably can't even see it, but it gets it down to either fifteen minutes of latitude and longitude, that's what this one is, or 7 and ½ minutes of latitude and longitude. And the basic maps that we use in the United States, the USGS maps, are 7 and ½ minute, that's what we are dealing with, 7 and ½ minute quads, and it's just this little tiny as they say sometimes postage stamp of the real world. When you hear us talk about quadrangle maps, we are really talking about these maps that show a small quadrangle of the big latitude and longitude system that is on the Earth.

And you will be learning about lat and long, as we call them short because they are the basic ways that we measure things. That's how GPS works, that's how believe it or not, your state boundaries are defined by Congress, as it runs up this line of latitude and down across this line of longitude till it hits the river and it goes up there to this latitude. That kind of stuff is used to define those kinds of boundaries. Again with the advent of GPS, why everyone's able to, you know, at least get some level of precision. It isn't very precise, these handheld GPS devices but everyone is able to get some level of information in there that's in a latitude and longitude. The more sophisticated GPS units can convert that into other coordinate systems which we will talk about as well in this course. That is the basic way that the earth is divided up for mapping purposes and so that's why we talk about the USGS quadrangle map.

The Carson City map which we are using, that quadrangle is a nonplanimetric map, it's a topographic map, and it shows the vertical relationship as well as the horizontal relationship between features on the map.




As you saw, and if you have it there in front of you, just look at it, you know that, the quadrangle maps, the topographic maps, they show both natural things, all the mountains and the creeks and all that, they also show the cultural features such as roads, buildings, other improvements that man has made. The location of all of these things can be related to one another, basically with two different factors.




One is describing the distance between them and that's where map scale will come in, and the direction between them from the observer to the feature or back the other way for that matter, and those are going to be in angular terms. We are going to learn, you know, about angles and bearings and that sort of things so that we cannot just figure out where we are at the moment, but where is something else that we are looking at. So the terms and symbols are important and that's where we are going to go with this next section. So I'm just giving you an introduction here to that and now we are going to take a look at those things in specific terms and study those things very closely.

## Terminology

Now let's delve into a little bit more terminology. You may remember this drawing from the introduction earlier in the course, and I've blown it up some and we are looking at the entire earth here. I want to start referring to some of these things so that we understand the terms as we are looking at it.

As I mentioned earlier, the Earth has been divided up into this longitude and latitude system and lines that go due north and south are called longitude lines, or meridians. And you can see how they all eventually meet up here at the North Pole. And that's the definition of a true due north, south line as in that's it's running to the poles. The poles, the North Pole as well as the South Pole, that is what the Earth rotates around, or on a rotational axis. Based on that, close to how the Earth rotates, that we have set up this system for measuring things and identifying where you are on the Earth. So you have these due north south lines, called meridians or lines of longitude and there is a principle meridian or what they call a prime meridian, that is where they start numbering everything, start measuring everything from.

Now this was set up at an observatory in Greenwich, England, and so that's where we call it prime meridian, Greenwich. Zero degrees in Greenwich, and that's what this prime meridian is.

You see here, it's in a darker color and I will highlight it here for a moment, this line, that's the prime meridian. That is the due north south line that passes thru that observatory, in England. We measure everything from that so as you move west from that, this direction, you are so many degrees, and we will discuss degrees later, but you know, you are so many degrees west of Greenwich or so many degrees going that way east of Greenwich. Of course at some point those are going to meet, as you can imagine, around the Earth, they go around, all the way around the Earth and where they meet, is what we call the international date line.

At that 180 degree longitudinal line, it's the exact opposite side of the Earth from the prime meridian that passes thru Greenwich. On east west lines we have these lines of what we call lines of latitude, or parallels. The main one if you want to call it prime, it's not really called a prime latitudinal line but a prime parallel, but the one that we are most familiar with is the one that is actually the longest one, as well, it goes all the way around the Earth at the center, or widest part of the Earth, and that's what we call the equator. As you can see on the drawing that is this line here, the equator.

It is the due east-west line, that runs all the way around the Earth and it's been defined by mathematicians as to where the line is going to be, That line is 0 degrees, for north and south. And then we measure things for latitude which is our north or south position on the Earth. We measure latitude in degrees, and minutes and seconds, again we will discuss that later, but all the way up to the poles.

If I'm at the equator, I'm at 0 degrees, and if I go up the Earth, all the way up to the North Pole, then I'm at 90 degrees north. Because I'm at the very North Pole or 90 degrees south at the South Pole. That's how longitude and latitude work. Now, as you can see again looking at the diagram that the lines that we call parallels, or latitudinal lines, are parallel to each other. But notice again, as I mentioned earlier, that the lines of longitude actually converge at the poles, both the North Pole, as shown there, and the South Pole, down here. So, they are not parallel to each other, those lines converge or diverge depending on the direction you are facing, and so what we see is that longitude is our method of measuring things east and west, latitude is our method of measuring things north and south on the globe.

We have the prime meridian, we talked about that thru Greenwich, we have the equator, which is technically the longest parallel. All the others are shorter, because as you can see on the diagram again, they are shorter distances. For instance, this one at 60 degrees latitude, well that's much shorter distance around the Earth then at the center of the Earth, where the equator is.

So we have these methods of measuring things, and that is basically how GPS works. It's how mapping has always worked, in order to determine the longitude and latitude with things, you know, you see the old movies, and the sailor pulls out the sextant and he's looking at the stars and all that, well that's exactly what they are doing. They are determining their longitude and latitude based on the stars, because we know the relationship of the stars, so when you are on a different place on the Earth, you can determine by how the stars are related to one another, and to the horizon, you can tell where you are.

I'll give you a really simple thing, you might find this quite interesting, that when you are talking about latitude in the northern hemisphere, it's looking at Polaris. Now we call Polaris the north star. If you ever, you might have to get a star chart out if you are not familiar with where Polaris is, but if you find the Big Dipper, you know it's has a handle, and it comes into the Dipper, if you follow the outside of the Dipper, straight up, the first major star that you will hit is Polaris.

Polaris isn't perfectly at north, we wobble around it just a little bit mathematically but, it's close enough for star observation, just interesting. If you were to look at sea level, you know, just look flat, straight out ahead of you at sea level, whatever the angle is from sea level, up to Polaris, that's what latitude you are at. So you see at the equator, Polaris is perfectly flat, it's just right at the horizon, where is at the North Pole, Polaris is directly above you, 90 degrees above you. So if you are here in the area where I'm at, and if I were to measure the angle from level up to Polaris, it's about 30 degrees, 32 degrees, here in Arizona, so that's what latitude I'm at.

That's how they used to do it with sextants, we surveyors, we still do it all the time until GPS came along, we were always taking star shots of one sort or another, to figure out latitude and longitude and direction. This is the system that we call a cardinal coordinate system.

### Cardinal Coordinate System

Cardinal is a term that has a lot of meanings in the English language, in mapping, cardinal is referring to north, south, east or west. Those are our four cardinal directions and so when we call it a cardinal coordinate system, what we are saying is that I'm at 32 degrees north and 118 degrees west. Well that is explaining in a cardinal system, north or south, north of the equator or south of the equator, and east or west. East of the prime meridian thru Greenwich, or west of the prime meridian of Greenwich, that's how we measure and that's what we call a cardinal coordinate system.

Now, there are a couple of other terms that I want to mention. We talked about it already here about direction and distance and I'm not really going to go over that again we'll go thru some detail in a little bit, but you know, distance, how do we really measure distance here on the Earth?

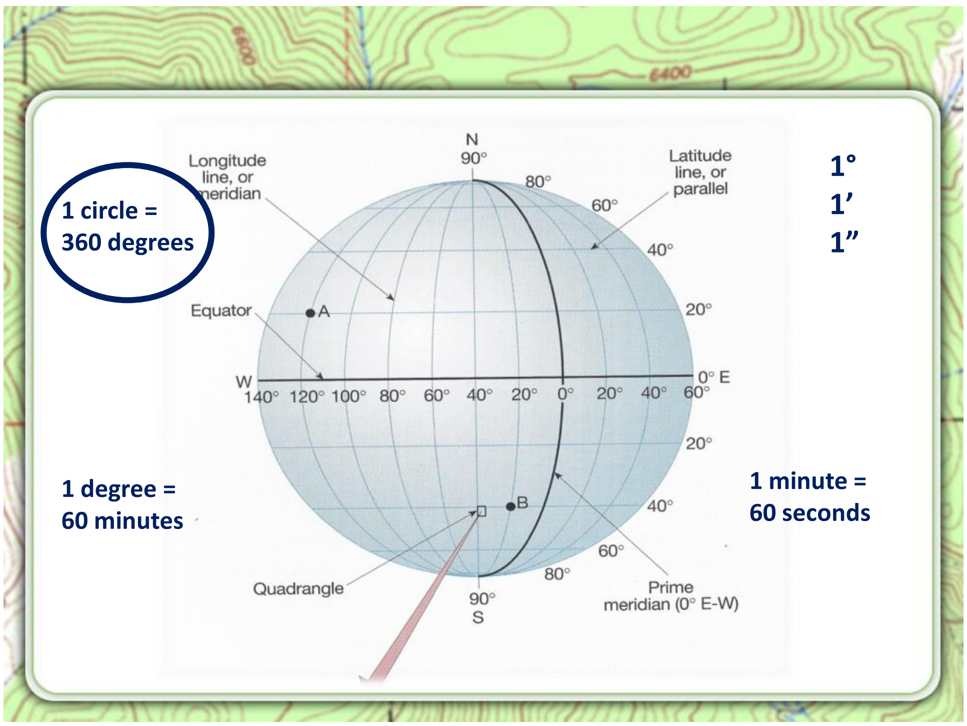
Well, you can measure it with longitude and latitude, there are formulas to compute, if you take the latitude, lat and long of one point and take the lat and long of another point, you can compute the distance between those and you can compute it in degrees, that's real simple subtraction. But you can also compute that in miles or feet. And of course, there are many different units of measurement, as we will see. But when we are talking about distance, we are generally you know, on a large scale talking about miles or kilometers, if we are on a metric system. Or we are talking about in a smaller scale, we are talking about feet and 10ths of feet, that's how we do it in surveying and engineering and most, and in geology and those sorts of things, those sorts of professions.

So distance, you know, can also be you know, cadastral plats are in chains, which is 66 feet, and you've heard of other things, rods, purchase, you know these different lengths that are determined, you know from history, whatever, but we bring them all down to feet when we are reading maps, or by miles for larger scale maps, so that we can relate one thing to another. You know so there's different units of measurement, there is also different units of direction, but primarily what is used in most of the Earth is some kind of degree, minutes, seconds systems. That is degrees of direction, and we will discuss that here in a little more detail so that we understand the terminology when we are talking about direction.

We are talking about the bearing or another system is called azimuths. A-z-i-m-u-t-h. Azimuths is a direction, azimuths are always based on north or south you know, and they go 360 degrees. Bearings go by quadrants northwest, northeast, southwest, southeast, but and we will see some of that and we will discuss that because we will need to know that and understand that in some detail. But the point is that's how we measure direction, is by some kind of an angular relationship to either due north or due south.

## Degrees, Minutes and Seconds

Now one more thing we want to look at before we leave this screen. And it's going to take you back to grade school perhaps or middle school where you took geometry. But it's to remind you how we define a circle, and that, because that's how we therefore will define directions. One circle equals 360 degrees. That's the way that we have set that up, and there are other systems around but 360 degrees is a measurement of direction which takes you all the way back to where you started. Therefore ½ a circle is 180 degrees similar to and we use an analogy with that.




When you talk about somebody that changes their life around or changes their direction that they were doing, then we say he's doing a 180. You can actually bring it down to a 90 degrees which is a quarter turn, if you will, so in other words, this line being north and this line being east that angle there is 90 degrees. Or square or so being ¼ of a circle, so one circle equals 360 degrees.

Within each degree, we have 60 minutes. It's the same as how time is done as far as there's 24 hours in a day, and each hour has 60 minutes in it. So one degree has 60 minutes and then we can take it down even further, one minute, each of those 60 minutes, one of those minutes has 60 seconds. And that is how we in most surveying, mapping and legal descriptions that you may read of property, and other applications of direction of bearing or azimuth, is noted in reference to these degrees, minutes and seconds. And so that's to remind you of how that works.

There is also a notation used and you will see it throughout our course and that sort of thing and that's these notations up here in the upper right of your screen. Notice that when you talk about one degree, rather than spell out the word degree, you can just put a little circle that's elevated there, that's the symbol for degrees. A minute is one quotation mark or apostrophe, I guess it is, that's our notation or symbol for minutes and then seconds is a double apostrophe or quotation mark. So if I was going to turn an angle I would note it like this, if I could draw this right. Note a 12 °, 25' and 13". That's the notation style that we use for noting direction and as you can see I'm not a great artist, or very poor penmanship. Good thing computers came along. But that's how we do that. And so one more thing just so you are aware of it here, understand that some applications of direction may not break it down into minutes and seconds.

For instance, there's a lot of old maps and deeds and property surveys that might say that you are suppose to go one and ½ degrees so obviously ½ a degree is 30 minutes. And you may even find some modern applications including some GPS units which do not carry directions out into minutes and seconds, they just do it in decimal. Decimal degrees or decimal minutes so recognize that you may see other applications of these things, for instance, if I went 35 point 75 degrees, Ok, that's 35 and ¾ degrees so that's the same as 35 degrees and 45 minutes.

If you converted .75 using the 60 minutes in a degree. So recognize that you may have different applications, different equipment or software that enters or displays this data in different formats, but recognize that all of it is based on the same principles that we are discussing here and that is a circle has 360 degrees and that there are portions of degrees and minutes and how they report those might be a little different. How we will do it for mapping in this discussion, we will use degrees, minutes, and seconds. And if you remember when we looked at the Carson City quad, at the corners of the quad, that it showed the minutes, degrees and seconds of latitude and longitude.

When we look at a USGS quadrangle map, as I mentioned earlier the 7 ½ minute series maps, which what we are going to basically look at 7 ½ minute quadrangle, you need to understand that map. Its borders, the outside of the map, not the edge of the paper, the outside of the map, the edge of the map, is exactly 7 ½ minutes in longitude and 7 ½ minutes in latitude. So that's why we call it a 7 ½ Minute Map. When you look at that map what you realize is that on the two margins on either side, on the left and right, they are on lines of longitude, which means they are due north, south.

Now you already know from the drawing we were looking at and our discussion, lines of longitude converge on each other as they go towards the North Pole or South Pole. We are in the Northern Hemisphere here. But you'll understand that if you were to measure closely, your USGS quadrangle map, the Carson City map that we are using in this course or any other map you will notice that it's a little bit shorter on the north end than on the south end and that's because those lines are converging as they go north.

Also, therefore, if that is, if a 7 ½ minute map is exactly the 7 ½ minute postage stamp picture off of this globe that we've been looking at, then you will understand that the north edge of your map and the south edge, or upper and bottom, those two edges are due east-west. That comes in handy later when we start to draw things, work with things, try to figure out the bearings between things, because those are going to be our references, to get an exact bearing.

Now with any kind of a map, planimetric map or topographic map, you have seen north arrows. That is in order to give you a general orientation and the USGS quad, has a north arrow at the bottom of it, it's not real obvious or fancy, like you see on some old maps and things, the artist put more time into the north arrow than he did the drawing itself, but that's not the case here. Because knowing where exactly where north and south are, where east and west are, is given to us because of the margins of the map. So that really pays off instead of trying to transfer a little tiny north arrow onto this big map, trying to figure out where north is, and we understand that we have these lines, the edges of the map that are on perfect north and south or perfect east west, we can use them to reference everything. That really pays off.

We've talked about scale and we will look at it again, but let's understand, as we've seen our definitions of what a map is, a scale is simply we've got to reduce the map from real world down to something a little more manageable. Take a look at the slide again, and just notice this is the whole earth, well, I can't show you the whole earth, I guess I can show you a picture from space, but even that's scaled down. It's too big. So, this is greatly reduced down in scale for us to be able to have a manageable, useful product, that we can do, that's how all maps are. Both planimetric and nonplanimetric (topographic) maps, they are to scale.

And they in fact they're quite precisely published to scale because you can use the data from them in some pretty good decent computations for how far things are apart from each other or how much higher or lower they are, we know that from the topographic things that we have learned. You can figure out a lot of what's going on there and you never even have to be on the ground. You know a tremendous amount of engineering and other design work is done from these topographic maps.

I will give you an example, power lines, these big transmission lines, you know they are able to use a USGS topo map and figure out where the towers need to be so that the sag and the wires doesn't touch the ground. That it's high enough for whatever's going under there and how far apart their towers need to be, and that sort of thing. They can figure that out without ever going onto the ground. You can do the same thing as far as designing other water works projects, that sort of thing. An awful lot can be done from a good topographic map, now when you get real flat shallow ground, usually a survey is needed to get a even more precise map reading just as trying to do streets and things here in Phoenix, where it's pretty flat. Well then you have to have a lot more precise measurement on the ground.

What I'm saying is the USGS maps have been used for decades to design and plan many, many major projects and that's because we are able to understand the scale and recognize what, what precisions we have with a scale, but we can measure something on the map and have a really good idea what it is on the ground because relationships of things are to that scale. That makes a map a very useful tool.

There's a couple of other things, one in particular that I want to mention I guess two that I mentioned earlier, we are going to go over to the Elmo and look at this. There are some things, I think I mentioned that I referred to as marginal notations.

## Marginal Notations

And if you take a look here, you can see, of course, there's the title, but there are all sorts of numbers here and lines and references and things and we are going to focus in on many of those as the course moves along. But these are what we call marginal notations. They are out on the margins of the map and they can range anywhere from these things that are about coordinate systems or look, here's an interesting thing, notice the 119 degrees, 52 minutes, 30 seconds, that's how many, that's our position in longitude from Greenwich at that corner of the map. And this is 39 degrees, 15 minutes and 00 seconds, that's how far we are in latitude from the equator to this corner of the map. And all four corners of the map have those. And they will be 7 ½ minutes apart cause this is a 7 ½ minute quadrangle map.

There's also information about a township and ranges, we will be talking about that, so you know where you are at in the public land survey system. If you are in a state where that exists. Now there is also on the map, you know as far as marginal notations, there is some other stuff at the bottom of the map and I will have to zoom out a little to get that in here.

If you look at the bottom of your map, we have some other marginal notations that are useful to us. We have the scale. It not only tells us what the scale is, 1 to 24,000. That means 1 inch on this map, equals 24,000 inches in the real world. That's what that means. Since there is 12 inches in a foot, 1 inch equals 24,000 inches is the same as 1 to 20. 1 to 2 thousand, 1 to 2 hundred, any variable of two hundred, that's why the 1 to 20 scale, that is why the 20 scale is what we use to read this, because it tells us exactly what's going on. In fact, since we are here, let's just look at that.

We have miles shown in this, I'm going to take the 20 scale, there it is, and I'm going to set it right here on zero, or as close as I can. Notice at the 1 mile mark on the map here, I'm at five thousand, one hundred, two hundred and about 80, five thousand, two hundred and eighty. See, now the 20 scale works perfectly with 1 to 24 thousand scale. That's what we, that's what we use. So we not only have the scale information here, but look what else we have in marginal notations.

We have what contour intervals are, we will be talking about that, that's how many feet in elevation are different between each one of these contour lines. That's what that's talking about. It gives us some other information here, alright. To the left of that you will see, there's what we call the north arrows, there's actually 3 different north's that are represented on a map, and notice the center one goes right up the same direction as the edges of the map. It has a star at the end of it and that's because that's Polaris, that's astronomic north. Then it shows you where magnetic north is. I'll talk about that in a second, and it shows you where the grid north is and that's based on a coordinate system that we'll talk about later, the state plain coordinate system.

We have a north arrow here and it's telling you magnetic north is 15 ¼ degrees east of that and this other grid north is 1 degree 47 minutes west of it, we have that information. There's other information about the publication and the coordinate system that are used on this map. You will have time to look at these later but, I'm giving you kind of a tour, if you will of how the map looks. And let's see, we also have a picture, just a very small picture of Nevada here, and it shows us where this map is in Nevada, then it shows, here's all the maps that are around this. We are just in this one 7 ½ minute quad, if you want to know what the quad to the north of you is, it's number 2 Washoe City. To the east, it's number 5, New Empire, to the southwest of us is

6, Glenbrook, so it gives you the name of the quadrangle maps that are around you. So that you can relate this map to others.

Finally, down in the lower right corner of the map, we have not only the name, which we have already talked about, and the date and that sort of thing, but we also have a very brief legend. We are going to talk more about the legend here soon. But this is just mostly for roads, just giving you road information. There's a whole lot more to the legends of these maps but there is that, located on the quadrangle map. As you can see, a tremendous amount of information in the margins of the map, and that's what we generically call, marginal notations.

So those are a few terms that you have, and we will have an exercise that's going to go through that will help you review these terms that we've discussed so far in the course, and then we will get down to talking more about the actual symbology that is used on USGS topo maps.

So, at this time you will want to take a look at Exercise 1, and go through that and then come back and start up the DVD or whatever you are watching here, and we will continue with the lesson.

## Exercise 1 Map Terms

Match the following terms with the definitions shown below by placing the corresponding number of the term in the blank to the left of the correct definition.

**Terms**

1. Longitude
2. Latitude
3. Prime Meridian
4. Equator
5. Cardinal Coordinate System
6. Planimetric map
7. Topographic map
8. Map notations
9. Map symbols
10. Direction
11. Distance
12. Scale
13. North arrow
14. Elevation contour
15. Map legend
16. Planimetric map example
17. Rotational pole
18. 7.5 minute quadrangle
19. 90 degrees

**Definitions**

| | |
|---|---|
| | Diagrammatic features on a map that represent natural or cultural features on the ground. |
| | A measure of the separation between two features in 3 dimensional space. |
| | A map notation that explains map symbols. |
| | The longest parallel. |
| | The stationary end of a central axis of a planet that revolves about that central axis. |
| | The magnitude of the geometric arc from the equator to the north pole. |
| | Map notation showing the direction to the north rotational pole. |
| | A road map. |
| | A universal, earth-based geographic system used to describe direction based on the relative location of the north and south rotational poles and angular relationship between two points. |
| | A map that illustrates only the horizontal relationship between features and not the vertical relationship. |
| | Imaginary geographic lines connecting the north and south rotational poles. |
| | The zero degree line of longitude. |
| | An area on the surface of the planet that is bounded by 7.5' of longitude and 7.5' of latitude. |
| | A map notation that shows how many units of measure on the ground are represented by a lesser number of those same units of measure on a map. |
| | A map symbol that represents an equal number of feet above mean sea level. |
| | Information shown along map margins that provides critical data for map symbol interpretation. |
| | Parallel lines surrounding the spherical earth that are perpendicular to the rotational axis. |
| | A nonplanimetric map showing both the horizontal and vertical relationship between both cultural and natural features. |
| | A line or course between two points in 3-dimensional space along which something is moving or facing in a coordinate system where one point at the end of the line is defined as the point from which observer faces or aims toward another point along that line. |

## Exercise 1 Map Terms – Answer Key

Match the following terms with the definitions shown below by placing the corresponding number of the term in the blank to the left of the correct definition.

**Terms**

1. Longitude
2. Latitude
3. Prime Meridian
4. Equator
5. Cardinal Coordinate System
6. Planimetric map
7. Topographic map
8. Map notations
9. Map symbols
10. Direction
11. Distance
12. Scale
13. North arrow
14. Elevation contour
15. Map legend
16. Planimetric map example
17. Rotational pole
18. 7.5 minute quadrangle
19. 90 degrees

**Definitions**

| | |
|---|---|
| 9 | Diagrammatic features on a map that represent natural or cultural features on the ground. |
| 12 | A measure of the separation between two features in 3 dimensional space. |
| 16 | A map notation that explains map symbols. |
| 4 | The longest parallel. |
| 18 | The stationary end of a central axis of a planet that revolves about that central axis. |
| 20 | The magnitude of the geometric arc from the equator to the north pole. |
| 14 | Map notation showing the direction to the north rotational pole. |
| 17 | A road map. |
| 5 | A universal, earth-based geographic system used to describe direction based on the relative location of the north and south rotational poles and angular relationship between two points. |
| 6 | A map that illustrates only the horizontal relationship between features and not the vertical relationship. |
| 1 | Imaginary geographic lines connecting the north and south rotational poles. |
| 3 | The zero degree line of longitude. |
| 19 | An area on the surface of the planet that is bounded by 7.5' of longitude and 7.5' of latitude. |
| 13 | A map notation that shows how many units of measure on the ground are represented by a lesser number of those same units of measure on a map. |
| 15 | A map symbol that represents an equal number of feet above mean sea level. |
| 8 | Information shown along map margins that provides critical data for map symbol interpretation. |
| 2 | Parallel lines surrounding the spherical earth that are perpendicular to the rotational axis. |
| 7 | A nonplanimetric map showing both the horizontal and vertical relationship between both cultural and natural features. |
| 11 | A line or course between two points in 3-dimensional space along which something is moving or facing in a coordinate system where one point at the end of the line is defined as the point from which observer faces or aims toward another point along that line. |

# Lesson 1 Map Reading & Interpretation, Part 2

## Introduction to Symbols

Now that you have learned some of the various types of maps, and the information that's contained on them, what we want to do now is look at some of the symbology or the symbols that are used on maps in order to get information.

You know a symbol in mapping, is a diagram, is a design, is a letter, is an abbreviation. It is some piece of information that's placed on the map, and of course you need to reference the legend to figure out what it means, it is kind of codes if you will. And it's understood to stand for a certain type of feature, a specific characteristic or an object on the ground. Different types of maps use different types of symbols. But you know with planimetric maps you are used to, and you look at a highway map, or a Google map, there's a line for a road, or a double line for a road, or a double line for an interstate, you are used to that. You are used to the symbols for an interstate highway. In fact, some of the simplest legends is what we already saw.

Let's just take a look at the Power Point here. You have already seen this with the legend's at the lower right corner of a USGS topo map, it's given you four different road symbols, for different types of roads. You know whether it's paved or not or it's a light duty road or an unimproved road, or a dashed line means it is a jeep trail, that sort of thing. You are also used to these symbols here, you know, you are used to the Interstate Route, the U.S. Route, the State Route, highway numbers would be inside of those. So, you know we are already used to those kinds of things, even on a planimetric map, you are used to these symbols, used that way.

With USGS maps, topographic maps, there are a tremendous number of symbols that are used because of all the things that are in nature out there as well as in culture that man has built and done, you know, all of those things have to have a symbol. The legend that's on the map here, you know as we just saw, is extremely limited, just roads and highway numbers really, but there is another document which is included in your material, that is the official USGS legend. And it shows all the symbols they use and there's hundreds of them in there. So that pamphlet is something you can use.

## Types of Symbols

You know, features that are on maps that we use symbols for come in three basic categories, there are area types of symbols.

### Area Features

That's where you are trying to show that something applies to an entire area. Here's an example of that. Take a look at this screen, you know, we have got blue up there in the upper right, that represents water. You know, that whole area is in that lake so it's all shaded blue for water. And with USGS maps and it's vegetation, trees, then it's green. And you can see entire areas are shaded by green. So there's two symbols, these are being area symbols.

### Line Features

There's other things that we will see. We will see some examples here in a few minutes. You have area features, you also have line features, and we have talked about those already. But let's take a look at the screen here and you know, there's a road there's also you see that PLSS line, that's the public land survey system, that's a section line. If you look closely at your map you will also see lesser roads. You will see an old railroad grade that runs through there, you know a line, you can find where railroad's are actually running through or where ditches run through, creeks, all of these things shown by lines, not property lines, but administrative lines are shown that talk about where the edge of the national forest or where the edge of the state park are, all of that is on this quadrangle map that you are looking at.

We have all sorts of things that are line features and of course the contours themselves are lines, which we have talked about so then you also have things that are called point features.

### Point Features

That is there's a point on the ground there that something has happened or that something is there and it shows you that using symbology. And here's a couple of examples on your map, small buildings, a gravel pit there in the lower right corner all sorts of other things if you look on there, and if you just look across the entire breadth of the map that you have and you will find all sorts of point symbols. And so you have three basic types of symbols, area, line and point features. And we are going to go into those in a little more detail and see what those are.

But let's understand that all of that is in order to help us to understand what the map is telling us, what kind of information is there, it is drawn to scale as best as they can, obviously vegetation lines are kind of plus or minus and they can change since the map was made. But you know the roads, unless they have been reconstructed and moved to another place, the roads are accurate. The railroads are accurate, the streets are accurate, and the edge of the water is accurate unless there has been some activity that has changed that. And of course the point features, they usually remain very accurate as far as buildings, and water tanks, and graveyards and mines and all of that sort of thing. They are very, very precisely shown. Again as we review this map now, you are going to get an opportunity to see all of those different things and see how that works and start to see how much information, it's absolutely amazing really, how much information is shown on one of these maps.

## Symbology

Now we are ready to start talking about symbology and as we have mentioned already, maps are made up of symbols. All about symbols that are precisely placed on the USGS map, and they help us understand what various things are, obviously we cannot write in what each thing is, the symbols much more precise for locations and you can group a lot of things together. In crowded areas you actually had to put a notation on each thing, what it was, you could never fit that all on the map. Symbols are really important. Now, in the document, and in your course materials, you got the document that comes from the USGS that is their master legend for all of the symbols that they use, in case you want to get that from online, or in case they have updated it, or anything here is the web address that you can go to.
http://egsc.usgs.gov/isb/pubs/booklets/symbols/roads.html

Now it's kind of a long one there so we will leave it up there for a few seconds if you are going to jot that down. But that is the web address that you can go to and get this particular document that we are going to be looking through which gives us all of the map symbols that the USGS uses on their quad sheets.

## Exploring the USGS Topographic Map Symbols

So what we want to do now is I'm going to have us start taking a look at some of these symbols in particular, and you may recall that we already discussed that symbols come, there are really three different types of symbols. You have shading that is used for large areas of something in particular, we saw water and vegetation, you will also find a gray shading and sometimes pink shading that is used for metropolitan areas where they don't go into a lot of detail of what's going on there and they just shade it, kind of corporate area of the city, and we have that on our plat as well, the map, the USGS map that we are using, Carson City quad.

We also have lines and we looked at a few examples of that, roads and highways and creeks and aqueducts and that sort of thing, ditches and then we also have points and we going to look at all examples of all three of those from the document that we just discussed and that you have.

I'm going to move over here to the overhead which we commonly call Elmo, and first off this is the cover of that document here, just to make sure that you are looking at the correct document that you want to, that I'm about to discuss. So that is the same one that I showed you the web site address for, now what I'm going to do is swap that out of there and put on the specifics here and zoom in, there we go.

Now, this is in, they kind of grouped these in different types of features and they are in here alphabetically. They start out with **bathymetric** features which are talking about some things that have to do with water, and especially underwater. I'm not going to go through everything but it's just amazing how much detail there is on a USGS topographic map. You just look here, you know, we are seeing underwater we are seeing a where there's an area where it will be exposed at low tide, there's a channel that's where the ships can go, that's underwater, here is where there's a sunken rock, you know, and they show that sort and that's amazing to get that kind of detail.

And then continuing on this where it's just again in kind of alphabetical order, as to a what we are going to look at, and I'm going to slide it down and here's **boundaries** and you know, all different types of boundaries, you know, sometimes we don't even think about all of these things. You know, national, state, county you know, your cities, national parks other special areas, national forests, special areas within forests with ranger districts, and national forest system, land status is even given on their maps.

They have taken these same maps and added information that tells you about whether it's a federal land or not, so we have a lot of information that's given there, depending on what version of these you are looking at. I'm going to move it down to the buildings. This becomes more useful to us.

**Buildings** are shown, larger buildings to their actual scale, smaller one just a little dot for a house, or a bigger house but much larger buildings, they have used other symbols. As you can see, different symbols and some of those are, at least in the past, were to indicate that it was not a permanent building and that sort of thing.

But you know, look here, a little square with a flag on it, that's a school, one with a cross on it, that's a church, athletic fields, all of these things, you come down here, racetracks, and let me just slide that just a bit, and then you can see these are airports that are paved, this is with dashes like that is an airport that's unpaved landing strip, all kinds of features and buildings, that show up, water tanks of different sizes, the dark ones are generally covered ones, open is an uncovered one that is still a water tank, and you have covered reservoirs here. You have other things down on that list.

Now I'm going to slide this over and get up to the top of the next column and discuss the **coastal features**. Now of course, I'm a Arizona boy, and I don't know much about the ocean. I've been there many times but it amazes me what all is shown on here and the details of it, and coral and groups of rocks and here's a shipwrecks that you can see that are exposed above ground. Jetties and break waters, sea walls, even oil and gas platforms out there. All of this information given to us on these maps is just amazing detail of the symbology.

I'm going through this and obviously you are not having to memorize all this, although many of them you get used to them and you will actually get very used to certain types of lines, certain colors, that sort of thing, as you use this more and more and you become quite familiar with it, it's very rare after many years I've used maps, thirty-seven in particular. Well that's been since I have been in the surveying profession. I've played with USGS maps since I was a kid, and that's where I got so interested in them, you really get used to a lot of things, with use, where you don't have to look up anything. But for those of you who are new to this, hey, no problem. You've got this document, you can look these up and you will very quickly catch on to what these different things are.

I might add that over the years I've done a lot of different things for schools. I found one of the best things that grade schools that interest kids in mapping and science and surveying or geology or engineering. I'd go to these career days, and I'd go to these class, you know, and I found one of the best things you can do was take in several copies of the same map. Kind of what you all are doing with the Carson City quad, and just walk into that classroom, and have all the kids, you know, there would be third graders or whatever, and have them all just talk about the symbols.

And they'd get so charged up, and you would ask them, well what do you suppose this is with a flag on top or a cross on top, what do you suppose these things are? To hear them guess, and they'd get all charged up and excited. That's a great tool you can use for interesting kids in map reading. It's one of those things, you know, that I feel really comfortable with, just because I have used them for so long, so these symbols, very quickly, once you get used to them and you can just look at one of these maps, and you just instantly know what that looks like out there, and what's going on.

So that's the importance of these, now the next category that we are going to look, now a lot of people have a real difficult time understanding and we are going to go into to that to discuss how you use contours. But let's take a look at this.

**Contours**, remember are elevation information and we have different types of contours. We have what we call an index contour that is the one where we actually get the elevation, that means everything along that line, in this example whatever that says 6,000 or 8,000 I don't have my glasses on, let me put them on, 6,000. Here the intermediate ones, , it won't give you an index, it just gives you the contour and you will have to go to like every 5th contour and it will have the index on it, or every 10$^{th}$, depending on what scale they're at.

And then you see here, look at this, you have contour lines going around so there's something happening here with the little ticks that point in, well, that's a depression, so that would be like a gravel pit or an open pit mine, that sort of thing.  We'll be learning a whole lot about contours because they are really the secret to understanding the three dimensional aspect of how we use USGS maps.

And as you look down the list, I'm not going to go to those, they even have bathymetric contours, which is contours, you know, how deep is the water there? They work the same way as we're just looking, they have index contours and supplemental ones.  A lot of information there for you, regarding even the depth of the water, at least at the time of the mapping.  Now going again to the overhead then, the next thing in line here alphabetically is co**ntrol data and monuments**, some of that will not directly affect you, but it's to let you know what this stuff is.

And they list these things here, boundary monuments, horizontal control, these triangles, you know, when you see a triangle with a dot on it, that means that there's what we call a triangulation station. They are usually on the mountain tops or hilltops, and what that means is there's an actual monument up there on top of the mountain. That has longitude and latitude on it in the record, it's not stamped onto the monument.  We have all sorts of information here about monuments, and you will learn to use some of those as we talk about the public land system here in a little bit, some of that will make more sense to you.

Continuing on to the next page, there some more control monument information there and then it goes to, something I would never think of, but obviously in some parts of the world important, **glaciers** and the contours and limits on a glacier and where glaciers are retreating and where they are advancing. Well I would have never thought of that.

Amazing stuff that you can get on there, and then with the **public land system**, land surveys in general.  There's quite a symbology to that. As you can see here, you know if you are familiar with the public land system, some of the major lines every six miles, range lines and township lines.  If it's solid, that means where it's shown on the map is really, known, it's precise. Whereas if it's not that well known they'll dash it like this, where it's approximate, and if it's really doubtful, it's got even longer dashes.

So you can look at a map and you can tell what they knew, or what we knew, the government knows about an area, and the quality of the surveys in the area and whether it's easily identifiable or not.  I'm going to put the Carson City map up here for a moment and I might have to zoom out a little bit to get this. But if you take a look here, you will see an example of each of these, here's a range line, it's a really dark heavier red line, but it's got the shorter dashes, so it's an approximate, they don't know exactly where that is.  Ok, they have put the best information they can to show that, and then we have section lines here where they are not that really well known so they are dashed.

If I go down to the bottom of the map, and you have to let me move this for a second here, and get that oriented right.  Take a look at the very bottom of the map of Voltaire Canyon, see this line is solid, so they know exactly where that section line is, they know that perfectly. Whereas going out the other three directions, they don't know it as well.

So see, you can just look at the map and see that symbology tells you if I'm trying to figure out. Well let's make up something here, that you're working and you'd be up in this area here, and you are trying to determine, maybe somebody's you think maybe doing an illegal activity, maybe they are mining or something in here, and this side is federal and this side is private, well, I would know that this section line is only approximately shown on here so I wouldn't go out and try to determine exactly where I am there, and make a decision based on that.

Then when you get the really longer dashes with big spaces, then you know that they're really guessing. Where those lines are, so that's just an example on how you can use this information to determine various things that are going on, on the ground and what you know, what you can be more comfortable with, and what you're not as comfortable with.

These are the corners themselves and lines where they meet. The interesting thing is where you get the little tick mark, what you see at these points here, and these are different types of corners, and we're not going into all that stuff here. But when you get the little tick mark there, where section lines meet, well that means when the USGS was making this map, they found that corner. So they feel pretty comfortable where that corner, that one corner is.

But when you have these red lines and they don't show an example of that on here. Where you have these red lines cross, and there's no tick mark, that means they didn't find anything there. So it also gives you an idea whether you have a real likely chance of finding that monument on the ground. If it's really obvious at the time the USGS was there, well they marked it so, and if it wasn't, they'd mark it otherwise.

I'm going to move down, skip the **marine's shoreline**, down to **mines and caves**, for a moment. And just notice that we have symbology here. A quarry or an open pit, slightly different, those are two picks, here's two shovels, pointing down that's gravel, sand or clay, just a borrow pit that sort of thing along a highway. A mine entrance, have a lot of that, in the areas I've worked most of my career in mine shafts, if there's just a little digging there, we call that a prospect. Dump out stuff, you have dumps and tailings, all sorts of information there.

Again, more than you are used to on most planimetric maps that we look at, highway maps or Google maps, or whatever. There is a lot more information on a USGS topographic map than you are used to. In fact, just about anything that's going on, on the ground, that could affect anything that might be done in there is going to have some kind of a symbol, some kind of notation, something that we know what it is. So, tremendous information, you are going to be doing an exercise here in a few minutes that lets you practice on some of these, going to force you to look up quite a few of them and then make some decisions.

Later in the course, as you get further along, we'll be giving you scenarios of things that you have to do and things to look for and that sort of thing, so you are really going to have to pay attention to the symbology used to make sure you are driving down the correct road that we have asked you to, that sort of thing.

We're just reviewing all of this, just to give you more of an idea, cause again, and I don't expect you to memorize this but to give you an idea of how much detail is actually shown.

Going back to the overhead we have what we call **projection and grids**, and these are about mapping and numbering systems, that sort of thing. You know we talked about at the corner of the map, where you get the exact latitude and longitude of the 7 ½ minute quadrangle.

Well, here we are, they call that the neatline, these lines on the edge of the maps. Those are called neatlines which are exactly due north, south, east, west. And we will use them for referencing so at the four corners of the map, you will get these, the exact longitude and latitude at that point. But out along the edge of the map, you have other places where they will show you additional points. You will have what they call a graticule tick. It's just going to be a little tick mark, and it will have that number, something like that. What that means is that's where 55 minutes is, and they will do that like every two and ½ minutes, or ½ a minute, depending on the scale of the map.

Even out in the middle of the map, as we will see later, you will get what they call a tick mark or a graticule intersection. What that's doing is showing you, this is where a certain longitude and latitude meet. Even out in the middle of the map, you will have to go over to the margin and figure out which ones they are. To find one of these marks, but this will show you where it is out on the map, itself, where it crosses another line that you would want to go and look up.

So the map is filled with that information, and as I go through these things, you might even want to stop the video and just pull out the USGS quad that we've provided you, the Carson City map and look for examples of all these things.

Obviously there is no oceans, that we got on there, but just about everything else is on there. See if you can find some of those things like these tick marks, find those and then go up to the margins and line up and see what they are. We also have the state plane coordinate systems, which will be discussed here. These are tick marks. You will find them where they have either feet or meters or both along the edges of the map, and they will also have a tick marks inside the map that help you figure out where you are in the state plane coordinate system. That's another referencing system that we will discuss and then there's another that is used a lot more by people nowadays, in certain professions like archeologists that use nothing but what we call the UTM.

That stands for universal transverse metcator grid. That's a different grid system but you will see on the margins of the map, these are, these are UTM grids, are also given to you. So we will explain what those mean, but this is some more of that symbology.

**Railroads**, you can tell from the symbology, if it's a standard gauge, which is four feet eight inches, or is it a narrow gauge. Are there sidings? Is there a railroad in the highway or a railroad next to a highway which happens in some parts of the country. We have an underpass, where the railroad stops. You see if you look really closely there you will see railroad stops there and there meaning that the road is over top of it whereas it's the opposite here, the railroad is over top of the road here. Right, extreme detail. Other information, of course the railroad yard, they might not show all of the tracks, they will just shade it like this and show you all of that information.

Now we come to some more water, this time not ocean based, **rivers, lakes, canals.** A perennial stream, that means that it runs all year, and a perennial river. As we have here in Arizona, intermittent streams, you know they don't flow all year round, intermittent rivers, we have those too. You have a stream that is alive and then it disappears. It falls down into the geology and just disappears from the surface. They have symbols for that. Small waterfalls, large waterfalls, small rapids, big rapids, even different types of symbols for whether the dam is made of masonry or if it's a dirt dam or does it have a lock in it, is there a road over the top of it, everything. Everything you can imagine is covered there.

Now, as we go over to the last page in that document, we have a few more river and lake things and let's take a look at those. We have lakes or ponds that are perennial meaning they are wet all year round. We have intermittent ones, so different symbols. If it's a dry lake, they might even write that sometimes, or they have this symbology. They have blue for the lake and yet it's got dirt in the middle, so that is a dry lake.

As you see washes, canals, elevated aqueducts, tunnels and aqueducts. Here's an important one and when you are out hiking or camping or and looking for springs or seeps. Those are shown on the map and that means, when you see that, that doesn't mean somebody just guessed there is one there. When the USGS made these maps, especially back in the 20's, 30's, 40's and all the way through the 1970's when they were making all the maps themselves, they actually had people, mapping technicians who went out on the ground and spent several days on each of these quads.

They would go and find out the name of things. They would go look at something and see trees that are greener in an area, and this is especially true there in the desert and they would go over there and they would see, there is a spring there and actually locate that spring, on the aerial photos that map it was based on. Usually these are very precise. I mean maybe plus or minus a hundred feet or so, for things like that and these people also went out there and looked for some of these section corners or other monuments. They went to buildings and saw is that a church, is that a postal office, is that a school, what is it? Put the name on there, if we need the name, or the correct symbol on it, so these were field checked.

Now in the 70's, 80's, and 90's, the USGS really cut back on money, and of course the contours and things don't change that much, especially outside of a city. So the USGS started doing what we call the photogrometric updates or revisions. They would re-fly the whole thing and they would add in all of the new streets and some of the changes, but they wouldn't send somebody into the field to look for that spring again, or that sort of thing. So if it's in an area that's developed well you have a chance that the feature may have changed.

But just recognize that the base layers if you will of these maps, most of them had people actually on the ground seeing what was going on. They wouold even talk to the locals, find out does that stream run all the year round or not and that kind of information, is generally quite precise. It makes it really useful for you and I, out there on the ground, trying to use this information.

Now you will recall that on the bottom of the Carson City map, lower right corner of all quads, they have a really brief legend about roads. I'm not quite sure why they actually do that on there since it's so brief and incomplete. If you go to the overhead now and you see now here's the complete set of symbols for **highways**.

Whether they are paved or super paved or primary, that means they can handle a lot of heavy truck traffic, or are they a light duty, or they are unimproved or four wheel drive or even a trail, and oftentimes on a map, jeep trail or four wheel drive trail, it will tell you that. Is that a divided highway, is it under construction, at the time they took the picture, underpasses, overpasses, drawbridge, everything.

Everything you can imagine is on there about a road that you would somehow impact any project that you might be doing. So, that's really more complete than what was on, the other, on the maps themselves.

The upper right corner of the last page of this document we have **submerged areas and bogs**, how they mark marshes, and that sort of thing, also areas that are just subject to inundation, they may be flooded regularly or during certain events. Then we even get information like this where you might have a dam and the lake that backs up behind it isn't always full, but they will mark where the maximum pool is. Max Pool 431, so that means four hundred thirty one feet above sea level. This is where that would be, so you can look at the map and see how far the lake would stretch if they let it go all the way up to the elevation on the spillway on the dam.

So that's useful, if you are building something, you don't want to build it in what might be flooded next year, even though the lake's 50 feet away from you now, if you had a major run off, and they let the lake fill all the way up, that's how far it would reach out to you. That's what that flood pool elevation is about.

We also have some other **surface features** that are listed here. Levees, things that are just disturbed even, tailings, mining activity. Then we move down and we have some **utility** type things, power lines and a telephone. They will often write, just like it says here, they'll actually write on there what that is. Above ground pipeline, interesting most pipelines are below ground, so it wouldn't be picked up in the mapping, unless they had specific reason to. So, they do have the symbol for underground pipeline, you might wonder well, how did they get the underground pipeline? Well, in a lot of areas, not really wet lush areas, but a lot of the rest of the country, when you put a pipeline in, the scar is there for years and years to come.

Just the vegetation change, you can see it in an aerial photo, exactly where it is, so that's how they determine where underground pipelines are. They determine where they were, or are, and so that field-checking person I was talking about, would actually go out there and verify all that, that's a gas pipe line or whatever, and they would get that. They can have above ground and below ground, that doesn't mean that all below ground utilities are there.

If you are doing construction, you want to call Blue Stake, or one of those kind of services, because that's what really counts to find out what's underground. In other words, you can't rely totally because this is what the aerial photo could show and be verified by the person that was on the ground.

Now, last but not least, we have **vegetation**. You recall that we have talked about, and you know you have seen we have shaded areas for water, swamps and stuff and we also had lines for roads and that sort of thing, but we have shaded areas for vegetation. We have already talked about this and it isn't very clear but it's a slightly green tint. If it's shrubs, then it is spots with a lot more space in between them. If it's an orchard the spots are all lined up and organized and you can tell what you are looking at. Vineyards are lines that are running in the direction of the vineyard. I guess somebody thought mangroves were more important than most other types of trees, maybe that is they are just so thick and nasty, where they grow, so they even have a symbol for that.

That was a really quick review of all of those things and as I encouraged you a moment ago, take a look at all those things. You are going to go through an exercise now, and that will lead you through that, force you to look at some of those things. I'm going to encourage you to enjoy yourself while you do it, because it's really quite interesting to figure out what's going on.

There are some other oddities that are not listed on here because they don't happen that often. After you get to know these things a little bit, and you look at some USGS map, and you see some odd situation, a symbol or the contours do something that doesn't make sense, you will suddenly realize, hey, I know what this probably means, there's something unique here, and I will give you an example with contours.

Now contour lines don't cross themselves, contour lines are elevations. If it's a hundred feet above sea level here, and it's a hundred and fifty feet above sea level here, those lines never cross, because they are 50 feet in elevation difference. At one time I was looking at a map, that was here in Arizona, and I noticed on the map, the contour lines crossed, and I wondered what that meant. I went to the place where it was and it was a project I was doing and found out it was one of these big overhangs in the sand stone cliff where it went way back underneath there. It was one of those places where you might find Indian ruins, or cliff dwellings, and there weren't any there, and then I realized that's why they are showing contours crossing.

Something that's not suppose to happen, and yet they were showing me that, so they are indicating something's different here, and in that case, it certainly was, it was a huge overhang of a cliff there, so I learned that one. That's one you are not going to find in the booklet that we just looked through, and yet you can figure these things out, because you understand what the different symbols are. Now again, with contours they are a little more complicated and we will discuss those in particular, but this has been your introduction to the symbols used on maps, and that especially with USGS maps and how much detail and information is there.

So we are going to encourage you now to go take a look at Exercise 2, and work through that symbology and then, I'll see you here back when you are done with that and we will continue our discussion.

## Exercise 2 Symbols

Match the symbol with the correct definition.

**Definition**

1. State Boundary
2. Spot Elevation
3. Spring
4. 4WD Road
5. Vegetation
6. Index Contour
7. Buildings
8. Water Tanks
9. Approximate Section Line
10. Mine Shaft
11. Found Section Corner

**Symbol**

a. 

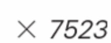
b. 

c. 

d. 

e. 

f. 

g. 


h. 

i. 


j. 

k. 

## Exercise 2 Symbols - Answer Key

**Answers**

1) j

2) g

3) e

4) k

5) h

6) i

7) d

8) b

9) f

10) c

11) a

## USGS Pamphlet Handout

# Topographic Map Symbols

## What is a Topographic Map?

A map is a representation of the Earth, or part of it. The distinctive characteristic of a topographic map is that the shape of the Earth's surface is shown by contour lines. Contours are imaginary lines that join points of equal elevation on the surface of the land above or below a reference surface, such as mean sea level. Contours make it possible to measure the height of mountains, depths of the ocean bottom, and steepness of slopes.

A topographic map shows more than contours. The map includes symbols that represent such features as streets, buildings, streams, and vegetation. These symbols are constantly refined to better relate to the features they represent, improve the appearance or readability of the map, or reduce production cost.

Consequently, within the same series, maps may have slightly different symbols for the same feature. Examples of symbols that have changed include built-up areas, roads, intermittent drainage, and some lettering styles. On one type of large-scale topographic map, called provisional, some symbols and lettering are hand-drawn.

### Reading Topographic Maps

Interpreting the colored lines, areas, and other symbols is the first step in using topographic maps. Features are shown as points, lines, or areas, depending on their size and extent. For example, individual houses may be shown as small black squares. For larger buildings, the actual shapes are mapped. In densely built-up areas, most individual buildings are omitted and an area tint is shown. On some maps, post offices, churches, city halls, and other landmark buildings are shown within the tinted area.

The first features usually noticed on a topographic map are the area features, such as vegetation (green), water (blue), and densely built-up areas (gray or red).

Many features are shown by lines that may be straight, curved, solid, dashed, dotted, or in any combination. The colors of the lines usually indicate similar classes of information: topographic contours (brown); lakes, streams, irrigation ditches, and other hydrographic features (blue); land grids and important roads (red); and other roads and trails, railroads, boundaries, and other cultural features (black). At one time, purple was used as a revision color to show all feature changes. Currently, purple is not used in our revision program, but purple features are still present on many existing maps.

Various point symbols are used to depict features such as buildings, campgrounds, springs, water tanks, mines, survey control points, and wells. Names of places and features are shown in a color corresponding to the type of feature. Many features are identified by labels, such as "Substation" or "Golf Course."

Topographic contours are shown in brown by lines of different widths. Each contour is a line of equal elevation; therefore, contours never cross. They show the general shape of the terrain. To help the user determine elevations, index contours are wider. Elevation values are printed in several places along these lines. The narrower intermediate and supplementary contours found between the index contours help to show more details of the land surface shape. Contours that are very close together represent steep slopes. Widely spaced contours or an absence of contours means that the ground slope is relatively level. The elevation difference between adjacent contour lines, called the contour interval, is selected to best show the general shape of the terrain. A map of a relatively flat area may have a contour interval of 10 feet or less. Maps in mountainous areas may have contour intervals of 100 feet or more. The contour interval is printed in the margin of each U.S. Geological Survey (USGS) map.

Bathymetric contours are shown in blue or black, depending on their location. They show the shape and slope of the ocean bottom surface. The bathymetric contour interval may vary on each map and is explained in the map margin.

U.S. Department of the Interior
U.S. Geological Survey

## BATHYMETRIC FEATURES

- Area exposed at mean low tide; sounding datum line***
- Channel***
- Sunken rock***

## BOUNDARIES

- National
- State or territorial
- County or equivalent
- Civil township or equivalent
- Incorporated city or equivalent
- Federally administered park, reservation, or monument (external)
- Federally administered park, reservation, or monument (internal)
- State forest, park, reservation, or monument and large county park
- Forest Service administrative area*
- Forest Service ranger district*
- National Forest System land status, Forest Service lands*
- National Forest System land status, non-Forest Service lands*
- Small park (county or city)

## BUILDINGS AND RELATED FEATURES

- Building
- School; house of worship
- Athletic field
- Built-up area
- Forest headquarters*
- Ranger district office*
- Guard station or work center*
- Racetrack or raceway
- Airport, paved landing strip, runway, taxiway, or apron
- Unpaved landing strip
- Well (other than water), windmill or wind generator
- Tanks
- Covered reservoir
- Gaging station
- Located or landmark object (feature as labeled)
- Boat ramp or boat access*
- Roadside park or rest area
- Picnic area
- Campground
- Winter recreation area*
- Cemetery — Cem

## COASTAL FEATURES

- Foreshore flat — Mud
- Coral or rock reef — Reef
- Rock, bare or awash; dangerous to navigation
- Group of rocks, bare or awash
- Exposed wreck
- Depth curve; sounding — 18 23
- Breakwater, pier, jetty, or wharf
- Seawall
- Oil or gas well; platform

## CONTOURS

***Topographic***

- Index — 6000
  - Approximate or indefinite
- Intermediate
  - Approximate or indefinite
- Supplementary
- Depression
- Cut
- Fill
- Continental divide

***Bathymetric***

- Index***
- Intermediate***
- Index primary***
- Primary***
- Supplementary***

## CONTROL DATA AND MONUMENTS

- Principal point** — 3-20
- U.S. mineral or location monument — USMM 438
- River mileage marker — Mile 69

***Boundary monument***

- Third-order or better elevation, with tablet — BM 9134 BM 277
- Third-order or better elevation, recoverable mark, no tablet — 5628
- With number and elevation — 67 4567

***Horizontal control***

- Third-order or better, permanent mark — Neace Neace
- With third-order or better elevation — BM 52 Pike BM393
- With checked spot elevation — 1012
- Coincident with found section corner — Cactus Cactus
- Unmonumented**

## CONTROL DATA AND MONUMENTS – *continued*

***Vertical control***

| | |
|---|---|
| Third-order or better elevation, with tablet | BM × 5280 |
| Third-order or better elevation, recoverable mark, no tablet | × 528 |
| Bench mark coincident with found section corner | BM 5280 |
| Spot elevation | × *7523* |

## GLACIERS AND PERMANENT SNOWFIELDS

- Contours and limits
- Formlines
- Glacial advance
- Glacial retreat

## LAND SURVEYS

***Public land survey system***

| | |
|---|---|
| Range or Township line | |
| Location approximate | |
| Location doubtful | |
| Protracted | |
| Protracted (AK 1:63,360-scale) | |
| Range or Township labels | R1E T2N R3W T4S |
| Section line | |
| Location approximate | |
| Location doubtful | |
| Protracted | |
| Protracted (AK 1:63,360-scale) | |
| Section numbers | 1 - 36 1 - 36 |
| Found section corner | |
| Found closing corner | |
| Witness corner | WC |
| Meander corner | MC |
| Weak corner* | |

***Other land surveys***

- Range or Township line
- Section line
- Land grant, mining claim, donation land claim, or tract
- Land grant, homestead, mineral, or other special survey monument
- Fence or field lines

## MARINE SHORELINES

- Shoreline
- Apparent (edge of vegetation)***
- Indefinite or unsurveyed

## MINES AND CAVES

| | |
|---|---|
| Quarry or open pit mine | |
| Gravel, sand, clay, or borrow pit | |
| Mine tunnel or cave entrance | |
| Mine shaft | |
| Prospect | X |
| Tailings | Tailings |
| Mine dump | |
| Former disposal site or mine | |

## PROJECTION AND GRIDS

| | |
|---|---|
| Neatline | 39°15′ 90°37′30″ |
| Graticule tick | 55′ |
| Graticule intersection | |
| Datum shift tick | |

***State plane coordinate systems***

| | |
|---|---|
| Primary zone tick | 640 000 FEET |
| Secondary zone tick | 247 500 METERS |
| Tertiary zone tick | 260 000 FEET |
| Quaternary zone tick | 98 500 METERS |
| Quintary zone tick | 320 000 FEET |

***Universal transverse metcator grid***

| | |
|---|---|
| UTM grid (full grid) | 273 |
| UTM grid ticks* | 269 |

## RAILROADS AND RELATED FEATURES

- Standard guage railroad, single track
- Standard guage railroad, multiple track
- Narrow guage railroad, single track
- Narrow guage railroad, multiple track
- Railroad siding
- Railroad in highway
- Railroad in road
- Railroad in light duty road*
- Railroad underpass; overpass
- Railroad bridge; drawbridge
- Railroad tunnel
- Railroad yard
- Railroad turntable; roundhouse

## RIVERS, LAKES, AND CANALS

- Perennial stream
- Perennial river
- Intermittent stream
- Intermittent river
- Disappearing stream
- Falls, small
- Falls, large
- Rapids, small
- Rapids, large
- Masonry dam
- Dam with lock
- Dam carrying road

## RIVERS, LAKES, AND CANALS – *continued*

| | |
|---|---|
| Perennial lake/pond | |
| Intermittent lake/pond | |
| Dry lake/pond | Dry Lake |
| Narrow wash | |
| Wide wash | Wash |
| Canal, flume, or aqueduct with lock | |
| Elevated aqueduct, flume, or conduit | |
| Aqueduct tunnel | |
| Water well, geyser, fumarole, or mud pot | |
| Spring or seep | |

## ROADS AND RELATED FEATURES

Please note: Roads on Provisional-edition maps are not classified as primary, secondary, or light duty. These roads are all classified as improved roads and are symbolized the same as light duty roads.

| | |
|---|---|
| Primary highway | |
| Secondary highway | |
| Light duty road | |
| Light duty road, paved* | |
| Light duty road, gravel* | |
| Light duty road, dirt* | |
| Light duty road, unspecified* | |
| Unimproved road | |
| Unimproved road* | |
| 4WD road | |
| 4WD road* | |
| Trail | |
| Highway or road with median strip | |
| Highway or road under construction | Under Const |
| Highway or road underpass; overpass | |
| Highway or road bridge; drawbridge | |
| Highway or road tunnel | |
| Road block, berm, or barrier* | |
| Gate on road* | |
| Trailhead* | TH |

## SUBMERGED AREAS AND BOGS

| | |
|---|---|
| Marsh or swamp | |
| Submerged marsh or swamp | |
| Wooded marsh or swamp | |
| Submerged wooded marsh or swamp | |
| Land subject to inundation | Max Pool 431 |

## SURFACE FEATURES

| | |
|---|---|
| Levee | Levee |
| Sand or mud | Sand |
| Disturbed surface | |
| Gravel beach or glacial moraine | Gravel |
| Tailings pond | Tailings Pond |

## TRANSMISSION LINES AND PIPELINES

| | |
|---|---|
| Power transmission line; pole; tower | |
| Telephone line | Telephone |
| Aboveground pipeline | |
| Underground pipeline | Pipeline |

## VEGETATION

| | |
|---|---|
| Woodland | |
| Shrubland | |
| Orchard | |
| Vineyard | |
| Mangrove | Mangrove |

* USGS-USDA Forest Service Single-Edition Quadrangle maps only.

In August 1993, the U.S. Geological Survey and the U.S. Department of Agriculture's Forest Service signed an Interagency Agreement to begin a single-edition joint mapping program. This agreement established the coordination for producing and maintaining single-edition primary series topographic maps for quadrangles containing National Forest System lands. The joint mapping program eliminates duplication of effort by the agencies and results in a more frequent revision cycle for quadrangles containing National Forests. Maps are revised on the basis of jointly developed standards and contain normal features mapped by the USGS, as well as additional features required for efficient management of National Forest System lands. Single-edition maps look slightly different but meet the content, accuracy, and quality criteria of other USGS products.

** Provisional-Edition maps only.

Provisional-edition maps were established to expedite completion of the remaining large-scale topographic quadrangles of the conterminous United States. They contain essentially the same level of information as the standard series maps. This series can be easily recognized by the title "Provisional Edition" in the lower right-hand corner.

*** Topographic Bathymetric maps only.

### Topographic Map Information

For more information about topographic maps produced by the USGS, please call: 1-888-ASK-USGS or visit us at http://ask.usgs.gov/

ISBN 0-607-96942-3

9 780607 969429

# Lesson 1 Map Reading & Interpretation, Part 3

## Use and Application

I have had the opportunity now to take you through some basic things about maps. We looked at the use and applications of maps a little bit, and we talked about some of the notations, marginal notations, and we went into understanding some about latitude and longitude and how all of that measurement system works.

Now that I've shown you all the symbols, and we've taken an exercise on that. We are going to go into other notations that are on there and help you understand the coordinate systems more particularly that are on there, and please don't let those scare you away.

I mean, if we wanted to scare you away, we could bring in all the math and the things that are involved with these various coordinate systems, but really we are going to keep it pretty simple. But enough information that you will understand how to use any of those things, in your determining where you are at, and how you are going to get to where you want to be. I want to emphasize something, once again, and that is you know, I think I mentioned this in the introduction into the course, GPS is a fabulous tool, it has limitations as far as it's precision. It's certainly not something that you can use to make a decision on, as to whether something on this side of a line, or that side of a line, and you need to be very careful with that.

Most handheld GPS units have a plus or minus of about 30 meters, that's a 100 feet, so you know, that's not real precise if you are trying to for instance. I'm aware of a situation where a person went out and there was a well that had been drilled really close to a property line, and they were trying to determine, whether it was on federal land or private land. They used a GPS unit and they actually found corners on either end of the line and used that to make the decision, and it turned out that they were wrong.

They actually had to, it didn't make anybody remove the well, but they had harassed somebody quite a bit before it was actually done by a surveyor and found out no you were wrong. Say you've got a corner down here, get a GPS position on it, that could be up to 100 feet off, so what if it's a hundred feet that way and then you go up to the other corner at the other end of the line and you shoot it, and it's off a hundred feet that way, and so you, that's very possible, you know, you are going to compute that line like this, when in fact, it's running this way.

You have to understand the nature of error, of what we call positional tolerance, or a circle of error. And so, that's why I'm giving you this because a lot of folks in resource management and law enforcement and lands, realty specialists and that sort of thing when they go out on the ground and they take a GPS unit, you just need to realize what your limitations are. Now there are ways to get that more precise, but never really precise enough to make those kinds of decisions unless the object you are looking at is way far away from the property, way in excess of that 100 foot circle of error. So you want to be very cautious with that and understand the nature of that.

Given that information, it's not our purpose to teach you how to use your GPS unit, but you can take classes or read books or even from some manufacturers, learn different techniques to get GPS data. Again that is what we call the resource grade GPS units, the hand held units. You can get information to get them down a little closer, a little tighter precision. That takes extra time, extra effort, and sometimes extra software. Let's recognize that the skills that we are talking about here in this course about map reading, even if the GPS was very precise, it still only gives you where you are at the moment.

If I'm standing here on a road, but I see maybe a mile or so away, let's use a law enforcement example. I see what looks like it could be a meth lab or some illegal activity going on over there, on federal land. I want to determine that position more or less and not just for a report, but to come back to it, or send someone else into it. To analyze the situation, you are going to need a good old compass.

We will talk about that in the course here a little bit, because when you go to the field, not that you go to the field for this course, because you would have to go to Carson City, Nevada. When you go to the field, you still need to have a compass and understand how a compass works, and the fact that a compass points to magnetic north, not to astronomic north. I will come back to that here in a second, but a compass is a very important tool and I can't stress that more. Now, if you have a digital compass or something, some GPS units have a digital compass or something that's built in, that's great.

But you need some way to be able to determine the direction from you, where you are at with your GPS unit, and you know this position, at least plus or minus 100 feet. You know where that is, but you see some activity way off in the distance. You need to be able to get a direction or what we call a bearing, or an azimuth. A direction in degrees, minutes, seconds, from you to that. So that's why a compass is very important and it will be mentioned in the course.

Now, one more thing, before we go on, remember when we looked at the bottom of our USGS map, we had really three north arrows, and I'm going to grab my map here and put it on the Elmo just to remind you of that. Astronomic north is what the latitude and longitude system is based on, and that is what this north arrow is with the star. Remember I told you about Polaris and all that, and the state plane coordinate systems, which are unique to each state, they have a grid, and that is what GN stands for here. GN is grid north. Notice that it's almost 2 degrees, it's a degree and 47 minutes from there. But the one that I want to point out, which is where we make mistakes with our compasses, and we will discuss this a little bit as we show it to you, but it is magnetic north.

Remember that your compass, whatever it is, is pointing to a magnetic pole, and that magnetic pole is thousands of miles from the North Pole as we define it with latitude and longitude. And here at the time of the making of this map anyway as it shows the north arrow, it was 15 ¼ degrees. I think it says, or a 1/2, I can't read it but over 15 degrees that way, so you understand if you are standing here and you turn your compass because you want to walk north, your compass is going to point that way, and that is not going to be related to latitude or longitude at all. You are going to have to come back, 15 and some odd degrees here to get to that. That is called the magnetic declination.

## Magnetic Declination

That's what this is discussed here, this is all the information here as of 1994 at the center of this quad. And you might wonder, why did they say that, what does that mean. That's because the magnetic pole changes. It changes every day by a small amount, an amount you and I would not notice with our compass, although we would notice with more precise instruments. But more importantly, it's over time, over many years it changes, and it has moved hundreds of miles, thousands, over a thousand miles, in just the last couple hundred years.

Now that will help you understand why we don't use magnetic bearings for property lines and descriptions, because you know, what was north two hundred years ago is several degrees different now. And so, you will find back on the east coast, especially in the colonial states, you will find where a lot of their old property lines and things are described by magnetic and that is a problem. Surveyors when they redo that or realty specialist when they are dealing with these properties they have to make some kind of adjustment and a lot of it is guessing.

They have to make some kind of adjustment to allow for what has happened since that time. If they are going to go to the field with a compass, because it could be two, three, four, or five degrees different. Ultimately the projections are that they have these what is called isoconic charts that the government has made them up the USGS and other agencies, the Navy. They determine where the North pole, the magnetic north pole will be and its going to move another thousand miles or so in the next few decades. Recognize that that is a moving target literally. We don't base any of our mapping on magnetic north.

So you need to if you bought a compass or you already own one, before you go to the field to do actual work not just this course. We will talk about that declination and adjusting for that. You need to look at your compass manufacturer's instructions are because usually they will have something in there that will tell you how to adjust for declination. Even though the needle will point to magnetic north, you will be reading true north, or whatever the direction you are looking. Because you can adjust a compass to do that.

So I am recommending that you think about and that is why there are three north arrows on USGS maps. Now you know with other planimetric maps like a highway map, you know they keep it real simple. You know there is just one north arrow and it is generic enough for the whole state, highways, maps whatever you are looking at and it is for you to reference.

Of course with USGS quads, north is always up on the map and with most maps north is always up. There are some rare exceptions and that is why north arrows get you generally oriented in the right direction. What I am talking about here is the fact that there is quite a significant difference between magnetic north and true north (or what we called astronomic north). It changes over time and it has changed over time and will continue to daily. Therefore, it is something you want to be very cautious about and be very aware of.

So I am giving you that heads up because as we start to discuss some of these things, we are going to talk to you about how to determine a position of something that is away from you on a bearing from you. You want to make sure that is on astronomic because that is what our mapping is all about. That is what our measurement system is all about. That is what GPS is based on. It's extremely close to the same as astronomic north. So we want to make sure that we are using the tools the right way. I am sorry it is so complicated but that's how it is.

We could not base our north on magnetic because it changes every day, so we had to come up with something else and we did that based on the rotational poles of the earth. And that was how lat and long were designed and how we determine where the equator is and all that stuff. Be sure that you check that out as we go into these discussions about how to figure that out. Also one of the other lessons we are about to go through, is I am here and I want to get to there and how do I get there. I want to get to there on the map, what is the bearing. So I need to determine on the map what the bearing is, so that I will start walking in the correct direction. Maybe it is something you can't see.

One of the other things that the USGS topo maps will do for you, is you can actually tell what can I see from here. If there is a mountain or a ridge or something in between you and the other object, you could tell that from the map before you even go on the ground.

You can look at that information and determine I am standing in this valley and I want to get to a point in the other valley, I don't know which direction to start walking. I will use the map to determine what the bearing direction is from me to that object , then I will use my compass to point me in the right direction. I will start walking that way and that is how you get where you wanted to be.

There is a lot of great applications here and as you go through these next lessons, we have more exercises that will lead you through and reemphasize what you have learned. Then as we gets towards the end of the course, you are going to have several scenarios presented to you where we tell you drive from here to there, you need to tell us what should be the best way to get from where you parked to such and such place. You see a fire , or we have another scenario, where a cell user has called in and given you there position and they are with an injured person and you have got to figure out what is the best road is to get in there and all that. All using this map.

So those are just some heads up for where we are going here, some real down to earth applications of this stuff. You know one of the beauties by the way of distance education on something like this that is prerecorded, is that if you don't get it, you can play it again. And you can play it again after that and run through it and make sure that you understand what we are saying and that is a little different than a lecture at college. You know you are sitting there and heard the professor say it once, and that was it. You got to make the best of it.

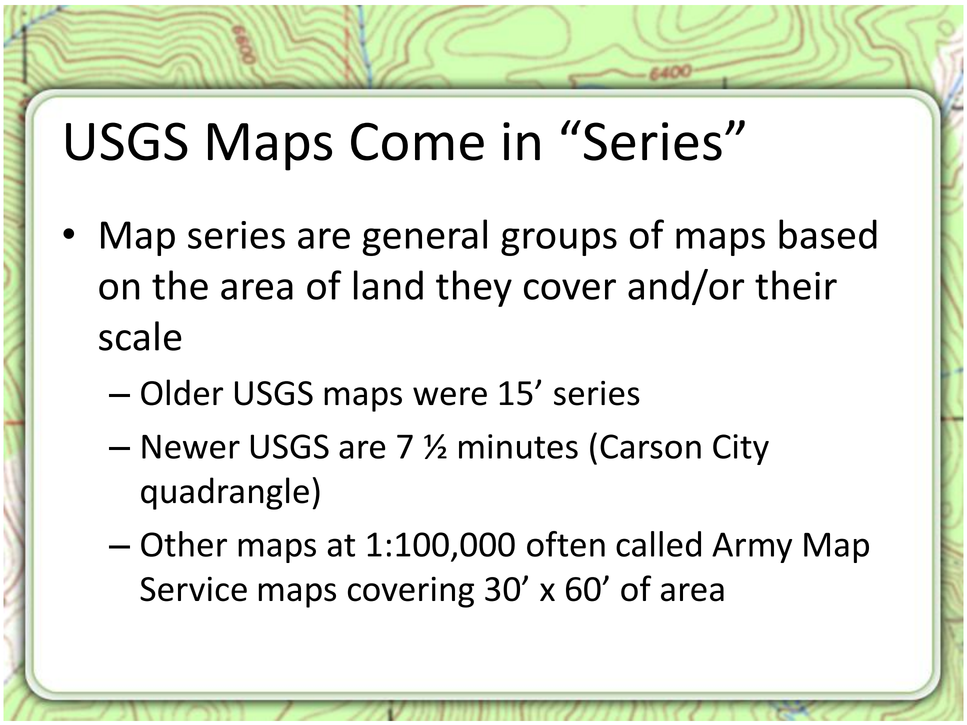
So you have that advantage here, and we have given you the tools and the resources to put all of this to work other than a compass which you need to buy yourself when you go the field, or before you go to the field.

We are just trying to line you up with a great tool which is the whole science of map reading that will allow you to make some really specific applications of all the stuff we have already talked about. With the symbology, the shading and all that stuff . So now how can I use that in everyday work? And that is where we are headed now. So enjoy it and I will see you at the end of the course.

## Lesson 1 Map Reading & Interpretation, Part 4

### Map Series

Now there is one more small item that we want to discuss now that we looked at different types of maps and discussed the difference between a planimetric map and a topographic map. And that is what I just want to mention and we call that map series. Map series is really talking about a general group of how the maps are made.




And as you can see on the slide here, maps are based on generally the area of land that they cover and/or the scale that they are at. You know the map that we are going to look at in this course is as you have already seen is the Carson City quadrangle map. That is a 7 ½ minute map. I showed you a little bit of what that is and I will repeat that here just in a second.

But understand that there are some parts of the country that are still only covered by 15 minute series maps. They have not gone down to the detail so if you think about it, a 15 minute map covers four times the area by both length and width as a 7 ½ minute quadrangle will. We will be looking at 7 ½ minute but recognize sometimes you may get and it will tell you in the lower right corner of the map what series it is. If you are in doubt, just look at what the latitude and longitude is on any corner. Go to the other corner in either North for latitude or East/West for longitude and see if it adds up to 7 ½ minutes or 15 minutes, and then you will know what map series you are dealing with.

Recognize that with a 15-minute map, some of the issues that we have already talked about, about scale won't work. You will have to figure out other things. How to make it work. And scale validation is one of the skills we are about to talk about. There are some other maps that are available. The old Army Maps Service use to produce maps at 1:100,000. Again this is a ratio type scale, so 1 inch on the map equals 100,000 inches on the ground or 1 foot equals 100,000 feet, whatever you want. These are maps that cover 30 minutes by 60 minutes or degree of area on the surface of the earth. You will occasionally find those. I know we here at BLM still use that scale, maybe not covering that same area, because we have modified the map borders to fit just the lands that BLM administers. Other agencies have done similar.

But the point is, there are different series of maps, whole groups of maps that are grouped together based primarily on their scale or the area that they cover. And so that is just a discussion of map series, so that you understand it.

Now let's take a look real quick at the slide and remember that when we are talking about minutes and seconds, we already discussed all of that. And we will review that some more later but, the quadrangle map that you might be looking at covers just this what we called postage stamp size area here. And that is whatever area we have selected. But as you can see on this slide on the left is a 15 minute series map which covers 15 minutes of latitude by 15 minutes of longitude. On the right we have the 7 ½ minute which is a much better scale for us to work at, but as you can see a 7 ½ minute map is 1/4th of a 15 minute map.

So again we will be studying the 7 ½ minute quadrangles here because that is the majority of the country is covered by that. But recognize that there are all sorts of other map series. Recreation maps like the Forest Service sells, Parks Service sells or gives when enter at the entryway of the park that will be at all different sorts of scales so don't get that confused. And again we will discuss scale verification in a little bit, but map series just so that you understand that they come in these different series. To help you make sure you are looking at the right thing or we will show you how to validate what you are looking at so you can figure out how to make it work. So that is our discussion on map series, now we will move on to another subject.

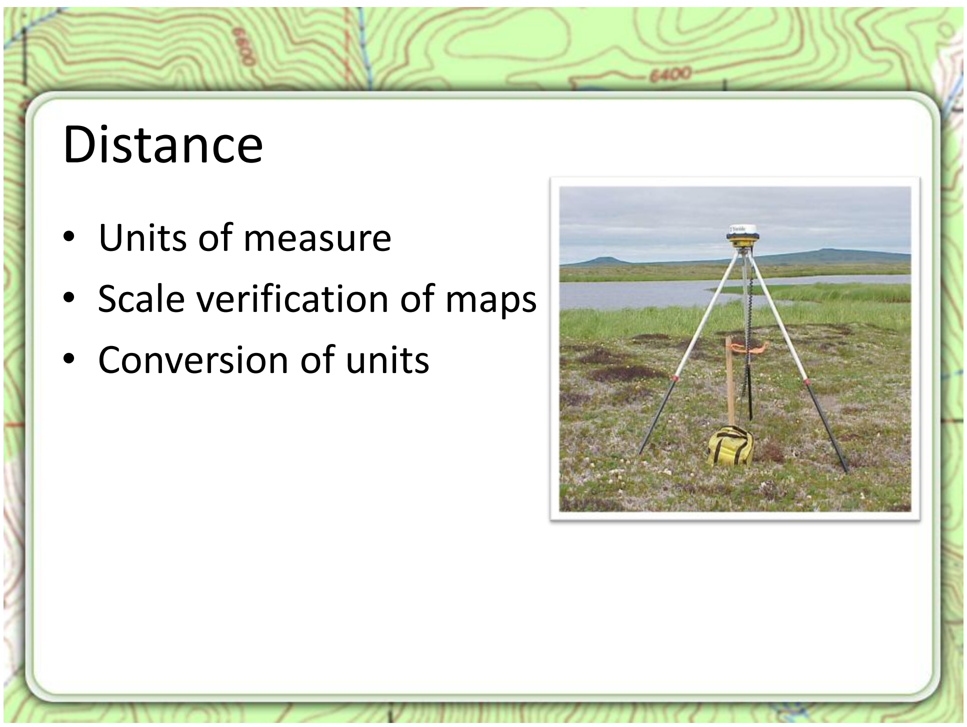
## Lesson 1 Map Reading & Interpretation, Part 5

### Map Reading Process

Well welcome back. We're now going to start talking about some of the actual applications of the map reading process, how we can determine direction and distance. You know when it comes to any kind of mapping or orienteering, doing things out in the field, out in the woods, hiking, or whatever, even in some engineering applications. There is really two components and they are distance, how we measure distance on the ground and how we therefore convert it to distance on a map. Secondly, direction, how we measure direction in the field and how we measure direction on a map and convert back and forth between those units. So that's the direction if you pardon the pun that we're headed here.

### Distance

In our discussion we will talk about distance first. Now, we have three subtopics here if you will under distance.




We are going to talk about the units of measure. We're going to talk about how to verify the scale of your map. Just because the map says it's this scale doesn't mean that it has been modified by someone and we'll talk about how that happens. It's one of the first things you want to do with a map. Then we'll talk about the conversion of units.

The picture there at the bottom of your screen is a modern survey grade GPS unit. Just an antenna sitting on top of a tripod and little boxes with power and a controlling device and a bag underneath it. it looks like it is way out in Alaska somewhere. I want to talk about GPS for a moment because as I mentioned earlier in the course sometimes we think we have got it, we don't need map reading skills because we have GPS. Well you know, GPS at its best tells you where you are, plus or minus a certain amount. But it really has a hard time telling you how to get from here to somewhere else. Or you see something at another location, where is that at? GPS really doesn't do much for you and so what we are talking about in this part of the course is the distance and direction. Distance first obviously, but the distance information that we can gather to determine certain things.

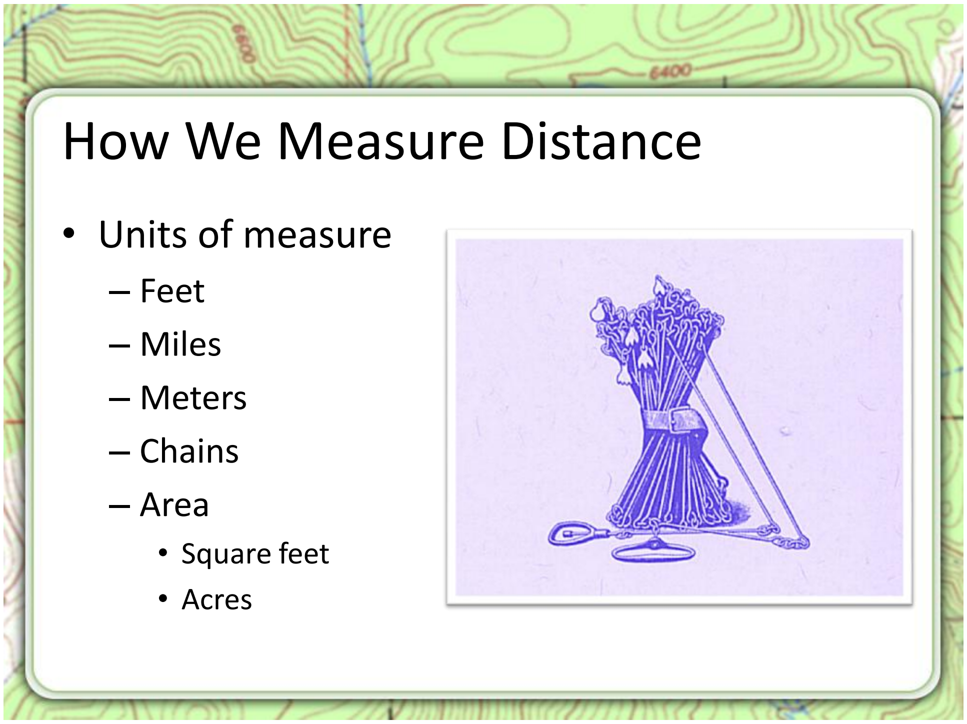
I want to give you a scenario. We alluded to some of these already in the course because we use these kinds of real world scenarios several times in this course. But you are perhaps hiking or driving or something in the field and you notice some distance away something going on.

I will use the example of what looks like it could be a Meth lab. Somebody has pulled an old beat-up RV or trailer out there, there are some strange looking and strange smelling smoke coming out of it. There is a lot of activity there that wasn't there 4 or 5 days ago. You see some 55-gallon drums outside maybe. You see people coming and going. Maybe someone camping nearby has complained about it. But you become aware of this. The last thing you are going to do is take in the danger, security situation of walking up to the Meth lab and saying "Hey, I'm with the Federal Government. Don't mind me. I just want to get a GPS position here." You do not want to do that. You may be a mile or two away sitting on a little road and you can see it way down in there in the valley or the canyon and you want to figure out where it is so that you can report it. Send someone that has never been there to it, like a law enforcement person or perhaps you want to figure out how to get down there.

Maybe you see some smoke down there, a fire, there is a different scenario. You want to get down there and stop the fire with a few shovels full of dirt instead of letting it spread. But you want to figure out where is that on the map because I can't get from here to there. Even if you know where it is you can see it, the best thing you can do is get a compass bearing to it. We'll talk about how to do that later in the course. But you know you could get a compass bearing but in many cases the straight line from me to their which is all the compass can tell you. The straight line from me to there goes over 500-foot cliff. It crosses over a river where I can't cross it. It has other obstacles along the way so I'm going to have to go way out and around.

Even when you know where you are and even if you learn how to get coordinates and we will show you in this course, on something where you are not there. You are looking at it over there. How to get position on it over there. You still have to figure out how to get there or the best way to get there or the safest way to get there or in some cases, the only way to get there. We still have to integrate a GPS unit with a compass, some way to measure distances which we're going to talk about. And to figure out how to get there. A traverse if you will, of different roads, trails, ridges, whatever it takes to get to that location. I'm again mentioning this about GPS so that we understand that GPS is a fabulous tool we surveyors use it all of the time and all of you do. Many people driving around, I saw one at Target the other day for $101 bucks and it looked like a pretty nice unit for a hiker or someone like that. It's cheap, the average person can have a GPS unit. But what does it actually provide you? The point is that map reading skills are still critical. The GPS unit provides you with just one piece of information. Where am I at this moment? That's about it. You need to be able to apply all of this other information that we're going to give you in this course, to the map, to the ground, to figure out the best way to solve things.

As you can see on this slide, there are several units of measure that we use to determine distance of something.




These are the ones you are most familiar with; feet or miles, the metric system, meters, or kilometers perhaps, and one that you may not be as familiar with. It's the one that was used for most land surveying or boundary work, at least the initial surveys of the Public Land System and that was chains. As you can see on the right that's a picture of an old Gunter's chain. Just a series of 66 hundredths of a foot length, pieces of steel linked together like a chain and it's called a chain. 1 chain is equal to 66 feet. You can also see there at the bottom. Area, which we do in acres for rural areas and square feet for more urbanized areas.

But this is how we measure distance and area. Historically, the world has used all sorts of things to measure distance, right. The distance that we now call a foot is basically the length of a man's foot and that's what they kind of did to measure things. It wasn't real accurate. Obviously changed from person to person. But it was a pseudo of a standard that they came up with for a way to measure things. The span, you can read about that in historic books and the Bible, the distance from the elbow to the tip of your finger, that's a span. These things were used and then as time went on we got to rods which are 16 and a half feet long. Perches, same thing. Different units of measure. Now, mankind has used all of those.

The slide that we looked at is giving us the ones that we basically use today; feet, miles, and their relationship to each other which you probably know. And meters. And we'll talk about their relationship with feet. And then chains which is a boundary surveying type thing. With any kind of distance measurement, when we measure something on the ground like from me to the corner of the room is 40 feet, well if I have a map that is on the same scale as the world, then I will measure the same distance on the map.

The whole idea of a map is it is reduced down in scale so it is an easy document to carry with you and to reference to figure out where things are and how they relate to one another. So distances are changed by ratios generally. So what we are saying is so many feet or inches or whatever on the ground are equal to this many on the map. And we change that ratio so we can get more information onto the map. Does that make sense?

Let's make it real simple. If you hire an architect to draw up the plans for a house that you want to build, it comes on a usually 24 by 36 inch set of plans and it's reduced in scale. It's not actual size. I suppose if it was actual size, it's hard to get paper that big and if it's a big house. But you could have this and roll it out and the contractor would have it right there already measured for him. But that's not how it works. It's not practical to do that sort of thing. We reduce it in scale. So the architect is thinking, I want the house, I want this one wall in the house to be 50 feet long. But I don't have a piece of paper 50 feet long so I am going to reduce that scale so that it's just this much on the paper. So that's half the situation with distance and then you see the contractor looks at the drawing and says Ok, it's this long on the drawing that the architect provided with me but that's really 50 feet on the ground.

So he takes that computation and he goes back with it to put the real world and that is exactly what you and I do with all sorts of applications of map reading. We are constantly going back and forth between these scales of the real worlds and what's on paper and back again to make something happen, to make a decision, to take action on something, to report something, or just to measure something so you know what is going on the ground out there and how it relates to something that you want to build or design or you're going to deal with in the field.

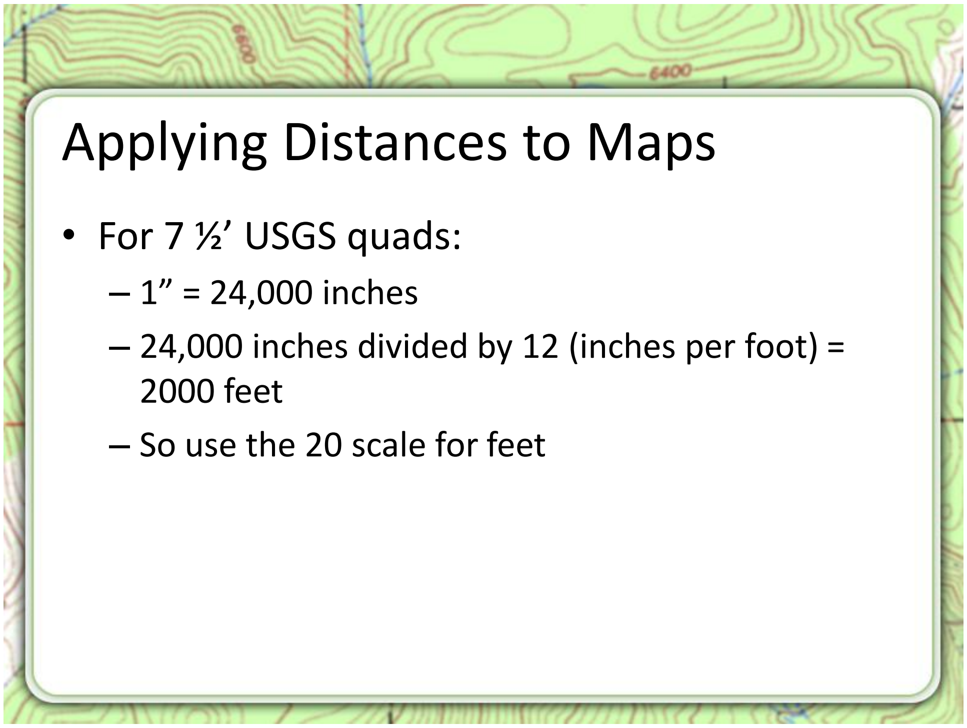
So applying distances in the real world we use all sorts of devices and many of you have pocket tapes that measure in feet and inches. Surveyors have them that measure in feet and tenths of a foot because in engineering that's how we use that. But you're used to football fields that are measured in yards.

Another unit of measure and you understand the relationship from yards to feet. All of these things are distances on the ground, but if we want to relate them to the map we have to change their distance so we may have some kind of tape we measure with or as surveyors use now, lasers that light beams on their devices or even GPS which gets a coordinate here and one there and can compute the difference between the two. There is all of these ways to get these distances.

Regardless of how you get a distance on the ground, which we'll talk about here in a little bit, you have to relate it to the map and that's what I want to talk about.

## Applying Distances to Maps

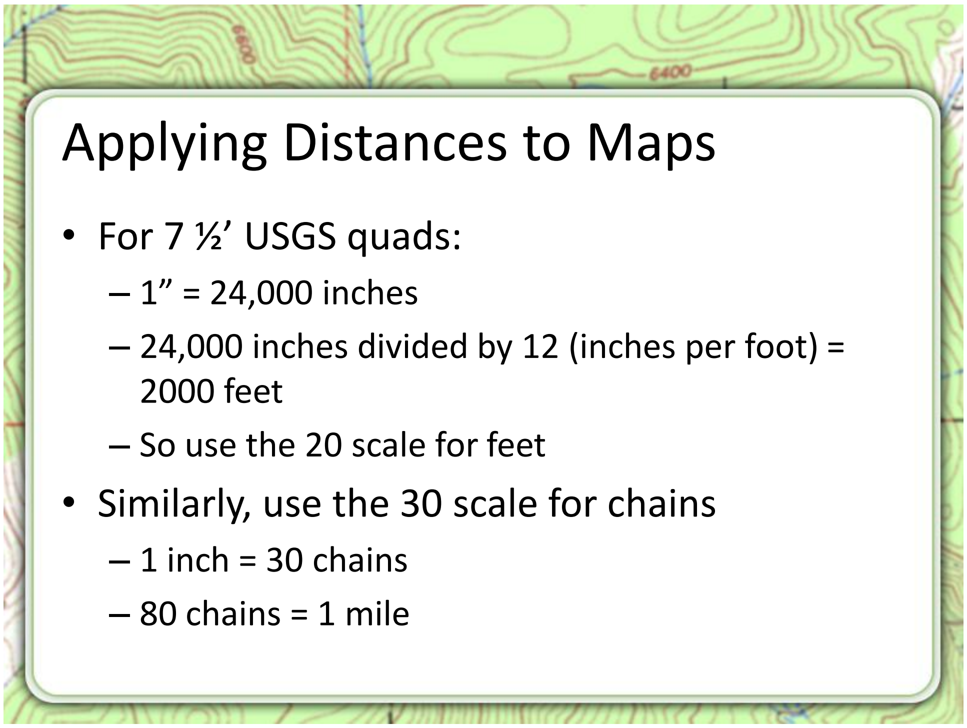
We can set up our scale as a ratio. In other words, one unit, whatever unit you want it to be, one unit on the map equals so many units of that in the real world. Now you see two different scale ratios here. 1 to 24,000 that's how we say that. It's 1 (colon) to 24,000 or 1 to 100,000. What the means is 1 inch on a map, equals 24 thousand inches in the real world. So that's a lot.




If you think about it, 24,000 inches divided by 12 because there is 12 inches in a foot, that's actually 2,000 feet. So 1 to 24,000 is actually 1 inch on the map equals 2,000 feet on the ground or 24,000 inches on the ground. That's what scale ratio is talking about. It's how we standardize and note it on the map or on the architecture or whatever, so that everyone can relate real world to paper back to real world. That's the idea. 1 to 100,000 therefore is exactly saying 1 unit on the map, it could be a foot. So your map is 3 feet wide, well one of those feet equals 100,000 feet in the real world. That's a long ways. You could divide that by 5,280 that is how many feet are in a mile, to figure out a ratio of one foot here equals how many miles. You can do this with any of these units but the important thing is that we recognize that the scale is given to us on the map and on the USGS maps that is provided for us.

We now understand what the mathematical ratio is of the real world to the map and so now we can start using the data back and forth in a standardized manner. You can mix those units which I just did for you a moment ago. Take a look at this. You can mix the units, I converted the 1 to 24,000 inches, I divided the 24,000 by 12 because there is 12 inches in a foot so I now know that 1 inch equals 2,000 feet on that 1 to 24,000 map. So you see we can have a ratio which is the same units on both sides or we can have something equal something and it could be different units on either side of that. And in this case 1 inch equals 2,000 feet or something many of you have seen these are a lot of recreational maps that government agencies put out 2 inches equal 1 mile. Different units on either side but now you understand what their relationship is. That is what scale is all about when we're talking about map scale, that's what we are talking about.

Now let's take a look at this slide for a seven and a half minute USGS quad, 1 inch equals 24,000 inches.




We just saw that. 24,000 inches divided by 12 I said that, 2,000 feet. This is why we use the '20 scale. Remember in some of the opening portions of this course we talked about the scale that was a device that you had to go buy and you had to use or if it wasn't provided with you in the course materials. That is why we can use the '20 scale because if 1 inch equals 2,000 feet well '20 scale means that 1 inch on that scale has been divided up into 20 units. So we can look at that and actually relate directly. In other words, you don't have to do the math when you look at the map. You're able to simply look at the scale and determine directly by reading on the scale as you place it on the map what that distance is.

Similarly, I'll discuss this here in a minute, if you use the '30 scale, you can use that for chains. That's if you are trying to figure out how far something is in the Public Land Survey System. 1 inch equals 30 chains is the scale that happens to work in a 7 and a half minute USGS quad. Understand that 80 chains equals 1 mile. Remember I showed you that picture of the chain. 80 of those is a mile. So 1 inch equals 30 chains is the scale you can use to read a USGS quad in the Public Land Systems units.

Now with the information that we just discussed, let's take a look at our Carson City 7 and a half minute quad and see how that plays and how that all makes sense. If you look on the quad, you may recall earlier we talked about all of the marginal notations, lots of information on the margins.

Notice on the bottom and center on the map itself in very bold letters because it's very critical, it's one of the most basic pieces of information of all; is the scale, 1 to 24,000. As we just did those computations, you will recall the 1 to 24,000 that is 1 inch equals 24,000 inches. When we divided the 24,000 by 12 because there are 12 inches in a foot, we came up with 1 inch equals 2,000 feet. You remember that we talked about using the scale, the '20 scale, 20 being a multiplier of 2,000. That gives us an opportunity to read directly from the map and to read our distances. And to show you an example of that I am just going to slide the map a little bit over and you notice that at the bottom of the map we also have what we call graphic scales, or bar scales. This top one is always in meters, kilometers actually. The next one is a mile. You can see that it is showing 0, 1 so that's a mile. Then the one below that is in feet and as you can see I'm showing you just the part from about 5,000 over to 10,000 feet but it goes all the way across the map. I am zoomed in so we can see this now you remember the scale that we talked about and how we want to use a '20 scale.

Now '20 scale means that an inch, this is an inch here, notice that 2 is here, 1 is at a half inch because the '20 scale, we are going to have 20 units here in that inch. So if 1 to 24,000 is the same as 1 inch equals 2,000 feet, then you see when I look at this, an inch is exactly 2,000 feet. So a half inch is 1,000 feet and an inch and three quarters is 1,500 feet. So I can count these ticks in other words and read directly to the nearest 200 feet and even interpolate between these to get even closer to that.

So let's just see and prove that on this map. Let me just put the 0 at the 0 that is here. On the left, lower left. We'll put the 0 there and I am going to compare it over to 1 mile. We have a little bit of out of scale which we'll talk about here later but notice that at the 1 mile mark I have got 5,000 and then I come over 100, 200, 300, about 5,300 feet on this. Isn't that what about a mile is? 5,280 feet.

So what I have proven is that this map is pretty close to the scale that it is supposed to be when maps are reproduced they can shrink or expand just a little bit but again we'll talk about that later. But what I have shown here is that I've got 1 mile or 5, 280 feet by using the '20 scale. Similarly, staying with the '20 scale but going down to the lower graph or graphic I should say and I put 0 right here. Notice the map says that's 5,000 that's 6,000 that's 7,000. I can look here and say I put 0 there and 1,000 is there and 2,000 is there and 3,000 is there so what I am doing is showing you how the '20 scale reads perfectly on a quadrangle map, on a seven and a half minute quadrangle map.

Let me summarize that there for a second and then we'll actually use it on the map itself. I have a scale ratio from the real world to the map. We converted it to make it because 1 to 24,000 is inches and inches. We converted it to 1 inch equals 2,000 feet and because 2,000 is a multiplier of 20 I used the '20 scale. Similar reasoning for the '30 scale when we use chains but let us just stick with feet for the moment.

So now when I actually look on the map, let's take a look at that. I want to know Ok, this little X is indicating there is some mining operation; there may be a little digging there or something like that. We have a dry lake over here. From this edge of the dry lake to that little mining operation there, how far away am I? I never have been personally, never been here. I don't know what this is but I know that I can take the scale and I can lay it on there and figure out that from that edge of the lake over to this little mining operation, I'm going to read, that's 2,000 feet, that's 2,100, that's 2,200 so notice that the mine is probably 2,150 feet from that edge of the dry lake.

Similarly we have a little structure here, I don't know what it is a cabin or something. How far is it from the same mining? A little digging there. It is 1,000 2,000, I would guess right around 2,400 feet.

So I am using the scale ratio that we have proven that this map is that and that we have instructed you the 1 to 20 scale or the '20 scale I should say. That allows me to get the exact, not the exact, but it allows me to get pretty close to the distance of what two things are. This is our basic fundamental process. If I measure something on the ground, I can convert it to the map or I can read something on the map like we just did here and convert it to the ground. I know that I'm 2,400 feet away. Now I have mentioned this a couple of times, the '30 scale for chains. Let's use that and go back to the ELMO looking at the map. Here we are, I'm going to see these triangular scales as I've mentioned. You may have a different type but this one also has a '30 scale on it. What the means is, what it has done is taken 1 inch and divided it into 30 units. This is 30, that's 20, that's 40 but 1 inch is here. So it's divided into 30 units and we've just told you, I mean you could compute it but the '30 scale works for chains. A section, a square mile in the Public Land System is approximately a square mile anyway.

So I want to do is just prove how that works here. So what I am going to do is measure this section line. I have a section corner, approximate section corner here and I have an approximate corner over here and I am going to just lay the scale on their using the '30 scale now. As best as I can see it, oops a little bit off there.

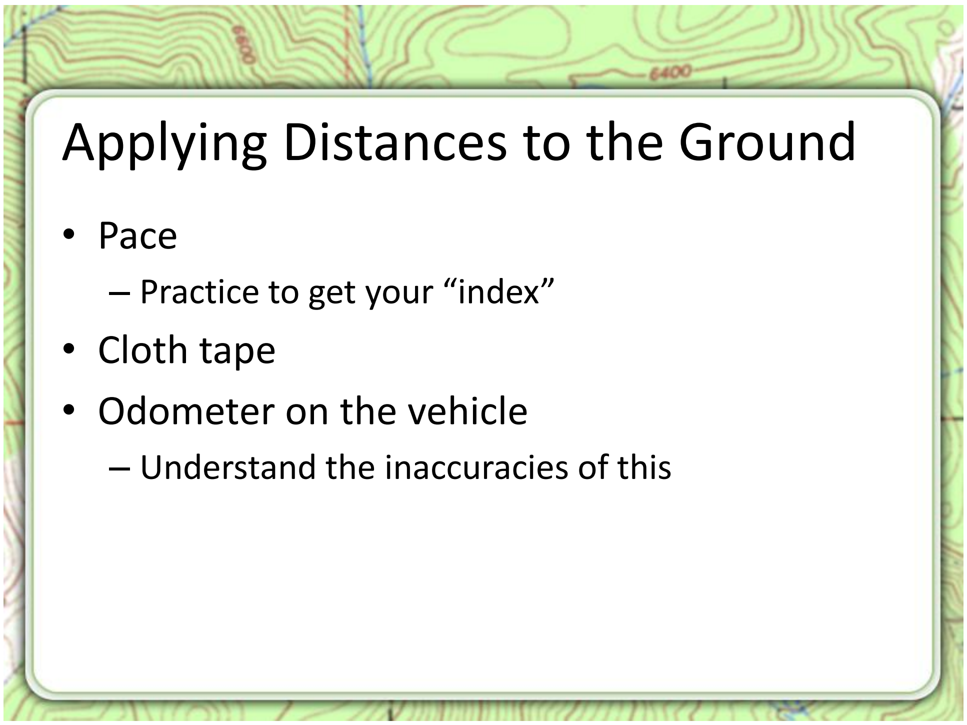
I'm over here and I'm right close to 80 chains. Remember this is chains we're reading here. So I'm very, very close to 80 chains which of course is a mile and so you see how that works. If you are dealing in chains, if you are processed with your application, let us say you are doing something with a land exchange. Chains and acres have a real simple mathematical relationship so that is one of the reasons why you can still work in chains and convert them to acres very, very simply.

Let us say you have decided that we are going to land exchange, we are looking at a land exchange and we are talking about going 10 chains or 660 feet. 10 chains from the section corner, we're going back to the map. I have got 0 there and so I can go 10 chains which would be right here, 10 chains, that would be 660 feet.

Let me show you, I'm going to mark that with this pointer here. I am going to go back to this '20 scale, 10 chains is 660 feet right? I am going to get that 0 on that section corner as best as I can and take a look. I've got 5, 600 plus a little bit so it's very close. So what you see here is that we are using both of the different scales and units to be able to read something on the map. To take something from a real world application and put it on the map and come back. Hopefully that makes sense and you need to practice with that a little bit and I encourage you to take the 20 scale and the 30 scale if you want to do that. Measure a few things on this map and of course we have exercises along the way that are going to ask you some of those distances and test your ability to do that. This is very fundamental but it's very, very important. Not only knowing how to measure with the scale but understanding why the scale works, why the math works, why that ratio of 1 to 24,000 comes out to a 20 scale and for chains it comes out to a 30 scale.  So hopefully that provides some information.

## Applying Distances to the Ground

So with that information now the next thing we need to look at is how to apply distance to the ground, either to get the distance on the ground or put into the maps so we know something or vice versa.  Say using that example we looked at a few minutes ago that I wanted to go from that little cabin or structure or whatever that was and I needed to go 300 feet.




I want to mark that on the map but I want to go 300 feet on the ground and there are different ways to do that and let's talk about that for a moment so we know how it's done in the real world.  First of all, if we are going to apply distances on the ground, in reality you can pace.  Let's talk about that for a minute.  Pacing is just walking at your normal stride normally to get a distance.  Most people do not walk at some even amount so what you want to do is determine what your index is.  Bottom line, you can get a tape out and borrow it from somebody if they have one, even a 25-foot tape.  Or a 100-foot tape if you have a longer one.

But you can determine what your index is.  Take your normal steps on the ground, on the level ground and see how many it takes for you to go a certain distance.  If you can actually pace 3 feet, a yard, 3 feet, if you take 33 steps, you will be at 99 feet and of course that is not very precise but it might be close enough for what you are doing.

Let's say that cabin or structure that we saw, you have identified a hazmat site that is near there and you want to know how far it is from that cabin and you don't have anything to measure with.  Well then pace.  Pace out there and your paces may be at 2 and a half feet, which is a little closer to what most people's pace is.  You should learn that, at least on flat ground.  It can change as you go up a hill or down a hill and that sort of thing.  Or around objects, I understand that but this is an approximate way to get a distance.  You might pace out there and say you pace 100 feet, or 100 paces I'm sorry, and so if you're 2 and a half feet pace well then that's 250 feet.

So now you know the hazardous material that I found, a leaking 55 gallon drum is sitting on Federal land, somebody has dumped it and I have identified that it is 250 feet from that structure, that cabin.  So you now have an approximate distance on the ground and you can now go to the map and use the '20 scale, go 250 feet and plot it on the map.  So that's part of what we are talking about here with applying distance to the ground and understanding how to come up with distance.

There are other ways, obviously if you have ever seen a cloth tape which used to be longer tapes, used to be made of steel or metal but there is a lot of things that are fiberglass or cloth and surveyors have these and a lot of other folks, engineers and foresters and other people have these cloth tapes.  Sometimes called rag tapes.  100 feet long, that's great because then you can measure this with a great deal of precision.  And then you'll just be off just a couple of tenths usually unless you are going up a steep hill.

But recognize that this is another way for you to apply this distance on the ground.  So pacing wasn't that good, cloth tape is a whole lot better.  Frankly, if something is 500 feet away and all you have is a 10-foot tape that is going to take forever.  I would probably pace it out and pace back one more time and mean the two, average those two just to come up with a distance close enough for plotting on the map.  You would be able to tell a crew that's going out there to clean this up or investigate it and say look, if you find that cabin, you want to go and we'll talk direction here in a little bit, but you want to go east 500 feet and you'll find it there.  It's just over a little rise then they will be able to find it because you were able to apply a distance on the ground and you can plot it on the map or vice versa.

But here is the most important thing, you related the location of the hazmat site to something that is on the map.  Everyone that has a copy of that 7 and a half minute map has a little square at that point.  So they all have that.  So you see what you have done is supplemented what the map has. You have given them additional information that relates to something on the map.  So that they are able to very quickly get to the place and identify what it is that you have found.  So your pacing is fine, a cloth tape is a lot more accurate and can certainly be done.

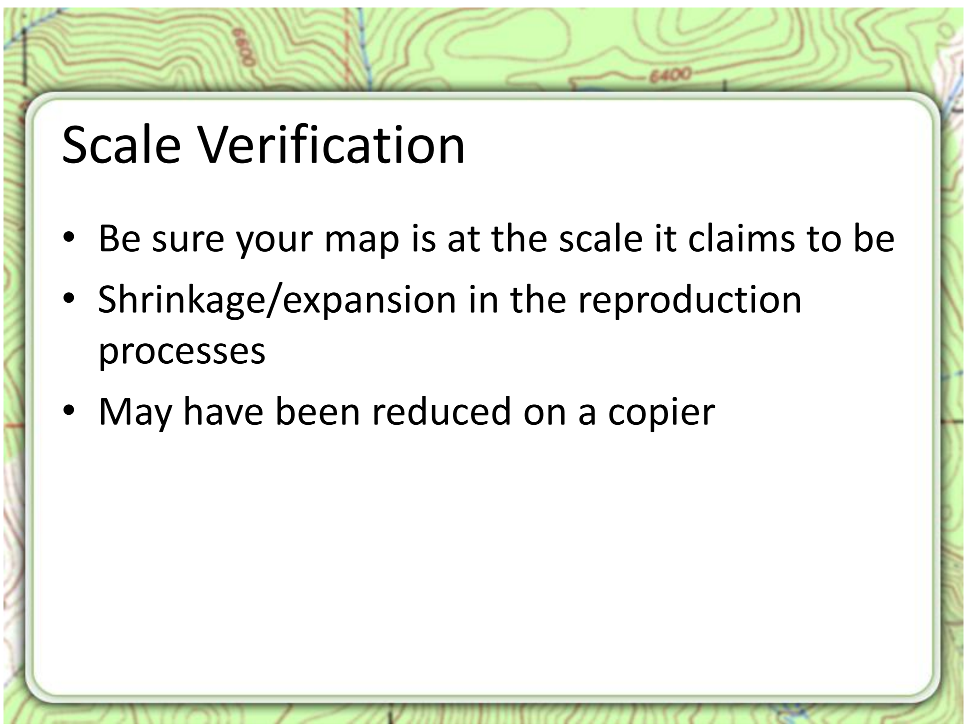
There is another one if you are going quite a ways, say you are driving down the road and you have looked at the map and realized, there are a number of roads that go off of my road but I have scaled it and I need to go a mile and three quarters and it is that road that goes off to the right.

So you can use the odometer on the vehicle if it is one that you can reset to zero so you can know where you're at an intersection, then reset the odometer to zero and then drive that one and three quarter miles.  That saves you time because when you get out there, make sure you go down the correct road to the right so you don't mistake one earlier or one later and you go down and drive a ways and realize oh that's not it I better go back and try the other one.  Trial and error takes up a lot of time and if there is an emergency, an injury, health, or safety kinds of issues then you do not have time to mess around.  So get the map out, scale how far it is from the intersection you know you are at.  For instance, on your Carson City quad, if you are in town then you know the names of the streets, look on the street signs and then find that intersection there and say you have to drive out this road out of town, which turnoff is it? Well I'll scale that and it's at 4 miles.

So you'll know that and then you can use the odometer and now recognize that an odometer is reading to the nearest tenth of a mile. You need to relate it in miles and recognize that an odometer reading to the tenth of a mile, a tenth of a mile, Ok there is 5,280 feet in a mile so a tenth of that is 528 feet. But you have probably got a plus or a minus of 100 feet and maybe even more in reading that. So when you get to where you're going the odometer hasn't quite turned up far enough and it's not a full distance, full length on to the number so you have to kind of adjust for that. So that is what I'm talking about the inaccuracies of using an odometer. It's even less accurate then pacing. Now, with that information, we can now talk about, we know how to measure distances on the ground and how to relate them on the map and back again.

## Scale Verification

Now, I have alluded to this two or three times in the last several minutes of this course and now, we need to look at it for sure and that is called scale verification.




Now there's an issue here. As you saw, the map, it said 1 to 24,000 and that's great. But many of you have seen or someone has taken the USGS map and they have Xeroxed it so they have an extra copy. Let's just understand that Xeroxing or any other reproduction process is not perfect. It does not protect the scale perfectly. Frankly, somebody could on a Xerox, they need this great big area but they have to fit it on an 8 and a half by 11 so they hit the scale reduction. They tell it well, reduce this by 25 percent and that is just an approximate on most copiers.

So it reduces it so here you are working on your file and you have got a Xerox copy of a map and it says 1 to 24,000 on it but it is not 1 to 24,000 anymore. So one of the first things you want to do with a map is to verify the scale regardless of what it says you just want to make sure, is that what is currently the version I am looking at is that the scale that it is actually at? Or is it at a different one because somebody has manipulated it? that happens all the time.

Your maps claim to be something but what is it really? Shrinkage and expansion in the reproduction process or it has been reduced on a copier. This map that I am using here for the course, we used a piece of software. There is software that you can buy by the state and that is from Nevada. All of the USGS maps from Nevada are on one piece of software, which is several discs and a lot of data. So I put it to the plotter and they've scanned it off of the original maps so there is a little bit of scale change there in their scanning process depending on the quality of their scanner. The software I have that I sent to my plotter or printer, well what scale or what accuracies does the plotter or the printer have?

I have found that this map that I have got and that I'm using is not at exactly the perfect scale. For most uses that doesn't matter, what you're really looking for is something that has been reduced or manipulated somehow and has totally changed. I just want to show you a simple way and it's really what we just did with the scale a few minutes ago but now we are going to do it for a different reason. I was doing it before to show you how the scale numbers we gave you were the right ones and how that math worked.

But now I want to show you for the purposes of verification whether I am actually at the right scales. I'm going to slide over here back to this gadget. The overhead projector here. I'm going to show you once again down on the scales themselves. Now remember that this top one is in meters and I'm not going to mess with that today. The second one is in miles. I can mess with that or this one here is in feet. Well I think I'll measure it in feet and I'm going to use the '20 scale and we know that the map is 1 to 24,000. That's what it tells us and I'm going to assume that's what it is. Now if this map was plotted perfectly, which is very difficult to do through software and through a plotter or printer. But if it was then this should work perfectly. But when I get here and I line up the 0 here on say 5,000 feet, I think I'm pretty close there. And then I come down here to 10,000 feet, slide it up a little closer, I can see that my 5 because from 5,000 to 10,000 is 5,000 feet so it should be a 5 on this scale. It is slightly left of that isn't it? So this map is not at a perfect scale and you will find that to be true with just about any map other than the original of if you got the copies that actually came from USGS which they don't even do that anymore. If you get an original like that well then you have a better chance to have a perfect scale.

Recognize that this is ok and it's close enough. At 5,000 feet I'm off maybe 10 or 20 feet but if you're sending somebody to a leaking 55 gallon drum, if you're off by 5 feet they will probably still see it, they will probably smell it, they will probably see what is coming out of it. they will be at the right place because it's close enough. What if somebody had taken this map and had reduced it on a copier? Well then when you laid this down as I just did, it wouldn't be anywhere near close. You would realize that it is probably at some odd ball scale. Even though the thing still says 1 to 24,000, it's probably at some other scale and that's random. They said to reduce it so they could squeeze it onto an 8 and a half by 11.

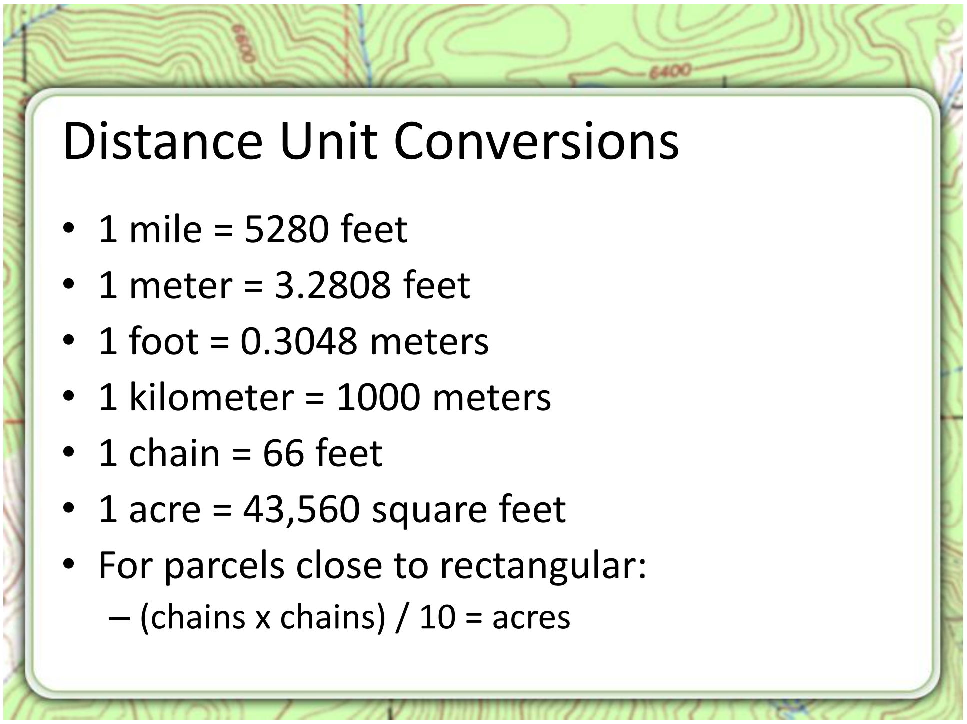
So you need to be aware of that by the way people expand these two. They think well I'll zoom in on this and have more detail on the map, well you can see the map more clearly but, recognize that even minor differences in the map and how it was drawn and reproduced when you expand it, those are made even bigger. Those errors are expanded as well. So just recognize that you can't get that kind of precision even if a map is that accurate.  Accurately scaled.  It is difficult to get down to a few feet.

So just recognize that and again this usually happens folks with maps that are in project files that people are using to actually work in the field and maybe they didn't want the quad or they needed multiple copies of the quad so they just Xeroxed it and shrunk it down.  Just recognize before you make any decisions with distance on the ground or distance of some object and you're using a map, make sure that you have looked very quickly with scale verification.  Just take your scale, your 20 scale, put it on the feet or you can do it on the miles although it's a little more difficult to estimate what the inaccuracy is.  But if you put it on the feet, graphical scale there or bar scale as they call it, then you will be able to look right at it and you can see Ok, I'm off just a little bit.  That way you just don't get fooled by the one that somebody messed with it.  Think about it.

If you are doing something pretty critical out there on the ground and maybe you measured it with a cloth tape, a 100-foot cloth tape, you measured on the ground.  You measured the distance very, very well but then you want to plot it on the map.  But you want to make sure you're not plotting on a map that is maybe 10 percent off.  You might not even be able to see it looking at the map.  It might look like it's at the 1 to 24,000 scale.  But what is going to happen is you're going to scale the 500 feet you measured with your cloth tape on the ground and you are going to scale it at the wrong place on the map.  Because you did not verify the scale.  We always want to do that.

## Distance Unit Conversions

Now, the last thing that I wanted to discuss here about distance, is to discuss the different conversions and we'll just leave this up for a minute or so and you can read it.  you don't need me to read the whole thing but these are common conversion rates between different units so that you can understand.  I even put the metric in there from meters to feet and feet back to meters so you can even do that if for some reason you are measuring something in meters or you are using the scale for the meters on the map then there they are.




The chain and the acres so also at the bottom of the slide, you can see, remember I mentioned earlier that acres and chains have mathematical relationship. See if you have a parcel that is pretty close to a square or a rectangle, you can take how many chains it is wide by how many chains it is high. Multiple or times each other and divide by 10 and that's acres.

Actually BLM Forest Service and other Natural Resource Agencies is how they measure areas of fires. You hear it on the news, well this fire is 4,000 acres or something well they may be able if they have it digitally if they have some aerial photos or they have GPS data around the fire then they can compute the area. But usually what your standard firefighter out there on the ground, especially when the fire is small, they go out there and measure in chains on the ground so this fire has kind of covered 3 chains this way and 6 chains that way. Not that the fire is a perfect rectangle but that's how they do it. 3 times 6 is 18 divided by 10 1.8. They'll call in and say this fire is up to 2 acres. Ok 1.8 acres. That's because chains and acres have this easy relationship.

You don't have to take a calculator with you or divide by 43,560 in the field. You are able to just very quickly estimate areas and that is one of the applications for that. That information is there as well.

So we've got an exercise for you that is next that you'll be using to test your skills with distance and it'll ask you a number of questions from that Carson City quad. Then when we're done we'll come back and start talking about direction so I'll see you there.

## Exercise 3 Distance, Scale Verification and Conversion

**Questions regarding distance and conversion between units of measurement:**

One chain is equal to how many feet?

a. 50
b. 66
c. 100
d. 33

One mile is equal to how many chains?

a. 5280
b. 100
c. 80
d. 50

One mile is equal to how many feet?

a. 5280
b. 100
c. 80
d. 50

To convert from feet to meters, you would need to divide feet by what value?

a. 66
b. 3.2808
c. 100
d. 0.3048

**Questions regarding scale and verification:**

The USGS 7 ½ minute series topographic maps of the continental U.S. are mapped in what scale?

a. 1:24000
b. 1:2000
c. 1:40
d. 1:100

The scale of 1:24000 means what?

a. 1 unit on the map equals 24000 units on the ground.
b. 1 unit on the ground equals 24000 units on the map.
c. 1 unit on the map equals 20 units on the map
d. 1 unit on the map equals 2000 units on the map

A scale of 1:24000 is also equal to what?

a. 1 inch = 12000 feet
b. 1 inch = 80 chains
c. 1 inch = 2000 feet
d. 1 inch = 1200 feet

To measure a distance in feet on a 7 ½ minute series topographic map, which scale on an engineers scale is the best to use?

a. 10 scale
b. 20 scale
c. 30 scale
d. 60 scale

When measuring distances on a 7 ½ minute series topographic map with the 20 scale, one tic mark on the scale is equal to how many feet on the map?

a. 10.
b. 50.
c. 66.
d. 100.

To measure a distance in chains on a 7 ½ minute series topographic map, which scale on an engineers scale is the best to use.

a. 10 scale
b. 20 scale
c. 30 scale
d. 60 scale

When measuring distances on a 7 ½ minute series topographic map with the 30 scale, one tic mark on the scale is equal to how many chains on the map?

a. 1
b. 5.
c. 80.
d. 100.

The best way to verify the scale of a map is?

a. Measure between known points of the map.
b. Compare an engineers scale to the graphical scale on the map.
c. Ask the source of the map about the scale accuracy
d. Measure the map margins to see if they add up to the correct lat/long

---

**Questions Regarding measuring distances on the map**

---

The straight line distance, in feet, from the intersection of King Street and Minnesota Street to the intersection of Long Street and Mountain Street is?

a. 5280
b. 2640.
c. 1500
d. 3800.

The straight line distance, in chains, from the SE corner of Governor's Field to the intersection of Silver Sage Drive and Koontz Lane Is?

a. 80
b. 104
c. 66
d. 100

You are looking for a section corner. On the map, you scale a distance of 225 feet from a sharp bend in the road. After parking in a safe manner at the bend in the road, the best way to measure the scaled distance on the ground is?

a. Pacing
b. Using a 100 foot cloth tape
c. Odometer on the vehicle.
d. Wild guess.

## Exercise 3 Distance, Scale Verification and Conversion – Answer Key

**Questions regarding distance and conversion between units of measurement:**

One chain is equal to how many feet?

a. 50
**b. 66**
c. 100
d. 33

One mile is equal to how many chains?

a. 5280
b. 100
**c. 80**
d. 50

One mile is equal to how many feet?

**a. 5280**
b. 100
c. 80
d. 50

To convert from feet to meters, you would need to divide feet by what value?

a. 66
**b. 3.2808**
c. 100
d. 0.3048

**Questions regarding scale and verification:**

The USGS 7 ½ minute series topographic maps of the continental U.S. are mapped in what scale?

**a. 1:24000**
b. 1:2000
c. 1:40
d. 1:100

The scale of 1:24000 means what?

a. **1 unit on the map equals 24000 units on the ground.**
b. 1 unit on the ground equals 24000 units on the map.
c. 1 unit on the map equals 20 units on the map
d. 1 unit on the map equals 2000 units on the map

A scale of 1:24000 is also equal to what?

a. 1 inch = 12000 feet
b. 1 inch = 80 chains
c. **1 inch = 2000 feet**
d. 1 inch = 1200 feet

To measure a distance in feet on a 7 ½ minute series topographic map, which scale on an engineers scale is the best to use?

a. 10 scale
b. **20 scale**
c. 30 scale
d. 60 scale

When measuring distances on a 7 ½ minute series topographic map with the 20 scale, one tic mark on the scale is equal to how many feet on the map?

a. 10.
b. 50.
c. 66.
d. **100.**

To measure a distance in chains on a 7 ½ minute series topographic map, which scale on an engineers scale is the best to use.

a. 10 scale
b. 20 scale
c. **30 scale**
d. 60 scale

When measuring distances on a 7 ½ minute series topographic map with the 30 scale, one tic mark on the scale is equal to how many chains on the map?

a. **1**
b. 5.
c. 80.
d. 100.

The best way to verify the scale of a map is?

a. Measure between known points of the map.
**b. Compare an engineers scale to the graphical scale on the map.**
c. Ask the source of the map about the scale accuracy
d. Measure the map margins to see if they add up to the correct lat/long

---

**Questions Regarding measuring distances on the map**

---

The straight line distance, in feet, from the intersection of King Street and Minnesota Street to the intersection of Long Street and Mountain Street is?

a. 5280
b. 2640.
c. 1500
d. **3800**.

The straight line distance, in chains, from the SE corner of Governor's Field to the intersection of Silver Sage Drive and Koontz Lane Is?

a. 80
**b. 104**
c. 66
d. 100

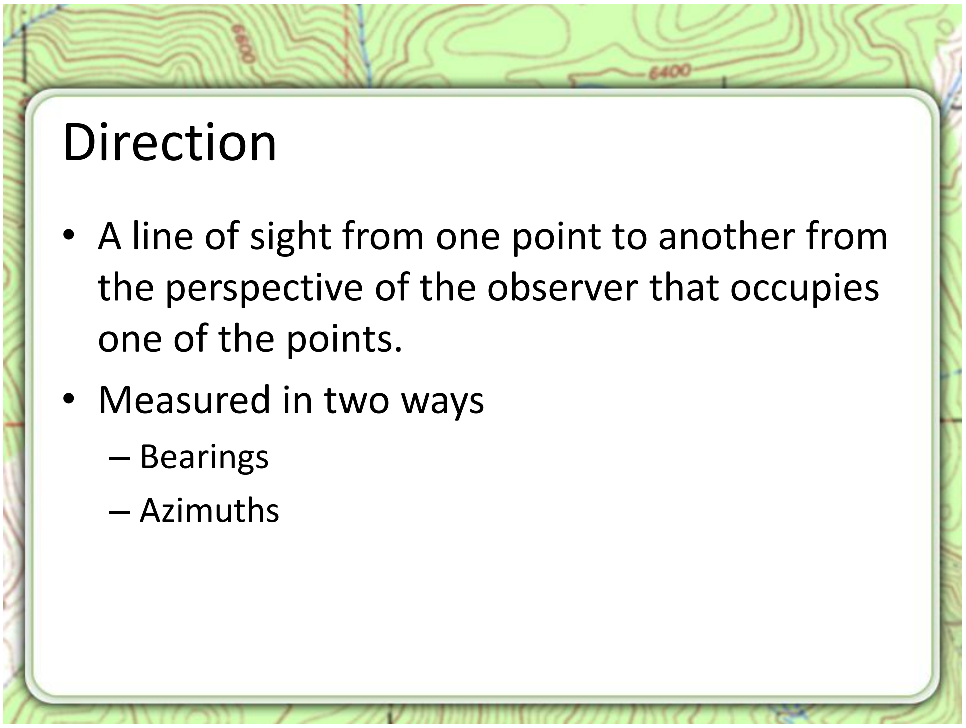
You are looking for a section corner. On the map, you scale a distance of 225 feet from a sharp bend in the road. After parking in a safe manner at the bend in the road, the best way to measure the scaled distance on the ground is?

a. Pacing
**b. Using a 100 foot cloth tape**
c. Odometer on the vehicle.
d. Wild guess.

## Lesson 1 Map Reading & Interpretation, Part 6

### Direction

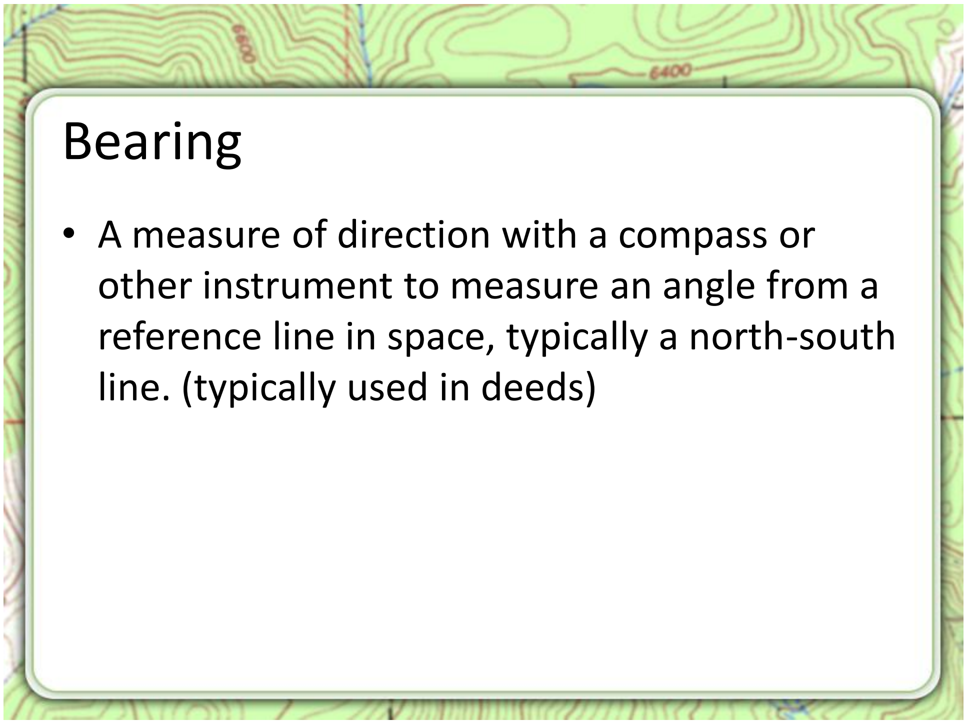
Well now that we've discussed distance and how to measure that on the ground as well as on the map and relate them to one another, let's talk about the other major component and that is direction.




You can see on the slide here the definition of direction is a line of sight from one point to another from the perspective of the observer that occupies one of those points. So you've got two points and you might remember that from basic geometry or trigonometry, it takes two points to divide a line. You're standing on one of those points looking at the other one. That's directions, the way we measure the direction of something.

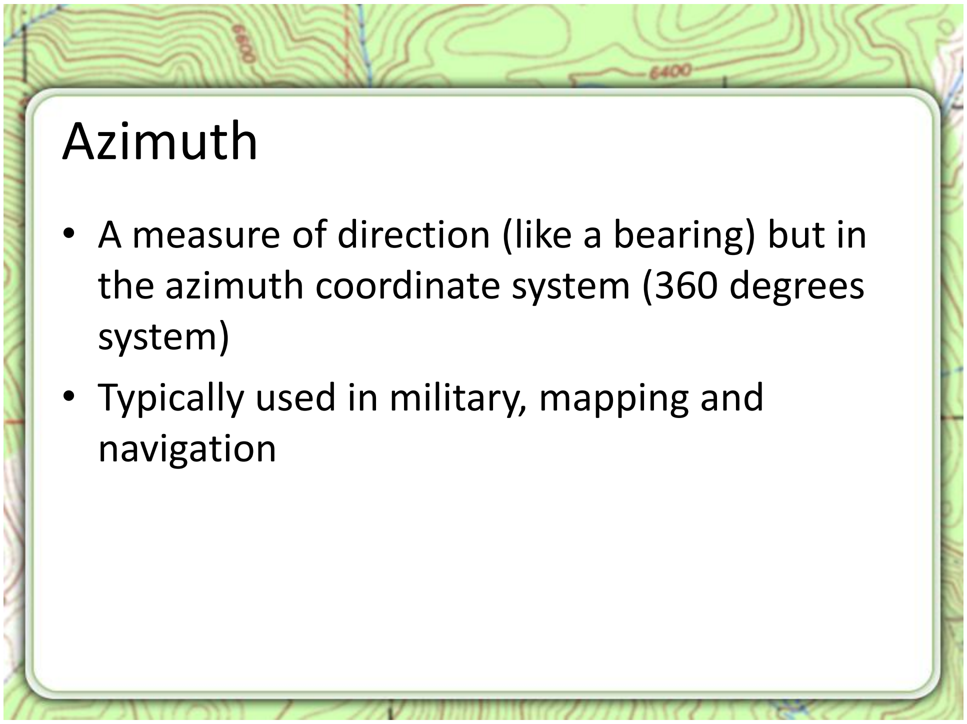
Direction is basically in the United States measured in two ways and that is either by bearings or azimuths. I will show you both of those so we can discuss those. The first one of those I am going to go to is bearings. Now bearings are used by an awful lot of people. Surveyors use them a lot too. Almost every deed you have ever seen, for property, uses bearings. You have seen that in old legal descriptions that are parts of deeds. That's north 20 degrees and 15 minutes east and that's what we are talking about. Those kinds of directions.

That is a method of measuring direction and it is probably the most common in the civilian world. The military is far more the ones that would use azimuths but we will discuss that because sometimes we are dealing with, you may get some information in an azimuth and you need to understand how to use that. A bearing, let's take a look at this slide.




A bearing is a measure of direction with a compass or some other instrument. Of course surveyors use very precise instruments, to measure an angle. What we are interested in is the angle is from a reference line in space which is usually north and south, and again this is typically used in deeds. When we measure an angle from either due north or due south over to the direction that the line is going. That is the bearing of the line. That is how we define that.

And then the second method is the azimuth and here is the definition of that.




It's a measure of direction which is the same as a bearing but it only goes from one direction. The bearings went from either north to south and measured to the left to right or east to west if you will. But in an azimuth system, it's a 360 degree system meaning usually azimuths are north so it measures everything from the North. We are going to look at both of those now and see how both of those work.

We will start with bearings which is the most customarily used. Take a look at this next slide. Here are how bearings are measured in the United States.

We have zero degrees at either due north or due south. And 90 degrees is at due east and due west as you can see here. What we do is we divide that into those quadrants as you can see northeast, southeast, southwest, northwest. And we measure how many degrees something is from north or how many it is from south and either way then we say whether it is east of south or west of south or east of north or west of north.

So what we are talking about is measuring a direction using 0 in the north end here as due north and then we measure how many degrees it is over to a line say we're looking at a line going like that. How many degrees is that? Let's recognize that degrees are not tied to a distance. As you can see, just looking at that diagram, if you're really close to the radius point or focal point or intersection point, and two things are say 20 degrees apart. If you are really close and you only go out 100 feet then it's not going to be much distance. Whereas if you go a mile it's a much greater distance because those get further apart as they go.

Some people try to that aren't used to measuring bearings or any kind of an angle, try to relate it to distance but that's not really the way to do that, it is about direction. The distance gets greater as you move away from your focal point. Of course that is the foundation of the whole science and trigonometry.  Is the study of that and those relationships and how far away you are and that sort of thing.  So don't get caught up in that.

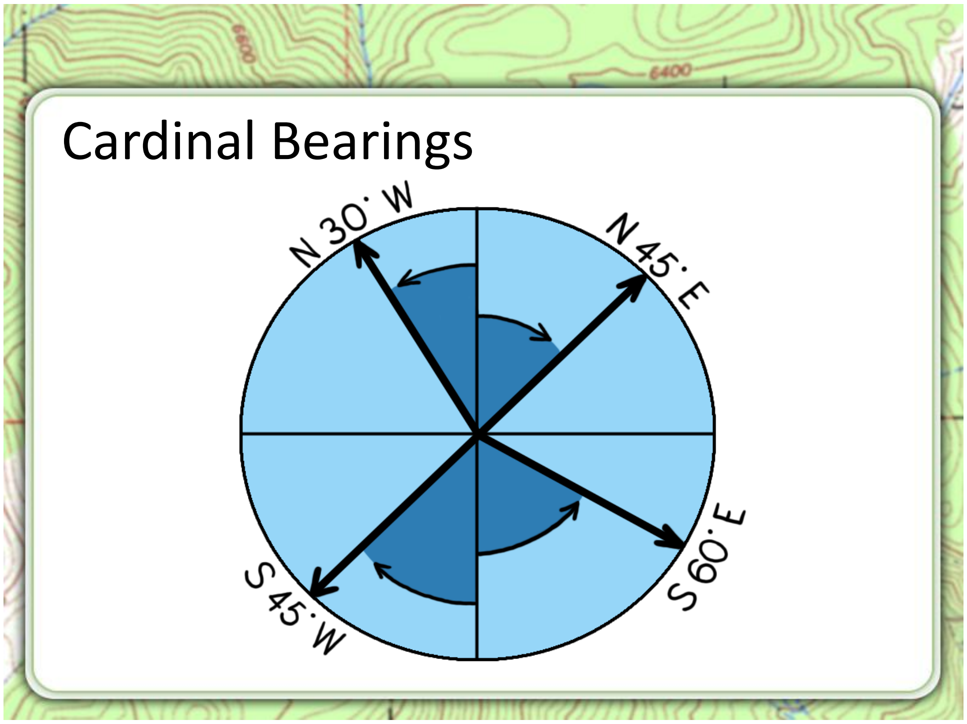
Back to this slide, if this is where I am standing, this radius point is where you are always standing when you are talking about a direction, and so if a line from that point goes off like this then what I am interested in is how many degrees is it from due north over to there.  I can measure that with a compass in the field or with a protractor on a map.  That's exactly the tools that we will use to do that.

So let's just say that that angular measure there, I'll just draw it again so you make sure which one I am drawing.  From due north, to the line that we are talking about, let's say that's 12 degrees.  I measure that to be 12 degrees.  So what we do is we call this north, 12 degrees east. That's the nomenclature that is used and you have probably seen it in deeds.  North 12 degrees east.  You see that in deeds or other documents.  What that means is we are 12 degrees east of due north.  That is exactly how bearings work in all 4 of the quadrants.

So let's do one in the northwest quadrant. You're looking at this, you're standing here, and you are looking at a line and it goes out like this.  I don't want to measure this angle here, that's not where we measure from.  You could do it and subtract from 90 if you wanted but what our bearings are actually telling us is how far is it from due north over to here.  So I can measure that either with a compass, in the field, or a protractor on the map.  And let's say that that is 80 degrees.  So we would call that north, 80 degrees west.

Similarly down here.  Let's say we'll put this one at the 45, at 45 degrees.  Well it's going to be south 45 west because you are standing here and you are looking out this line here and from due north, or south here, due south over to there is 45 degrees so that's at south 45 west. South, 85 east if this was 85 degrees.  That is how cardinal coordinates work or quadrants, cardinal quadrants work, and that's how much of what we do in government is done and that's how all real estate is done, it measures those off of that.  You are going to have opportunity here in a few minutes in this exercise to do those things.

Let's take a look at this slide just to review and make sure that you understand what's happening. Notice that we do not cross the north/south line.




It starts on a different quadrant when you cross that. So this is north 45 east here because this angle is 45 degrees. This is 30 degrees and it's northwest so we crossed the north/south line so we start over again with our measuring. If you are also paying attention, you realize that the measuring starts over again when you cross an east/west line, doesn't it? Because this is north 45 east, north 60 east, north 90 east and when you get to north 90 east that is east, Ok.

And then we start back down. You don't go to north, 92 east, something like that, no. It would be south, 88 east would be that line. So you see the 0's that are at the north/south line as you cross them and the 90's are at the east/west line. So we measure from 0 to 90 then we go 90 back down to 0 and then we go 0 back up to 90 then we go 90 back down to 0.

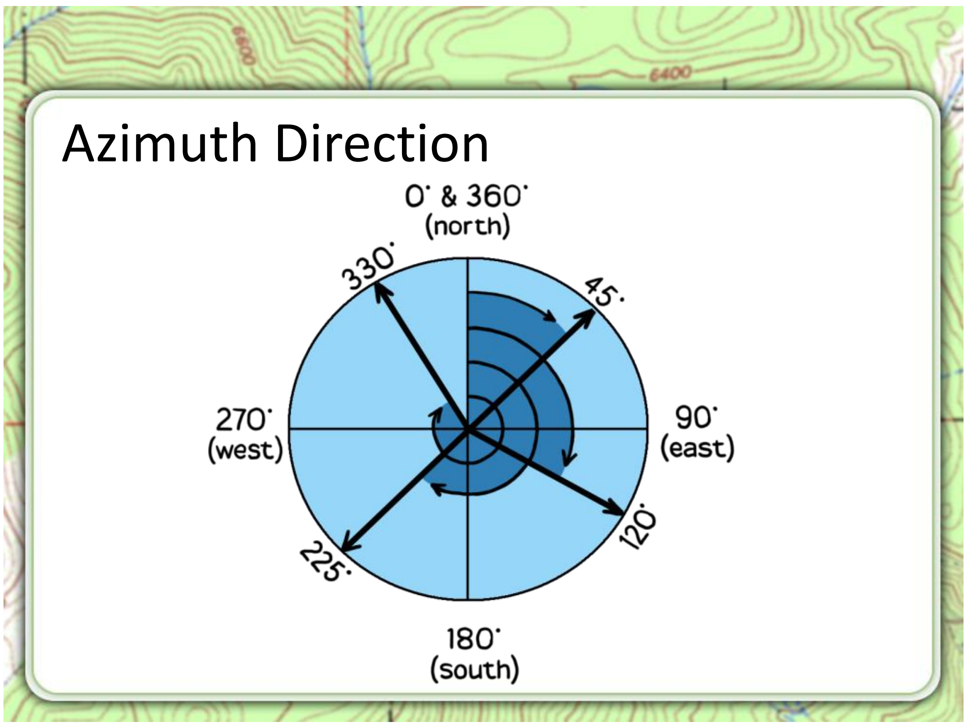
That's how this works and here are four examples of bearings and that's how we measure direction using bearings. Now you may recall in an earlier discussion that degrees can be divided into 60 minutes, 1 degree equals 60 minutes and we can go even further, 60 minutes is divided into 1 minute is divided into 60 seconds. So recognize that you may get a deed that says, let's just make one up, north 45 degrees, 12 minutes and 30 seconds east.

Let's go back to our screen. We have already drawn north 45 east on here right? So 45 degrees, 12 minutes and 30 seconds is going to be just slightly different than that line. It's going to be a little bit more. This is 45, 45, 1230 would be there.

So bearings can be brought out into much greater precision based on what you know. A lot of times the deed will tell you that. You and I can't really measure that closely with a compass or with a protractor on a map. We can't measure down that close, we are lucky to get to a quarter of a degree with most protractors and with a compass you're holding it and your hands are moving and you're lucky to get it within a degree or two. That's good enough for a lot of the applications that we have but just recognize that a lot of the data that we have from deed records or other information or permits and other things, may have it down more precise.  That means it was probably surveyed by a surveyor or somebody with surveying instruments actually went out and measured this and that's how they determined those precisions if you will and you're just not going to be able to mimic that without surveying.

An instrument of some kind, some sort of device that measures much more precisely.  But that doesn't matter for what we are doing here.  With mapping, if I can get you within ten feet of the leaking 55-gallon drum then you will probably know that's it.  You will probably recognize it if I get you within 100 feet of the smoke where lightning has struck.  You will probably spot it, you'll smell it, you'll feel it and then you can go over and put the fire out.  We are talking about practical applications here, not precise measuring which is what surveyors are charged to do in this world.

Now that was bearings.  We have one other and that's azimuth which I have already defined for you.  It's based on a 360 degree system. Take a look at this slide and you'll see in this case we're calling north, 0 and most systems use that.




The military do have some that's south.  So due north is 0 degrees or it's also 360 because a circle has 360 degrees.  It's either one, we just call it 0 or better, we just call it north.

So now notice when we have a 45 degree angle, the azimuth of that is 45 degrees.  You're standing here and you're looking out that line and it's 45 degrees.  But now you're still standing here and you look at this line, it does not use the quadrants and come from the south like the quadrant system does with bearings.  It's an azimuth.  It wants to know what is the angle from north, it always measures it from the same reference.

So what is the angle from north?  In this case, well that's 120 degrees.  So we call that an azimuth of 120 degrees.  We don't call it southeast something, right.  120 minus 90 would be 30 degrees so that could be south 60 degrees east in a bearing system but in the azimuth system it's just 120 degrees. So if you were looking due south, what would that be? Well that would be an azimuth of 180 degrees. So just continuing on, we have a thing here that would have been southwest 45 degrees but now it's just going to be simply an azimuth of 225 and that's because it's always measured from here all the way around to there.

So if you were looking due west it would have an azimuth of 270 degrees. In this case here, a line that would have been north 30 degrees west in the bearing system, is going to be 330 degrees of an azimuth because that's how many degrees there are of angle all the way around to there. So you can see if you had a line, it was just slightly west of due north. Say in a bearing system, north 1 degree west, and I'll attempt to draw that. It kind of runs out that way. North 1 degree west in an azimuth system it would be an azimuth of 359 degrees because it's 1 degree from the 360 which is the full circle.

That is how the azimuth system works. It's relatively simple and you know azimuths are actually easier to work with in some cases because you can add and subtract those things because in the bearing system, as you add and subtract bearings that you've crossed the 0, you've crossed the 90's and you have to take that into consideration when you compute those things, with an azimuth system you don't. azimuths are actually more favorable in the computer world and in simple math it's a lot more basic.

So we have these two methods, or if you will ways to measure and relate angular changes. Angular directions, changes in direction. They are measuring the same thing, they are just reporting it in two different ways. Again, you have an exercise that will assist you with that.

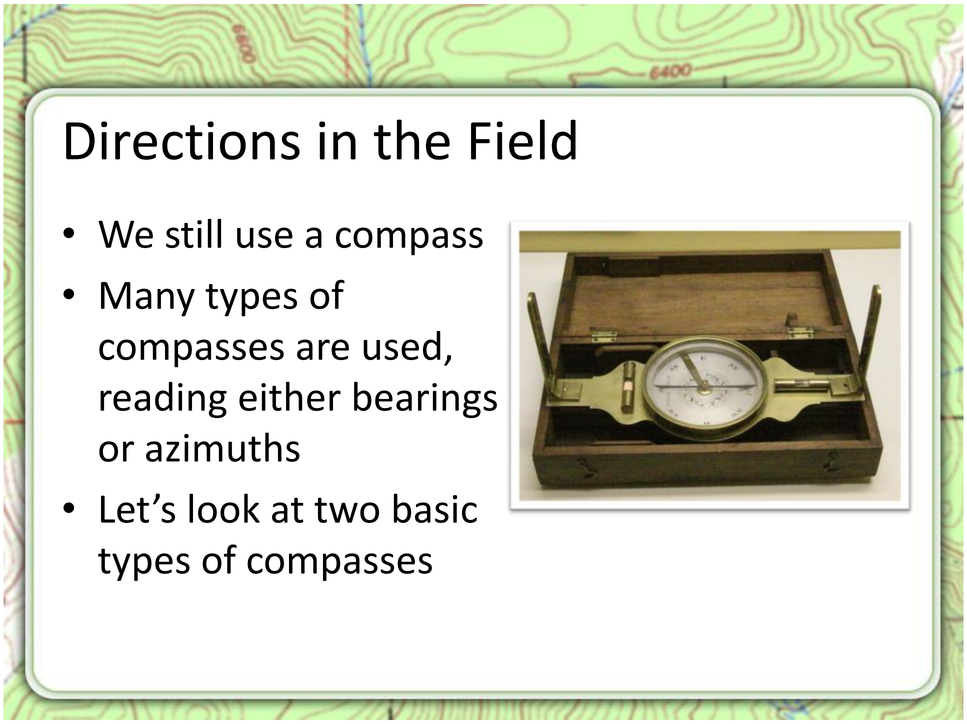
Here in a moment, what we're going to do is talk about, alright what do I do with those things in the field? How do I use that information and now relate it to some gadget that I have in the field to determine that direction? I can see the Meth lab over there and I want to measure my direction, from me to that Meth lab or that hazmat site or to the fire. I want to measure that so that I can relate it to something I know on the map. I might have a GPS unit and I know where I'm at coordinate wise, but I want to know the direction to the fire from me.

Or I may have been given information that there is somebody with a broken leg and you need to go out and deliver this or whatever, and you need to go north 45 west, you get a compass out so you know where that is so you're not guessing. Some people kind of have a built in thing in their mind, a built in compass, I suppose you can call it that and they always know where north is. I'm like that. Almost anywhere in the country I've ever been but for some reason when I go to Anchorage, for some reason I'm always messed up, up there. Generally I always know where north is whether I've been in a plane or driving. I have a pretty good idea of where that is and I guess it's just because I'm a surveyor. But some people don't. Some people have a real difficulty with that.

Obviously the reason you are using a device is because it will know where north is and you can use it to measure what the bearing is to somewhere else. That's why we use a compass in the field and why we'll use a protractor on the map so that we can, a little more precisely determine these things in those applications. Understanding the way we measure those things. It's one of the two ways I just presented to you with bearings or azimuths.

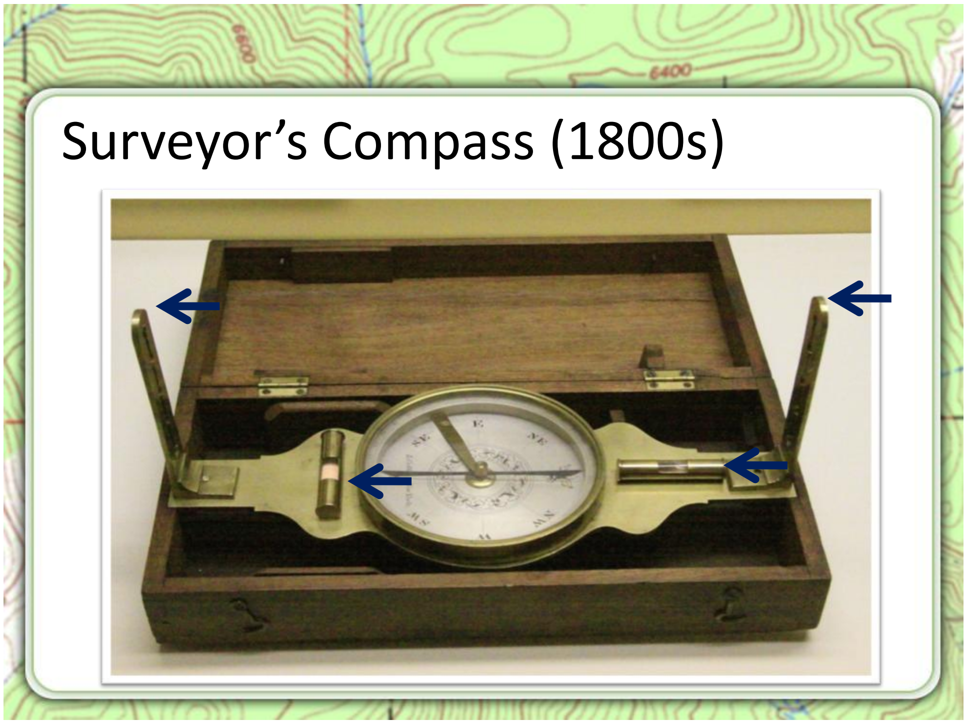
## Directions in the Field

So when we go to the field, how do we determine direction in the field?




We still use a compass. There are many types of compasses, some read in bearings and some read in azimuths just as we have learned those two things. There are a couple of basic types of compasses we are going to look at.

Notice that picture there at the bottom of the screen. That is a picture of a surveyor's compass not a modern day one but an old one that was used back in the 1800s to lay out the Public Land Survey System. Surveyors used large dialed compass so they could get a little more precise.

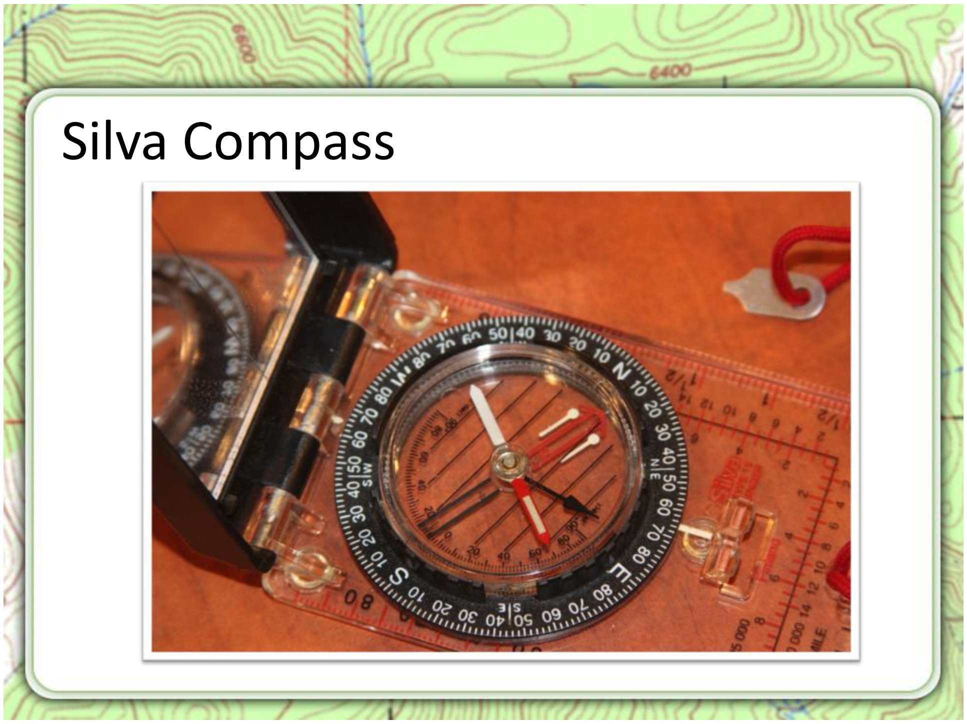



Notice that it has a couple of level vials on it so they could get the thing level. This is one here and another one here at 90 degrees to it and that's so they could get the compass level so they don't have any error introduced because of that. Then you notice it has two sites on it and take a look at that. We have a site sticking up here and a site over here. What the surveyor would do is rotate the compass until it's at the correct direction or azimuth that he wants to go. Then he can actually look through the sites and see. So let's say that I turn it due east, what is due east of me? So you turn it to due east and you look at it and look down through the sites and say that rock, or that tree is due east of me. That's where we are going to measure or that's the direction we are going to go with something. Or perhaps the surveyor was, or anybody was using that kind of a compass was sitting at some kind of a corner, property corner and noticed the houses sitting over there.

Well I want to plot the map. When I make the map I want to show the house and how it is in relation to the property line. So I can turn the compass over and line up my scope, that's not scope but the sites and look through there, line that up with the house and then read the compass and then it tells me what the bearing or the azimuth is from this corner to the house. That helps me plot that in a more precise way.

So that's how it was done with all of the early surveys here in the United States, including in the Colonial states, were done with compasses like that. In fact, variations on compasses were used even as late as the early 1900s in the government surveys and private surveys. It wasn't until more expensive units, devices we call theodolites or transits, started to come along. Surveyors were using anything more precise than that. And so compasses are still around and we still need them or some variation of them today when you go to the field.

Now I got a couple of different types of compasses I want to show you briefly. Over here on the overhead projector, I have what's called a Silva compass, that's S-I-L-V-A, I believe that's because it’s used by Forrester’s in Silva cultural work, I think that’s where the name comes from but don’t quote me on that.




But notice it’s just a piece of plastic, a relatively cheap piece of plastic. It has a mirror on here and that is for citing, you can still do the cite. What’s on the end, it’s a cite. You have a 0 or a place to cite down on the other end here where the string comes in. There’s a line marked all the way through there and you may not be able to see it but yeah, I got that light there, sorry. There is even a line across there if you will, on the mirror. So what we have is an alignment going through here. Same principle as the other compass. It gives you a line of sight to use.

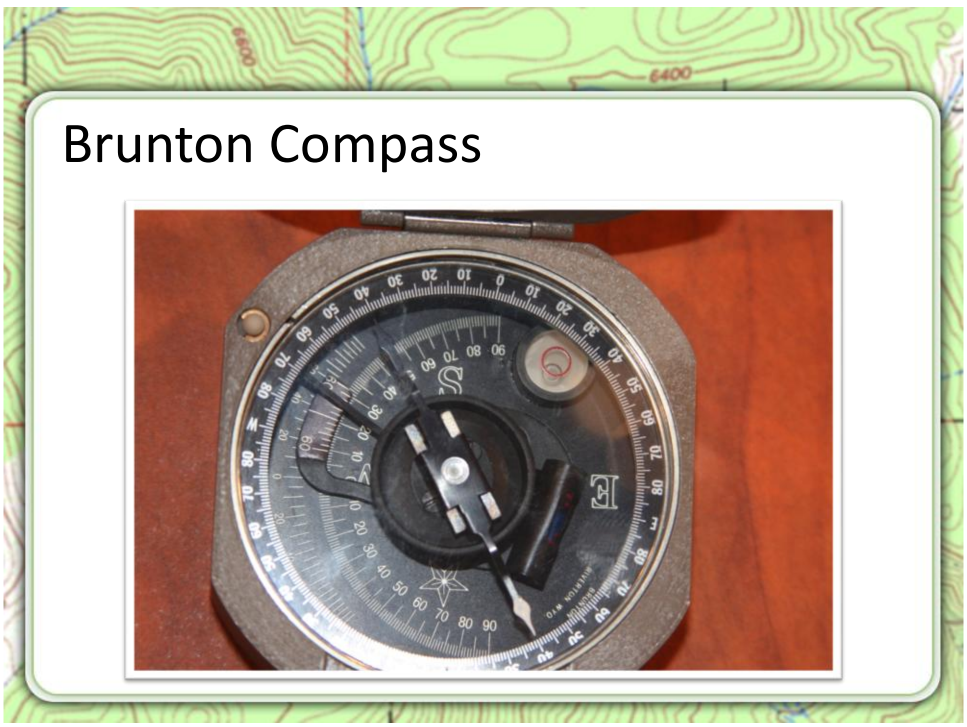
I’m not here to teach you all of the ins and outs of using a Silva compass or anything else but I do want to do is make sure you understand that it is following these same principles which we have just discussed. What I want to do is zoom in on the compass itself. Of course north is north so I don’t have a choice so it’s kind of pointing down which for us surveyors is backwards. That’s kind of the direction of north here in the building that I’m in. You notice that this is a compass that is operating in quadrants just like we were talking about. From due north, look at the bearings, these are degrees in one degree. Here’s 0 which is north, right. 10,20,30,40,50,60,80, 90 at due east. Then it goes back down to 0 at the South. Then it goes back up.

You can’t see that with a shadow, sorry about that. To 90 which is west and then it goes back down. So this is a Silva compass that is used and it’s graduated in bearings. Nearest degree, so if I were to line up my compass down something I’m wanting to cite just as a very rough example of this. Let’s say that’s the direction that I’m looking then I know that I am looking when I look at where the compass points or where the needle points that I am looking at about north 40, I don’t know what, 3 degrees west. Somewhere in there. That’s the direction that I’m looking.

That's how a compass works and that's what you use in the field in order to determine direction and as you can see, I mean if you're standing there holding it in your hand and your hand is shaking a little bit or the wind is blowing or whatever and you're trying to cite down this site on the compass and pick out something down there. It's not going to be that accurate. You can be a degree or two off and that's Ok. It's close enough to what you are probably going to be doing out there in the field. But I wanted you to see is that a compass, you can go buy a compass at a sporting goods store and you can get one that's in bearings or in azimuths, either way, and it works just like what we showed you. That's how you relate direction in the field to direction on the map.

I haven't showed you direction on the map yet. We'll show you that here in a second. I'm going to switch over to a different compass, a more expensive compass.

It's called a Brunton compass, that's the company that makes it but it's also called a pocket transit.




It's a small device, not much bigger than the other but this one is made out of metal. I am going to zoom out a little bit on this so you can see this device on the overhead.

The Brunton compass still has the same principles. It's made out of metal so it's a little more sturdy it has some other applications as well. You notice it's the same, it has a mirror over here with the line in it. It has a cite here which I can actually tip up if I want and it has another cite just similar to the one you saw on the surveyor's compass on the picture a few minutes ago. What you see is you have an alignment or an orientation of this compass running down that alignment of the compass.

Notice, here's your arrow and it is tipped white and that's our north. So I can turn this and you see a star there. Brunton uses a star for north. 0 is at about north, am I at 0, yeah I'm pretty close to it.

This one, if you notice is also in bearings. This is a bearing compass. 0 to 90, 90 back down to 0, then 0 up to 90, then 90 back down to 0 and it allows you to read directly a bearing. It works in the same way and I don't have any azimuth compasses I'm going to show you, I'm just going to tell you when you get one it will simply have 0 and it will go all the way around to 360.

I have 180 at the south and all of that. I guess I didn't have that quite right did I, there you go. There's 0 and then I hit it. Notice that, I hit it and then it moved. That's my point. They're not super precise because little things, the Brunton compass have a level bubble as you can see in there. So you can hold it level and that sort of thing.

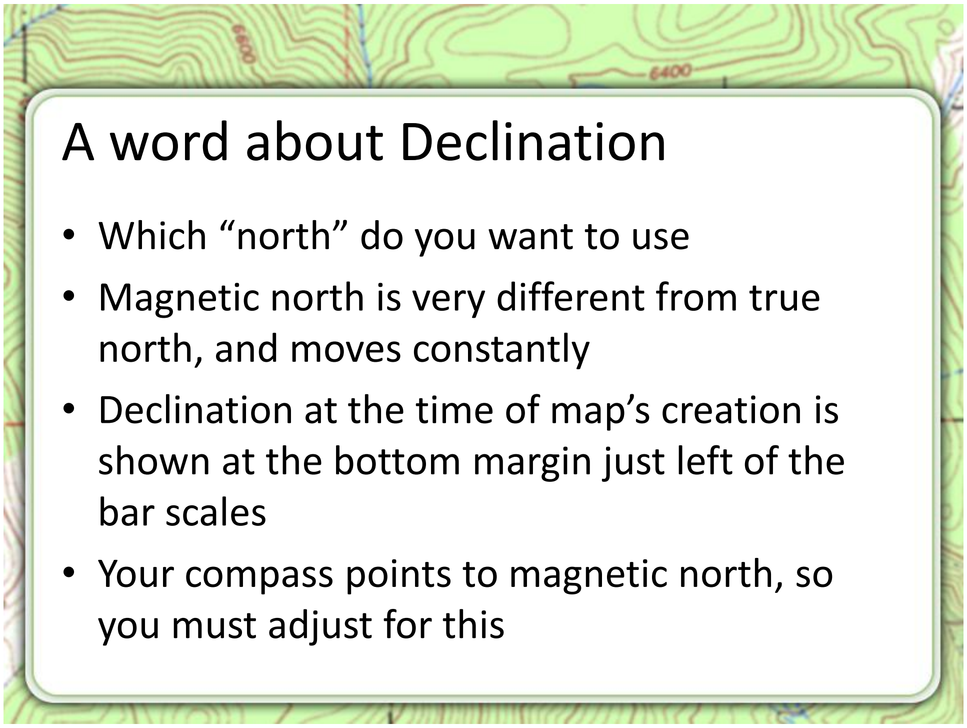
But again, it has the same limitations as the Silva compass I showed you and that is simply because it's not, it's just not the precise of a device, not that precise of a measurement but close enough for what you and I are trying to do. If I can see smoke from here and it's probably 5 miles away but I can get a bearing or azimuth to it, plus or minus 2 or 3 degrees somebody is going to see it. Somebody will be able to do it. What you want to think about is the reason you want to give them where that smoke is they may be coming in and it may be a helicopter coming in from a completely different direction from where you're at. We are going to see later in the course if you go and get 2 or 3 bearings from different places to an object you can actually compute its distance too. You can compute its exact position even when all you have is direction.

So there are some real uses of these devices in the field and that is something that you need to own one and practice with and work with so that you can understand how to use it and its limitations. But go out in the backyard or go down to the street in front of your office and practice with it. see how it works and get familiar with it because that will really pay off when you're using your map when you're actually doing something for real out in the field. None of us unless you happen to be in Carson City taking this course, none of us are actually going to be able to go to that place unless you go there for vacation.

So we have to imagine what it looks like and we can learn almost exactly what it looks like based on all of the data that is on that map. Things that we haven't even begun to talk about yet. Recognize that you can know a lot of things. I can know that there is a mine that's almost due west of the city of Carson City. I think it's called the Premier Mine on the map. I can know that, I've never been there. But I know that from the map and I know the directions because I can look at the map to figure those things out. That is how directions work in the field. I want to talk about something with these compasses though, that is very, very important. This is one of those things, some things just aren't very simple.

## Magnetic Declination

What I'm going to talk to you about it magnetic declination.  But here's the problem.




The north pole that we use for measuring bearings is at a fixed place, computed place.  But notice it asks which north do you want to use?  Because there are many north's.

Magnetic north of course is what a compass depends upon and magnetic north is very different from true north.  Magnetic north moves constantly, it actually changes everyday.  It has changed drastically, it has moved like 1,500 miles over the last century.  So it's drastic changes where the north pole is and of course a magnetic compass is pointing to the magnetic north pole.  So what you need to know is what is the direction difference between true north and magnetic north.  Or what we might call astronomic north and magnetic north.  That difference between those two is a declination.  Now if you're in the eastern United States, places like Ohio and that, well the declination is 0 or really close to 0 meaning well your compass is reading exactly what it should be.  But as you move further east or west of that alignment at least currently, then you start getting to have a complication with declination.

Here in Arizona, we are at about 11 degrees I think of declination.  For your map that you're working with up in Nevada it's over 15 degrees.  That's a big difference.  In other words you can't give somebody the magnetic bearing and if they assume it's the astronomic or true north bearing then they are going to be way, way off.  Because 15 degrees is a lot, especially if you go up 5 miles looking at that smoke.  You are going to be sending them a mile or so off to look for that fire.  So declination is important.  Remember this, your compass points to magnetic north.  You don't have any choice unless you are wearing something magnetic, a belt buckle, or a hammer or something that you have on you.  Then it will point to that.  That's another thing for you to think about with a compass.  Make sure there isn't any what we call a local attraction.

But recognize that the declination is something you need to know what declination is now and you can look at what the declination was at the time the map was printed or created.

Let's take a look at what your map tells you in the marginal data. At the bottom of your map in the margin just to the left of the bar scales which we were looking at earlier in the course to verify scale and understand about scale. Just to the left of that you will see a little diagram and it's at that same place on every topographic map that USGS put out. Let's take a look at this. It's a little diagram that's telling you about declination. Of course they don't know what declination is now but it's telling you what it was then.

You can actually go to websites and things to find out what the declination is today in any place just plug in your latitude and longitude and it'll tell you. The daily changes are very small things that you won't notice. But let's understand, you see with this diagram and I think I'm zoomed in about as much as I can. You have a star and that stands for astronomic north. That is what surveying and mapping and everything is generally based on.

So you have astronomic north and then you have MN, that is magnetic north. It is telling you here that it is 15 and a half degrees, that's the angular relationship here, between astronomic and magnetic.

So understand that if you're in the field and you have not adjusted your compass to the declination, when you look down, when you let the magnetic needle point north, and you look down those sites, it is actually if this is the declination, it is actually looking down that line. You will be 15 and a half degrees off. So you have to adjust your compass for that declination.

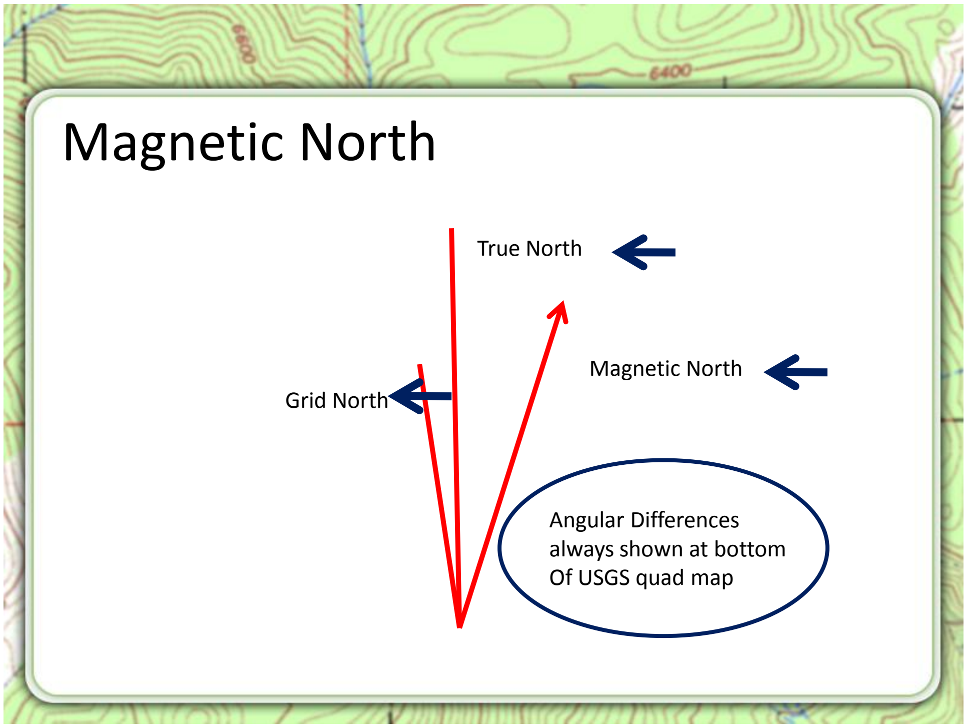
These compasses I showed you here both of them you can adjust it so that you can actually read what the true bearing is, or true azimuth. But some of the cheaper compasses, little boy scout compasses, they don't do that. Of course you can do things mathematically, you can just say Ok I know I'm at 15 degrees declination and I pointed this and it's saying 45 degrees so I'm going to subtract 15 so I'm actually looking 30 degrees. You can do that but that can get confusing. Do I add it or subtract it? Which way am I? That sort of thing.

So it's best to have a compass that you can actually adjust and those two models that I showed you, you can do. There is many others that do that but that's something to ask when you go buy a compass you need to say can I adjust the declination? Because you want to be able to do that. Now go on back to the map then for a moment. So you have magnetic north over here that's because here in the west this is always going to be off to the east. You could if you were in New England where it would be off to the left, to the west a little bit.

We also have one other thing called GN which is Grid North and that's not something that we really need to worry about, it's 1 degree and 47 minutes, almost 2 degrees there.

But Grid North is something that you and I aren't using in natural resource management and that's related to the state plane coordinate system.

What we are really interested in is that star which is true north. That's what the map margins are based on. Magnetic north so it's letting you know what that difference is. If we keep that in mind when we purchase or borrow a compass, that'll pay off. Understand declination, let's look up the slide, I just drew it here simply in the slide. Understand that true north is an astronomically, mathematically computed thing and that's what most mapping is based off of. Your compass is going to change depending on where you are and again I mention here in Arizona it's 11 degrees and it's 15 and a half degrees up there in Nevada and as you go further north and west it becomes drastically significant.




So you have the MN which is magnetic north and you have the GN which is grid north. You always want to take a look at that. The angular differences will always be shown in that little diagram just to the left of the scale. You want to take a look at that especially if you are in an area, let's say you work fire or law enforcement and you have been sent to a state away for some crisis project or a fire that you're working on, you need to be aware that the declination may have changed quite a bit. If you have a compass that can adjust the declination and you have learned how to do that then you can change that from where you're working. That means then you can read directly. The needle may still point magnetic but the dial around the outside is going to read the true north, or astronomic north. That's what you want to make sure of.

Let me conclude this discussion. We're going to go and look at doing this on the map next. But when it comes to compasses on the field and that sort of thing, I mentioned earlier to go out and practice. If you are in doubt about how to adjust declination and how to use these things, I strongly recommend you find someone in your office or somebody you know or a relative or something that has been in surveying or engineering or mapping. Essentially those types of professions because that's who knows about that sort of thing. Ask them to help you to do that.

If you are always working in the same relative geographic area then you can set that declination once and you're good unless the Earth's poles reverse or some cataclysmic thing takes place. So you'll always be good. But you need to understand that and make sure of that. So you want to know that when you buy it but I'm suggesting some help so you know how to use it, how to set it, how to adjust it so if you do go to a different area.  Make sure you got it down so that way you can use those tools with confidence in the field.

The next thing we are going to do is go over and take a look at how to measure angles, direction on the map itself and that will be using the protractor so I'll see you over there in that unit.

## Lesson 1 Map Reading & Interpretation, Part 7

### Hands On

So now that we have looked at directions and distance for that matter and using it, understanding the measurement systems, the units and how we relate bearings or azimuths, that sort of thing. Now what we want to do is start using that on the map itself. Now before we do that we have to look at one of the tools that we mentioned earlier in the course that you need to have and that is the protractor. There are actually several things called protractors out there in the world, we are not talking about the one with a pencil in one end and a pinpoint in the other although those can do similar work. But we are talking about a protractor that actually has angles and degrees on it and we showed you one earlier in the course. So we'll go to the overhead over here and take a quick tour of the protractor.

A protractor, regardless of its design does the same thing. There are some that are far more complicated than this or full circled ones and they're all nice. But there is a couple of basic things we want to know. First of all, you can see that we have the numbering that we are used to, let's assume north is straight up, 0 here and then here's our angles and our degrees, 10,20,30,40 and of course we have tick marks and we'll zoom in later for that. All the way over to 90.

If you notice, these are bearing here, 80 up to 90 and then it switches and goes back down to 0 whereas you can go from 0 to 90 here and keep going if you are working with azimuths. So they have thought of both of those possibilities with most protractors. If not it's just some simple math to figure it out. So we have that information and of course to go in the completely opposite direction going this way but on the same line going that way is 180 degrees.

So what's very important with any protractor is to realize that this 0 tick mark as well as this 0 tick mark are in alignment with this edge. And more importantly, are in alignment with that edge where it meets this tick mark. This tick mark in the center is the radius point of the arc or the circle that's out here, Ok both of these circles.

It's the radius point of those and it's also called an index or a 0 point or a focal point and whatever they call it, doesn't matter, just understand that its purpose is to be aligned with those zeroes so we can determine a line. Say we have a line right here that is due north then we can put this on that line. And then we can read our angle of our aligns that are going out from here as long as our focal point is at the point of intersection of those lines.

Let me draw you just a simple example. I'll move that aside for a moment. I'm going to draw a line and say that that line is due north and south. Here is a point that we are interested in. At that point, there is a line that goes off in that direction. We want to know the bearing of this line and the reason we want to know the bearing of that line is because we are doing some mapping or something out there on the ground that we need to know the direction of that line. That point could be where you are standing at a point on the map that you can find and you're looking at that hazmat site or whatever out over that way. In order to do this we would take the protractor, we're going to line up the zero and all of this alignment on that line. But we're also going to move this tick mark until it is at the point we are at.

So I line up the tick mark and I'm going to zoom in just a little bit to make sure that you can see that. The two lines intersect there and my tick mark on that side has to be there and at the same time this line on the compass has to be aligned with the due north/south line that I have. So once I have done that, then I can come over here and read the bearing. So if that's north, that way, then this is going to be northeast using bearings. My bearing is going to be north 40 and a half degrees or 40 degrees and 30 minutes, do you see that? Because I am a little bit right of the 40, you may not be able to see it there but I suppose if I focused that in even more you could, sure. Notice that there are degree symbols on here but there are also little half tick marks in there. Those are half degrees.

On this one I am right on that half degree tick mark. What I am as I'm 40 degrees and 30 minutes east of north so my bearing would be north 40 degrees, 30 minutes east. If it is an azimuth of course it's just an azimuth of 40 degrees, 30 minutes. Since we are in the northeast quadrant it's the same as the bearing only referenced different by calling it an azimuth. That is the process that we use with protractors. We'll have several opportunities to do that and looking at the map itself.

What I'm going to do is give us three scenarios and we're going to do them. You're going to do them with me on the map. Now one of the things that we want to remember though, is that I drew a line here and just said it was north. You have to know where north is at any time on the map in order to be able to draw on it correctly. Because if you have north rotated somewhere then that is not going to work. It's going to throw your bearings off. Everything will be rotated based on how much you were off. So it's best to know where north is and let's think for a moment.

Do we know anything on that map that tells us where north is? Now one you might think of is the north arrow down at the bottom. That's true but that's a little short line and you would have some trouble and some inaccuracies projecting that up into the map. So what we are going to do is use the margins of the map. The left margin and the right margin of the map are due north. The reason we know that is because remember this is a quadrangle, a seven and a half minute quadrangle. It is a perfect postage stamp of certain latitude and longitude that don't change on the edges. Those east and west edges of the map are true north. So what we have to do is be able to bring those lines in, bring something in parallel in order to be able to do that. Let's take a look at the overhead and see how that works.

Here we are on our favorite or at least current quad sheet, or quadrangle map, the Carson City map. What I want to know is what is the bearing? If I am standing at the premier mine, what is the bearing to the water tank? I know it's off to the northeast and I can kind of tell by just standing there but I want to know what that is. Now I've got the map zoomed out somewhat so you can kind of get your area right. Carson City over here and the premier mine is in this area here. We have several things that we want to learn here.

First of all let me zoom in for you on the premier mine. Now, as with many things, it is uncertain, we have several mines here. These are all symbols of tunnels that are going into the ground. They have the name over here off to the right so I'm going to assume it's that one but I could be wrong. If I was actually standing over here on the ground I could actually look for these others and see which one I'm at. So let's assume that the one that I am at is this opening here. That's where I'm standing. I know that because I'm standing there on the ground but I have this map and I want to know the bearing over to this water tank. So what I'm interested in is the line between those two, the bearing.

First thing I'm going to do is draw that line. I'm going to go from the premier mine and I'm also going to go to the center of the water tank. When you have a generic sort of assemble that covers more than just a dot, you'll want to go to the center of it unless somebody tells you otherwise. I'm lining this up as best as I can. I'm going to draw a line and extend it past them because the protractor is that large. So now I have drawn the line that I want to know the bearing of. Now here is the problem as we just mentioned, I need to know where due north/south is. You need to be very, very cautious. Some people assume that the section lines are north/south. They were supposed to be but these surveys were done back in the 1800s and the surveyors didn't get them very precise at times so you don't want to take that risk. So do not rely on those other than just as a general thing. There's all sorts of them and you could start measuring between them.

Let me just slide over to where you can see another one. You have one on one side of the Premier Mine and another over here. They're probably not parallel to each other. So you want to be cautious with assuming those. So what we really want to do is bring in something from the margin because as I said the margin is the best place, is what we know to be true north. Now what I'm going to do is slide this over and zoom out so that the Premier Mine is showing as well as the margin of the map.

What I'm going to do is take my '20 scale and I'm going to actually measure the distance. There is actually 3 or 4 different ways that you can determine north out here. This one is the simplest because it works for the particular thing you were working on. What I am going to do is measure the distance with the '20 scale from the Premier Mine and I'm going to keep this scale as close to east/west as I can because you can warp it as this becomes a longer distance. You want to keep it just as straight as you can or just due east/west, as you can. Just guessing that, but that is close enough.

I am going to read and I know you may not be able to read it but I can read that that is 18,200 feet. Now what I'm going to do is move down a little ways and measure over that exact same distance, 18,200 feet. I'm going to mark that place there. Now as you may recall by definition, if you have two points that are of equal distance from a line then those two points are creating a line that is parallel to the other line.

So you see I know that the line over here on the margin is due north, so I now come over to 18,200 feet because that's how far the Premier Mine was from that margin. I now have two points where if I scribe a line between them, and I'll go out a little bit. I now have a south line. Very, very simple to do that and again this method allows you to do it specifically for your project at hand.

Now if this line is due north/south, and this is the line I'm interested in and that I'm looking down at the water tank, I can take my protractor. Now remember, the protractor, I want to put the index point, this point here, I want to put it right at the intersection of those lines. I want to have the north/south line aligned with the 0 here and the 0 down here and along this edge of the scale. Is that right? Does that make sense? So I'll double check. I think I moved it a little bit. Those are the kind of things that happen. The tick mark is there and this is a line on the zero. So now I can look over here and I can read 50 degrees, 51, 52, and it's about half way between 52 and 52 and a half. I can read that angle so I might call that north 52 degrees and I could call it 0 or call it 30 but it's about half way in between. So I think I would call it 15 minutes because there is 60 minutes in a degree so half of a degree is 30 minutes and a fourth of a degree therefore would be half of that. 30 divided by 2 is 15. So I can say I'm at north 52 degrees and 15 minutes east. That's my bearing from the Premier Mine to the Water Tank.

Now I have measured that with the protractor. Now I could do that with a compass out there too. You might be wondering why would I do this? Let's make up a scenario. Let's say I'm at the Premier Mine and I don't know where, I have a compass with me, let's say that. I look and I can see that the water tank if over there. What I am measuring though is the fact that maybe there I something between me and the water tank or there is something over here, maybe this house is on fire. This little house right here. So I checked my bearing to that and I also shot with the compass that line from the premier mine where I'm standing, to the house that's on fire. What I did by shooting the water tank is I gave myself a check. I read my compass to the house that is burning but I want to make sure I got it right. So I read my compass to another item and then I can plot it on the map and oh yeah, my compass reads 52 degrees northeast. I'm Ok, I'm Ok. I can double check this here. Let's do this now.

I'm going to put the tick mark at the exact same place on that line. I'm going to align the 0, this alignment here. Then I'm going to look at the line which I didn't draw quite long enough there. It hits there, that's 71, 72 degrees. North 72 degrees East is my bearing over to that house that I see that's burning. Now that's essentially how you do this and how you use a protractor and how it will work for you.

I introduced another subject there if you will and that is double-checking yourself. Don't just stand there and take one compass reading to something. Take one to another thing that you can see it's just a check to make sure that your compass was working right and that you had the declination right. That sort of thing and you'll be able to catch that when you do these sort of things and check them on the map.

Now let's do another one. This time I want to use that same water tank. I want to get a bearing to that water tank but I am at a rest area that's over on Highway 395, Right on the south edge of Carson City. Now if you go back to the map, here's my water tank that I'm interested in right there. Here is the rest area that I'm interested in. So what's the first thing I am going to do?

I'm going to scribe a line from the rest area over to the water tank. Now the rest area is a little loop in the road. You see that, you've got your real map in front of you. You can be looking at that too. It's on the south edge of Carson City.

I'm just going to use the center of it as my point and I'm going to scribe a line from it to the water tank. I will zoom back out here in a second or zoom over there. But I am going to scribe that line. Now once again I have to know where north is, right. This time where I'm standing I am at the rest area. So what am I going to do? I'm going to go to the margin of the map and measure that distance. I'm out at the center of that. So from there to the margin of the map I'm right at 4,500 feet. So then I'm going to come up here a little ways and I'm going to get on 4,500 feet. I'm going to mark that. Then I am going to scribe that line from there through the rest area, you can see that highway is pretty close to north/south.

Now I have a north/south meridian or reference line from which to work. I can then take the compass. Once again, place it and make sure that this is aligned with the line that I have drawn and that the index mark, which I know is kind of hard to see there, is at that rest area. Now what do I need to do here? I need to turn this around because my bearing is the other way. Right? It's only logic.

So what I am going to do is turn it around to show that it works over here too. I am going to take the tick mark and put it at the rest area. I am going to align this to make sure that I have it right. A line on my north reference line. And now I am going northwest this time now aren't I?

Going northwest. So 0 is here and I come down to here and I got 60, 65, 65, 30. 65 degrees. So I am North, 65 degrees, 30 minutes West. Alright, north 65, 30 west. Now something that you may figure out if not somebody tells you or I will tell you now. You may have already figured it out but recognize the way bearings work. I was standing at the rest area looking at the water tank so I had a North 65 West reference. If I were at the water tank looking back at the rest area I would be South 65 East. It is the same number but the quadrant is reversed. Does that make sense? That is true in boundary descriptions and that sort of thing.

The bearing is simply reversed to a different quadrant, same numbers if you are going in the other direction on the same line. Let's take a look at the slide here. You will recall this from earlier discussion, right? This is north 30 degrees west here, because that is a 30 degree angle there. But if I happen to be standing out on this end of it and looking that way, Ok? So I'm looking, I'm standing here but I'm looking to the radius point. My bearing and my reading on the compass is going to be south 30 degrees east. So that makes that simple to think about but it is also something to remember.

It is one of the more common errors by people using a compass in the field. Is to either look at the compass backwards or just not pay attention. Kind of like when I put the protractor on there well I had it upside down or I had it reversed I needed to turn it around because I was going northwest. I could have measured that to the southeast and got the same number but I would have been reading the wrong quadrant.

I would have to really be paying attention because I would actually be going northwest. And you might think well they're in the city that's probably obvious, that water tank is northwest to me, but when you're out in the woods or out in the desert and you don't have a lot of clear reference things out there for you to look at but you are trying to get bearings or azimuths in between you and something else.

It can get complicated because you are not quite sure which way you looked especially if you are writing it down in a book or something, you know on a sheet of paper or a notepad and then you don't get to look at it for another couple of weeks cause other things have come along and now you are going to try to figure out, well it says it's northwest but was it northwest? It does not look right when I draw it. So just pay close attention to the direction. I always just double check. I always think well that's north, northwest, Ok just make sure that I am thinking clearly of what I write down is the correct information.

Now we have one more that we are going to do on the map so let's go back over there and take a look at that. I am going to flip the map over and have us a new area to go to. This example is going to be up in the northeast portion of your map that you have. And what I am going to do is assume I'm standing at the Lakeview Interchange, so that's this US395 which is apparently a freeway here and it meets a road that goes off along the side of Washoe Lake. And there is an interchange here as you can see, I'm going to assume I'm standing, so I'm going to pick the center, I want to stand on the center of the bridge, don't get hit by traffic, center of the bridge there Ok so that's where I'm going to be measuring from. And what I'm going to do, I can see a radio tower off to the east and I want to get a bearing to it.

Off to the east I see a radio tower so I look over in east and sure enough here is Sugarloaf, the name of this mountain, that says radio facility and there is a little dot there. So there is probably a little building or a set of antennas or something like that that is located there. And I want to get the bearing to that.

In this case we are going to get the distance to it also. First thing I am going to do is go from my center of the freeway interchange, and I'm going to go to the center of that little box that's on there it must be the building or the antenna itself which is probably what I'm seeing. And I am going to draw that line. And now while I'm here I guess I should get the right scale. I'm going to use the 20's scale and I'm going to put it on there and on there and I'm going to see that that is 10,000 to the box, 10,700 feet between these two. And now I want to know the bearing to Sugarloaf Mountain. What is it that I have to do next? I have to get a north line through the Lakeview Interchange.

So I am going to go out to the margin of the map and I am going to measure that. The Lakeview Interchange over to the margin of the map keeping my scale pretty close to due east/west. I am measuring 15,950 feet. And so I am going to come up here just a little ways and I'm going to put the scale right on 15,950 feet, keeping it east and west as best as I can. And I am going to put a tick mark at 0.

I'm then going to take a straightedge, a scale always works good for that. I am going to scribe that line through my tick mark I just made and through the Lakeview Interchange. I'm then going to take the protractor and I'm going to set it here and remember my focal point must be at the point where these two lines intersect. I do that. I put it right there. I align my protractor then to get it on the zeroes on the north/south line that I have drawn. That is my reference line. I can now read the bearing of the line over to Sugarloaf. I want to get right in so we can see it. I am slightly above or north of the 90 so I am at a northeast.

You can recognize how you might goof up real easy when you're at north 89 east vs. south 89 east, those are very close to each other. You always want to pay attention to which way you are to both the meridians as well as the east/west line. So here I'm north of it so it's going to be a northeast and as I count my numbers down, 60, 70, 80, 85, 86, 87, 88 and a half, even closer to the 89 but we'll call it 88 and a half. So what I have is a bearing from the Lakeview Interchange over to the radio facility. I now know that it is north 88 degrees and 30 minutes, that is what I'm calling it.

You could almost call it 45 minutes, couldn't you? And sometimes you know you are playing games with numbers like that to be able to figure those things and kind of interpolate that, kind of playing games. But it doesn't hurt especially if it is a real long distance away, 15 minutes or so, it depends on how careful you have drawn and all of that but 15 minutes can make a bit of difference from where it is.

Now let me give you a real application here. We will show you more about how to do this later but you might be wondering well, if I can read it with my compass, then why do I need to plot it on the map? Well because what we go into in a later lesson is what if the thing you are looking at is not on the map? We are using items on the map to learn how to do this but what if the thing I'm looking at, you know we didn't map the Hazmat site, you know it existed prior to whenever this map, '74 or whenever it was photo revised. Or we didn't map the RV that is the Meth lab that got there last week. You are mapping it.

You are the first one to map it and so what you have to do, you have to go to something that you know where you are on the map, get a bearing to it. Again using the Meth lab you don't want to go over there and get a distance to it. But there are ways to get 2 or 3 bearings from places you know into the same thing and we can compute where it is you can plot where it is on the map without ever going there but by looking at it from a distance.

So that's why it's important to learn how to do this on the map because what we're really training you to do is to be able to identify something on the ground that is not on the map and relate it correctly and accurately to the map, on the map, in the right place.

So that is a discussion on how to use the protractor and you can see how it is your paper version if you will of the compass which is your field version of angle measuring device or bearing measuring device and also you can see that we talked about early that pacing or the odometer or a tape of some kind to measure something on the ground. And you can see that that is your field version of the scale.

And this is the paper version or map version of it but they work hand in hand. And what you have to know when you are dealing with distance, you have to know is the map scale correctly and what is the scale and with direction where is north? Which we showed you how to bring the margins in very simply.

Bring the margins in to figure out where those are and then to scribe a line that is due north and south so that you can put the protractor on it and do the same thing that the compass is doing in the field. So those are great skills and we are going to take them one step further and we'll do some more plotting on the maps here in the next subunit here of this course.

## Exercise 4 Direction

**Scenario:**

We have been dropped on C-Hill outside of Carson City by helicopter as part of a fitness training exercise and left with only a compass, map, pencil, and protractor scale. We are told that we have to be at the Premier Mine in 2 hours if we want to be picked up for a ride back to the office. We have to find it and be sure we arrive at the pickup point. To test our skills and to be sure we know what we are doing, find the following:

1. What is the declination you need to have your compass set at?
2. What is the bearing from C-Hill in the southeast central part of the Carson City quadrangle to the Premier Mine?
3. What is the bearing from the Premier Mine to C-Hill?
4. What is the bearing from C-Hill to the center of the athletic field in the western part of Carson City, NV?
5. What is the bearing from the athletic field in Carson City to C-Hill?
6. We pull out our compass to take a bearing along the line to the Premier Mine. Someone has switched compasses with us, and the compass we now have is an azimuth compass. We will have to determine the azimuth so we can read the compass directly for the bearing to the mine. What is the azimuth from C-Hill to the Premier Mine?

## Exercise 4 Direction – Answer Key

---

**Scenario:**

We have been dropped on C-Hill outside of Carson City by helicopter as part of a fitness training exercise and left with only a compass, map, pencil, and protractor scale. We are told that we have to be at the Premier Mine in 2 hours if we want to be picked up for a ride back to the office. We have to find it and be sure we arrive at the pickup point. To test our skills and to be sure we know what we are doing, find the following:

---

1. What is the declination you need to have your compass set at?
   **15 ½ degrees to the east**

2. What is the bearing from C-Hill in the southeast central part of the Carson City quadrangle to the Premier Mine?
   **N 83 W**

3. What is the bearing from the Premier Mine to C-Hill?
   **S 83 E**

4. What is the bearing from C-Hill to the center of the athletic field in the western part of Carson City, NV?
   **N 43 E**

5. What is the bearing from the athletic field in Carson City to C-Hill?
   **S 43 W**

6. We pull out our compass to take a bearing along line to the Premier Mine. Someone has switched compasses with us, and the compass we now have is an azimuth compass. We will have to determine the azimuth so we can read the compass directly for the direction to the mine. What is the azimuth from C-Hill to the Premier Mine?
   **277 degrees**

# Lesson 1 Map Reading & Interpretation, Part 8

## Map Coordinates

Now we want to talk about now about map coordinates and what we have done so far is look at you know the symbology that is used on maps and some of the information that is there and we have also spoken about how to measure bearings, how to measure azimuths, and how to measure distance, scale, all of those things.

Now we are going to understand more about the coordinate systems that maps use and therefore GPS uses. And being able to start relating those things to one another. I have had people in BLM as well as other agencies ask me well you know "My GPS reads in latitude and longitude and I don't really understand what that is, can't it just tell me what section I'm in or township?" They want to know the PLSS system.

You know there is no software really for that and in many cases there is a lot of plusses and minuses out there and we don't know where everything is until we have gone out and surveyed it rather accurately. Those original surveys, while some of them are amazingly good, some of them are not and sometimes the section lines are running differently then we think. So we don't know in most cases and there isn't software that will just do that. And you can, if you have played with Google Earth, there are routines where you can bring in the Public Land System and overlay it. But even that is subject to a lot of estimates and some parts of the country are off 2, 3, 400 feet. So you want to be very, very careful in doing that and I'll just say this as a surveyor to anyone using a map or a GPS.

You know if the thing you're talking about or the object you are worried about or the incident or situation, if you are trying to decide who's land it's on, if you're anywhere close and I would say within 3-400 feet of a property line don't rely on your GPS or your mapping software or a GIS is the same way; a Geographic Information System. They are just built on whatever record data and measured data the GIS people had to come up with and many of that they just scanned it, and got a coordinate like we're about to do, off of the map.

So it's not that precise, so you really want to be cautious. I know situations where federal agencies have cited people for trespassing when they didn't even have a survey done. And the darn thing was so close to the property line, that even as a surveyor I wouldn't say where it is I need to actually get the instruments out and run it. I know places where, I know one in particular where the Forest Service had a guy saw off the back of his deck on his cabin and they told him it was trespassing and they were using a dog-on compass, looking down that line. Any metal in the area could draw it over a little bit, just a little bit.

So they made this guy do one and when the survey was done his deck wasn't across the line. So that's my point. You got an oil well and you're trying to decide is it on that land or is it on private land or BLM land. And if it's anywhere near a boundary then you need to step back and not take any official action. You need to get someone else out there.

Unless you can see from monument to monument, which you can in some parts of the country. But even then you want to be careful and I don't want to go too far off here. We are going to talk about Public Lands in this unit and recognize that even in the Public Lands System you find a monument, you know a brass cap and it's marked a certain way and you say Ok, that's the section corner. But you don't know, you haven't been trained that it could on the corner have a little WC which means it's a Witness Corner. That means it is not at the true point.

It's witnessing where the true point is. I have known people who have made that mistake too. They have found two monuments in a relatively flat brush free area. They can see, they have one of the people on the crew stand down on that one and I'll stand on this one. His fence is five feet over on us, let's trespass him.

You need to get some advice from a surveyor in BLM that is cadastral survey. Because we may be able to just look at the record and be able to tell you hey, that one corner is a witness corner or it is a closing corner or it's some of these other types that don't occupy the true point and you don't want to make a decision off of that. So that's why I say generically you want to be very, very cautious.

You can have a GPS unit that reads lat and long out to the billionth of a second, I'm being somewhat facetious here. Incredibly precise reading but your GPS unit cannot get it within several feet no matter how well it reads. So, what you have got to do is make sure that if you are within a few hundred feet of a line or a decision making factor like that, that you get something better than that.

Because your GPS unit reads in lat and long and I'm about to show you how to put lat and long onto a map or take it off the map so you can put it into your GPS unit if you have one where you can enter in what coordinates you want to go to and then it tells you to go this way, this way. It's going to tell you direct line of site if you will to the point but you have got to be careful with that technology because it can't tell you the status of the land.

It can't tell you who owns it and when you get down close to it, it is not accurate enough. There are so many other anomalies in how we monument stuff as surveyors, how things are marked, what really is out there. You just don't want to take that chance. The federal government has goofed up an awful lot of stuff over the years because of those misunderstandings. Bottom line, get the right people looking at your situation and if it's a surveying boundary position related, the right people are surveyors. Once you know where the line is but you are trying to figure out the status of the land, well then land s and realty people can help you with that.

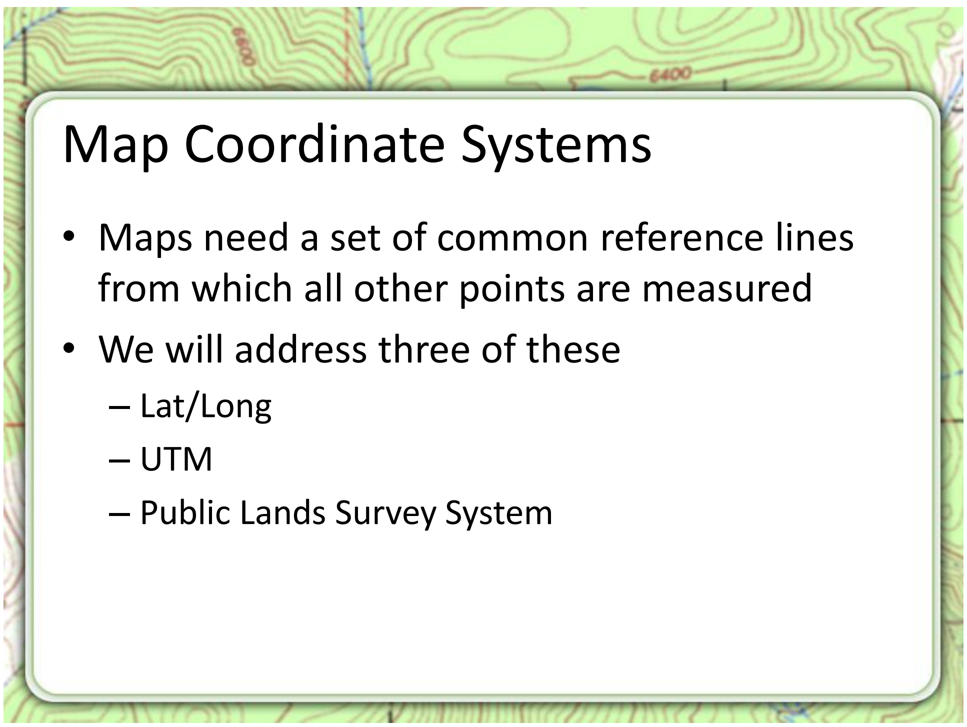
Get the right experts on for that part of your project or your question before you take official action that is for sure. So with all of that, that's kind of a caveat to what we are about to discuss, map coordinate systems. Recognizing that coordinates, what's the old saying? Garbage in, garbage out. Map coordinates, it depends how they were gathered and how accurate they are. Your GPS unit handheld that you have, it gets a coordinate just off of one set of signals from the satellite.

Recognize that if you were to be standing at the same place an hour from now and take that position again you will get a different answer. The reason for that is because the geometry of the satellites has changed. There maybe more precise because angles, strength of angles we call strength of figure. Real shallow angles or real almost straight angles are not very accurate to do positioning with.

The geometry of the satellites is changing constantly so you might be surprised you would get several different answers like if you took a position at the exact same place once every hour for eight hours. Now frankly, if you did that in most cases you could mean that, and probably have a much better position. Who has time to sit there for eight hours at one place? And then you got to go do that at the next point even if you're doing one line with two corners on it. It would take you two days to do it.

So it is not practical and the instruments that surveyors use are much more precise for that. So recognize that the source of your coordinates it could just be somebody scaling something off of a map, it could be from a digital document like a geographic information system. Which is simply a digital map. It has the same inaccuracies as the map does.

As I show you these this is how we relate things you know if I want to call in on the radio and say there is a fire and here is where it is at, this is its location. I need to be able to relate to you in a coordinate system that you also understand.




Now there are dozens and dozens of coordinate systems but if we look at the slide here, maps have to have a set of common reference lines from which all of the other points are measured. You have to know how things relate and so we are going to address these three: latitude and longitude, UTM which is Universal Transverse Mercator system, and then the Public Lands Survey System which is not a true coordinate system but it's a very handy system of reference to figure out where things are so those are the three coordinate systems that we are going to address in this lesson here or this sub lesson I guess or unit.

Let's remember something that we want to review a little bit. It's been a couple of hours in this course since we've talked about it. So a little bit of review about latitude and longitude. Take a look at this slide.

Remember here is our globe and remember that we have a principal meridian that is running through Greenwich, England and that's zero. We measure all of our longitudinal lines from that based on the axis of the Earth. Out here in the United States we are somewhere way over in here. We're in the 100 degrees or so West. If you take a look at and while you're looking at this diagram just take a quick look at the quad sheet that we're using, the south/west corner say of the Carson City, Nevada is at 119 degrees, 52 minutes, 30 seconds West.

So it's almost at 120 degrees West. And then the northing on it is at 39 degrees or 7 minutes, 30 seconds, that's the latitude. Remember that latitude 0 is the equator and we have latitudinal lines. That one was almost 40 degrees so the Carson City, Nevada quad is about here. On that globe. And that is a common reference system. Latitude and longitude.

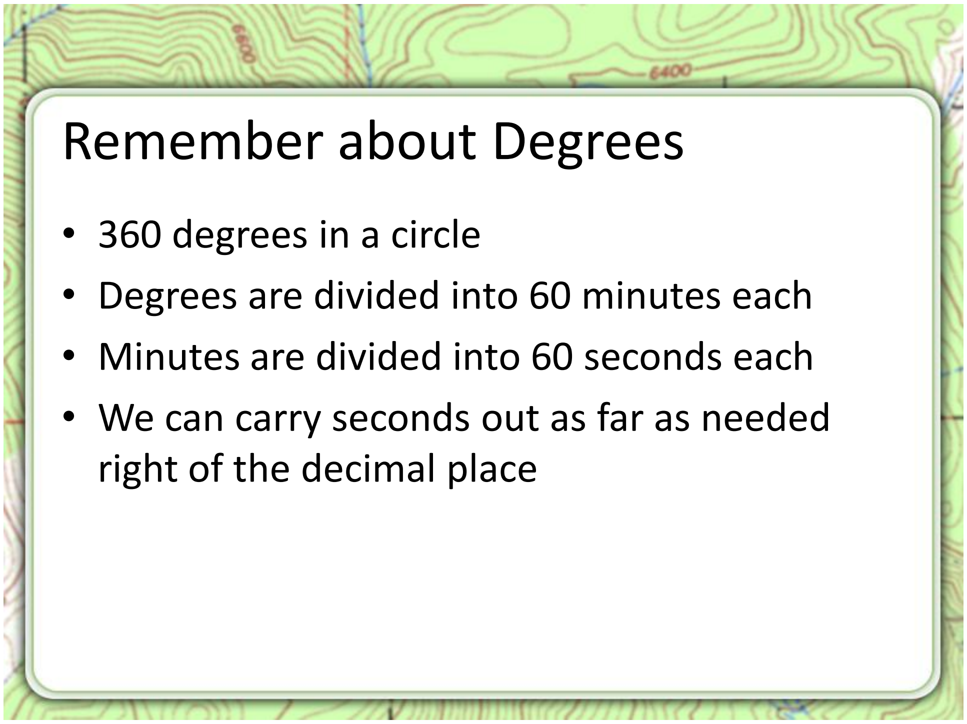
A system that has been around a long time and as I mentioned in the beginning of the course where we talked a little bit about the history of some of these things. It's a system that has served us well. It has some anomalies to it, there are things that aren't real simple and consistent.

We all wish the world was set up on a grid, a true grid where everything is just 90 degrees to each other. But that's impossible because the Earth is round. In fact, it's not even round, it's a sphere and so there are anomalies to all of these things. But the latitude and longitude system is something that has worked very well for both sailors and other navigators and those guys that are trying to get to the North Pole back, Admiral Perry and people like that. Well they were using star shots and other things to try to get to the North Pole. A magnetic compass wasn't working to get to the North Pole because the magnetic North Pole is a few thousand miles from the true North Poles.

It's always been used and so when the military designed the GPS system, they invented a slightly different system but it's close enough to what everyone else has always used. That is what we call WGS84. It's a reference datum and I'll talk about datums here in a few minutes. But it is a system that the GPS units are on. That's what they are broadcasting and those satellites are several thousand miles out in space. They're all in polar orbits. But in different planes.

They are constantly broadcasting where they think they are, what their projected orbit is going to be. That is because the military studies, they upload every 12 hours, they tell the satellites, based on what you have done the past 12 hours pulling the Earth, this is what we predict you'll be doing for the next 12 hours. They broadcast that information, in fact each satellite broadcasts all the information for all of the other satellites so that your receiver can know what satellites to look for and which ones they should be expecting to hear.

I'm not going to go into great complication with that but what it is doing is giving orbital data based on latitude and longitude. When your receiver gets 3 or 4 or 5, the more the better as far as geometry is concerned for precision. But when it gets all of that data, your receiver is taking that information and computing where it is based on where the satellite said they were at the moment that they were broadcasting that. That's in a real simplistic nutshell.




Now, I also want to remind you as we've done two or three times, that in a circle or a 360 degrees, remember that degrees are divided into 60 minutes each. Each of those minutes can be divided into 60 seconds and in fact you can carry the seconds out as far as you want to the right of the decimals. As I mentioned, garbage in and garbage out. Most of the time when you see things that are carried out to the decimal seconds, it's not that precise. That's just the way they are reporting it, it's not truly that precise.

So let's talk about latitude and longitude first. On the slide, you see the southwestern part of the topographic map that we are using, the Carson City quad. I've just highlighted a little bit in red and I'm going to put the arrows here.

Oops, that's not an arrow, just a second. I want you to look on your map and see those same places. What we have are information about latitude and longitude. For instance, let me erase these and start again.

## Lesson 1 Map Reading & Interpretation, Part 9

In the southwest corner, I'm going to talk about latitude first. Down here in the southwest corner, notice that the latitude is this number over here on the left. 39°07'30", all right. And then as you go up this map, if the next place you see one of those references in that same font and that same kind of a number is there, and that says 10 minutes. Now what that means folks is that down here in the lower left of the map is 390730 and you have gone two and a half minutes of latitude to get there. Because 390730 plus two and half which would be 2 minutes, 30 seconds, is ten minutes. So this is 39, this point here is 39 degrees, 10 minutes. As you go on up the left side of the map you will see that every two and a half minutes is marked with a tick mark and a reference number in that font. All right. That is how you know where the latitude, those are your reference lines for latitude. And similarly, we have the same thing for longitude down here in the southwest corner.

We have 119°52'30", now we have to remember that is a West longitude and so as we move to the right we are going east, that means it's going to get smaller. When you get over to here, you see that it says 50 minutes, 00 seconds. So what we know there is that if this is 1195230 and this is 50 seconds on the right then what we've done is we have traveled 2 and half minutes again, Ok 2 and a half minutes. This point is 119 degrees and 50 minutes and you notice that there is a tick mark there as well. That's how we know where the references are. It's not just on the margins, we know that the margins are at the specific points but now you see that every 2 and half minutes is tick marked in the map or on the maps, sorry. So you know right where you are.

Let's take a look at that one more time real closely and see what I'm talking about. 1195230, you go to the right and see the black arrow, that's 50 minutes. As you continue right you will continue to see that there are every 2 and a half minutes tick marks that show you where those are. Now the beauty of this is, remember how we were drawing north/south lines earlier? and I didn't show you east/west lines but we could have done that. Well take a look at this slide. What I'm doing here, the black line near the top of your screen, I just connected the tick mark at 10 minutes and the tick mark that was just out in the space out here. But see what I do is I look at this tick mark there and then I come over to the margin and I see oh, that's 10 minutes. So what I've done is drawn the black line, the black line is drawn at 39 degrees and ten minutes north of latitude and that line is that latitude all the way across there. So if you will that's a due east/west line.

Because now what I'm seeing is I don't have to just measure the distance to the margins, all I need to do is really connect the lines between the correct tick marks and notice I say correct tick marks because there are additional tick marks here and you're going to learn more about those as we go along.

So back to the slide again, you see the red line going up there, that is simply a straight line drawn from 50 minutes and to that tick mark which is also 50 minutes so I know that that red line is a true north/south line. It is consistently with the longitude of 119 degrees and 50 minutes. And that provides us with another way to get north in an area where we are working on a map. It shows you that you can further carve the map down, not just seven and a half minutes of longitude and latitude but you can get it down to 2 and a half minute squares or rectangles I should say, of latitude. Which is a great tool in order to start identifying the longitude and latitude of things in particular that you want to figure out.

Let's say, go back to the screen for a minute, let's say that you have found a fire right there. Right there. Well how am I going to tell somebody, there is nothing on the map as far as, well it's kind of over there you know what are you going to say? No, give them a specific latitude and longitude. Once and maybe you're not at the fire. You're down here on the road, Ok. So but you can see that fire up there as we are going to show you ways to determine that position. But once you know that position even if you could go there, you get your GPS out if you have one and get latitude and longitude then you need to call it in. Now, what we want to do is if you are on the road down here and you call this in, you want to figure out well what's the best way for me to get there? Up this road or up this creek or what?

We'll talk about that stuff here in a little bit. But our point here is we are going to learn how to scale on the map to get the longitude and latitude of anything out here for a number of things. We can get those longitudes and latitudes very simply. I could go out there on the ground and be actually standing at something that I can see on the map. Maybe it's just one of those X's that we saw earlier that are indicative of a mine. It doesn't have a name and you know. Who knows where it is. I know I'm standing at that mind but it's really difficult. Well it's the little X that's kind of southwest of the other 4 X's and no.

Let's scale on the map the latitude and longitude so we can call it in. It'll be close enough that a helicopter comes in, he'll see the smoke. Or a crew drives up and they are looking for a car that has gone off the cliff. Well they can drive up and they are going to get within a hundred feet or so. They can get out and look and they will see it. So that's our goal here is to be able to plot latitude and longitude on the map to determine things or to do it vice versa. You have a lat and long that someone has called in and you want to plot it on the map to figure out how to do that so that's where we are going to go with this next discussion here. Now we want to pause. I have mentioned this term earlier.

## Datums

We want to talk about datum's and you know this is where people, I was just talking about maps and they go off into this thing that is complicated. Well I don't want to make it real complicated for you and I am going to give you a couple of basic things here about datum's. A datum is a coordinate system. It's how they define mathematically define a coordinate system. It's where they say the equator is. How they say the shape of the Earth is. All sorts of things that you and I don't even want to get into. But as you notice here, USGS quads are drawn using NAD which is any North American Datum's.

There are different Datum's for all over the world. I think there are 120 or so. The North American Datum 1927 coordinates. So the edges of the map are on the latitude and longitude 7 1/2 minute quad. They are on those coordinates based on the NAD 1927. Now in 1983 folks, the USGS, the Coastal Geodetic Survey, and other agencies did a major adjustment. And that's because GPS was coming on the scene, we started getting far better precision on many of our monuments out there in the field. They did a major adjustment. It is better, it is better. But understand that your map is still at the 1927. it would take a huge effort to redraw these maps to the '83.

We need to realize that in some parts of the country they have already done another adjustment since '83. So the USGS and others had decided that 1927 was the datum that they were going to stick with. That's good because now we are all on the same datum. But recognize that your GPS unit may have a choice when you set it up or you can toggle between 27 and 83 or maybe even others.

So you want to realize that that is the last point there on the slide. GPS units may use one or both. So make sure one is set for, which one the direction says it does. Because that is going to impact you. Now the 1983 grid or datum is on your map but it is off-set. It's off-set and so what they have done is shown it with dashed tick marks. You notice the tick marks that we looked at here before. Those were solid and that's because they are 1927. but if you take a look at this slide, you will see down near the lower left corners of the map again, the published coordinates here, 1195230 and 390730 those are the 1927 datum and they are for the exact corner of the map. If you look closely you will see a dashed tick mark right where this red circle is showing you. That is the NAD 1983 tick mark.

So what I can tell without doing anything, I can just look at this map as you are looking at it there and I can tell you that the shift between the 83 and the 27 was almost due east/west because that tick mark is almost exactly east of it isn't it. But there is about 2 or 300 feet shift there. It shows you that in this area and it is different in every part of the country because of how it was adjusted, but in this area 119 degrees, 52 minutes, and 30 seconds in the 1983 datum, is about 300 feet east of where it is in the 1927 datum. So what does that tell you? If you have got a GPS unit that only reads in one of the more up-to-date modern datum's then you are going to realize that Ok, I have to off-set everything by about that. The different of those tick marks because that's how much the numbering system if you will, the coordinate system shifted when they came up with the new datum. Now we don't want to make it any more complicated than that so we're not.

Let's just leave it at the fact that your map is at 1927 and if you have any way to choose what datum your GPS unit is working in then do that. Recognize that most maps were still sticking with the 1927 and even non-USGS. So that everything consistent of that way. But recognize that there are coordinate systems in particular latitude and longitude we're talking about now that have been adjusted to take out certain errors.

We can't afford, nor mess with changing all of the maps in the countries. So we just have left the mapping at that same standard. That's the bottom line. Make sure you understand it. If you want to know how much the datum shift is you can look on your map at least a couple of places where the tick marks will be dashed and that will give you an indication of how much that has changed.

If you got a GPS unit and all it does is read in 1983 then hey, you'll just know, when I get a lat/long off of this I am going to be in this example here on the Carson City map. I am going to be at 300 feet too far east. What I give them now that is close enough to see the smoke. But it may not be close enough to call in an accident. Especially if you are in the trees and people can't see very far from one spot to the other so just think about that. That's our discussion on datum's and that's what you need to be warned about.

Now what we are going to do next is go back over here to the map and we are going to do a little messing around with latitude and longitude. I'm going to show you how to scale that and determine that on there so let's go to the map once again and take a look at that.

We'll look again at the southwestern portion of your Carson City, Nevada quad sheet. I'm going to pick a place here that I want to determine the latitude and longitude for. So I'm going to pick a point out here in this area and I'll zoom in real quick for you to see where that is. I'm going to pick this little X and now this X is not a mining X but it is rather a spot elevation as we showed you and we are going to discuss a little more about elevations later. I'm on that hilltop and we will explain to you how we know we are on a hilltop later. But I want to get longitude and latitude for that.

Based on what we just saw, what can I do? I can first of all draw my reference lines on here. Remember, I have a tick mark down here that says 50 minutes and remember how I showed you that we have a tick mark above it that is also at 50 minutes and so if I scribe a line there that line is at 119 degrees and 50 minutes west, longitude. It's that same longitude all the way up and down. You will recall that if I come over to the left margin and go with the 10 minute tick mark that is there and I connect it to the tick mark, the same tick mark, and scribe a line there. I now have a line that is at exactly 39 degrees and 10 minutes north latitude.

So I now have reference lines that are really close and I know what the latitude is on this line and I know what the longitude is on this line and I know what the longitude is on this line and I know what the latitude is on this line. So I have control if you will, or reference that is accurate, as accurate as we can get it, all the way around my project area.

Now there is an interesting fact and let me just explain that for a minute. This is only true for latitude, longitude is quite different. Longitude you can imagine the amount of the distance that is in the longitude changes drastically because as it goes toward the north or south pole it is converging. The relationship between those lines is significantly different at different places on the Earth. But with latitude you are very, very close at all points on the Earth to one second of latitude equals 100 feet. One second of latitude equals 100 feet.

Now here in Arizona it is about 101 feet and it is probably about 102 or 103 there, but hey close enough right. My point is, one second of latitude is very, very close to 100 feet. So let's think about this. If that relationship is true, more or less, plus or minus just a little bit, then let's think about it. what I just drew on the map is a 2 and half minute by 2 and a half minute quadrangle. So if I know that it is 100 feet roughly in latitude, then I know that I should be able to put the 20 scale down here and the distance between the two latitudinal lines that I have should be very close to 15,000 feet. Now let's think why I know that.

It's 2 and a half minutes of latitude, right? How many seconds are in that? Ok well a minute is 60 seconds and I've got 2 minutes so that's 120 seconds and then I have got 30 seconds of latitude, right? So I have 2 and a half minutes. So I have 120 seconds plus half of a degree which is 30. so 120 plus 30 is 150 seconds. If there is 150 seconds in latitude then 100 feet times 100 feet is going to be 15,000 feet. Let's see if that is true.

Let's go back to the map. Using the '20 scale. I'm going to measure from the southwestern corner and I'm going to have to slide this down here some for you. I'll zoom in to where we are going. But if I put my zero on the southwest corner of the map and I come up here to the 10 second tick mark, notice that I am about 151, 152 and a half, somewhere in there, 153. See how close that is.

At the most I am going to be about 2 and a half seconds off. I can eliminate a portion of that by simply using the scale down to my point that I'm interested in from the closest side. Now, the point that we are going to is there. And so I'm almost right in the middle, I am a little closer to this one up here so I'm going to go from there. What I am going to do is I'm going to measure with the '20 scale from that line of latitude, south, I'm going to keep it relatively north/south to the point that I'm interested in. I'm reading 6,650 feet.

So now that I know that distance from the North, I'm just going to call it 6,600 so we stay out of the half second. I'm going to be able to do a little bit of simple math. There is a couple of ways to do it but one real simple way is to simply say well divide that by 100s since there is roughly 100 feet per second of latitude then that means it's 66 seconds and now we are south, right? We are south of the point of the line of reference ahead. So I am going to subtract it from 10 minutes. So if 10 minutes, it's actually 39 degrees 10 minutes but let's say 10 minutes I can convert that to seconds or I can convert, as you can see on the screen we are showing you that I'll just simply take the 10 minutes and 00 seconds and I'm going to subtract from it, 66 seconds. What that ends up giving me is 8 minutes and 54 seconds. 8 minutes, 54 seconds. So now I put my 39 in front of that and I have 39 degrees, 8 minutes, 54 seconds north of latitude at that point.

Just to prove how this works, let me turn the scale around and I'm now going to measure from the south line up. Up to that same point, I'm going to put my 0 on the south and come up to our little X here and I've got 85, 86, say 87. 87 seconds. Now as you can see on the screen let's take the 390730 which is the south line of this map and I'm going to add 87 seconds to it.

So I've turned the scale around and I'm going to measure this, I measured it and I had 8,700 feet so divide it by 100 that's 87 seconds. If I add this time, right I'm going to add because I'm measuring north from my reference latitude this time. I might reference latitude just 390730 so if I take 390730 and I add to it 87 seconds, I get 390857. Ok 390857 and I have 390854 when I measured the other way and that 2 or 3 seconds is floating in here because I didn't ratio this and scale it just exactly. Again, why is that?

Because we are using a one second equals 100 feet when that is not super precise it's more like 101 or 102. So if I did that and you actually got a calculator out you could compute this more accurately. But having done it this way where I have come up with and by the way, it is best to do this both ways so if you did your math wrong on one side you don't want to be a whole minute off or something like that.

Then you will catch it and what I have done, I have got 390854 from the north and 390857 from the south. I am about half way in between but I would just average those two. I would just mean those and tell the helicopter pilot or whoever I am calling whatever this into that the latitude is 390856 or 55 and half whatever. It probably doesn't read that close anyway. What you have done is narrow it down. By meaning that I have narrowed this down to about a 150 feet circle. Close enough for anything to be seen and that works very well.

Another way to do this math is to simply convert your minutes and seconds to seconds. For instance, for this computation I just did, I've got 52 minutes and 30 seconds. I could just take the two minutes and drop the 50. 2 minutes and 30 seconds. The 2 minutes. That's 150 seconds right. Similar to what we computed early. 150 seconds plus 86 or 87 seconds. I could add those together and that comes up to as you can see here on the screen, 247 seconds. I convert that and that's a little tricky to just see how it's done on the screen. I convert that to minutes and seconds and I get the 2 minutes 57 seconds which means that I add that to my 5230.

Now that was our look at latitude and it is relatively simple, was more accurate that you can see plus or minus a second or two. Well, that's a hundred feet or so and that's pretty good. There are other devices that you can buy. There a thing called Topowade that you can lay on here and it will scale that or you can just figure out a ratio to actually compute the exact distance that you have.

In other words, the one hundred and fifty seconds and it was one hundred and fifty two and a half, then you can ratio that to what you measure and come up with a very precise latitude. That's fine. I just wanted to show you here the principles of how you can do that. Now, with latitude, that you recall, we had the one hundred feet equals a second of ARC of latitude.

Longitude is not that way and as I mentioned earlier, longitude starts out that way at the equator and as you move North or South, those lines are getting closer and closer to each other to where just a mile south of the North Pole and the distance between two lines of longitude is just a few feet.

So we can't do that with longitude exactly. What we have to do is scale it slightly differently and I am going to show you how to do that. We are just simply going to slant the scale and make it work so that we can read directly what our seconds are and where we are at. So let's take a look again here at the southwest part of the map. But now this time, let's pay attention to what we are doing.

Notice the point that we are interested in. And if I lay the twenty scale on here and measure the longitude, it is only twelve hundred here. Now, I can measure and scale that way. But I am going to show you that for longitude you can actually do this directly even more precisely than the latitude.

What that's going to require is for us to use the fifteen hundred, excuse me the one hundred and fifty seconds, there are one hundred and fifty seconds of latitude, (excuse me longitude), across here, it's just that they aren't equal to 100 feet. But we can force the scale to do that and here is how we do that.

We turn the scale and as long as zero is on this line, down here, and one hundred and fifty is on this line, I now have…because I have slanted this, I have worked the scale to fit perfectly. So now what I want to do is slide that up to where I have those conditions at my point that I am actually going to look at. So what I am doing now, is I am lining up the scale so the zero is on this line of longitude and the one hundred or one hundred and fifty line is on this line of longitude. And I am right over top of the line that I am interested in. Now, let me zoom in so we can see exactly what we are going to do here.

Now I can read that I have sixty here, sixty five, sixty six, sixty seven, sixty eight, about sixty nine seconds. See by slanting it that way and forcing it to ratio correctly for longitude, I am able to read exactly the seconds. It is exactly about sixty eight point six seconds. So there are about sixty nine seconds of longitude further west…longitude in the United States is going west.

So the line that I have referenced off to the East here, is the fifty minute line, right? fifty minutes and zero, zero seconds and it had one hundred nineteen degrees in front of it. So that was one hundred nineteen degrees, fifty minutes, zero, zero seconds. Now I am going to add sixty nine seconds to that. Now sixty nine seconds is more than sixty, sixty is a minute. So what I am actually doing is adding one minute and nine seconds. So now I know that the longitude of this point that I am after is one hundred nineteen degrees, fifty one minutes and nine seconds west.

So that is how we come up with longitude. And it is, as you can see, even more precise as long as I slope-scale this correctly, I'm able to read that number directly and get it quite close.. And again, you can do the similar with latitude if you want to get your calculator out, we just didn't want to make you have to do that, so we showed you within a second or two.

That's how you scale things on the map that are referenced in longitude and latitude and that's close enough for almost anything we are going to be doing with mapping. It's not close enough to do a boundary survey; it's not close enough to determine whether someone is trespassing or not; it's simply how we use latitude and longitude to get it.

So, let's say you are in the office and someone calls in and says there is a car accident and someone has rolled their jeep and they give you the latitude and longitude. Well, you can do the reverse of what we just did to figure that out. You get to within the little 2 ½ minute rectangle based on the numbers they gave you, they've called in the latitude and longitude and then you can just scale correctly to get that. Let's look at the map and make an example of that.

I'm going to pick some numbers that are really close to what we are dealing with here, but let's say that they have said that there is an accident and the latitude is thirty nine degrees and ten minutes, right at thirty nine degrees and ten minutes. Well, we happen to know exactly where thirty nine, ten is because that was this line. That line I've drawn is at thirty nine, ten. And then let's say that the longitude that they give us is, we'll make up a number here, is one hundred nineteen degrees, fifty one minutes. Let's call it that. One hundred nineteen, fifty one.

I've made this easy for me. I've got this latitude line here at ten minutes. So all I need to do is be on that line at one hundred nineteen, fifty one. I know that this line I drew here is at fifty. So I need to be one minute further west of it. Well, one minute is sixty seconds, right? So what I am going to do is put my scale across like we did before and I am going to put the zero on this line and I'm going to put the one hundred fifty on the west margin of the map and they told me it was at one hundred nineteen degrees and fifty one minutes so that's sixty minutes? So I'd want to be at sixty minutes. So I am going to have to slide this down until sixty minutes is on the latitudinal line Ok, and there I go; I have got the place where the jeep was turned over.

So the reason I want to do this…somebody with a GPS, somebody in the jeep, you know, they're injured, but they have a GPS unit or a cell phone, well, great. But the first thing I want to do is to plot it on the map, and then I can take a look at the bigger picture of the map and say, Ok, how do we get there? How do I get to that spot? You know? I can see that there are trails over here that a four wheel drive jeep roads. They are probably the closest. We do have some creeks in here. But that requires hiking up these creeks and carrying people out.

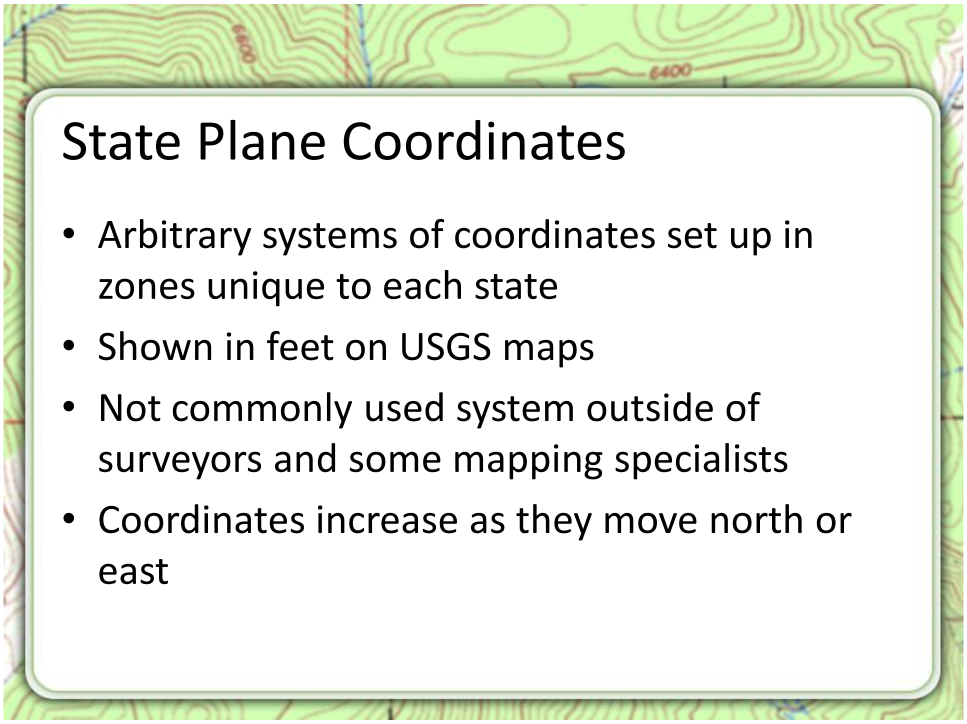
Obviously if he is driving a jeep he got it down there somewhere. Sol he probably came off of this road, so I am going to be able to direct the fire crew or rescue crew, I should say, up this road and give them an idea of how to get there. Or maybe it's me that is going to drive up there. I planned a way to get out there. That is the purpose, as you can see, the reverse here of what we have done. We have taken something that someone has called into us and I have plotted it on the map so that I can see how it relates to the other things. It is just like all the other things we have been talking about in this Unit and that is we know somewhere on the ground that is not on the map.

We have information about something on the ground. I'm standing there and I've got the GPS coordinate. Or I'm standing there and I've used some bearings, which I will show you in a little while how to do, but I know about where I am on the map. I need to relate that to someone else who is not there; who is never going to be there maybe; just someone in the office who is just going to relay the information, a dispatcher, perhaps. And I have to relate to them where I am at, how to get there.

What if you don't have a GPS unit but you can tell where you are on the map. You're on a hilltop of whatever. You can scale the latitude and longitude and give it to the dispatcher. So, those are some simple applications and I'm showing you why we need to know this. So latitude and longitude are really our best and most fundamental methods we use for determining our location. And it's something everybody can relate to whether they have a GPS or not; they can scale or figure something out. But that's the best way to do that. So that's latitude and longitude.

## Lesson 1 Map Reading & Interpretation, Part 10

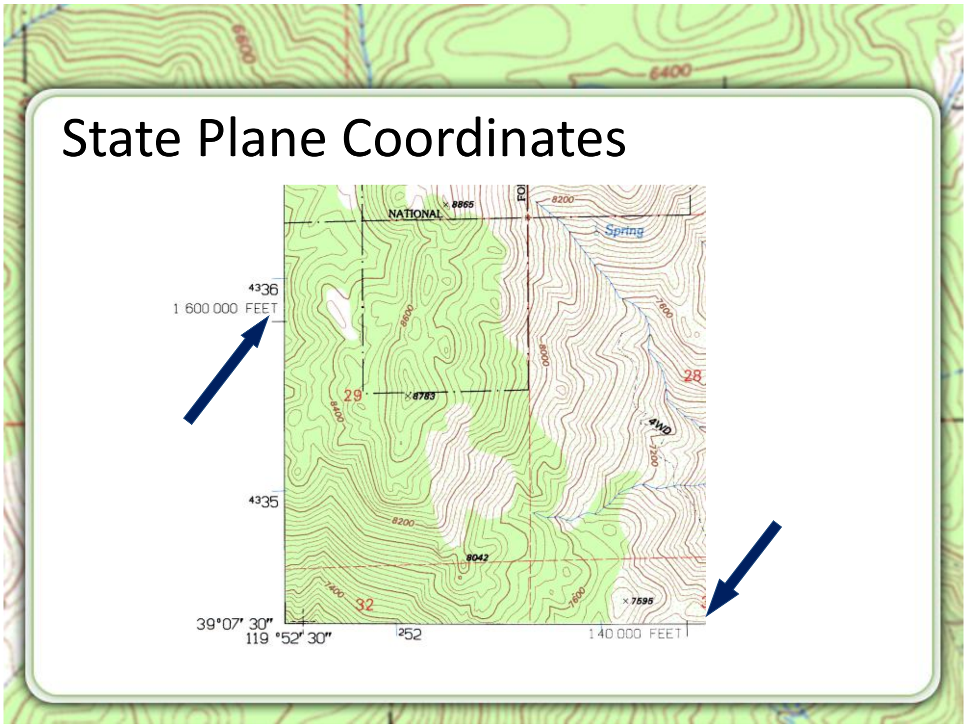
Now, I am going to change gears and go to something that is not used much and I just want you to understand what you're seeing on the map and we're not going to go into a lot of explanation of it. There is a system called the State Plane Coordinates and they are a rectangular grid that's established, actually, at sea level. It may sound strange to you, but that's where it is. Let's take a look at this slide. These are arbitrary systems of coordinates that are set up in zones that are unique to each State.




They are shown in feet on a USGS map, although they can be computed in meters. They are not commonly used outside of surveyors and some mapping specialists, so that's why, you know, if you get things in State Plane Coordinates there's a good chance that people may not know what you are talking about. You might say, then, why are you teaching us this here Dennis. Well, I want you to understand what those marginal notations are so that you don't get them confused with something else.

The coordinate systems in each of these zones, you know, like Arizona we are three zones and California's got seven. They set up these zones so that the numbers never get too big and they are coordinates. And they are set up on arbitrary meridians and base lines that create how they number the coordinates and the coordinates increase as you move north or east. Now, take a look on this next slide and you'll see where those are actually located on your map.

Again, I am sticking with the Southwest part of the map just so that everything we've looked at is in the same area and you'll see that there is the arrow on the upper left up here is pointing to a tick mark that's outside of the map, slightly straddles the margin, and you notice this is one million six hundred thousand feet. That is how many feet you are north of the baseline for that zone. And then you can see on the lower right part of the picture there is a tick mark on that margin of the map and that is showing one hundred forty thousand feet.

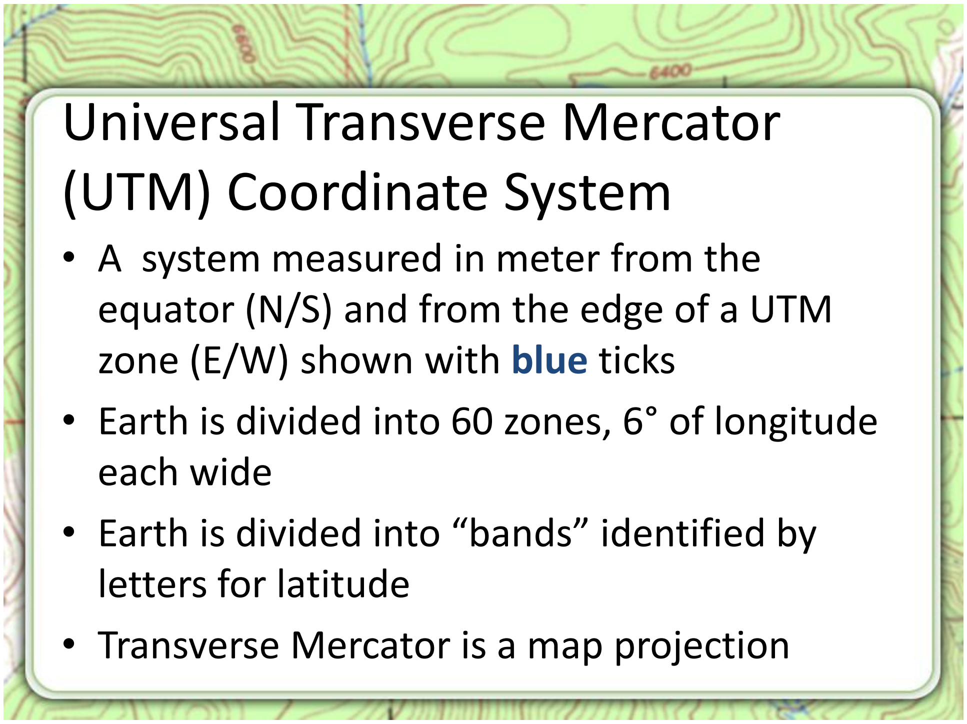



That's how many feet you are east of the meridian or north/south line that that grid system is based on. Now, folks, you may remember earlier we look at magnetic declination and we looked at the little north arrow that's at the quad sheet. And you remember that it not only had a star for astronomic north and then it had the magnetic north with MN, but it had a GN, Grid North. That grid is referring to those State Plane Coordinates system. So understand that it is rotated differently than north. The example here on the map, it was almost two degrees. That varies based on wherever you are in the zone.

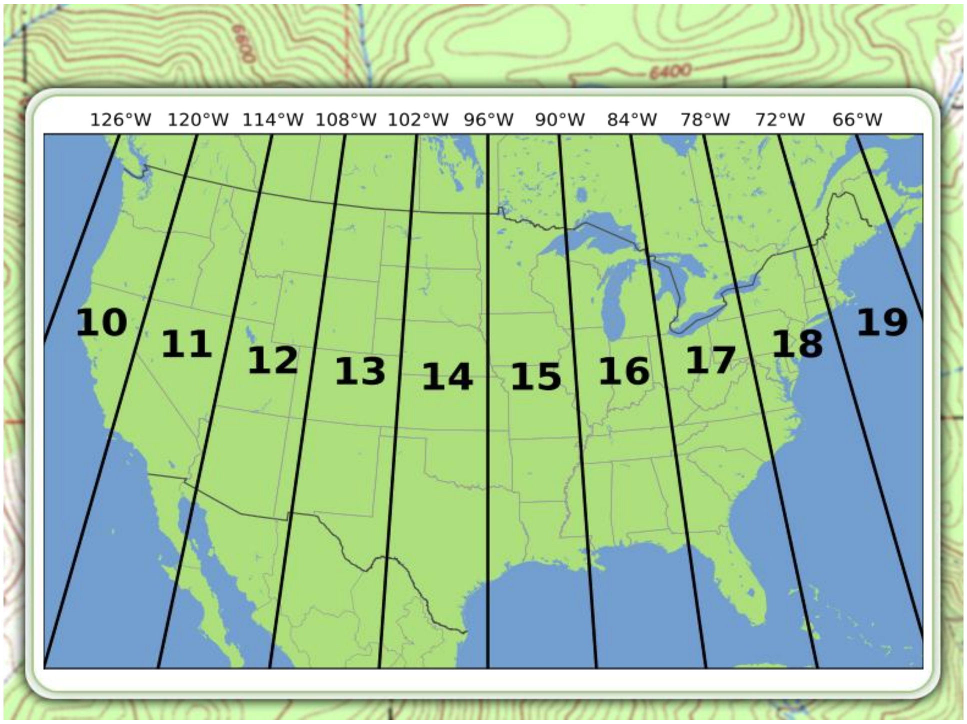
So north is not as precise, or I shouldn't say is precise, but is oriented differently than a State Plan Coordinate system. So you are not going to use that much. That's fine. But when you look at the map…let's go back to that slide one more time.

You can see that's what these tick marks are about and these numbers are about and now you understand what those are for. If you ever have to use them, you'll know what they are. But recognize that most people aren't familiar with them so those are a system that is there on the map but not necessarily what you want to tackle. So that's our State Plane Coordinate system.

Now another system that has been around awhile; you haven't seen it used as much until the last couple of decades. It is the UTM which stands for Universal Transverse Mercator.




UTM is a system that is measured in meters. It is metric. It is measured north and south of the equator. And from the edge of a UTM zone. They've created zones. There are sixty of them on the Earth, and obviously with three hundred and sixty degrees, why then there is six degrees of longitude in each of those zones. Also, the Earth is divided into bands that are identified by letters for latitude, but you usually don't actually see those used.



You might wonder what Transverse Mercator is? Well, remember Mercator was an ancient map-maker and he came up with certain datums and projections of the Earth and how maps could be made. And if you have ever looked much at maps, or at different projections of maps then it would show Greenland as really small or they show just this humungous island out there. That is because of the projection of the map.

What you are trying to do is take a round globe and put it on a flat map and that distorts things. Well, Transverse Mercator is just one of the systems that Mercator began with and we've modified it some. It's simply a definition of how we are going to make a map. So don't worry about that. But UTM is the system based on that.

Take a look at this slide. Here is a map of the forty eight. Lower forty eight. And here are the zones that we are in, not that it matters that much. This helps to see how the system is laid out. So we have these zones and we're not really worried about the bands that run the other way because since everything is measured from the equator, it doesn't really matter.

Now here we are again in the Southwestern part of the quad, the Carson City quad and I want you to notice that you have tick marks here. These tick marks are in blue. There is one there, one there and one there and many other places outside of the map. Those tick marks are outside of the map, they're in the margin. Those are UTM coordinates.

Now, I mentioned that UTM has been used a lot more over the last few decades and surveyors don't really use them and a lot of other folks don't, but what is happening is you start seeing other users of maps, they have started using UTM as their reference system.

The first ones I ever saw were Archaeologists who were using them. That's what forced me to start learning about UTM because Archaeologists were using the UTM system to define where they found an archaeological site or a cliff dwelling or something, so we had to start paying attention to how UTMs work. This isn't something surveyors normally work in. Now, the way that UTMs work then, they are telling you how many meters they are from the equator and how many meters they are from the edge of a zone. So, going back to that slide one more time.

You notice that here we have, it's an odd system, a forty three small number and a thirty five big. What that actually indicates is that you are four million, three hundred and thirty five thousand meters from the equator. Ok? And so if you go up to this next one up here, then you are four million three hundred and thirty six thousand meters from the equator. So you've gone a thousand meters, right? So you can scale that, figure that out too. If someone tells you the UTM coordinates that they're at for zone twelve are four million, three hundred thirty five thousand five hundred meters, then you know that you are going to be somewhere about halfway between those two.

So that's somewhere on a line due east to west like that….it is somewhere there. And then depending upon the zone, it is marked for the zone that you are in, that the map is in. Down at the bottom of the map, we have a small two and then a fifty two and that's indicating that you are two hundred and fifty two thousand meters from the edge of that zone. And what that means, and they don't show it here, but you can go to the next one increased to the east and just off the map and it will be at two fifty three, so that's two hundred and fifty three meters from the zone. So you know you have gone a thousand meters as well.

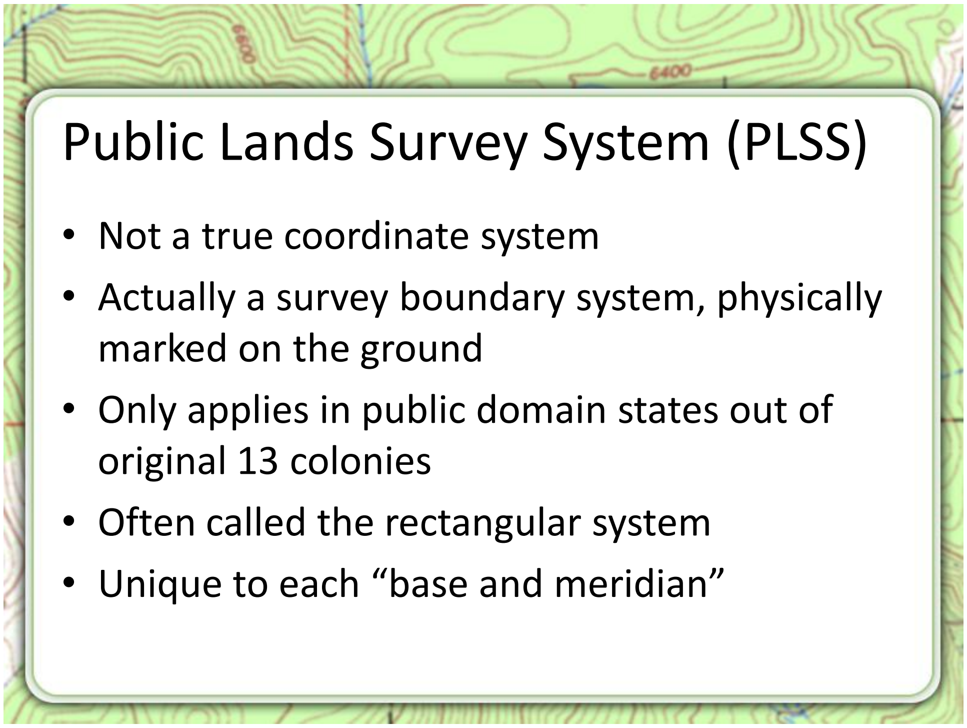
So, it's another system that is just very similar to the lat and long that you can scale things on here to determine where you're at and at least get halfway close. There is software that's available to people that know how to convert between UTMs and lat and long, and ch ch ch, it will do it precisely and you don't have to even think about it. And frankly that's one of the better ways to do it.

UTM has become popular even more lately because GPS units can read in UTM but, the GPS unit collects the satellites in a lat and long system, but it converts it to UTM if that's how you have it set or it converts it to some other system if that's how you have it set. If you have a unit that will read both, then you can flip between those and say it's telling you UTMs but it's in lat and long, which is easier to scale, I think, that you just saw, to find yourself on the map.

So recognizing these systems do go back and forth you have to have some software to make sure that you are doing it right. But bottom line, that's what those numbers mean in the margin of the map. They are blue ticks and they are the meters from the equator if you are going north and south and from the edge of the zone if you are going east to west. And you can scale those and figure out where you are roughly at any given time. Alright? So that's another system that is used on UTM. We've got a couple of questions on the exercise that's coming up that will see if you picked that up. Not real complicated, just to make sure you understand. Actually, not surprisingly, there's a number of different reference systems, right? We've got lat and long, right, and two different datums, as we discussed earlier. And then we've got State Plan Coordinates, that's three. And then we have what we just looked at with UTMs. So we have four different coordinate systems shown on there.

## Lesson 1 Map Reading & Interpretation, Part 11

Now, the last system that I want to show you is called the Public Land Survey System. And it's very important that we realize that this is not a true coordinate system. It is not about coordinates.




It is about land ownership. It is a survey system that marked things physically on the ground. For most of the public domain, every half mile on the section lines, every half mile there is an actual physical object in the ground that marks that. And of course the measurements of these, the public land survey system, in fact, started in 1785, in fact it was a vision of Thomas Jefferson's.

And some other people, contemporaries of his, kind of modified it some, for the first twenty or thirty years it got modified a little bit here and there. But basically started in Ohio and moved out West and South also, and several of the Southern states, wherever we consider a public domain to be. And set up this, we call it a rectangular grid, it isn't perfectly that, but it is not a mapping system. It is a land ownership system. It is a system of marking boundaries on the ground. Again, it only applies in the public domain states.

So the states that came out of the thirteen colonies are not included. Texas is not included because it was a separate country and it was surveyed in its own way as was Hawaii when they were acquired by the United States. This is often called the rectangular system, or public lands system. It's not a true rectangular system, but it looks that way on a map, but we are going to talk about how that works. It is unique to each of the base and meridian systems. In other words, it is not a coordinate system that is one-time for the whole world. So take a look at this map.

And see that this is, I know you probably can't read things here and you can identify the state is that you are in. I am in Arizona down here and the yellow indicates, it is says in small print there, and I apologize, but in small print there the Gila and Salt River Meridian. Almost all of Arizona is in that system. That means that our townships and our ranges are numbered from an initial point which is just a few miles west, southwest of Phoenix here.

Other than this little part of the Navajo Reservation which is part of a different system. So you can look on this and see what state you're in and if you are in a BLM office they probably have a large version of this map somewhere in lands or in cadastral that shows you these things. We here looking at the map for our project, our course, here is the Carson City, Nevada map. It's in Nevada. Of course Nevada City is somewhere near the angle point in the Nevada/California border there near Lake Tahoe.

Ok, so we're up in there and that area in green on the map is the Mt. Diablo Meridian. The Diablo is really a hill, not a great mountain, but a hill east of San Francisco, and that's where they started measuring the surveys for that part of the country.

And on this slide, what you see is, an initial point, the red arrow pointing to it, and you notice how they number the townships and ranges. At that initial point, they create a line that's east and west and they call that the baseline. And then they create a line north and south which they call the principal meridian for that system, for that unit, for those states, or state that is covering. And then they numbering the townships based on that.

So the first township north of the baseline is township one north. Township two north, township three north, does that make sense? Now going south? One south, two south, three south. Similarly, these six square mile units are called townships. But we refer to them as townships north or ranges or rows, if you will. Some people think the "R" stands for row, but it doesn't.

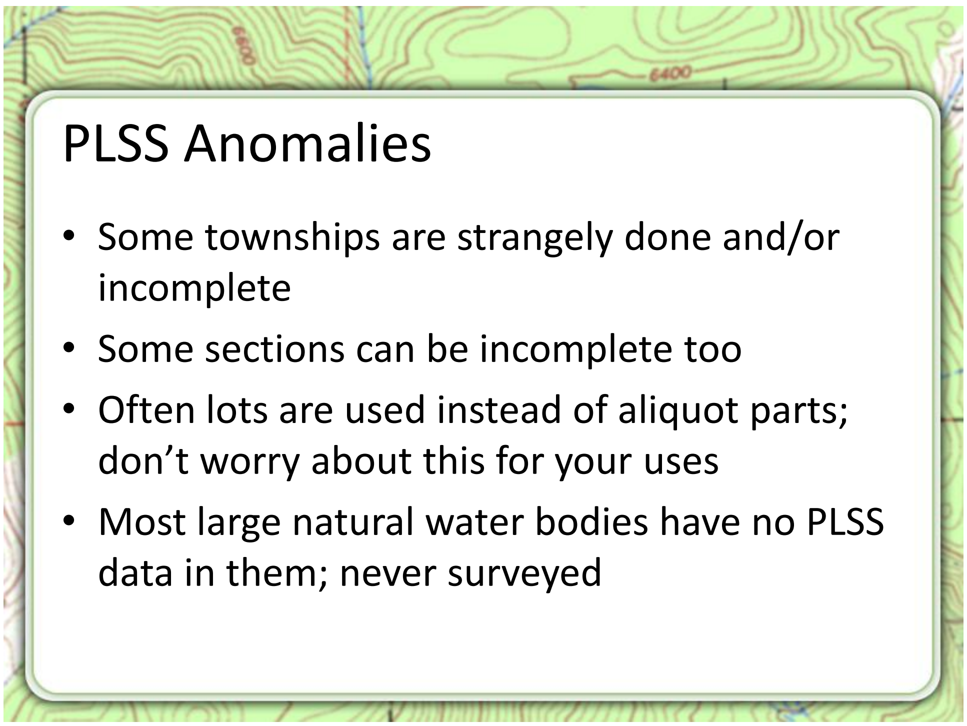
Those are ranges. And so the first township that is east of the principal meridian is one east, two east, three west. So, if I am out here working and I am at this township here. I am in township three north, one, two, three, north of the baseline and one, two west of the principal meridian. That's how townships are numbered. And so if you see a deed for some piece of property, you know, or you're looking at some other document, BLM or any other agency is using that has to do with land and location, you know the first thing you're going to say is township four north, range eighteen west, or whatever.

And it will name the meridian, you know, the Mount Diablo meridian or the Arizona Gila and Salt River Meridian. Or out in the Midwest, the northern upper Midwest, the Sixth Principal meridian. And what that is telling you that it is a unique township, six miles by six miles and where it is. It's a unique name for that base of meridian, Ok? So if I'm in here, we are probably 2 north, 3 east in the Arizona Gila and Salt River system? I know that we are within six miles by six miles where I am at, simply by using that nomenclature, alright?

Now, take a look at this slide and let's talk about our township where our map is. If you have looked on the map, we actually have four townships that are in the map, but the majority of the map, especially the southwestern part, which I've been talking about today, is a township twenty north , range fifteen east. And being in Nevada, I know that that means it's in the Mount Diablo meridian.

And so the township that you and I, that most of our map covers, Ok, is twenty ranges east of the initial point on top of Mount Diablo and fifteen townships north on that initial point on top of Mount Diablo.  So that's how that township is defined and described: township, range and meridian.

That identifies a unique six mile parcel of land that we call in a public land system, a township. No don't get that confused if you're from the east and even some places where the public land system exists in the upper Midwest. They have political entities that they call townships.  Those may or may not follow these township patterns.  Those can be different things.  They are almost like counties.  Where they could be odd shaped and covering more than one township or less than one township in a survey sense.  But from a survey and public land survey system sense that is how it works.

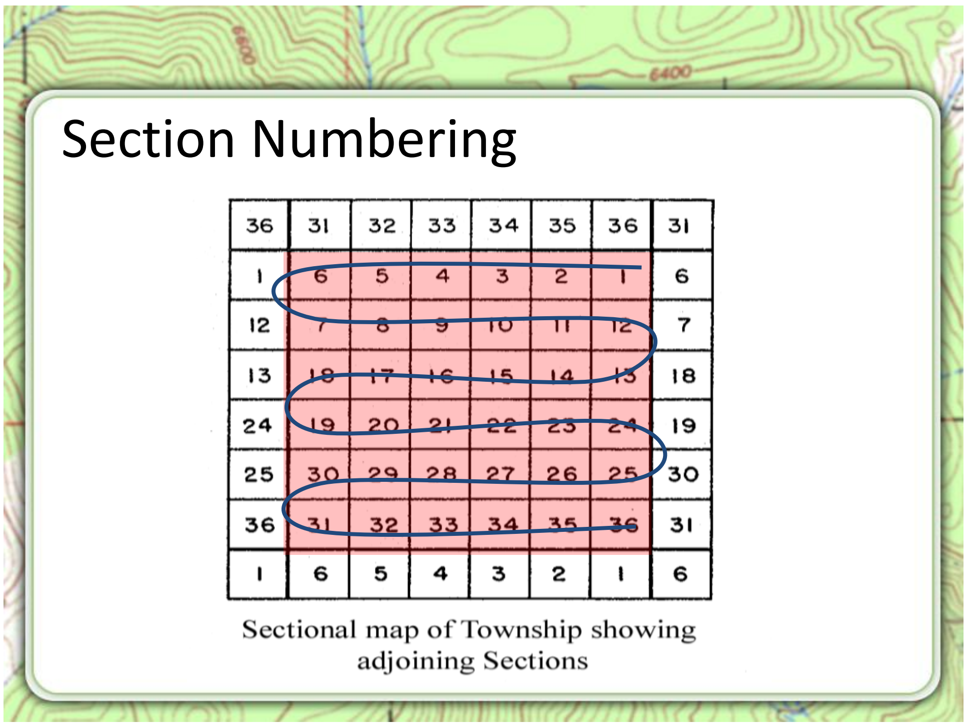



Now within each normal township, and I emphasize normal because there is always some abnormal things here and there and we are not here to discuss the intricacies of the public land system for you. But with a normal township, it is six miles by six miles so that means it has thirty-six square miles in it right.  And those sections are numbered and other than a few places in Ohio where the numbering system was a little bit different, this is how the rest of the public domain was done.

Section 1 is in the upper right corner and the numbering system for sections follows this pattern until it gets to the end which is section 36, because there are thirty-six sections in a township. Thirty-six square miles. So we call these sections and a section is a square mile more or less. It is not perfect in fact there isn't any of them on the ground that are perfect.  But understand that is how the public land system relates to something.  So now, you have a parcel of land and somebody says I am in Section 16 of Township 20 North Range 15 East Mount Diablo Meridian, I know within a square mile of where I am because that is a unique naming system.

So that is how township numbering works and you know looking that slide you can also see what the township number excuse me the section numbers are in the adjoining townships are ok.  And the reason it follows that pattern is there is never any two numbers that are the same that match up right next to each other, so you don't have any confusion.  You have really a unique numbering pattern there. That is the idea.  So that is the public land system that gets us down to within one square mile which is a pretty amazing ability of a system on the ground.

Now what I want to do now is take you inside one section.   We will go inside one square mile and see how that public land systems works there.  Let's take a look at the slide. Now some of this is difficult to read I know.




What we are looking at here on this slide is one section and what we are about to learn is that sections can be further divided down into what we call aliquot parts.  Don't worry about that word.  Aliquot is a French word that simple means equal. It doesn't really mean equal in area but equal in rights but we re not going to go very far with that. But I want you to understand is what you are looking at here is one square mile. That is one square mile section.

And a section can be divided up into a quarters of a section. And what that means is generally you find the midpoint of all four sides of the section and then you connect those.  And there are exceptions to that but for our discussion that is good enough.  You connect those and what that does is create four quarters of the section and we go by simply the cardinal direction that it is. This entire quarter here is the northeast quarter of that section. This is the northwest, this is the southwest and all of this down here is the southeast quarter.

So we can divide it up. So now I want you to think about it not only can identify a township by its township and range number, but I can identify a specific section, and then I can identify a specific part of a section. So someone can call in and say there is a fire in the northwest quarter of section 16 township 15 north range 20 east Mount Diablo Meridian. We have got this down to within 160 acres of where it is. That is pretty good down to a quarter section, but you can go even further down as that drawing showed and now I am going to blow it up just a little for you. I can carve up quarters into halves. That is the west half of the northeast quarter or the east half of the northeast quarter, both of them in the northeast quarter right. Or what is more commonly done especially in fire and some other resource applications, we go into quarters of a quarter.

So what we are going to do is take this southwest quarter here and we are going to divide it up even further into quarters of a quarter. I'll blow this up further for you there. So now I can get down to a 40 acre parcel by simply saying the northeast quarter of the southwest quarter of section 16, township, range and meridian. See how that works. We have got a specific 40 acres of land. Just so you understand, 20 chains on a side that means it is a quarter of a mile of a side. So quarter mile, quarter mile, quarter mile, quarter mile. It is a mile around it but its only 40 acres of area. That is a pretty small area.

If you call in a smoke with that accuracy again, the helicopter, the truck or whoever is responding to the fire or whatever the emergency is, that is a relatively small area on the face of the earth to be able to do that. And you can see how the nomenclature that we are using here is abbreviated instead of writing out all of those words take a look at this.

This 40 acres is the southwest quarter of the southwest quarter of that section. And we do just SW1/4SW1/4, ok. Don't put a comma in there by the way the comma means you have actually changed location, so just remember that. Northwest quarter southwest quarter, section number, township number, range number. You know a lot of times you are only in one meridian on a certain BLM officer or Forest Service officer whatever so you don't have to give the name of the meridian unless you are in where two of them meet. So you see I can get this down

I can actually get this down to five acres to even half acres, simply by using different combinations of this. This is the midsection line. This is the southwest quarter and we are looking at a portion of the southeast quarter over here. But I can have the west half of the northwest quarter of the southeast quarter. Think about that. That has got us down to 20 acres. As you can see on these here, south half northwest quarter southwest quarter southeast quarter, that seems actually long but you know what that has got it down to a 5 acre parcel. That is a very small piece of land on the ground in land management agency work.

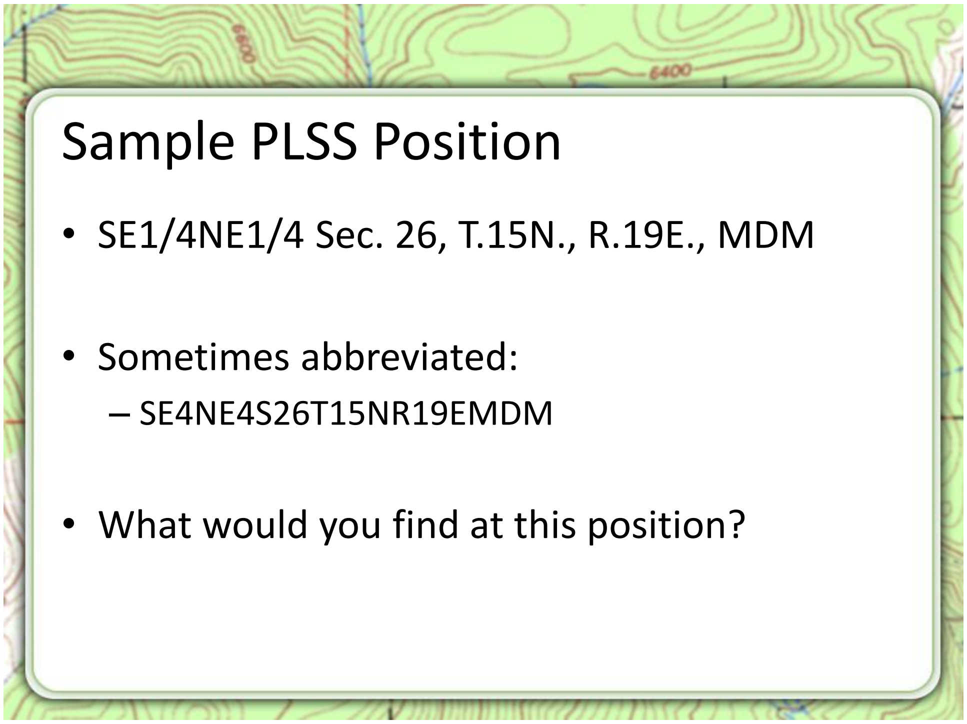
So that provides us with a tremendous, I won't say precise but specific location on the ground based on this. And what is happening is we have this stuff on the map. We will go look at the map here is just a minute. But there are a few little anomalies that I want to mention in the public land systems so that you don't get confused. So here is a list of them.

Some townships are strangely done or they are incomplete. There are just all sorts of reasons for that so just recognize that sometimes that is what happens. Some sections can be incomplete too they are just partially surveyed and the rest was never done and that is especially up against really rough country. Sometimes you will find things called lots that are numbered or lettered instead of aliquot parts, don't worry about that for your uses. You can generally still call something an aliquot part for calling in fires or whatever and fire never worries about those things. Also understand that natural bodies of water that are large and when I say large maybe

50 acres or more on a lake, or maybe a 150 foot wide rivers or stream and up they will have no PLSS data they will be excluded from the survey.

So what you are going to have is if you have a big river coming through, instead of calling it the southwest of the southwest, they will divide it into lot 1 and lot 2. That is just a surveying thing but for your purposes to call in a fire or something. Of course if I had a river flowing through I would say I am in the southwest of the southwest north of the river. Now you have really narrowed this down. So there are some anomalies in the public land system that you don't really need to know worry about. Because for mapping purposes and calling in things, getting directions how to get somewhere this is all close enough and works really well.

Now I want to take a look here at a sample public lands position. Let's say that you are told to go to the southeast quarter of the northeast quarter of Section 26, Township 15 North, Range 19 East, Mount Diablo Meridian. That entire string there. I read it all the way out for you and that is how we would abbreviate it. That is how it is done in a lot of our computer programs for lands databases and that sort of thing. So the southeast quarter of the northeast quarter, so I know that is a 40 acre size so that is pretty specific. Section 26, 15 north, range 19 east Mount Diablo Meridian.




By the way sometimes you will see them even abbreviated like this and notice it still works. SE4 because in the public land system it is either a half or a quarter. So if it was the south half of this it would say S2SE4NE4. We can string it in one long way and that is especially useful in computer programs and software that uses it. So what would you find at this position.

Well that is on your map and I suggest you go and take a look at your map now and see what is in that position, in that quarter of a quarter, in that section in that township. So I am going to move over here and we are going to look at that on the slide of the overhead which we commonly call the Elmo.  So let's take a look at this.

Take a look here at the map where the southeast corner of the map so you can see Carson City over here and it kind of reference things.  I am going to start at the corner of the map and come in here until what  we call a range line.  It is the eastern boundary of one township and the western boundary of another.  And if you notice, there is in red there, and I will zoom in for you, the range numbers.  It is 19 East on this side and 20 East on this side.  Doesn't that make sense, because they are increasing as they go further east.  Because Mount Diablo is west of us, San Francisco is west of us here.  So this is 19 east and this is 20 east.  I know that 19 East is where I want to be so it is somewhere here. Again I will zoom out somewhere in this area of the map.

So now let's take a look at the township and you have to realize that we have to go look for that number as well. Let's go back to the map and I am way over here on the left side of the map look for a similar place.  Here is the northwest corner of the map up here and I am going to come down and I am going to look for where the townships are marked and sure enough it is marked right here again in red.  This line is the township line and it is north line of township fifteen north and the south line of township sixteen north.

So I have now identified fifteen north nineteen east I am down to a six mile by six mile specific township, I know where I am at. So now what we have got to do is find the section that is in there.

So what we have done is identified a specific township in the Mount Diablo Meridian so we have this down to a six mile by six mile area on the surface of the earth using the public lands system. If you go back to your handout that shows the section numbers and how that is done, well then you can just look at this township and start following because now you know what township it is on the map.  AND you know the maps are not aligned with the  townships.  That is because the maps are based on longitude and latitude.  Townships are based on the public lands system. They are not directly related, but once I start looking at that and I realize that this is down towards the bottom of the map.

So let's go back and take a look there Section twenty six.  I came down and twenty three, twenty four, twenty five, twenty six twenty seven.  There is section twenty six township fifteen north, range nineteen east Mount Diablo Meridian.  Now you remember what I showed you.  You want to split those lines in half.  There are some odd balls sometimes where that doesn't work and I am not here to discuss those,  But if you notice using the twenty scale, I am about at fifty three hundred, well half of fifty three hundred is twenty six fifty.  So I am going to go to twenty five, twenty six fifty and make a mark.  I am going to do the same thing on the north line of that fifty three hundred.  Doesn't that make sense a mile is fifty two eighty, twenty six fifty  of section twenty six. I am going to do the same on the west line and on the east line.

Now I am going to take those four tick marks and call those in public lands nomenclature those are called quarter corners because they mark the corners of the quarters of the section.  I am going to connect those quarter sections.  You remember the legal description that we are looking for, let's go back to the PowerPoint and review that real quick.  The legal description I am after is.  I already got  nineteen east figured out, fifteen north figured out, section twenty six figured out. See you read these backwards because it is the southeast of the northeast. So what I need to do is find the northeast first ok, so back to the map.

If you remembered how that works. This is all section twenty six and this is the northeast quarter. I am just going to lightly shade it. That is the northeast quarter. So now I have got that almost all the way down, but the legal description told me I am in the southeast of the northeast, so I am going to split this again. Since those are about half a mile about twenty six hundred, I am just going to go about thirteen hundred, up to the north line thirteen hundred, then thirteen twenty would be the perfect since a half mile is twenty six forty. Thirteen twenty. See what I have done is scribe the midpoint on each of those and I now go back to my legal description because it was the southeast of the northeast. So I now know that this is the forty acres we are after. And the question I asked you when we began this discussion was what will you find at the southeast of the northeast. And as you see their on the map you are going to find a Dry Lake.

Who knows, maybe that is where the HazMat site is. See this is what happens an awful lot. People will have the map with them they will know where they are on the map, they will look at it. Usually they can almost eyeball those without even having to draw the lines. You can see that I am definitely in the northeast of the northeast or whatever because I am close to the corner of the section. Well then, you just call that in and say I am in northeast, northeast section, township, range. And everybody that is listening on the radio, everybody that needs to know has got you down to at least forty acres. That is pretty good and that is how the Public Land System works.

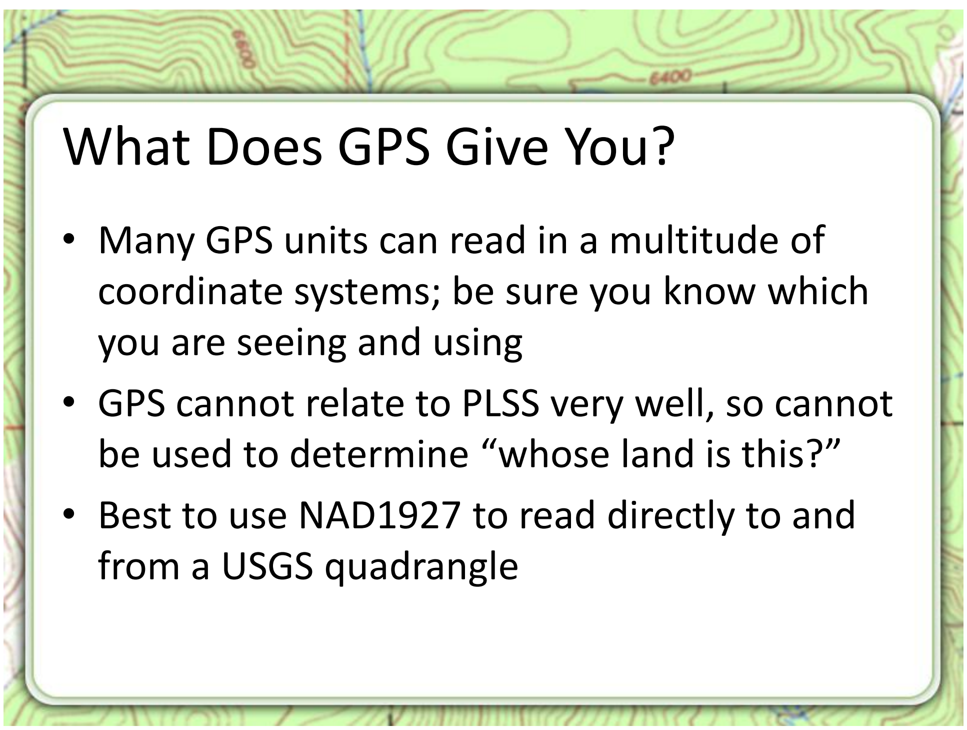
Now so obviously, somebody calls it in and you can now figure out where it is, or if you are the one who is going to call it in, you can figure out where it is. We still have some more things to learn about interpretation of topo maps in this lesson but, this gives you a really good idea of how these different (you may recall I said the public land system is not a coordinate system) but it is a reference system. And it is something that you can use quite well. By the way, you go out on the ground in a lot of these places and if you pay attention to the line weight and dashes, or whatever they are giving for the public land system, remember the first part of this course when we looked at that symbology and we looked at that booklet that the USGS give out that is about quad sheets and I gave you a website on how to get to it too. You know when you look at that you actually can learn whether those lines are surveyed, how old they are, if they are just guessed at. That is good information, but if you are working in an area that has been surveyed, and you think you are really close to a section corner or a quarter corner.

The section corners and quarter corners throughout the public domain where we actually did the survey which is the majority of it. You will find a monument out there. Many of you have seen the old iron post with a brass cap or the older ones are wood post with the brass cap or stones. Those maybe harder to find with an untrained eye, but if you are working in a township that you know is brass cap, you can really make that is exactly where you are by going to find the section corner. In fact you can find the section corner, get a bearing from it to the HazMat site that you found. Now, you will really be able to plot this precisely, and you can pace that distance or drive the truck if it is a ways (odometer) or get your tape out right. You can use the tools that we have discussed in the course so far to be able to locate things.

You see with UTM, with state plane coordinates, and with lat and long, there are no real monuments on the ground with just a few exceptions what we call triangulation stations. You see a triangle on the map with a name next to it. There is a document somewhere that you can get usually on the Internet that will tell you the precise latitude and longitude, and state plane coordinate on it. But that requires extra research and there not very often, they are a lot of times on mountaintops or real significant ridges, places that were really easy for surveyors to see a whole gamut of things around them.

With the public land system, you have got a monument set every half mile on the ground around the exterior of those sections. So a lot of times you can actually go find that or some evidence of that, something to help you. Now again making decisions whether that is the actual corner or not or something that you need for a trespass, again my earlier discussion about getting help from cadastral surveyors and cadastral is still valid. I'm just letting you know that sometimes you may just find that mark on the ground and that is a great thing to tie to for something else that you are doing. Especially make sure which quarter of a quarter, or what section you are in. You may be in an area that is relatively flat, there is not a lot of unique topographic features in the area for you to figure out and I in the southern part of that section or in the northern. You know you might be able to find that brass cap with the marks on it and then you will say okay as long as I am north of that I am probably in that section instead of the other. That is how we use these different reference or coordinate systems.

So now I am going to review one more time. You have heard me say this three times that is because GPS is a great tool but it can also get you into trouble. So let's just review now that we have looked at all of this.



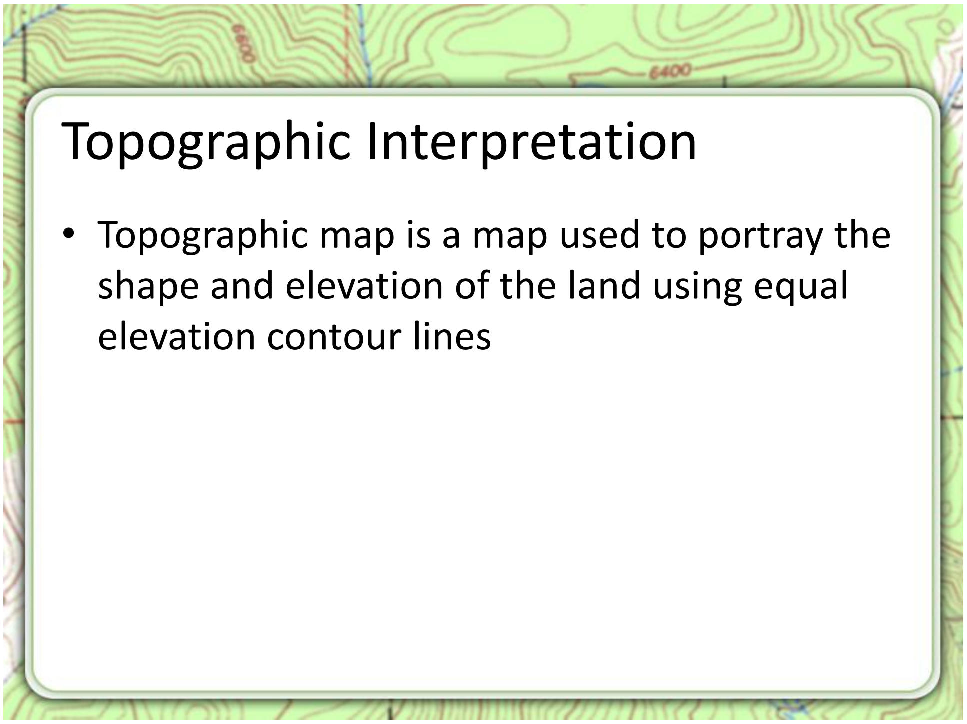

What is it that GPS gives you? Many GPS units can read in a multitude of coordinate systems; be sure that you know which you are seeing and which one you are using so that you can relate it to your map. GPS cannot relate very well to the public lands system so you need to be very careful in deciding whose land is this because it is not on a GPS position. And again you need more help if it is anywhere close to a boundary. Use NAD27 so you can read directly to and from the GPS unit and relate it to the USGS quad.

So what we have done now is, we have not only talked about symbology, and map notations that sort of thing in the beginning of the course, then we went into understanding distance and scale and then we went into direction and now we have talked about how these coordinate systems or reference systems work for us to use to relate things that we have just figured out to someone else in a system that they can relate to. And that is where we have gone so far. Now we are going to shift gears now and talk about one of the most unique things about topographic maps and that is elevation data and that is what we cover in our next section, so I will see you over there and you can enjoy the exercise (web problem) now.

## Lesson 1 Map Reading & Interpretation, Part 12

Well we are still in Lesson 1 of this course, it is the longest so don't panic you don't have to go another two segments as long as this one has been. But what we have been talking about is interpretation. The various things on the map, again the symbology, learning how the maps are constructed, and understanding how use coordinate systems that sort of thing to reference ourselves on a map.

We have one really big area yet to cover and it is what we call topographic interpretation and I want to remind you that a topographic map and here is its definition.




A topographic map is used to portray the shape; that is where the word topo or topography actually comes from. The shape and elevation of the land. And what we are going to do is use contour lines which are equal elevations. A contour line maintains a constant elevation. I want to distinguish that from as you recall the first few minutes of this course where we gave you the two basic types of maps. The other one being a planimetric map. Planimetric maps have all of the information in a scale just like the topographic maps we have been using, but they don't have elevation information.

Now we have not discussed elevation information yet in this course because we need to give you this information first about the contour lines. When you look at the map, your seven and half minute map, your Carson City map that you have, you see all of those that are in shades of brown and of differing line weights, you know thicknesses of line. But you see all of those lines, squiggly lines on there. Those are the contour lines and that information is what we use to determine what the shape of the land is out there. The elevation of it. Once you learn how to use those, you can predict exactly what it is that you are going to come across and find if you were to walk a certain way or go to a certain place. You would know what the lay of the land, ok we will use that term, what it would look like and you would have a good idea of obstacles, and situations in the topography that you could predict because you looked at the map and you understood what is going on.

For instance, you want to get from A to B, you see a cliff, you don't see the cliff but you don't want to walk a line from A to B and then find the cliff. You can even look at contour lines and we will see this here in a few minutes, and you can determine, well I will go this way it is not as steep. So there is information there that helps you. Now it is in a third dimension, because everything we have discussed so far had been two dimensional. Which of course is what reality a planimetric map is. Now we are really going to take on what is unique to a topographic map and that is the contour information. Now if you take a look at this slide here we have above the rectangle above is a map with contours. It is a topographic map. Below it we have if you will a relief or three dimensional attempt. We are looking at it from the side, you know off the top and side. We have a little bit of a three dimensional look. And it is of the exact same piece of information. It just gets us started talking about topographic interpretation.

If you notice, that where we have a hill, going up here, traveling this way up the mountain. So what we see are contours and we will see here in a minute how these contours increase and you can tell that you are going up versus down. We see a creek here and it shows up in the topographic map not just because it is marked with that dashed line, but because of the way the contour is laying as we will see here in a few minutes. That tells us that we have a creek there. And even still you see a place where contours do this where they don't meet and they create a place like this if you will almost a land bridge. That is because now we know we have a pass there or a saddle between these hills. And of course when you look down below that is true. Where we are high here, come down into a creek and back up another hill. We are coming up a creek here, but going this way we are going back down. And we can tell that information by looking at this contour map and studying the relationships of the contours to one another.

In fact, while we are looking at this, let's just notice, down here in the supposed real world picture we have a little bit of a crater there a little bit of a depression. It may be natural, it may be manmade, it doesn't matter. When the map was drawn, it existed and we have the contours up here, which if you look very closely and we have some examples of this on the seven and half minute Carson City map, those contours have little indentations there and it has little lines that indent and that means it is a depression. So you see I can even tell that there is a pit there, or a hole or crater. And if I am planning to go ATVing or jeeping out there, why I am going to look at that and I am going to be aware or tell the other drivers to be aware that hey over in that area somewhere, you can't see it from here, just over that hill or whatever, there is a crater there. Be careful there might be a sharp edge, or drop off into it that sort of thing. Or it is just an identifiable feature that you could be at to get a bearing to something else. The point is if there is elevation change, the contour will show it.

Now let's go to the map on the overhead over here and talk a little bit about this stuff. Go to the bottom of the quad sheet that you have. Your Carson City map, just below where the scale is, we talked about that earlier, the bar scales are there. Notice that it tells you contour interval forty feet. Now what that means is, that elevation wise, every time you cross a contour line, you have gone up another forty feet, or down depending on which way your going another forty feet. Now they do mention here supplementary contour intervals, and I am not going to go into that. Sometimes in really flat places they put in the ten foot contours, because you may have to go a long way across the map before you get to another forty feet. But what we are going to talk about here is the forty feet difference between each contour and that is what that means. And that is what that indication is on the map. Now what this all means is we have—contours are kind of weird, let me put it this way. Maybe it will help. They are a horizontal representation of a vertical position. Now if I have, now you have to remember that on the map it is as if you were looking straight down on them. And so if you see a contour and it goes around in a circle, all the way and meets itself that means at that point the hill is pretty much circular in nature and at that elevation it is circular. And we can see some examples of that; we can also see some things that are obviously not that way.

Let's go back to the map and let's take a look. I am going to go over here on this edge of the map and I am going to show you a couple of things. You have, let's understand, the difference between these dark lines. In other words, if I am at this position on the map and I go to this one, I have gone up forty feet. And I can tell that I am going up because these are called index. Index is usually given every five contours, and they give you an even amount of elevation. So when I see this I know that down here, I am at eight four hundred feet elevation. And if they are in forty foot intervals, then look I can count one, two, three, four, five. Five times forty is two hundred and guess what that would be eighty six hundred. I will just slide the map down and notice that is another indexed contour eight six hundred. So then I will go, one, two, three, four, five, that is another two hundred feet and that should be eighty eight hundred. And sure enough it is.

Now you notice that the contours that are indexed are all brown, but those that are indexed are a heavier line weight than the ones in between. That just helps you follow this more closely and pick up real quickly which ones are the indexed contours that have a number on them. The others are what are in between. So I can tell that I am going uphill by looking at the contour intervals. Eighty four hundred goes around that way, then eighty six hundred then here is eighty eight hundred. And then I have what is called a published elevation eighty nine eighty two. And that is actually on a little triangle there. If you remember from a few minutes ago on the discussion, I told you that when you see that triangle that means that is what is called a triangulation station there. It means there is an actual monument there and we know its elevation. So I know that this is all uphill.

Now if I were to be standing, let's say in this area here, at the edge of this clearing. We have a clearing that comes out sort of a thumb shape, and I am in that area, and I am wondering what elevation I am at or close to, I can simply look at the map and identify where I am at on the map and see oh I am at eighty eight hundred feet above sea level. There is various reasons why you might want to know that. One in particular if you are working with helicopters on a project and they are limited to a ten thousand feet well then you will more or less that and you will know what project area you may have to hoof it into because the helicopter cant land there unless you have one of those high altitude helicopters.

But there are other reasons; it is not necessarily that I want to know the exact elevation but rather the relationship of the elevations. Do you notice that here is what I mentioned a circle that is not a perfect circle, but the contour meets itself, we will discuss what that means but bottom line is, that means there is a hilltop up there? Somewhere in there is a hilltop, and this is the closest that it came to in this case, the nine thousand foot contour interval because I am at eighty eight, one, two, three, four, five. So this is the next indexed contour. It just wasn't big enough or long enough to get an index on. So this is a hill that is coming up on every side. This is a saddle over here as I showed you earlier. This is a hill top that is probably slightly over nine thousand feet in elevation. When I come over to here I have a little more information.

I went from nine thousand, and then it is nine thousand again over here that means in between here has probably dropped at least slightly below nine thousand. So but not forty feet. See if you dropped forty feet below nine thousand, there would have been another contour in here, but there isn't. s what I know is that I have got a shallow saddle here. And then I am back at nine thousand and then I go one, two, three, four, I am not quite at enough elevation to get another five. That takes me up to the ninety two hundred interval and so notice, that they have... this is what we call a published spot elevation and they are telling me that the highpoint on that hill which is obviously inside that little circle. So we have that hilltop pretty well narrowed down, very small area. The elevation that they picked up for that when they mapped this was nine thousand one hundred seventy feet above sea level.

Now again as I mentioned, it is not necessarily the elevation but rather the relationship. Now that we understand how these hills are working, let's take a look at this. Notice how the contours.. how far apart they are then they get closer together. Notice if I go this way they are even further apart from one another. What do you suppose that means? It is actually indicating that this is steeper this way than this way. The contours are farther apart from each other, therefore you have to go a greater distance horizontally to drop forty feet. Obviously if I am standing here I have to go this far to drop forty feet and this far to drop another forty feet. That was eighty feet. Yet if I was over here at the same place I only have to go only half the distance to go those eighty feet.

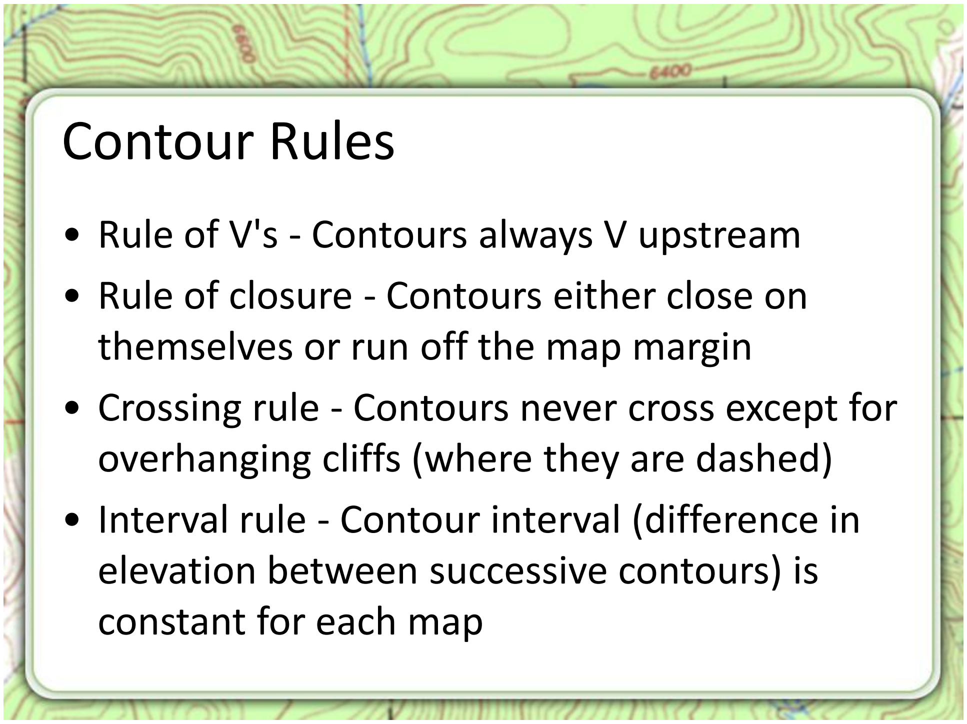
Or if I moved down here and go two contours it is even less of a distance. So this is much steeper. And obviously if you had a cliff and actual vertical cliff, the contour lines will all come together, wont they. And we can find some places on here where that is relatively well shown. Let's just take a look here at the mouth of this North Kings Canyon. Notice here there is a creek coming out here but of course it is at the low point and we will talk about that here in a minute. But notice how close these contours are. These are not direct vertical cliffs, but it is extremely steep there. It is not some place that I would want to be trying to hike unless I absolutely had to be in there for safety reasons to rescue somebody.

So that tells you a lot doesn't it. I am going to move a little bit further. Notice how there is a lack of contours in here. Now I have given a spot elevation of fifty five thirty four, I can see an index contour of fifty four hundred, so if I go fifty four hundred, then go one, two, that would be eighty feet, fifty four eighty. This is fifty five thirty four, so what I see here is a very large area that is relatively flat. Nowhere in here does it rise more than forty feet from here. Except right there. It has risen another forty feet so a contour picks up and actually goes up even higher than that and the spot elevation tells us that. But you need to understand that when you have a forty foot contour interval, there could be a large boulder out here or a raise of some kind, you know a mound of dirt, or something. But if it is less than forty feet, depending on where it fits in between the contours, it may not show up. So it is very possible that if you had a twenty foot high boulder or a volcanic plug sticking out of something but it is just twenty feet, it may not show up on the quad because we are down to forty feet and that is as close as we show those.

So what you are seeing is that it is very important to realize that the relationship of the contours to one another is what really matters for you and I out there in the field. In fact, contours are such valuable information you can figure out all sorts of things about the ground out there and what is going on. For instance, take a look at this slide. I can tell because the way that these contours are grouped together that that is a ridge. And you know a lot of times a ridge is the best way to get up or down a mountainside. And sure enough it is. I don't really want to go down off this way which is steep or the other side of it which we can't quite see from this view. Especially if I am trying to ride an ATV or get a horse up there or something. The ridge is the best way to go. So you can plan routes and that sort of thing and figure out what is easiest or fastest or what is safest by simply studying a map for a few minutes and understanding what is going on.

## Contours

Now there are several rules that we are going to go over here about contours and they will help you understand.




This is the first one we are going to look at and we will call it the rule of V's and that is contours always V upstream. What do we mean by that V upstream? Well take a look again. This is one of the ways that you learn to look at a map and know whether it is up or down. If you didn't understand that you would look at this alignment, an you would wonder well is that. I see the contours are changing forty feet every time I cross one but is it going up or down. Well you see here is a creek running down through here and another little side creek on the side. What we learn here is with the rule of Vs what did the rule of Vs say- contours always V upstream, so that means this is down because the contours V. See these are Vs. Does that make sense? And when you look at the map below and I can see that because it is in three dimensions, I can see that is downhill going that way.

Notice that even on the little side creek which has very little water in it ever. I can tell just by looking at it. It hasn't made much of a canyon or a ravine, but I can tell because the Vs are going this way. And the contours I know that this is downhill. So when you have a creek or ravine or some opening like that, you will have Vs you can look at. Now where you don't have anything to look at is where it is just a slope. And there is no distinct river or ravines or waterways. Well you are going to have to as we just did a few minutes ago and that is look at the contours and count. Look at the index contour, find the next on and count above or below it and you will know which way you are going. Frankly you won't have to look at those. You don't even need to know what elevation you are at like the map we were just looking at on the slide. I don't know what elevation and I don't have any indexes on there. I have no idea as to what elevation I am at. I could be down near sea level or at fifteen thousand feet for all I know up on Mount McKinley.

I don't know. But what I do know is I know which way is up and I know which way is down on that hillside. So you see the point is, sometimes it is not the precise elevation that is our interest but it is the relationship of the contours to each other. For me to understand what the land looks like out there on the ground. Second rule about contours, the rule of closure. Contours either close on themselves or run off the map margin. You can't have a contour line that runs along and then suddenly ends. Just think about the definition of a contour. It is a constant elevation line so that is easy for us to look at in two dimensions. But if the hillside is going like this, then that contour is going to follow that. Which is exactly what we have been looking at.

Contours the rule of closure is contours either close on themselves or run off the map margin. Let's look at this slide again and see if this rule is true. That we have for the majority of these, because it is a small area we are looking at, these contours run off the map. That is because they have to go on to the next page of the map to come back around to where they were. And notice that the only place on this example, where the contours close on themselves is at our little depression down here. And that makes sense, it is a small little limited area, and the lines come back on themselves. It is just a small little crater. Now what we are going to do is switch to the overhead and look at map and see where we were looking a little earlier, let's see that these rules are true here as well.

Where the contours close on themselves, you know that you have a full picture of that part of the hill. The highpoint of the hill is here, and hey just happen to give us this. They don't always give us that and I will show you one of those here in a second. But the contours close on themselves or what was the other rule. The come along and go around here and then they go off the map. That is because they are going to close on the next sheet of the map. That makes sense. Contours can never run off and just stop somewhere. That doesn't make sense because elevation cannot just stop. So that is a simple rule. Now I want to show you. I have been showing you hills where there is a published elevation. I guess I have shown this one already where there isn't.

Let's go to another one here. Here is a point I can tell that this is a point sticking out from the mountain. The main part of the mountain is real steep back here; there is a creek, rule of v's. I know that is downhill going that way. I can look here and see that the contour is really flattened out in here. They are not near as close together. So this is not flat but a point, a thumb that sticks out from the mountain out here. Which might be really good to know. You can look at it if you need to see down into this canyon or across to the next hillside. Being out on a point like that is a pretty good spot. Plus I can see by the shading that there is no brush up there. That might be a far better place to be than some other one back in here on the hillside in the brush or trees. Now here they gave us a published elevation, what is that eighty two twenty six, but notice over here that we don't. Now this is interesting. This is eighty two hundred, so this is plus forty. Eighty two forty, so these are plus another forty.

There are these two little circles, what does that mean? That means that on this hillside, there are two points on it. They may be volcanic plugs, little highpoints, but the hill comes up, goes back down again, comes back up and goes back down again. Not that much but those two little knobs there might be quite easy to identify on the ground, if you are trying to figure out where you are on the map. You could be looking around, because that is what we do. We take the map with us and maybe I am doing some work in here and where am I. I want to figure out on the map, so you look around and try to find something that stands out.

Maybe these two rocks, points, they could be pinnacles or something. And I see those and ok and I could get a bearing to them and see that they are northeast to me. I know I am standing back here in this little ridge or this saddle. So you see, you don't have to know lat and long immediately, or section, township or range immediately, or UTM or anything. You could just look at the map and understand contours and have them help you figure out where you are at the moment. You don't even have to get positions or worry about that unless you are going to call it in or something. This could just simply be I have been looking around out here at the trees, I'm a forester and we are talking about timber cut or something or there is an insect infestation here and you now you have to walked quite a bit and kind of realize that I don't know where I am.

I know I parked the truck back over here somewhere, where am I right now. You can look at it and see I am at the head of a little canyon that turns into a bigger canyon that forks into two, see look at the V. This is the creek that has water in it, but then there are ravines in the hill. There are two main ones that fork. A south and a north and I say oh ok I think I am on the north one, I can see these two pinnacles. I must be standing right about here. So I will go down this ridge to get to the truck, because that will be easier. I don't want to go down here and then have to go back up again to get to the truck. Make sense. That is the rule of v's and the rule of closure and how we can come up with these being closed lines which means that there is a little highpoint there. And its elevation is approximately eighty two eighty, probably a little higher than that because when it hit eighty two eighty, it gets to have a contour. So the highest point in there is higher than that. It is not as high as another forty feet would be because that is our contour interval.

You have another rule about contours and that is contours never cross. They will not cross themselves.  Does that make sense?  How could two different elevations cross one another? There is only one exception, and they will dash the contours for you and that is where you have an overhanging cliff.  Now I mentioned something like this in the first hour or so of this course, because it was one of those things that I have been using maps for years and I came across this and I wasn't quite sure what it was when I looked a map, and it was exactly that.  I had contours then I had a couple contours that went back underneath them but they were dashed and I thought how could that be.  I thought there was a mistake on the map.  But then I go to looking at what it was on the ground and I noticed, it was an overhanging cliff that went back quite a ways and there was an Indian ruin in there.

So I could see that so I think that must be what the dashed lines mean, then I looked it up and I found out that dashed contours mean that you have something underneath what you are looking at.  Those happen more often than not obviously in the southwest we have a lot of overhanging cliffs that are of enough size and show up at that scale.  But that is the crossing rule of contours. They don't cross unless there is an overhanging cliff.  We look at our sample on the slide.  There are no crossing contours.  None of these cross and in fact on the Carson City quad, I haven't found any that crossed there either so there are no overhanging cliffs that exist in there.

So but that is just one of those rules that we want to make sure of.  Now I have already mentioned this, but it is another one of our rules. Interval rules – contour interval, difference in elevation between successive contours, is constant for each map.  And I showed you that and the point we are making here is constant.  They don't change it unless they have a supplemental indexes or contour lines. And if you look in the USGS booklet, the brochure that had all of the symbols in there, they show you how they deal with those contours that are supplemental.  They change the line weight once again.  So you can tell when you are dealing with that, but here is the point. Forty foot contour interval unless they need the ten foot to show you something that is constant throughout that entire map. So that makes the whole map consistent.

So I can look at this map as a whole and I can see alright if I am understanding, I can tell where the hills are, I can tell where the saddles are, I can even figure out whether I can see from A to B, whether the mountains are in the way.  Because I can simply establish what the contour elevations are.  You know if I am at five thousand feet, and I want to see something on the map that is at six thousand, but I want to know if this ridge between us is in the way well then I need to know if that ridge is halfway in between us, well does the ridge get to fifty five hundred feet, if it doesn't and it is only at five thousand feet, then I will have line of sight.  I will be able to see that person over there.

So you can use the contours and knowing that the entire map is consistent with its constant elevation changes between those contours and I can study that whole area.  Of course I have studied this map a little bit because we are preparing for this course.  I have driven through Carson City a couple of times in my life and never paid much attention but I have a really good idea of what the terrain immediately west of Carson City Nevada looks like. In fact I could probably get around pretty well out there because I have memorized some of the roads and things because of what we are doing in this course.  But all of that I have been able to do that without even being there.  And that is the beauty, when you think about it, all of the planimetric things that we gave you in the course so far are tremendous aids to figure out where you are. But when you add in this third dimension, the contours, and when you get used to it, you study those, you start playing around with this map or other maps in the area where you live which will be even better because you can look at it on the ground. Look out your backyard at the hill that is out there, and look at the quad sheet and look at the contours you can understand it. It will amaze you once that happens and you get to the point where you eventually just look at a map just like that and figure out which way is up, where is a saddle, a ridge which is the best way to go. Fabulous information. So it is the third dimension that really brings in a lot of help for us.

Now we are going to go to this other slide here and discuss a different slide. I want to talk about profiling. And of course this is not the politically incorrect kind of profiling. This is profiling information on the map. You see I can figure out what any line, lets pick line A-E. B,C, D are just along that line, I can see what that looks like. Let me give you an example, even though this might not be something that you are doing. What if you are building a power line? This is how surveyors and engineers use this information, and the power line is going to go across Point A and it is going to follow that line to E. What does the profile of the elevations look like? On a map it is just a straight line crossing all of those contours. But what you can do is pick points along the line where the elevation makes major changes, or you can pick them all for that matter. I can look at the map and figure out what elevation A is at.

I can look at the map and figure out, B and C, and D and E. Then what I do is create a drawing to scale and that drawing is going to be line A-E, but in the third dimension. You are looking at it from the side. You are looking at it as if you were standing somewhere on a hill over here and looking at it this way. I am looking at that line. How will the profile of the land look? How will the land lay? And so what I do is scale on the map from A to B, lets make up something one thousand feet, and then I count one, two, three, four, five, six, seven, eight, nine, count how many contours and then I can draw that to scale. I can draw line A, sorry point A, at a certain elevation and then measure that same distance to come up with point B but then draw it on a piece of graph paper.

Usually this is best at its elevation and now I know the slope of that. I can do the same with C, D, and back to E. Now I know exactly what this looks like on the ground. My example was for a power line, the reason they are doing this, is that they know they can put a tower here. So far with towers before they have put new ones in so they can also put a tower here, then I will put another one over here. And it is nice and high because they compute the sag of those lines. The lines can never be any closer than thirty feet to the ground, something like that. But that is all part of their design. So they are using a profile to decide where towers go and where the sag will go. You see if you were to do this and you were going from A to B, but let's say that it had a rise in it, then you would know that by putting a tower there and a tower there, the sag of the electric line will be too close or might even touch it. Now that is an engineering example of profiling.

You know what I would use profiling for more is simply to decide how steep is a certain area. Let's say that you need to build a road, now some of you if you have any engineering background, highways are generally at five or six percent, interstates are not supposed to ever exceed six percent except in a few places. Which six percent means, it rises six feet every hundred feet that it goes.  You travel one hundred feet it rises six feet.  Six percent is pretty much the maximum grade most of you have ever driven on an interstate.  But you know residential streets and other streets kind of do it a lot more and you can even have much steeper things that a jeep can drive on, but you know you might be looking at I might need to drive a jeep into this place because we have got some heavy equipment that we need to haul in there, measure something or test something, or do whatever you are doing.

And I am going to look at this map; I can simply look at two or three places on there and get the elevation difference right.  That is what we did with the profile and I can divide that into the distance that those are apart and that will tell me the ratio of the aspect of that hill.  And I might say whoa, if we go that way, we are going to be at a fifty percent grade, which is really dangerous in a jeep.  Especially if you have to get sideways on it a little bit, you risk tipping it.  So by looking at the contours and doing a little profiling, I can see that you know if we go around this way and I will do my math over there, hey that is a lot flatter and a lot easier, a lot safer to take the jeep up.  There are many other applications for profiling, here is another one.

I am on this hillside and I have to get to something that is over on that hillside, can I see it.  Can I see it from here, so I can get going in the right direction?  A profile can be done in the office before you ever go out in the field.  Or it can be done in the field in the truck in a matter of minutes and if you have some graph paper it is great.  And you can plot what you need to know and see whether you can see from A to B or wherever.  Going back to the slide for a moment, you see that cross section there I just made up.  This profile line is called a cross section in engineering, but you know the real one that matters is across the saddle.  That would be the one I am interested in for line of sight.  And what I would want to know is can I see from X to Y.  Can I see between those two?  So what I would do is probably two profiles.  I would do a profile from A to E, you know I would move it up to that new point the line A to E I would profile it and then I would profile X and Y and then I can tell very specifically if I can see through there.  That is important information.  There are a lot of applications where that is needed.

So as you can see contours provide you with lots of information and that is how a tremendous amount of engineering is done.  With the engineers and surveyors, they look at these maps and use them to help them design roads, sewer lines, water lines, power lines, gas lines that kind of stuff.  Even just to decide can we put a house on that hill somewhere.  You know there may be a zoning and other regulations in your community that you can't build on more than a ten percent slope because of the soil type.  It's not good when rain is running down or you have heavy rains and it is running down a dead slope or a grade where it is going to fast causes too much erosion.  So how do we work around?  Well the way we can do that is by mapping.  And we can go in and look at the contours.  I have worked on projects where the contours are drawn at a tenth of a foot.  You can do them in a tenth of a foot.  That is a little more than an inch.  A tenth of a foot per, you can draw that close if you have mapped it that well to make decisions about where a parking lot is going to puddle and where we need to put a drainage system to drain the water out of the parking lot.

So this is all done with mapping.  That example far more precise that USGS maps, but the bottom line is once you understand contours and you are able to use them and kind of picture them in your mind, you will be amazed how you will be able to use them and how you will be to apply them, and how you will be able to look at other products that people are using or designing or building or working on. You will be able to understand what is going on. That is part of the benefits of being able to understand contours and to do profiling.

So that is our discussion on contours, I encourage you before you go to this next exercise to take a look at your Carson City map. Take a look at it and find some of the various things that we have talked about and make some decisions. Is this up or down, is this steep or is it real shallow, or is it flat, what is it. You know there is one place I have found, I will give you a hint, it is kind of on the east side of the quad where you have a depression like there was on the drawing that I have used in here.

There is one place where I saw there was a depression, it is a rather large area and it could have been a burrow pit where they have taken dirt out to build highways, or it may just be a natural occurrence there. There is even one of those there so take a look at the map, play with it some and then again as I said earlier do it with a map from the area where you live too where you can see what is going on. Pretty soon it will all come into focus and you will be able to use it and once you feel comfortable with that well then take this next exercise and I will see you on the other side of that exercise and we will start talking about some real practical applications as to how to use your compass in the field and use the map and start reporting emergencies and that sort of thing and doing it accurately, so I will see you over there.

## Lesson 2 Determining a Location

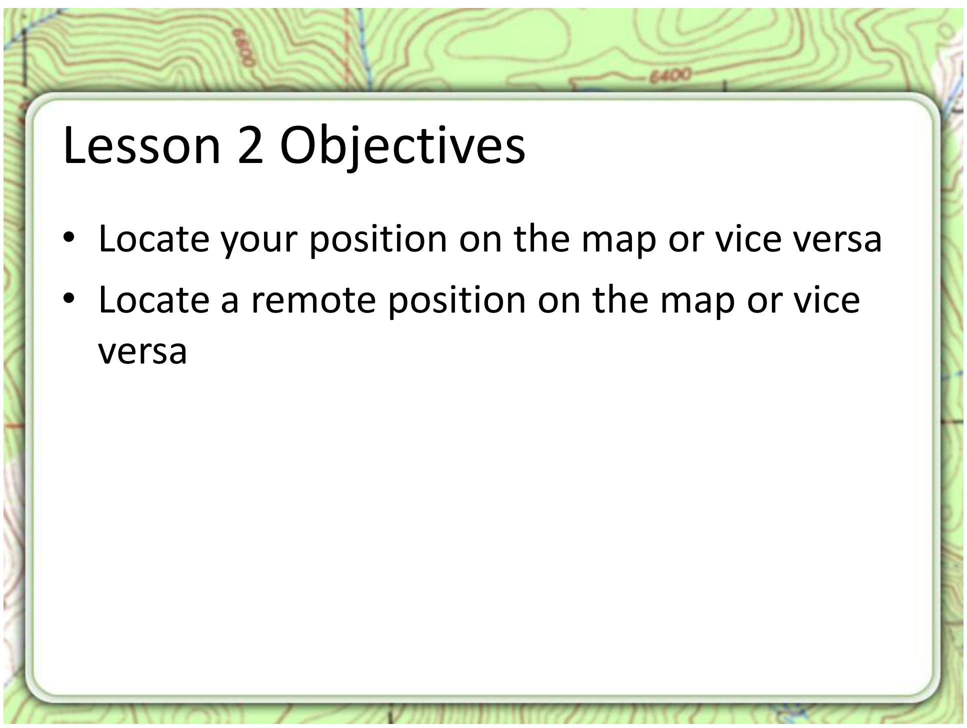
### Introduction

Well hello everyone and welcome to Lesson Two. This time we are changing gears and taking a lot of the information that we have looked at already in the course and going on to some new applications and new ways to use that data. Dennis Mouland here still with you and enjoying presenting this to you. And as you can see it's a new day, new tie and new shirt. So it takes us several days to get these totally in the can and ready for you to view and hopefully it has been of use to you.

Mapping as we have discussed is really critical skill for all of us and regardless of what we really do in BLM or any other natural resource agency that you may be affiliated with or frankly if you just go hiking on the weekends, it is a great tool. And while I am all for GPS, GPS can fail, the battery can be dead, you left it in the car or whatever, so we are looking at skills here that can solve whatever your problem is.

### Lesson Objectives

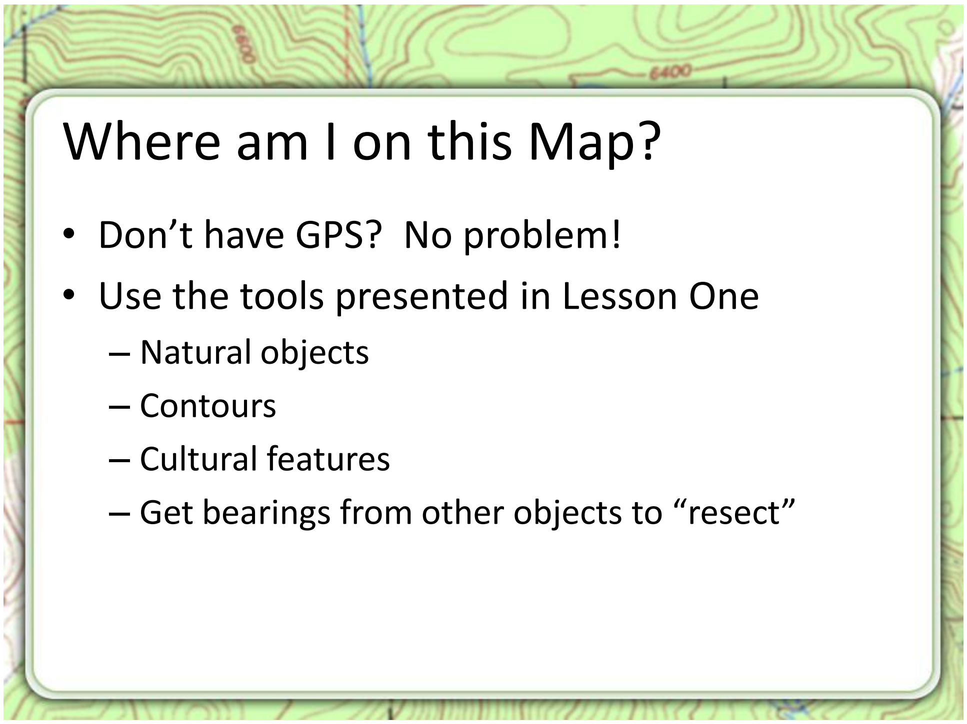
So let's set some objectives for this lesson. They are relatively simple.




You will be able to locate your position on the map which we have kind of talked about already or vice versa. And then we will talk about how to locate a remote position, in other words a position you are not at, as I have given you some examples earlier in the course. But you want the position of something over there. You want to know where it is. So those are kind of our objectives. They are relatively simple. And this lesson is not near as long as the first one. The first one goes through all of the basics of what it is the map is trying to tell you.  Now we are going to talk about how to use that information.

## Where am I on this map?

Now there is one basic question that we ask and again we discussed a little earlier in the course but really it is the question "Where am I on this map?"  Now if you have GPS, well then fine. You have a coordinate and you can plot that coordinate, whatever.  But if you don't GPS, if it is broken, its dead whatever, that is no problem.  You can still determine relatively accurately where you are.




We are going to use the tools that we learned in lesson one.  We are going to talk about the natural objects, the contours, the cultural features (meaning man made) and we are going to talk about getting bearings to things from other objects to do what is called a resection or resect.  And that is a trigonometry term for determining where you are by looking at the bearings to different things, so this is some good practical stuff so I am going to slide over to the overhead here and get us started.

## Getting Started

As you can see then what we are going to do is work in the northwestern part of the quad that you have. The Carson City quad.  You can see Washoe Lake up here, the Lakeview Interchange, and the mountains here.  And I am going to zoom in just a little bit.  You know sometimes, you are at place that is very obvious; you know it could be that you are right here where. You know you are on this road, and here is this trail that cuts off and it crosses the creek right there.  And that is where you are standing.  Well fine, you can just look around and see what you are doing.

You know hold the map north if you have to, if you can rotate it in your head that's fine. But just look and see you know that has got to be this place. You might be able to prove it if it is really critical. There is a structure over here of some kind, you see that little dot. I guess I could zoom in on that a little. There is something right there. And you could verify that if you weren't quite sure. But now look at the contours.

Based on what we learned in the last lesson, look at the contours. Not only is there a creek here, this is downstream this way because the Vs point up, right we learned that, but now I am out here where the contours are going the other way, I am actually on a ridge. A road is coming up a little bit of a ridge not a major one in here. Then this road goes downhill because it crosses a contour line and goes to the creek, and then goes back up. So I can take a look at what is around me and figure out things and that is really part of what we are talking about is where am I on this map. And many times you can that but there are other times where you might be in an area that is not, there is nothing really well defined. You are out in here somewhere.

You know you are somewhere in this area, but all we really have are contours and maybe there are trees like this there is a little hilltop up here. Those are the first things I start looking for trying to figure out where I am. But maybe there is just nothing really distinct in the area.

So you want to figure out where you are without using, I mean you try to use the contours the cultural features those things, but if you can't there is another way to do it and that is resection. That is what I want to show you because I think you followed from earlier in the course, the natural ability to search the map and the contours and those things that is something you have to work at and practice at to be able to do it properly.

So to make sure I am making myself clear, you want to look for the other things that we just discussed first, natural objects, cultural features, but when you can't, when you are not sure, or when they are is so generic that you are not sure where you are well then there is another way and that is to get your compass out and take some bearings.

## Resection

Now I want you to assume that wherever you are standing, you look down and I will zoom the map and let's say that you can see the Lakeview Interchange. You can see it, so you get your compass out and you measure a bearing to there. You have checked your declination and all that stuff that I discussed previously. You get your bearing there. And let's say that you get a south seventy seven degrees east. South seventy seven east. From where you are standing to that interchange. Remember we talked about using the center of the interchange unless you can see something really specific. Usually if you are a mile or two or three away why it is pretty small thing and you know you are lucky to get it within a degree or two anyway, so don't worry too much about it.

But south seventy seven degrees east. Now how am I going to deal with that? Alright what we have to do is first of all, put the compass onto the, not the compass the protractor, on because you have used the compass in the field. So what I am going to do is get my twenty scale again and I am going to measure to the Lakeview Interchange. And this time I am going to move the quad over because I am closer to this side. What I am going to do is measure the distance to the Lakeview Interchange, center of it from the side of the map. I have got fifteen thousand nine hundred and fifty. So I know where that is. And I come up here and do that again, and you may recall we used a previously this distance here, so I already have this marked on here. So that is my due north-south line. Remember I brought it in from the edge of the map.

Now what I am going to do then is place the protractor on the Lakeview Interchange. I am going to put the index point right on that interchange. And I am going to make sure that the zero and edge of this protractor are lined up with that north south line, which I drew. Then I am going to take the bearing that I had which was south seventy seven east. Now, south seventy seven east is going south east, I am going to be going from this back to me, so north seventy seven west. Think about that, make sure you are ok with that. North seventy seven west, well ten, twenty, thirty, forty, fifty, sixty, seventy, seventy five, seventy six, seventy seven. North seventy seven west. That is the bearing. See the bearing you measured is from you to the interchange. What we are drawing is from the Interchange back to you. So I am going to line up my straight edge on those and I am going to scribe that line.

Now, in reality what that means is I could be anywhere on that line. Because anywhere on that line, is that bearing to the interchange. So what I want to do is get a bearing to a second object that I can see from where I am standing. So let's say that from where I am standing, I can also see the intersection of this road and this road. This is a little state highway here. This has numbers eight seventy seven. And there is all side roads up and looks like it goes to a big barn, big structure and something else, a little tank of water in there.

There is probably a farm or a ranch there. But I can see that intersection. And you know it can be anything that is a definitive point. You know, you don't want to take a sight on the lake. That is so huge, that your amount of error would just be huge, but you want to find something that you can particularly see. You might be able to see one of these buildings in particular. And could use it if you know for sure that is just it. Well let's just say that from where I am at I can see that intersection. Lets say that from where I am standing which is somewhere on the hill, I am going to point my compass in that direction and I see, that it is north fifteen degrees west. North fifteen degrees west.

So, I look from where I am at, up to that road intersection and I get a bearing of north twenty five degrees east. So north twenty five degrees east from me to the road intersection. So that is going in that direction. So it will be south twenty five degrees west from where I am standing back to where I am standing. Once again, I am going to have to scribe a line here so I am going to zoom out and use the twenty scale and I going to measure from the margin of the map over to that road intersection. And I get fourteen thousand five hundred feet exactly. Then I am going to come down and mark another place fourteen thousand five hundred, thereby creating two points that are equal distance from the margin of the map which means that they are, the line that they make is parallel to the edge of the map.

The edge of the map is north. Then I will place a protractor onto the road intersection and put the index point right on the road intersection, make sure my zero and edge of the protractor is lined up properly, now I going to go south twenty five west. Zero, ten, twenty, twenty five.

South twenty five west is the bearing that I have from the road intersection back to me. Now I scribe that line from the road intersection to there. And where those two points cross, (and let me zoom in on it) where those two lines cross, is where I am standing. And that can be plus or minus depending on how far away. I chose points that are within two or three miles. Because points that are longer distance away don't work that well, or you have some people try to, maybe they are in an area where there is some prominent mountain peak and they shoot it all the time. But it is so far away that you get a lot of inaccuracies. So what we are doing here is choosing the closest and most reliable thing that we can find and shooting a bearing to them, knowing that the reverse bearing (coming back from them), is where we will be. Now we did two of these, you could do a third one or you could do it backwards and let me show you that on the screen here, on the map.

You could say, oh I just noticed that if I step around one of the trees, I can see another intersection. I can see this road intersection. And this is like a check. What if you had misread one of these and this intersection is not correct, well a third in geometry and trigonometry third observation is always recommended so that you have a check. Even the GPS satellites do that with themselves. They use, because they are doing three dimensional they need three or four satellites, they get a position but then they use the others as checks and they modify it based on what those are. So that is built into this. But you know I could do the same thing here with this road intersection and let me show you how to do it backwards.

I could either shoot the bearing to it or while I am on the map a drawing, why don't I just see what the map says the bearing is to it. Then I will use my compass to see if that is correct. So what I have to do is get a north line passing through the point where I think I am at. Now that is relatively easily done because if you remember this bearing was twenty five degrees, so notice what I can do. I can put the protractor with the index point at the place I think I am at and I can rotate the protractor until twenty five degrees is on that line. Now what I just did is I have just made this due north again. This is parallel to the line, in other words I am not having to redraw a north arrow and measure it all again, I just transferred it here. I am going to scribe a line that is my north south line there. Then I am going to draw from there a line to the other road intersection that I can see up to where I think I am. I am going to now put the protractor back at the same place; it is just reversed to the other side. I am going to put the index point on where I think I am and I am going to line up the protractor so it is lined up with that north south line and I am going to now read the protractor to where that road intersection is. I can see that it is ten, fifteen, sixteen, seventeen, eighteen, nineteen and a half degrees. Nineteen degrees and thirty minutes and that would be northwest.

So you see what I am doing, I am doing a check there, now the only thing left for you to do in the field, is to actually now that you have that bearing from the map, is get your compass out and look at it and turn it to north nineteen degrees thirty minutes west and you should be looking a the road intersection. So if you see what I am saying, you could have shot the road intersection, plotted it and seen it hit that, or you can do it like I did. Lets plot what that should be, and then I will check it that way. Either way, I have three bearings to different objects that I can see and they all bring me down to within a small area in this case, it looks great. So what did that do, what did I do. I have proven using trigonometry, using what we call resection, I have used it to tell me where I am.

Now let's go over to the western edge of the map and have another discussion of possibility of locating yourself. Let's say – this is inside of Lake Tahoe State Park. So I don't know what you are doing in there. Maybe you are in a search and rescue mission or something. But you know that you are on this ridge. Ok if you look at that, see how I can study the contours and I can tell that I am on a ridge here. It goes all the way up to a point that actually has two peaks on it. Not real super duper peaks, and then there is a point that comes out here, with another peak on it. You know I can find this. I know that I am on this ridge somewhere, but when I come down to the highpoint on this end of the ridge which looks down into this valley, it is very steep canyon really. I am not quite sure if I am at that point or not. I know that I am on this ridge. And I have found an abandoned car that I want to have towed out of here. So there are a number of ways that you can do what I am going to do here is kind of mix and match to things.

See I have used the contours to know that I am on the ridge; I just don't know if when I get on the hilltop here I can look down here but I am down here. Now you could pace back from there. Or measure somehow and get it but lets say that you are somewhere in here and but you are not quite sure and you want to get more precise location for this. So you start taking a look around at what you can see, lets just say that you can see from here, you can see the roof of this structure which is at a little place called Red House. So now I am going to assume that maybe that house is red. I can see that from where I am standing. So let's draw a line that is due north and south. That is the first thing we have to do. Let's place the scale at the red house and notice it is really close to the margin of the map. So I can do this really easy. It is about six hundred and twenty five feet. So I am going to mark another one at six twenty five up here.

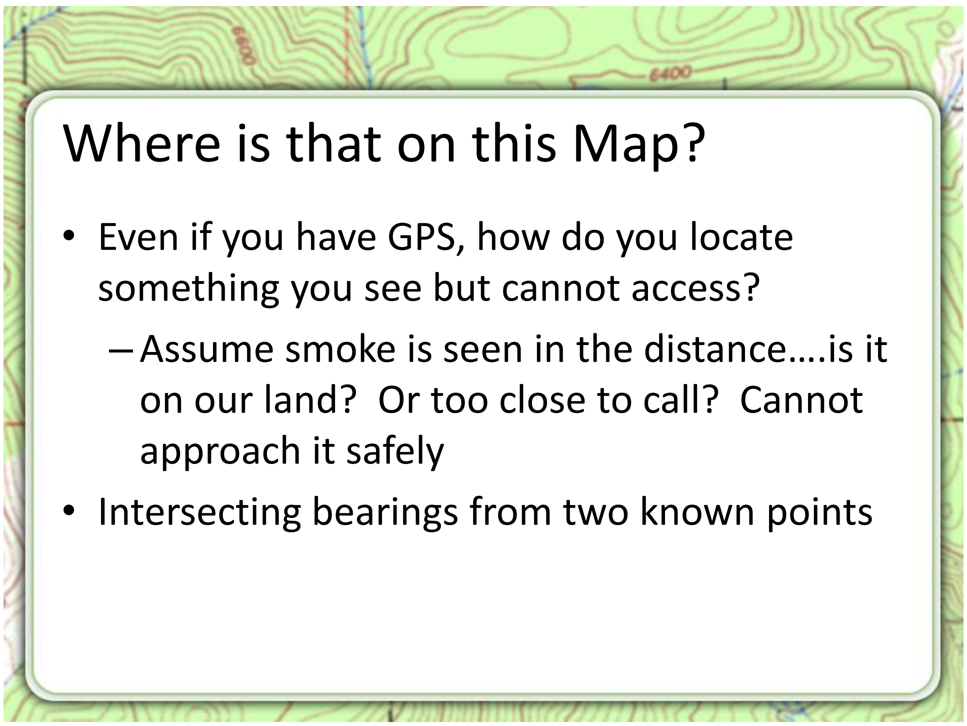
Why are we doing that? So we have our line that due north-south. I am going to pass that through that structure, that Red House. From where I am standing, I can see that that structure is at south forty four degrees west. That is my compass reading. South forty four west from where I am at. So that means from the Red House back to me, is north forty four east. I used the compass to see the Red House and see where it was; now I am going to use the protractor. I am going to put the index point right on the Red House, I am going to line the zeros with my due north-south line and I am north forty four east from the Red House. So I am going to count over, ten, twenty, thirty, forty, one, two, three, four. North forty four east and I am going to scribe that line. Now notice that if I know I am on the ridge I have almost perfectly identified where I am.

Then if I know I'm on the ridge, I have almost perfectly identified where I am. Just with one bearing down to the red house. And the reason I have been able to do that is because I know that I am here on this ridge, I am going to lightly pencil in where this ridge is just using the contours, you see. And so now I've got a bearing to that…I now know that I'm just within a couple hundred feet of this area here. And that may be close enough for what I'm going to do; and I could probably give a public lands description of this as probably the Northeast quarter of the Northeast quarter of Section 32, township sixteen north.

You know, look up the township ranges from the ridges on the map, what was it, 19 East. So I could give that and I don't even have to draw the quarters of quarter section because it is so close up in the Northeast quarter of quarter, right? So I can do that. But, you know, if I'm still not quite sure or I want it even more precise, if I can see that hilltop? Well, then get a bearing to that and bring that down and then it will give you a really specific area. You can scale off a latitude and longitude if you want.

But that's the bottom line of using the data and the information. You can use contours; you can use cultural features that you see, natural objects and bearings to things you see. You can use combinations of those things to figure out where you are, close enough for whatever it is you're doing. Obviously, as we joke in surveying, you're not close enough to build a Swiss watch, but you're close enough to report something and have them come in and take care of it or whatever your situation is.

So that's a powerful tool, really and let me review for you then on the slide what it is we just did. Where is that on that map?




Even if you have GPS, how do you locate something you see but cannot access? Let's review what we had just discussed, then, to make sure we are all clear on that. We can identify where we are by using bearings or azimuths for that matter. Everything I just showed you was with bearings, but with bearings to two objects and I recommended that you use a third as a check. But it's a great way to determine where you are standing if the topographical features or other cultural features in the area are not sufficient for you to figure out where you are. Usually you can see something; whether it's a point of a hill, a mountain, stuff down in the valley, road intersections, whatever. So, bottom line is, that's how you can determine where you are at any time if you don't have a GPS unit, or your GPS unit has failed.

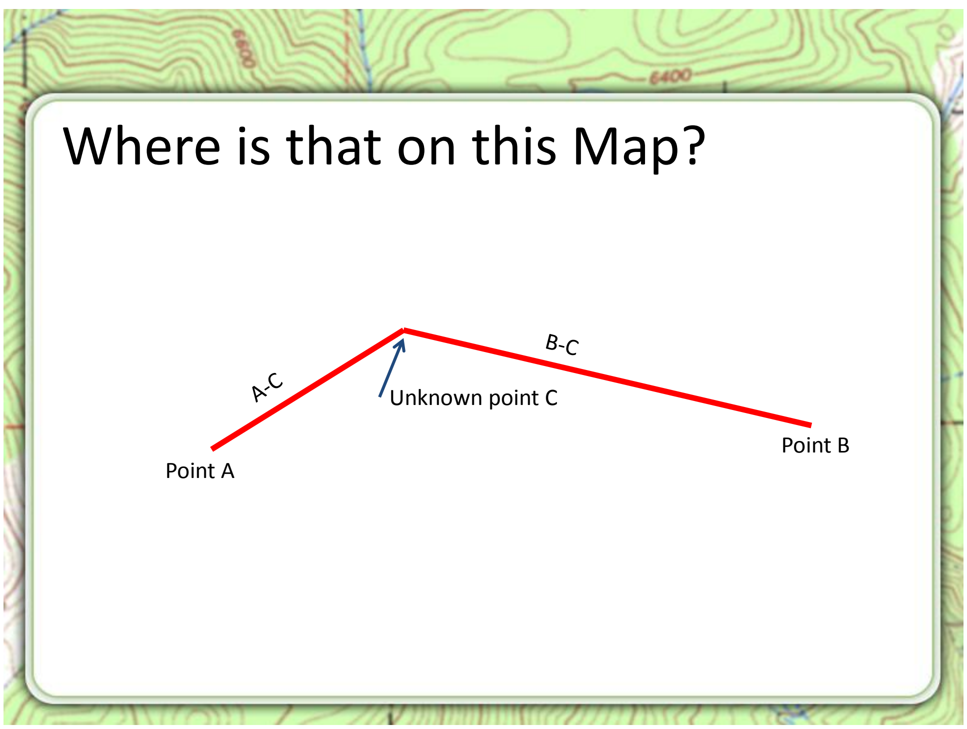
Now what we're going to do now is change gears and look at this a different way. What if I am at a place, you know, that I can figure out where it is on the map? But I see something off in the distance that I either don't have time to get to or it's too dangerous to get to. You know, I've used the meth lab example a couple times or it's a smoke and you don't have time to climb all the way up there and get the exact latitude and longitude of the tree that got hit by lightning; you know that could take you an hour or two or three and, hey, you have to call it in now before it spreads. So how can you get a decent location on something like that? Here's a place where GPS alone does not totally help you. You can figure out where you are, but where is that other remote location? Ok, that's what we'll call it…a remote location. So let's look at this slide

We're asking where that is on this map. Even if you have GPS, how can you locate something that you can see, but cannot access? Let's assume that there is smoke that you see in the distance. You want to know where it is; you want to call it in. Is it possibly on BLM land or is it on natural forest land? Or whatever mixture is in there? We haven't talked about land status…those are other things to learn in other courses.

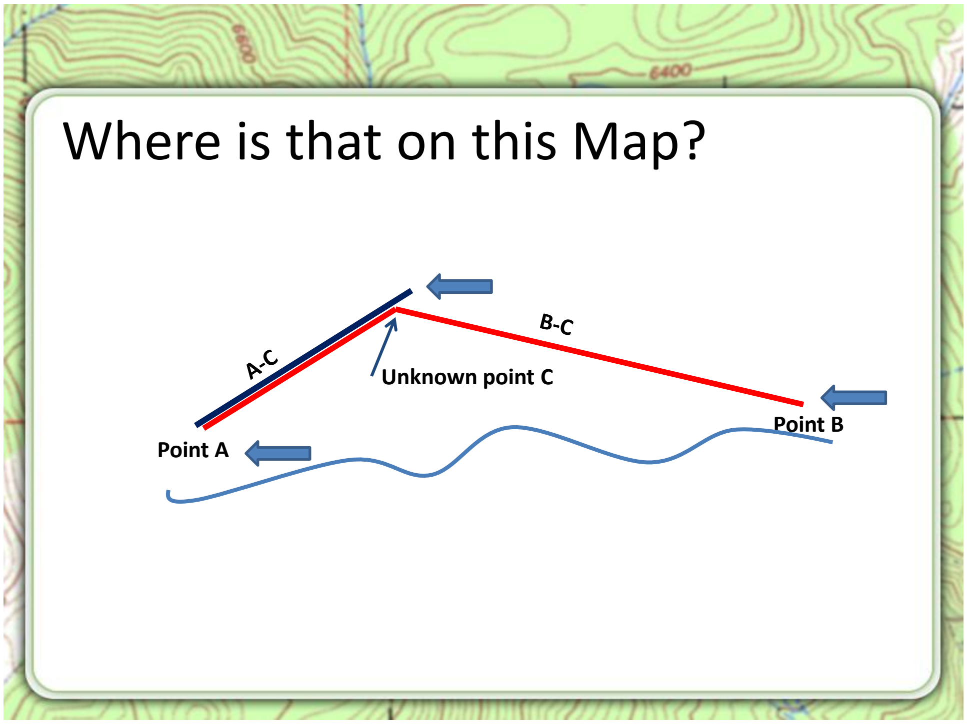
But if you can determine a section, township, range or a quarter of a quarter of a section, township, range, why you've pretty well narrowed it down to whose land it's on unless it's really close to the line. But, bottom line, how do we do that and if you recall, the process I showed you earlier is called a resection. That's where I'm here, I don't know where I am, but I get bearings to things that I do know where they are and that determines where I'm at.

## Intersection

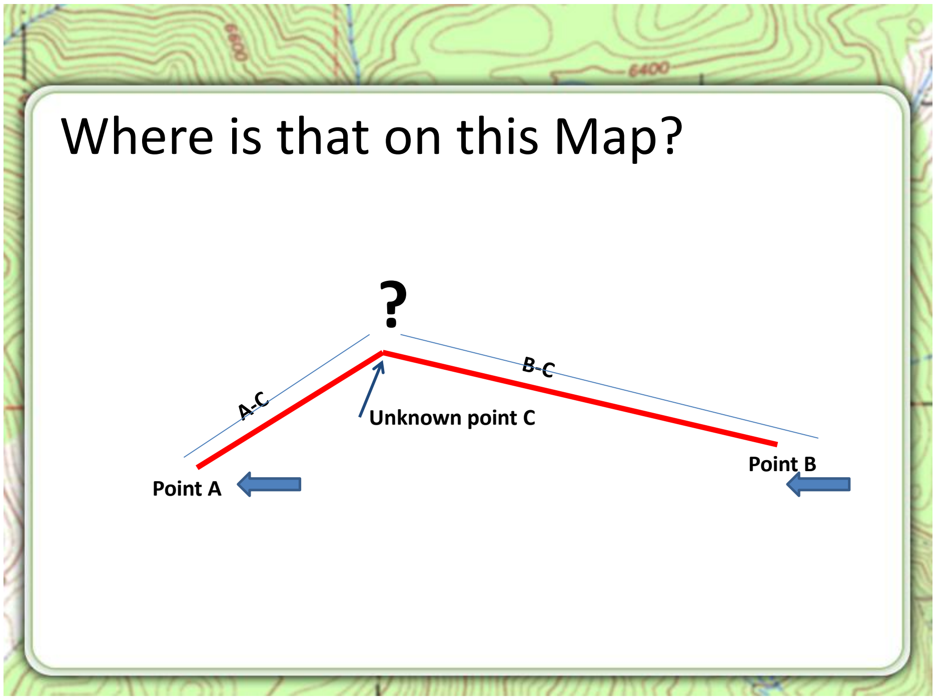
Now what we're going to do is called intersection. Not a resection, but an intersection. So take a look again at the slide.




You see the drawing on the bottom of the slide and here is essentially what we're going to do. I'm going to draw it on the map for you. Let's say that Point C sitting out here is where the smoke is. And you don't have the time or the ability to get up there at that precise position. Well, what we do is just use similar principles with what we did with resection. What we are going to do is to find Point A a place where you know is on the map, and you are going to measure a bearing from A to C and then we will go to Point B. And see the beauty of this is that you can just go to places on a road or somewhere that is relatively simple to get to get to very quickly between A and B you know you can drive down the road really fast. And you are going to sit at B and take a bearing up to C. And what's happening here is you are going to create an intersection of the two lines.




You know where A is you know where B is you don't know where C is, but you have a bearing from A to C and from B to C that will allow us to plot on the map a location for Point C. This is called an intersection and that's what we're going to do now.




So I'm going to move back over to the map and we're going to do one of these. Let's go back up to the Northwest part of the Topo map and let's do an example here. Let's say that you are driving along out here on this road that's called Franktown Road. This road intersection we used it the other day for one of our problems and I am going to use it again. I get here and I see a smoke off up on a mountain here. There are not really any roads on further up here. There's just one road. But there's a smoke up there and that's what I want to report. So you see this road intersection's a great place to get a bearing from.

There is a very definite point that you can stand in the middle of the intersection to get your, don't get hit again, but you can stand there with your compass and measure out the smoke. So let's say that you do that there and you get South sixty four West. Now we're going to go through the exact same process that we have done over and over and over again here.

I'm going to measure on the twenty scale and I'll back it out here for a moment. Ok, I'm going to measure from the margin on the map over to that road intersection to get that distance. And that distance is fifteen, five, six, seven, fifteen thousand seven hundred and fifty, it looks like. And then I'm going to just move down the map a little bit and I'm going to measure over fifteen thousand seven hundred and fifty again. I'm going to scribe a line because what am I doing here?

You all remember that I am determining where my North is, right? Then I am going to take the protractor and I'm going to lay it on there and put the index point of the protractor at the intersection. I'm going to line up the zeros on this line with my North arrow and the bearing I said was South sixty four West, so sixty four West. And then I'm going to scribe that line from the intersection to that point.

Now the fire is somewhere on that line. Now here is the process that you would want to do because you don't have time to goof off here with this. So let's say I'm going to go somewhere close by but far enough away that I have a little bit of an angular distance and get a bearing up to that smoke again. So let's say you just get in the car, now that you've got that first bearing, and you drive up Franktown Road and let's say you come up to where this little road goes off and you go up there and you see these two little houses, or structures, whatever they are, one on each side of them. And this one's got a fence around it so you don't go, but this one is something you can go stand on and not be trespassing and not get shot. Pick a bearing from there up to the smoke. And let's say that at this point, you measure from your compass South twenty five West. What do I have to do?

Same process over and over again. I am going to measure from the edge of the map and over to this point that I am at, this little house, building or whatever it is. And I've got sixteen thousand one fifty. And I'm going to come down a little South of there and measure over sixteen one fifty again. Sixteen one fifty. Scribe a line from the house to there and I now have my proper orientation. That line is due North which is equidistant to the margin on the map which is always due north.

Alright now I am going to put the protractor back on here. I am going to put the index point on the house because that's where I'm standing. I guess I should turn that around. I'm going to make sure I'm lined up on the North/South line and what did I say? South twenty five West. So South, twenty five West. So let's scribe that line from the house. So you see what I have done now. I will zoom in on where those intersect. I have now identified that the fire is right there because that's where those lines intersect.

And you know, just like I showed on the other example, where you can take a third one to make sure? Especially when you are calling in a bunch of resources like helicopters and stuff, you might want to make sure that you didn't read one of those way off. You could drive to a third location on that road the other way and get a bearing from there and plot it just to make sure that you've got it. But see you can do this, once you know how to use your compass properly, and the declination has already been set, all those things. Well you can get out of the truck or car and just get away from the vehicle so that you are not next to the metal.

You don't want to do this sitting in the car out the window because magnetic needle is going to drawn by the vehicle. But you can do this, get out of the car, walk away from the car, you know about ten feet, measure that, get back in the car and drive to the next one and measure that. In fact, the most time consuming thing will be you driving from Point A to Point B and getting bearings and maybe going to Point D so all of these will go up to C using the example I gave you earlier. And then getting the position. Now, let's say we have located this.

I've drawn it for you, where that is. Let's see how we're going to report it now. Just to tie all these things in together; there's our smoke right in that area. It appears that it's right where this road goes by so that would be good information to a fire crew, you know, that hey it is right next to the road or really close to the road so that they can get in there with a truck and a hose rather than have to go in there and fight it without water. So that's good to know. But as you're going to call it in, how are you going to determine that. Ok, you can use any of the systems we mentioned in the previous lesson. I could scale information off of the margins of the map or the tock marks, remember? Or I could also scale and get the UTM coordinates for this.

But in land management, we usually use the Public Land System where it's available. And I know that it appears to be in section twenty eight. And if I were to draw the lines as you recall, I went midpoint the four sides. If I draw those, I know that I'm in the Northwest quarter of section twenty eight and if I were to midpoint that quarter section on all four sides and draw those lines, I now know that the smoke appears to be in the Northeast quarter of the Northwest quarter of section twenty eight, township sixteen north nineteen east. That is probably the best way to call that in. That is how the fire folks will probably deal with it even after you've called it in. They'll determine a legal if you haven't, or if you were off some, they'll determine it. And that's how they'll usually report where the fire is for calling in additional help.

What we have done here is use intersection because we started at points we knew where we were on the map; or you know frankly, folks, if you don't have a road on your section to use and you do have a GPS unit, you can just get a GPS position where you are and plot it on the map, and write lat and long like we showed in lesson one. And then do this. But frankly, it's faster – much faster to just find something that you know and can identify quite certainly on the ground and you use that because it's a lot quicker than plotting a whole bunch of different things on a map to get to this.

Here, all I had to do was to find two things that I knew where they were on the map; plot two bearings, a third if you want to check it, and then I just had to quickly plot my quarter sections and the other quarter sections, right, to come up with where I'm at. In the end, I would call in a smoke that looks like a lightning strike or something. I've determined approximately where a description of the Northeast quarter with a Northwest quarter section twenty eight, sixteen North, nineteen East. That's what the dispatch or whomever you are talking to would want to know so that they could send the resources out there.

So as you see, we can determine where we are anytime on a map. If you have a GPS unit, you can usually figure out where you are, but you still need compass skills and the ability to read the map and that sort of thing to determine remote locations. Frankly, it is really fast if you are hiking or working, you're lost or disoriented, or whatever, it's really good and its really fast for you to be able to understand the map itself; all the information that's on there and to determine where you are based on the information you see.

You need to be careful with some of the things that can change over time. For instance, the green shading that's where brush is; I know that's where the brush was when they did the map, but that has since all burned off or it has been, like here in the Southwest, it's Juniper trees and they've pushed them into piles and burned them and there's nothing but grass out there now.

Those things happen or just nature occurrences change these things so be careful determining the exact place where you are based upon something that can change. Water levels in a lake, is one. Even creeks and things and you see a creek and it has water in it but then it doesn't have water. Well, that may be the way it is or vice versa. So be open-minded about that. But the bottom line is that if you understand how to read the contours, which we just discussed and how to read all the other symbology on the map, you're going to do quite well figuring out right where you are. So that concludes lesson two.

You have an exercise that you are going to have to do and then I will see you for our final lesson over here after you have completed that final exercise. See you there.

## Exercise 6 Determine a Location

You are uncertain of your exact location in the field and decide to take bearings to three different features you can see from your current location.

Your bearings are:

- To the south end of a shopping center between Carson City and the Indian Colony, you read N65$^{o}$E
- To the top of "C Hill", a bearing of due north
- To the Premier Mine, a reading of N56$^{o}$W

1. The elevation at your location is:
   a. 5910
   b. 5756
   c. 5401
   d. 5534

2. In which section of T.15N., R19E. are you located?
   a. 25
   b. 24
   c. 19
   d. 30

## Exercise 6 Determine a Location – Answer Key

You are uncertain of your exact location in the field and decide to take bearings to three different features you can see from your current location.

Your bearings are:

- To the south end of a shopping center between Carson City and the Indian Colony, you read N65°E
- To the top of "C Hill", a bearing of due north
- To the Premier Mine, a reading of N56°W

---

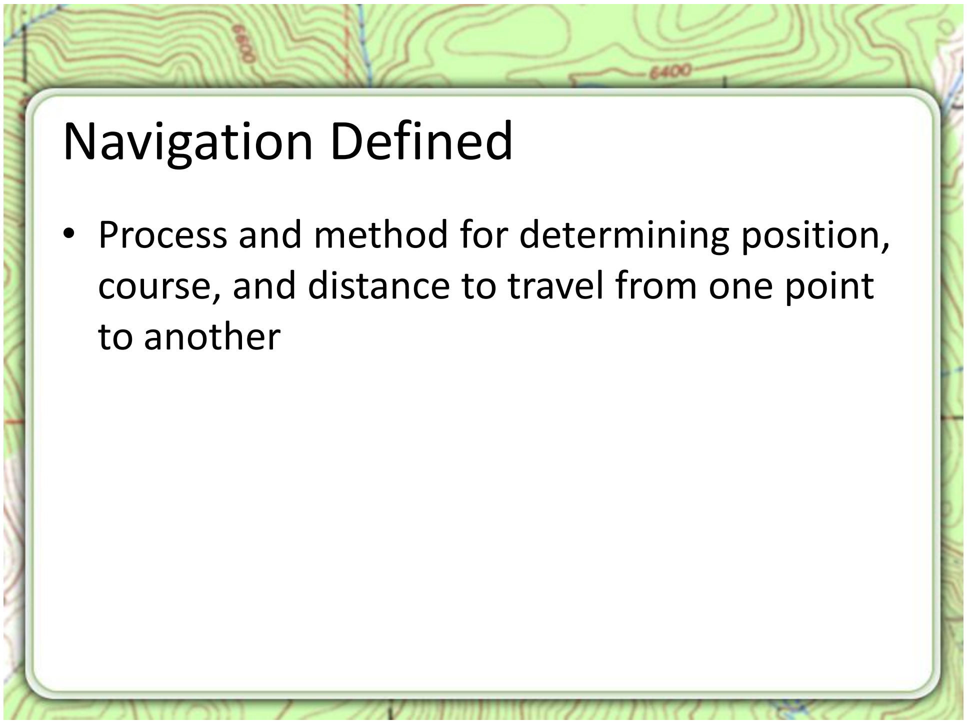
3. The elevation at your location is:
    a. 5910
    b. 5756
    c. 5401
    d. **5534**

4. In which section of T.15N., R19E. are you located?
    a. 25
    b. **24**
    c. 19
    d. 30

## Lesson 3 Navigating to a Location

### Introduction

Welcome to Lesson Three, our final lesson in this Basic Map Reading course. And in this lesson, we are going to discuss navigation. And navigation, we all think of the ships and ocean, but let's define navigation.



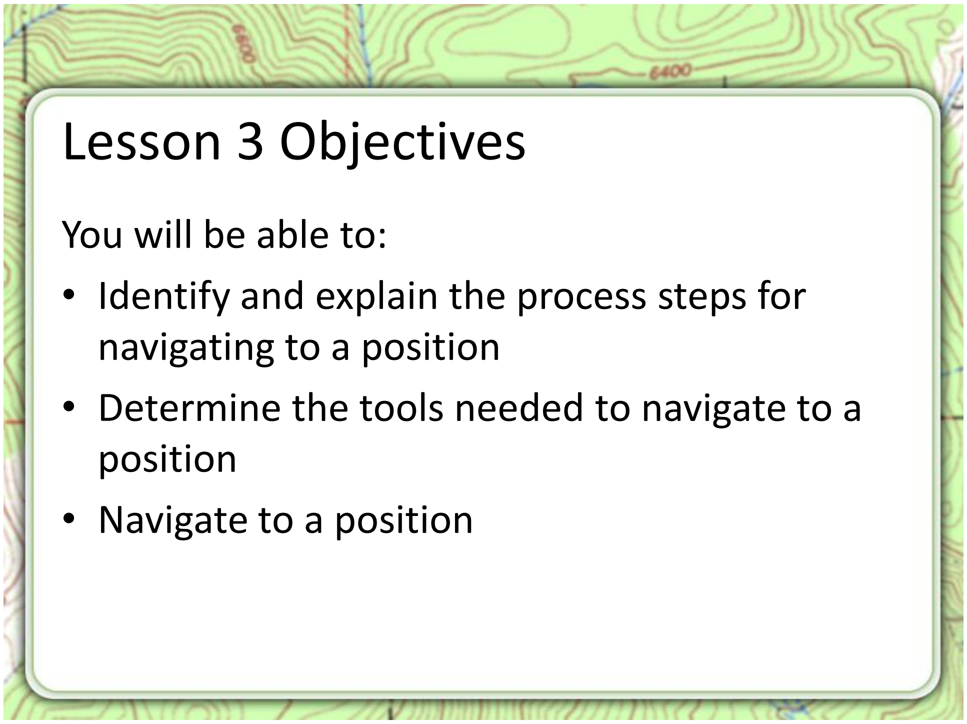

It is the process and method for determining position, course, and distance to travel from one point to another.

Now, let's talk about what that doesn't say. It is very rare in the real world, outside of the ocean, that you can plot a straight line to get from A to B. You can plot it, I guess I should say, but it is very difficult for you to walk or drive from A to B. I am here in Phoenix at the National Training Center filming this and I want to go to Chicago. Well, I can't drive a straight line. There are lots of fences, cliffs and rivers and all sorts of other things, so I have to take a highway. My point is this, that to navigate, I want to get from here to there, so I can just get a compass and walk.

Now sometimes that might be something that you have to do, but most of the time, and especially in the real world applications that we have given you and have yet to give you in this course as you finish it up, we need to understand that navigation is different on the ground than it is on the ocean. On the ocean, they figure out where they are, they know where they want to go, they plot a course and that's the way they go. Straight! Unless there's a reef or something in the way they have to go around, or an island they don't want to visit, they have to go around. It's a lot simpler in that sense.

## Lesson Objectives

What we have to do is look at a whole lot more information. When we are going to navigate and we are using that term generally to talk about how to get from one place to another.  So here are our objectives for this lesson.

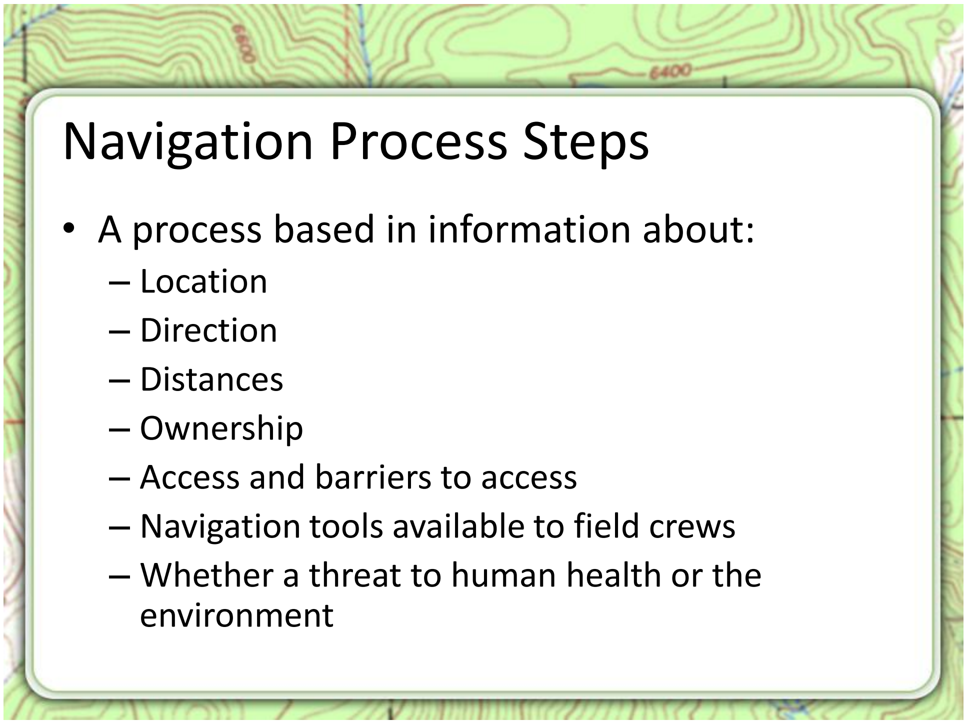



You will be able to identify and explain these steps, the process steps for navigating to a position.  See what kinds of things it requires.  We'll talk about the tools you will need to navigate to a position and they are essentially what we have already discussed in the course. And then we'll talk about how to actually navigate to a position.

Now I've already given you information in the earlier courses, or lessons I should say, as to how to navigate to a place just to get a bearing to it; how to just know what the direction is to something.  But, again, it's not just this straight line thing so there's a lot of things that we have to go into.  Let's take a look at this slide.

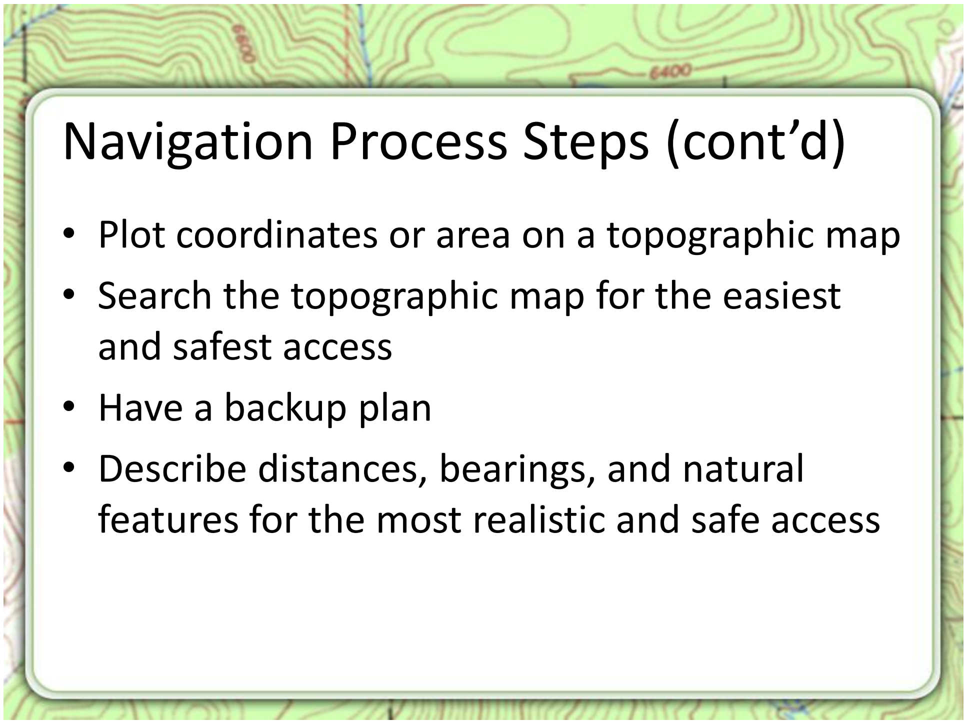
## Navigation Process

Here are those steps that you are going to have to think about. It says here, a process is based upon information.




And that information is what is the location you're at, what are the direction and the distance. What is even the ownership? You may not be able to cross private land or potentially there are locked fences, locked gates. What kinds of access are there to the area and are there barriers to the access. If you were being asked over the radio what's my best way to get to that fire or whatever; you know what tools the field crew would have.

They might have a GPS unit as we have discussed over and over, that just tells them where they are. And even if they have a GPS unit, but the way, there are some GPS units that allow you to plug in a coordinate that you want to go to, but all it can do is tell you the straight bearing and distance to where you want to go. That may be useful when you get close to whatever it is, but it's not very good when you have all these things about roads and access and locked gates and that sort of thing. We have the contours and the other information that we can look at on map and see that boy that would be a steep and dangerous way or is there a better way for them. So obviously safety and speed, but you know safety is always a factor there, and we never want to risk life or limb or even damage to equipment just because we were too hasty or not thorough enough in our examination of what it took to navigate from A to B.




So that's kind of what this lesson is about. The navigation process means that you're going to plot coordinates or an area of a topo map that you're going to. You're going to look at where you are or where someone else is. They are talking to you on the radio and you're going to determine how to get them there. You are going to search the topographic map for the easiest and safest access on their behalf and I might add that you are going to have a backup plan. Because you know the best laid plans of mice and men, they say, are quickly dissolved.

You can have the greatest route into somewhere and they get there and there's a locked gate or they get to a creek and it's washed out and they cannot get the ambulance, the fire truck, whatever it is across this crossing. You need a backup plan or another way for you to be able to get in.

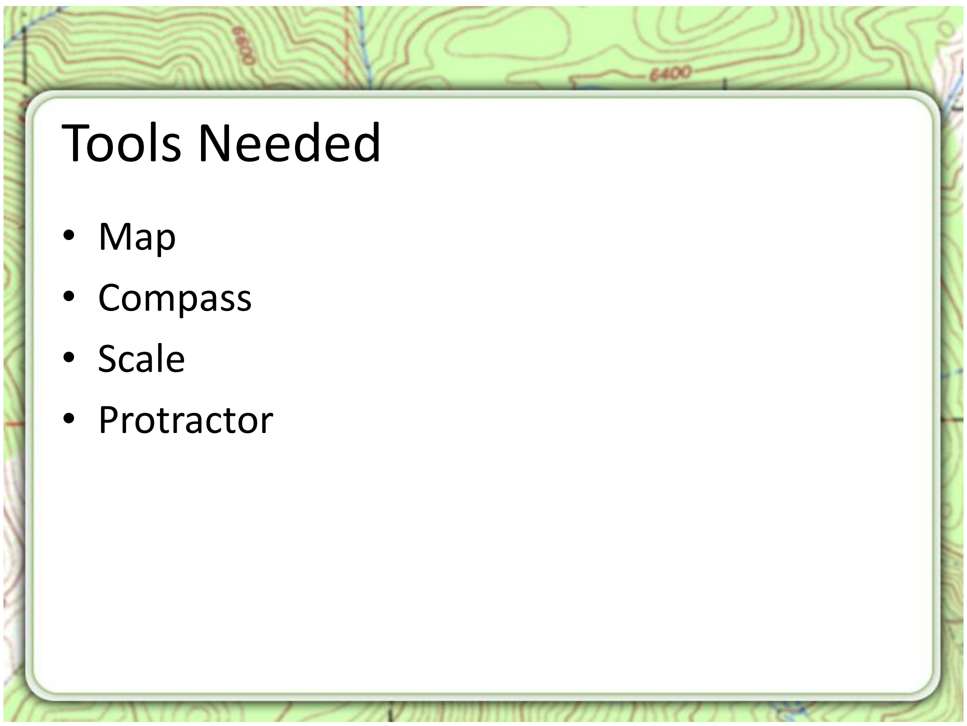
You're also going to need to be able to describe distances and bearings; nature features that are along the way; cultural features; because you want to give them information about the most realistic and safe access. You want to access what's the best way to get there and then you want to be able to tell them how to get there.

Now we've all met people who don't know, necessarily, which way is North on the ground, and don't even know what is North in their life, but that's another subject. But they have trouble orienting themselves and then when you give them a map or something, it is even worse. I've known people, and I'm sure you have to, that just can't even give directions to somewhere.

Well, you say I'm at this intersection on you cell phone and how do I get to that store that you told me about. Well you kind of go down the road, which way, well, I don't know, you go down the road where the trees are. Well there are roads with three trees, and kind of over on the left, you'll see a sign. I don't know what it says. You have had people give you directions like that. And it's maddening. Getting to the store is one thing, but getting to an emergency situation on the ground is another thing.  And so we need to become equipped with the knowledge that is on the map and the reality of how the map is a perfect representation of what is one the ground.

I mean it doesn't show every detail but it is to scale and is oriented correctly.  You and I have tools available to us to make sure that we relate ourselves and what we are seeing to that map so that we can describe and very confidently describe to people how to get somewhere.  We become more, not just confident in just how you give directions but more thorough, more complete and might I add, more cautious.  Well, you kind of go down there about a mile or two and the road goes off to the right, well, between one mile and two miles, there are eight roads that go off to the right.  Now that wasn't very good instructions if there is an urgent need to get somebody somewhere.  So we want to understand those things and be clear about what we're doing.

And the tools that we are going to use are exactly the same as the ones that we have already discussed in the course and that's the map, a compass, a scale and a protractor.



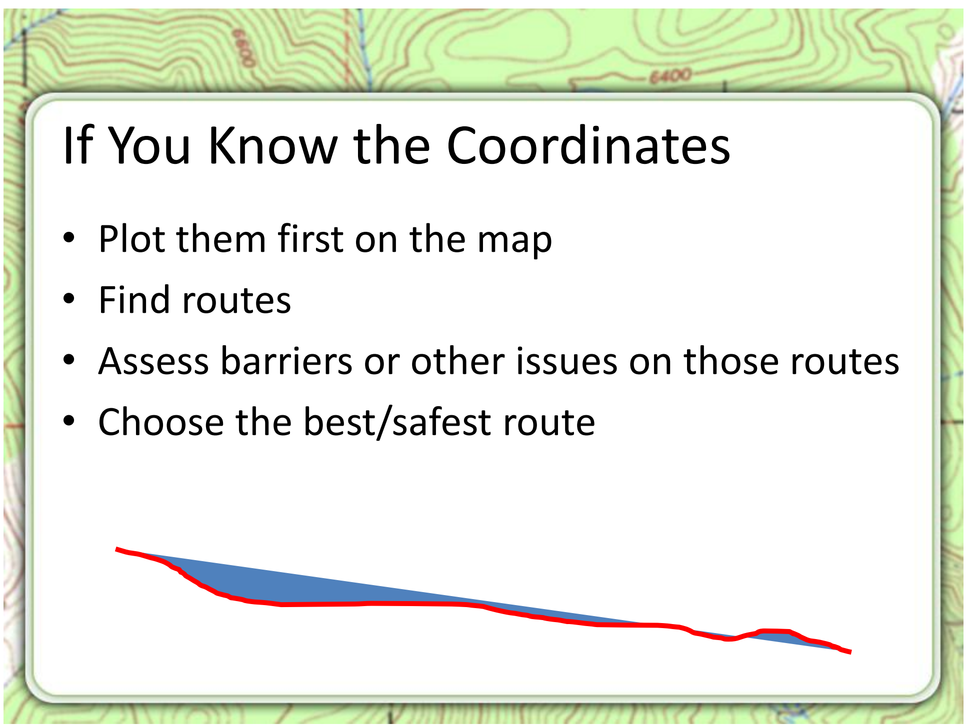

If you have a GPS unit, great that will add to your abilities but it will not solve the whole problem. You know, I am surprised sometimes with Google Maps, there are some other applications too, Microsoft's got one, but I forget the name of it. But you go there and say well I'm here and I want to go there, like cities.  And it plots on the map, the best route. Well, usually it picks the shortest route. It may not be the fastest route, or you can toggle some of them and they'll give you the fastest route but not the best route.  I'm amazed at how much can change. You know, those are assuming speed limit; those are assuming good weather; those are assuming all sorts of things.

That software is able to do that because they have preprogrammed into it coordinates, latitude and longitude usually for all these business, all these cities where they have a lat/long for the downtown of each city so that it takes you to that address.  Or you can plug in where's the nearest Safeway store or whatever. It will give you that and it will draw you maps and it will show you how to get there. That's great. But understand a GPS is greatly limited when you get away from cultured areas. When you get out to the boonies and tell it…well GPS software doesn't work this way. I want to go the Northwest of the Northwest of section 28, township, range, meridian. It doesn't know that. There are applications where you can put that over top of it. Google Maps or Google Earth I should say has an application where you can bring in section, township, and range over top of it. So that's pretty nice.

But still, you tell it I'm here at this intersection of these two roads and how do I get to that. Now it doesn't know all those jeep trails, creek crossings, locked gates, or any other obstacle that can get in the way or it might route you up a road that goes up a steep hill like this that an ambulance couldn't possibly get up. So that's why we have to have the map reading skills to use these simple tools we have used in this course. We have to have those skills to assess…and that's really what navigation is about. It is assessing all of that information and putting it together to at least have a more likely successful solution to whatever the problem is.

## You Know the Coordinates

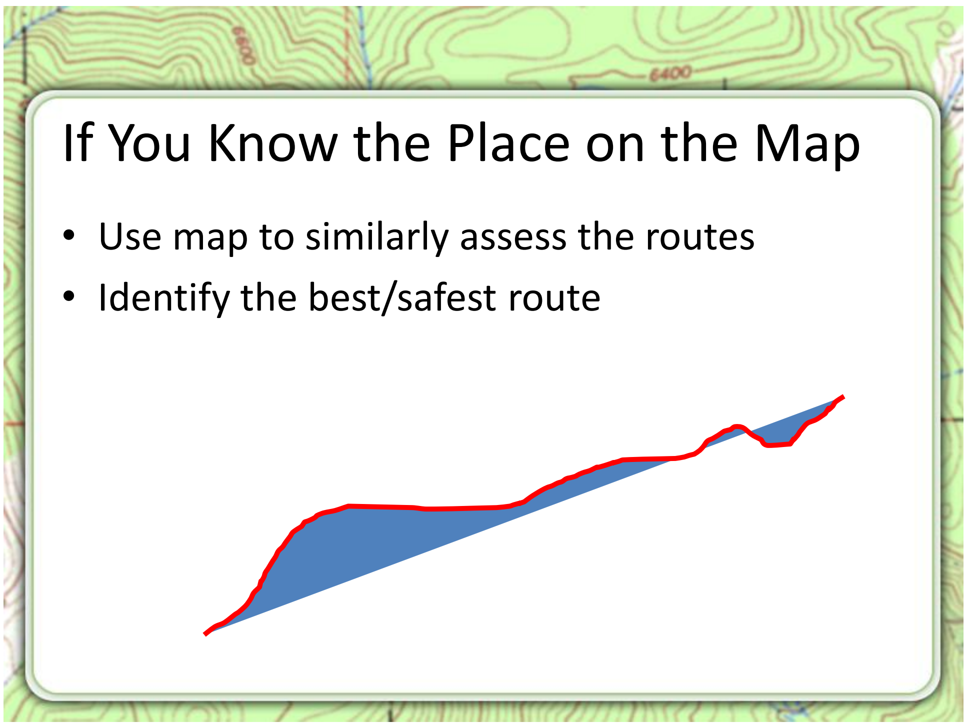
Now, let's summarize a couple of things here and then we'll go look at the map on this. Our first scenario is, if you know the coordinates you are going to.




If someone has called in and you have lat and long already or section township range or UTM, whatever, you should plot those on the map. You should make sure you know where those are on the map. Then you are going to start looking for routes to get there. Now it may be a given that you are going to have to drive there, or it may be a given that you can't drive there. You'll look at the map quickly and determine that there aren't any roads for at least five miles here. So what are we going to do…and it depends upon what's going on. Search and rescue teams can often be on horses, on ATVs; they can get into places and do things that you can't necessarily get a car in or an ambulance or something.  You know, get the person transported to the nearest road. All of that is part of that, but finding the routes, then as we see on the slide here. Assess the barriers or other issues on those routes like steepness and those kinds of complications and then we would choose the best and safest route.  So that is if you know the coordinates and you should plot them.  So that is the process if you know the coordinates to go to and someone has called them in.  We have one other possible scenario and let's look at that on the slide.

### If You Know the Place on the Map

If you know the place on the map already, then you are just going to use the map similarly to assess the routes and identify the best and safest routes.




You could have been out there walking, working, driving, whatever, and you come across something and you know the way that you came in was this real round-about thing because it is part of your job or what you are assigned to do.  But now you have come across some emergency or some situation and so you know right where you are.  You might have a GPS unit, good, or you know that you are about five hundred feet from that last road intersection, let me find that on the map.

So in other words, you know where you are on the map already.  But now you are going to have to tell someone how to get to you. If you don't know where you are on the map and you are the one that's in trouble, or you have found the problem, you use the skills we looked at in the previous lesson.  If you don't have a GPS unit, fine, hey, get some bearings, either resect or intersect, if you are trying to get it to where you are at you are going to do a resection, and so find out where you are and call that in.

But you may have to look at the map since you have it and tell them where I'm at you can't come up this draw. The roads are cut out, washed out there, you'll have to come around another way; that sort of thing. So it's really the same process, but a different scenario. You may be at the place and you are telling someone how to get to you or you're trying to describe to someone a place that you have not been that has been called into you. And that, frankly, is a more often scenario.

## Scenario

So we're going to go over to the map and look at those things right now. And really, I'm just going to do just one large and lengthy explanation here and we'll see how we go about this to come up with this information.

### Plot it on the map

Now, I am in the Southwestern part of the quad so that you can kind of take a look here and I have had someone call in some incident. And they've given me a latitude and longitude. You might want to write this down. The latitude is thirty nine degrees, o nine minutes, twenty seconds north. And the longitude is one hundred and nineteen degrees, fifty two minutes west. So now what we are going to have to do is use information things we learned in lesson one. And we're going to have to apply that to this map to figure out where on the map is that lat and long and then we'll do our navigation.

So this is our first step in the navigation process and that's to plot it on the map. So you will remember that latitude, where one hundred feet of distance on the ground is really close to one second of latitude. I showed you how you can use the twenty-scale to measure this. Now, let's think about this. The latitude we've got is thirty nine degrees, o nine, twenty. The southwest corner of your quad sheet is thirty nine, o seven thirty and the next tick mark is thirty nine ten. So we're closer to the ten, right, o nine twenty is going to be closer to the ten. And it's forty seconds; o nine ten is an even minute and seconds and o nine twenty would be forty seconds less than that. So what we want to do is come four thousand feet south of that line of latitude. So look on the map.

And what I've done is drawn these lines that are on the latitude line that's at ten minutes and what I need to do is come south of that of forty seconds, or four thousand feet. So using my twenty scale, I'm going to make just two marks. I can draw a line that's parallel to that. I'm going to come down four thousand feet, because that's how long forty seconds is, and I want to do that over here as well. Four thousand feet. And then I'm going to scribe that line. Now what that means is everywhere on that line, that line is parallel to the equator. That line is north thirty nine degrees, 0 nine minutes, and twenty seconds, Ok, north of the equator. And now I know where I'm at in the north but now I need to know where I am east/west. They told me one hundred nineteen degrees, fifty two minutes.

Now you will recall that with longitude, we have to bend the scale, or slope the scale here, using the hundred and fifty. And I'm going to zoom in on that a little bit. Putting zero over on the margin on the map and a hundred and fifty on this line. This line is the fifty minute tick mark. You can tell that from your mark. It's at fifty minutes and this is two minutes from that, fifty two minutes. So it's going to be very close to the edge of the map, isn't it? And in two minutes, there are sixty seconds in each minute, there's a hundred and twenty seconds. And so what I am going to do, I am going to turn that around and I'm going to put the zero here and the hundred and fifty on the left margin of the map, and I'm going to plot where one hundred and twenty seconds are.

Because that's two minutes. And now what I want to do is to draw a line due north from that because that line due north would be a consistent longitude. And I'm measuring twenty four hundred feet from where I drew that so I'm going to up here and draw, or put another point, at twenty four hundred. I'm going to plot that line. Now what that has done is given me a line whose longitude is consistently one hundred nineteen degrees, two minutes. So where those two intersect, is where the incident is located? Now, so what I've done is gone through my first step and that is to carefully plot on the map what it is we are trying to get to.

Maybe you're the person running the fire crew or you're the law enforcement officer. Or you're the person who has been called in because there has been damage to a resource sight or there's a hazmat situation. Whatever it is…injury, whatever, plane crash. These things all happen out there on the public lands and other lands that we all administer so the first step is where is it? What is the best information we have? You know, they might have called in section, township, range, too. But in this case, they had a GPS unit that gave us latitude and longitude so we just plotted it on the map. So, we know within just a couple hundred feet, with a little error in there, just from our plotting, but we know just about where this is. Now there are certain things I would do immediately starting to look at this. Let's go back to the map.

Now let me zoom in a little bit because this is where the incident appears to be. Now if the incident is a life threatening thing, I don't know for sure, but I do know that this area here…there's a hill top area that is relatively flat. It rises then flattens out, comes up a little bit more then there's a hilltop here. The brush, at least at the time this was filmed, there was no brush up here. This might be a great place for a helicopter to land. You know, and if you were dealing with that, then that might be something to point out that hey, southwest of the incident, and you can scale it or you can just guess it, but here I'll scale it. About a thousand feet southwest, there is a possible LZ, you know, helicopter language, or heli-tech language, landing zone. So that is something that you would know from looking at the contours, right? But let's say that this is something that they have to drive into.

Now I am going to zoom back out because now we have got to start talking big picture. Maybe they're coming from Carson City. And so when I slide this over and we are looking at Carson City, alright, I know that the main road that comes out here is this Kings Canyon Road. It comes out of town and heads out of this Kings Canyon. It does get somewhere near. I am still about two or three miles from my incident, but it does come up here and there is a four wheel drive road that comes up here. So what I am doing is starting to look at the map and see how can I get to this area? But this four wheel drive road ends…it is in a very steep canyon and I doubt that the road has continued. Sometimes maybe someone has built the road and continued it on, but I doubt it. And as steep as it is, I may not be able to get an EMT crew in there or whatever it is I have to do.

So that's not necessarily an option. But that was a nice single road all the way out to here and then up the four wheel drive road. So perhaps I need to look at some other opportunities here. Again, looking at where the incident occurred, or is, I see that the closed road, there's two of them. There is one that ends over here on the north-slope on north Kings Canyon. There's also a road on the other side of this divide that's in a place called Snow Valley. I don't know the name of the road, but you might have other maps that might give you a forest service road number or a BLM road number or something like that.

In reality, that looks closer to this than that road. You see, this road goes through the State Park. What if I know that those gates are locked and we don't have access? Well then we're out of luck then and I'm going to have to direct them up this road, and it ends here. I can see that that road ends here. But I can also see that with other than a little steepness in here, let's me zoom in so we make sure we're looking at this right, The four-wheel drive road ends here but it's almost on a bench here where you could come around and maybe find that maybe there's a ridge right here where you might be able to drive on up and then you get onto a very flat hill. It is very, very flat for a ways…it's not very steep. And you might be able to get a vehicle in here.

Now it gets steep back over here but this is what you are assessing and looking at. I've got to get to here. You might look at this, and if it is a life and death situation, you might look at this for five minutes and just realize that you know what? The only way we can do this is by helicopter; to save someone's life. We just don't have enough information and that is part of your navigation. And in that example in navigation we came up with the conclusion that it can't be done. Or it's so impractical, or we might have to try five different ways to get in there and in the meantime a helicopter could have gone in there and got the guy out.

So that's how those decisions are made. We look at those things and decide what resources we need. What kind of vehicles do we need to get in and do this, that or the other. But let's keep looking for a few minutes here. Go back to the map. Let me change the scenario just a little bit and say that you could get to these roads that are over here in Snow Valley. Now obviously I am off the map and you guys don't have the map and neither do I. So I would have to be looking at those. But if you go further north on this map, you will find that there is a series of roads that take off from Ash Canyon, in that area over on Carson City, where you can got on those roads and get up into this area. And these roads connect over into here and to here. And in fact, if you study carefully, one of the intersections that we discussed in Lesson 2, and I'm going to flip the map so we can see that.

Here, which we used for a couple of things, that road goes up to four wheel drive roads that eventually lead all the way up to that Snow Valley or Snow Canyon, whatever that was called on the other side, Snow Valley. And so I can look at that and figure out that now I am looking at that route and I'm assessing is it, you know, a dash line, or is it a four-wheel drive road. Or is it a superhighway in there. What circumstances are along the way? Deciding which one would be best.

But frankly, if I were able to access that, that would be the best route because that would get someone within, let's measure it. Because what you're doing, they might call in and say if we can't get off the road then how far is it from the road to the situation? Well, the nearest place I have the road is over here on the edge of the map, so let me just measure from here to the incident. Thirty two hundred feet. So it is a little over half a mile hike. But you know, search and rescue teams or EMTs, they can get in there pretty quick and do that. Or maybe it's a fire and they are going to hike in there, they are used to that. That's the sort of things that they do. Or it could be an archaeological site and you've got it and the law enforcement folks are asking how do I get there? And you tell them the best way is to drive up in here, it takes a while to go around there, but you can drive within just over a half a mile and walk back up there. And you can tell them it's not real steep, it's uphill.

It gets steep for a little bit, but it's not so bad. And you can get to it. So part of all of this is analyzing the big picture which means you look at the whole map. You look at where you're coming from, Carson City, and then you assess what the best route is in there and you may have local knowledge. A lot of times we do, you know, if you worked on a district or a certain area of management unit for some time, you know about locked gates, you know about where some of the private land is where we are not welcome and you may also know where we have rights of way and where we have legal access across land. And so those are important things to be aware of if you are in the business of law enforcement and/or other resource management, resource protection.

But, now after you have made that assessment, now you have to come up with directions. You have to give them specific directions. So let's take a look at something here on the map and just change our scenario.

So with the incident that we are talking about over here, and looking at the roads that are available and we have decided that the one over here by Snow Valley is best, what I have to do is follow that road out. Ok, now I am going to do that now on the big screen and you need to that looking closely. But you see I've got a four-wheel drive road that comes out of there and it comes up here at this drainage called Hobart Creek. And what I'm interested in is where does that road go and what does it connect to? So I'm following it here and it connects to another four-wheel drive road and it comes back around; there's a whole series of roads here on this mountain top.

Eventually it drops down to this road, which is the road that seems to come from Hobart Creek Reservoir, here, which is inside the State Park. And it comes up here and this road goes down this way. See what I'm doing is I'm checking the map for where are my connections. There the road comes down and it goes this way. Some water tanks here, but then the road seems to end, no, there it is, it goes on, and it comes down and it connects on Mc Ewen Creek. It comes out in Mc Ewen Creek which eventually connects in these roads and there's a subdivision here. There's houses, probably nice houses on an acre, two or three acre size lots, the way it's laid out. And it connects to that. So it comes out near these water tanks.

That's one route and then I have another route. I'm going to come back up the road and I'm going to get back up here to where it connected to the Hobart Creek Reservoir and I noticed that that road comes down, goes past the red house, remember we talked about that in a previous lesson, and then it goes off the map. Now, again, we are at a disadvantage here. We don't have the map next to it. But, you see, there is a similar road just three quarters of a mile away there and I'm going to bet you that those connect there, you know? And so I follow that and I realize that that road comes up here and connects onto a really good road, goes past one of our previous incidents here, and it comes back to that intersection that we have been talking about in the course.

So what I've done is I have two routes. Now the route that went through this subdivision is very possible that we don't have access there or maybe Carson City has the keys because I'm sure these water tanks are for their water system. They are up on a hill here; see, so that they are providing gravity flow on into the city. And so maybe we have to share keys there. And that's a route in there; it's a roundabout way, but it's not that bad.

But I look at this other one and I'm on paved road. This is not a paved road, but it's a darker like that, it's a good gravel road for at least part of the way and I switch to four-wheel drive roads to back here. It seems to switch. It's grayed to less of a nice road, but still it gets up and eventually gets in here. So what I have got are two different routes and when you look at these, you know, this one may be shorter but it might have more access problems. I don't' know but we may already know that. So I want to have directions kind of figured out for both of them. And so a lot of times, you might have a map and some offices I have seen might have a map of the whole district or field unit and they have plexi-glass over top of this so you can draw with grease pencil or something and highlight your routes and where things are and do this, that and the other, and erase it and figure things out for the next crisis.

I just want to assume for the moment that we are going to send an EMT crew, it's a steeper route up this other way, I'm going to send the crew in through this Franktown Road. So, what kind of things am I going to look for? Let's assume, for the moment, that everybody knows where Franktown Road is. So you tell them that they want to head west from US three ninety five out Franktown Road. And this road, this three ninety five is actually this freeway over here, this road has a state highway number four twenty nine, it says. And so I'm going to look at that and say alright, go out highway four twenty nine to Franktown Road, which also is a state highway number eight seventy seven and head west.

Now, the first thing that I'm going to do is I'm not going to say just go to the first major road to the left. I don't want to make something like that. Those are bad directions. So, it's like the story I was tell you a minute ago. We don't want to be, well, kind of go left and then the road kind of goes right and then kind of go down there. No, we want to give them something really specific. So let's zoom in here and let's take a look at it.

I'm going to use the scale. And not that I'm building a Swiss watch, here, right? I'm going to use the scale and I'm just going to say, it's upside down, and I know, but from the intersection where they leave highway four twenty nine, and where they're going to get on this highway eight seventy seven, and I'm not going to measure every bend in the road. I'm just going to measure as close as I can and that's about seventy three hundred feet. And just real quickly, I know well there's five thousand three hundred, right, fifty two eighty, so that's a mile, fifty two hundred eighty right there and that's about a mile and a half or a mile and four tenths. You can get a calculator out if you want.

You don't need to give it to them any better than that because what are they going to be using? What tool will they be using to measure this? They're not going to be using a cloth tape or pacing it, they are going to be driving the ambulance. So you're telling them look, it's about a mile and a half on the left, good gravel road, head southwest. They take off that. And now you are going to have to do some estimating.

Let's take a look at this. They're going to drive this road and stay on it. Now you are going to tell them to stay on that road and give them an approximate number of miles because the first intersection that they are going to have to worry about is here. So stay on the main road and then you're going to tell them to turn left. Now how far are you going to tell them? That's really difficult to measure that, now isn't it? Now, I could use the scale and go that's three thousand feet and that's six, seven thousand feet, right? You can do that. And another three, that's almost two miles. And you know what, that's probably going to be close enough. You could say, well, stay on the road for approximately two point zero miles, turn left.

Now, you could also say, who knows, maybe this road, there are signs or something, there are people more familiar with the area. This is called Lewers Creek. You are going to turn left about two tenths of a mile past Lewers Creek. When I look at the map, take a look. Will they mistake it for any other creek? Well, I don't know. If I go back here and look at this, they don't cross any other creeks. They go up a ridge, get on the side of a mountain, stay on the side of the mountain, and drop down a little bit into Lewers Creek. This is the first major water they are going to cross, if any.

If you see what I'm doing, is I'm making sure, let's say there's another road that's not on the map. Somebody built a jeep trail for a mine or something. You don't want them to mistake that, to waste time, so you tell them go up that dirt road, and maybe it has a road number and if it does, that's great, approximately two point o miles, about two tenths past Lewers Creek. Ok they then realize we have to be north of the creek, not south so they won't turn on the wrong road, and turn left.

What would I tell them next? I would say travel on that road about two thousand twenty one hundred feet, so that's about four tenths of a mile. Turn left. And then you can measure the next distance.

And let's just assume for our discussion and to keep life simple here that the road goes off of here and goes right back on at the red house. You can even tell them after three miles, whatever it is, I'm not going to measure it here, but you know after three miles you should pass Red House. It will be on your right. Another mile you will see Hobart Creek. Or you might just tell them stay on the road, Hobart Creek Reservoir. You might just tell them to stay on the road until they get to Hobart Creek Reservoir that should be an obvious object. And then what they are going to do, you are going to want them to turn right on this jeep trail past the reservoir.

So get your scale out or guess it. You know a straight line as they pass the center of this is about three thousand feet. You know they might not pick the exact same place but when you say after you pass the reservoir, go about a half mile. That's what I would say. Half mile and turn right. And then give them directions on down this way and as you can see what we're doing is giving them is approximate information because that's all you really have, but that's far more than what they had before especially if they've never been there. If the crew knows how to get to Hobart Creek Reservoir, well then tell them that. Go to Hobart Creek Reservoir and then I'll guide you in from there.

So there is a lot of communication there. You might talk to someone and they haven't got a clue where Franktown Road is so you're going to have to start with that. But bottom line, we are searching the map looking for routes to take. We are assessing those routes and then we are going to have to give directions on those routes. W are using all of the tools that we have discussed to get that done. Now if that was my number one route, I still want to have a backup route. Because, who knows, frankly Murphy's Law always gets in the way when there's an emergency and things like that and so I need a backup route for people to be able to get in and service whatever the problem is up there.

So at least I am going to have this in my mind. I am not going to mix the communication up with these folks and tell them two different ways to get there. We are going to try our best to get them in there that way. But if there was a problem, then what would I do. I would have a backup plan. And I've kind of already sketched it out and jotted down some notes as to how to get to this other place. Let's go back to the map.

You remember we were talking about the water tanks that the city had that are probably, there it is, yeah. There's that subdivision I was talking about. I don't know everybody in the area might know this as Lakeview Subdivision for all I know, and there's probably street names on these because this looks like a planned subdivision. But you could tell them how to get to these water tanks or how to identify these water tanks. Now they don't want to get quite to the water tanks, do they? If I zoom in here, way in, you can see that they want to be on the road that leads to the water tanks, but then they want to turn right. So you are going to have to tell them how far from the highway they are and right there is the highway.

So go down the main road, let's call it Lakeview Street, just for now, and you go down it and it leaves the subdivision and it starts up the hill and you're going to turn right and follow that road. And that road is going to take you around here you are going to cross McEwen Creek. You are going to run up McEwen Creek. I don't see any road intersections, or at least I'm not aware of any. But tell them they are going to run up McEwen Creek and that's good. As you can see it criss-crosses the creek a couple of times which is one of the reasons I was so nervous sending them up there first.

Because if the creek has flash-flooded or you've had spring run-off, well then there's a good chance that there might be some tough crossings in there and the other route didn't go up any creeks; it crossed one, but it didn't go up any creeks. And this is in a somewhat narrow arroyo or valley. And then we don't have any turns that we are worrying about. They are still following this road and it's going to bring them to some other water tanks and that's definitely something that I would mention to them that they should be aware of. And if you study the map closely, then you can see that if you go right along this hillside is another road. And it comes over here and hits this road, which comes down to the other location which is where we brought them in before from the Hobart Creek Reservoir site.

I have two routes, at least two and those are the only two that I really know of that can get me anywhere close to the situation that we were discussing. So let's summarize what it is that we just spoke about with the navigation process. The first thing we want to know is where is it that we are going. Unless you are there, you already know where that is. We look over the map; we look over the big picture of the map, and take a look at all the different possibilities as to how to get to where we are. I looked at roads, I looked at helicopter landing zones, I looked at the terrain in the area. I also looked at when I follow the roads, I follow them out. I started from the nearest roads to my incident, and followed them out to see where they go. To see if they split off, you have to keep that in your mind, to know that oh ok that one split off and dead ends out there so, let me go back to where I knew it was good and follow it all the way down. Then when you got a route or two and it is best to have two if you can, then look at them a little bit to see well does that go up a creek. Does it have a lot of creek crossings, what is the weather like. Is there still, here is another one.

You got people maybe they are up in real high country, snowmobiling and there has been and injury and well then the roads are probably are not going to work all right. And you would know that, or you would have to send in search and rescue crews or whatever on snowmobiles. What is the best route to get there? You know and frankly think about this and it is not our plan to teach this specific, but you think about this.

I could study that quad and figure out where the snowfields are staying in the spring, because I know which way the snow melts last on the north slopes and I could look at it and see you know what this road stays on a south slope almost all the way and then it gets into the high country. Hey, that is probably the best route; we could probably get the furthest up there and off load the snowmobiles and get them in there. Versus a place where you are going to hit a snowfield, you cannot get a truck through, and yet it gets out of the snowfield and goes on up for another 2 miles before you get to the real snow and that would be tough on snowmobiles where you use them for 1000 feet and then its dirt for two miles before they get to the snow again.

I can look at a map and especially know that whether the ground conditions of the area that I work in and figure most of that out. At least where the most likely problems are going to be. And if we have had some flash flooding , it is summertime and one of those thunderstorms going and we have had some real heavy rains, I can look at the map and say you know I better have a second or even third route because these two routes, they both cross those creeks. And that road could have been passable yesterday, but the big storm we had last night could have changed that.

So I think about those things, and I decide on which would be the best route and get some input and help from other people too. You know if you are not as familiar with areas or whatever. Then you start working and determining what the directions are. You start measuring and giving them to a 10$^{th}$ of a mile, that kind of information, so they will know how to drive up there and make sure that they get on the correct road. You don't want to give them vague things, you don't want to say well the road kind of goes west, it goes to the southwest and then it goes up a ridge. See because I can tell that from the contours. You want to give them that kind of information when you cross the creek, it will be the first road to your left. It is only about two tenths pass. I am giving them relationship information that I can see on the map, that they will now see on the ground, and I will never even be there.

That is what this is all about. When we think about access to things, what kind of barriers are there, what kind of a crew is going to be needed to get into where the thing is? If you determine there are no roads, there are no ways to get in there other than ATVs or helicopter then that is what you need to know. And you can also assess what the nature of the situation is especially if you are there. I will give you an example.

Let's say that you are onsite where a fire has started. The wind is blowing and you know that the fire is, you can see it moving rather quickly up a hill. Would you send the crew on the road that goes across that face? I can tell what those things are by looking at that map. That is what Navigation is about and if you remember our definition of navigation was it is the process and method for determining position, course and distance to travel from one point to another. And if you recall, I pointed out that is not talking about I am at A and I have got to get to B, I will get my compass, my GPS and I will stick it out there and I will just walk that direction. Man there is going to be all kinds of obstacles, and that can be a tremendous amount of work. I mean you have done that haven't you.

Where I need to get from A to B, if I am willing to contour, you know that term now, contour around the hill. I may have to walk faster but I never have to go up or down. Or would you rather go straight up this big mountain and back down the other side to get to that. That is a lot more work takes a lot more time, when you could have just gone around the mountain and stayed at roughly the same elevation. Those are all the sorts of things that we learned about determining the navigation of whatever it is we are going to do, trying to get from A to B, or trying to get others from A to B. So navigation is a bigger picture than just a straight line.

It is looking at the whole map and as I have shown you on the process, you look at the whole map, you look at the big picture, then you start to decide what are my access points to begin with and where is it I m trying to go, what roads are near there, follow those out. Study the contours, study it and look at what the situation is and make the best recommendation. That is what navigation is about.

Now you have an Exercise that you are going to do now that is going to give you an opportunity to test these skills that we have just learned, so take that exercise and do the best you can with it, and then when we come back we will conclude the course.

## Course Conclusion

Well friends, you have spent a few hours with me talking about maps, looking at maps, and learning the various tools used. As we come to a conclusion in this course, I just want to summarize what it is that we have seen, what we have done, and then I have one more instruction for you.

The first thing we did was look at the fact that you have planimetric maps and that is what most people use, they are great and have their purpose. But you have probably seen now that you have completed this course, how much more information you get when you take a planimetric and add topographic data to it. How much more information is available to you. How much more you can assess what is going on out there. Make recommendations and decisions either for natural resource management or just emergency management. So we have seen the incredible value of the topographic map.

These maps are not sketches on the back of an envelope, or on a napkin at the restaurant. They are very carefully made. The modern 7 ½ minute maps are made from photogrammetric processes of aerial photography and some field checking. They are incredibly precise and it is very rare that you will find an error on the 7 ½ minute quads. I use to find a few mistakes contour wise on the old 15 minute, but those were done back in the 20s and 30s, with just an instrument that they set up and measured and guessed a lot of stuff.

The 7 ½ minutes are incredibly precise, so hopefully you have seen that it something you can scale on and you can use bearings on. You can use all of the tools that we have discussed. We did discuss both the field tools, the compass and/or GPS unit, and the office tools and you may still be in the field, but that is the scale and the protractor and a mechanical pencil.

It is the same list that we have on the slide, that we saw earlier. The same basic tools you used frankly basically in grade school. Now we see that we can take those, take other information including even GPS data if we have it, and apply it to a very accurate map. We showed you all of the features, a bunch of marginal notations, data, symbols, different types of symbols, shading, line types, dots, you know those specific points. Objects and understand that those are relatively to scale. A tremendous amount of information on a map.

We talked a lot about uses and gave you a number of different scenarios along the way. Talking about how life, property, resources, crime, these things taking place out there that you need to get out and make decisions on how to get there. I have given you plenty of warnings along the way about being careful about deciding whether something is happening on federal or private land. If it is anywhere close, within several hundred feet of a property line, you probably need some other help with that. You need to be very careful. That is even true I might add on wilderness boundaries. I have seen where law enforcement has ticketed someone based on a sign that someone put up about wilderness boundaries when in fact the wilderness boundary was hundreds of feet from there.

So you want to be cautious with those sort of things. If you are close to some kind of property line or major administrative boundary where the laws and uses are significantly changed, such as wilderness. But you know with the tools that we have and talking about the uses that we have and the precision of the map, it is just amazing to interpret contours and natural features and figure out what is going on. What does that look like on the ground, what can we do, how can we get there, what is the best way to do that?

Where am I now, I am lost and I want to get out of here. I know where the truck is and here is another one that people do. This is a good idea if you have a GPS unit. Get a position on your truck, especially if you are going to be wandering all through the woods, the desert or whatever. I have done that a number of times and have been saved by the fact that I could tell the GPS, I want to go back to the truck and it is going to give me the straight bearing I may not be able to do that, but at least I know where the truck is.

I have worked in some areas where there weren't a lot of cultural or natural features for me to totally identify exactly where I am. Yet, once I know where I am, know where the truck is, and I have the map, I can see, do not go straight, go around this way and you will be back and better off. It is a fabulous tool.

We have seen the basic different methods that people use to relate to one another location on the map, lat and long, UTM and the public land survey system. You know there are all kinds of complications, anomalies, but what I have given you will work ninety five percent of the time. Most of the time even when you are in an anomalous situation like the public lands, you will still get somebody close enough to see the wreck, the fire, whatever it is that the problem is and be able to get there and safely take care of it.

With that we can draw this course to a close but with one more important assignment that I am going to give you. You have a final exercise that you have to take here to pass the course and it has got all kinds of stuff mixed in with it.

I hope you enjoyed the course and got something out of it. I want to encourage you to play with some maps. To take those maps, get the quads for the area you work and/or live in, go out with your significant other, or take the kids, or whatever, go out study it, take your compass with you, use it. Become so familiar with a quad, with a topographic map that anyone can throw a map in front of you of a place you have never been, and you can quickly assess all sorts of things. That is how comfortable you need to become with map. If you are working in land management agencies, resource management agencies, I am encouraging you to put this to work. It is like a lot of other things, you can take this course and I think I kind of understand what Dennis was talking about. Then you don't look at a map for six months, it is going to go away.

Maps can be a lot of fun, an incredible tool that we use and hopefully we conveyed that to you. So I am encouraging you to go out use it, have fun with it, and who knows, some day you may save a life with it - with the skills you have learned here. I hope so. Be sure and have the correct tools and go back and watch this video again. That is the beauty of distance learning like this. You can watch it again or review something if you are not sure, or if you have forgotten. But in the meantime we wish you well with all of your map reading skills in whatever applications you come up with. Take care.