# Drafting Maps for Cavers
## Somewhere between Mud and Print

*You've read all the articles, found a cave, hoodwinked some (former) Friends and surveyed the thing! Good Job!*
*Now you are sitting at home, surrounded by hundreds of muddy slips of paper - and not a clue of what to do. Relax - here it is: Drafting maps for cavers.*

## Introduction

What good is a cave map - who needs it? Nobody really. They do come in handy for figuring out where you are, where the cave may go, and where we might find new passages, but nobody is holding us down, pouring water in our ears, and telling us that we have to create a map. So what we do, we do for ourselves and for our caving groups. If I am going to do it for myself, I like to do it to the best of my (limited) ability.

A finished map really only has one function - to help another person navigate through a cave. Anything else is extra. But it is those extra things, the personal touches, and the artistic additions, that change the map into something to be proud of.

When I first started drawing maps, I read a lot of texts. These texts all went into great detail on surveying, survey gear, reducing the data, and loop closure. Unfortunately they left out a lot on the actual map making. A lot of texts assumed that the drafter had prior art or surveying training, and were not written for a moron like me. A lot of detail on pens, and lettering machines, not a whole lot on anything else. Even the newer On Station skips a lot of the most basic steps. It was hit or miss learning for me, and I left a lot of ink blotches along the way.

So I have written up the steps I follow to go from survey notes to finished map. I have included all the steps I use to get to a complete map on a fairly large or complex cave.

Stan by for disclaimer:

This is what works for ME. What you can do is take any of these steps in any order, in any way, shape, or form. Feel free to substitute, add thins or leave things out. I often leave out things on smaller maps. Do what works for YOU

Want to know the real trick to mapping? There are really only two. First - start small and keep at it. Drawing maps, like keeping book is a learned art. Your first map will look a little rough, your second a little better, and it will continue to get better from there. Second, the most important, DO IT. It won't get started until you sit down and do it. The hardest part of the map is over coming the initial resistance you feel to taking on a project that you don't feel quite up to. Remember, we all started somewhere, some of my original maps look that the cat threw-up on a piece of paper after eating crayons. I got better (ok so it took a while) You will too. Once you start, you are on your way!

## Chapter 1 - Data Reduction

Data reduction doesn't mean taking half you notes and throwing them away, although that would make the job shorter! What date reduction means, is taking all those numbers you carefully generated in the cave (distance, bearing, azimuth, ect.) and reducing them to a set of

simple numbers that can be used to generate a line plot. These numbers also tell you things like how long the cave is, and how deep.

These numbers are often called X,Y,Z coordinates. If you where to draw a set of axis, the vertical axis most usually is the Y axis and the horizontal is the X.
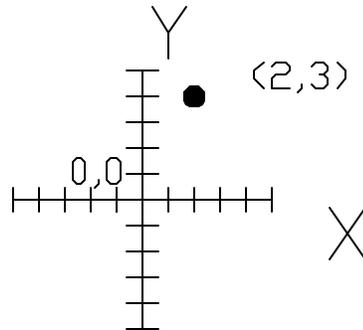


Normally we put the entrance of the cave at 0,0 and then add the survey points in from there. When you reduce the data, it takes the numbers from your survey book, and tells you where the survey stations are in X,Y,Z data, like 2,3 above. This way you can connect the points (literally) and create a line plot that looks like the cave (more on lineplots later)

Methods to Reduce Data
There are quite a few ways to reduce the data. When I first wrote this article many years ago, only a few people had computers in their houses. I spent a lot of time going over hand calculating. I haven't seen anybody do that in a long time. I will give the very basics of the hand methods so you can see what is happening, and you can skip over this if it bores you.

Hand Calculating
Used to be, people would come back from a survey, sit down with a calculator (or a slide rule) and generate data. It took a long time for short surveys and was impossible for long ones. You would end up throwing your calculator out the window. The steps are easy but they had to be repeated over and over. Here are the basics:
1) On a piece of paper, draw in a table for data, label the first point 0,0,0 (this is usually the entrance)
2) On a shot from A to B, you cannot use the distance as you measured it, because there is usually some slope to the shot. When we draw a map, we are looking for the true horizontal distance as if you were looking straight down from above. This means that the true horizontal distance is SHORTER then the measured distance!

Side view of shot from A1 to A2

Original Distance — True Vertical Distance — True Horizontal Distance
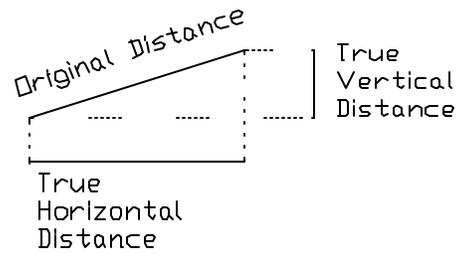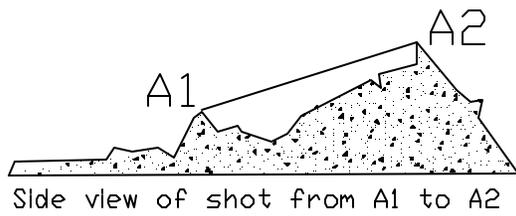
The formulas to generate these distances are Trig and are based on the Inclination (So that's why we take inclination!)
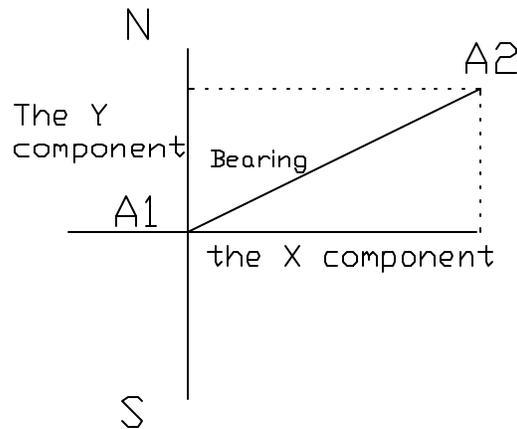
    True Horizontal Distance = Original distance * Cosine (inclination)

    True Vertical Distance = Original distance * Sine (inclination)

3) Now that we know what distance to use we have to find out where to put the point on the X, Y graph. This looks a lot like what we just did to find the true distance, but now we can use the bearing instead of the inclination. In this case we assume that North is straight up
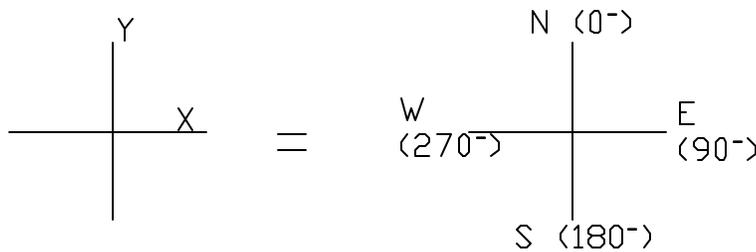


Each shot has a North-South (or Y) component and a East-West (or X) component we must find to put it on the plot. This too is trig



    X = True horizontal distance * sine (bearing)

    Y = True horizontal distance *cosine(bearing)

This is similar to the way vertical coordinates are done

4) The next step would be to do all these steps for EVERY shot! Then you add the X and Y component from shot 2 to shot 1 and get the position of the next point. Then add the next shot to get the position of the 4$^{th}$ shot. And keep going until you are done with your data. This could take all night!!

Now you see why we never do this anymore. This is just a short intro to the math - no need to go into it deeper unless you are really interested.

Computer Reduction
But the way to go today is PC. Most everybody either has a computer or has access to one. There are quite a number of programs specifically design to reduce caving data. These include programs like COMPASS, SMAPS, WINKARST. They all perform the same basic function of reducing survey data to X,Y,Z coordinates, but they vary in how the input is entered, and how it is viewed. They all have many extras that will help the map maker with his map and also some great ways to display data to help understand how the caves are orientated. Most can downloaded directly from the web with the various documentation that come with them.
One of the best parts of these computer programs is the large cave file management systems. After you get three or four surveys in a single cave, it can start to get complicated to manage all the data, and what connects to where. These programs were designed for large caves and can make you life much easier. Many will also generate several types of lineplots (more on lineplots in the chapter 3!).
Try a few of these computer programs and decide which one works best for you.
Most can downloaded directly from the web with the various documentation that come with them. Remember, most of these programs have a small cost that is charged on the honor system. If you find yourself using one, PAY for it.

# Chapter 2 - Computer or Hand drawn Map

Let me stop you right here, because you have a choice to make. Are you going to hand draw your map, or try to generate it on the computer? There are many pros and cons for each. Computer maps can take longer to generate, and need specialized software, such as Adobe Illustrator. Drawing on the computer can be frustrating if you don't already have a lot of skill using one to draw, or draft with. However there are bonuses like being able to quickly modify to map if new cave is found, or mistakes noticed. Several special effects can be added which enhance the map, such as textures, watermarks, or imbedded pictures. Many copies can be run off quickly, and rescaled, and the map is well protected against degrading over time.
Hand drawn maps can be a little quicker, have that certain handmade look to them, and you actually can have a recognized style drafting. I find I have better control over what I want it to look like. On the other hand, hand drawn maps can be difficult to draw, and once drawn are next to impossible to update or correct. Also, somewhere there is an original that needs to be protected like your first-born.

I have found that I enjoy the control and look that hand drafting gives me. The bulk of this article will be around hand drafting instead of computer drafting. But that is because this is what I know best. I think most people will get a lot from reading it, and that most mappers should try their hand at least once with hand drafting

There are two main ways to computer draft a map. The first is to do the whole thing on computer, that is import your lineplot into a drawing program and draw the map completely in the drawing program. Another, more popular method is to complete the lineplot and sketch map by hand, scan it into the computer, and finish it in a drawing program. Most of the folks I know doing more then just simple caves do it this second way.

Thus you need to decide early on how you will complete your map.

## Chapter 3 - Lineplots and Scale

If everything went well with reducing the data, all your hard work with the compass, tape and inclinometer will be reduced to a few pages of paper with a bunch of numbers printed (or scrawled) all over them. Now you have to turn all those numbers into a lineplot. A lineplot is exactly what it sounds like, a skeleton drawing of the cave, showing all your stations and the shots between them. These are the bones of the map that you will come back and hang the meat of the sketches on.

There are several ways to generate a lineplot. Any of the programs used to reduce the data will now generate a lineplot. Oh, and what a lineplot they can generate! Colors and rotating and flythroughs and 3-D. They are beautiful. They are great to see where the cave is headed, and what it looks like, but I have found they have their limitations when using them to draw the map. The main problem with computer generated lineplots, is that most of us only have 8.5"x11" printers attached to our printers. This means if you want an original map larger then 1 page, you will have to print many pages and tape them together. And most printers won't print out to the edge; so some trimming may be involved. It never seems I can get them quite right. All of this issue goes away if you have access to a large bed plotter, but few of us do.

A second problem is when you need to add points, you need to reprint, cut and paste to whole thing over again.

None of these are fatal flaws, and many folks use these as the line plot. I, however, tend to hand plot my points, and have for many years. I have found it gives me better control, and actually a better feel of what the cave is doing. Then I can add on points as it gets surveyed. I can pick the exact scale I want, and I don't have to worry that some printers can slightly change scales when they print (they can shrink the picture slightly). Here is how I go about this.

Material

The best material is graph paper at 10 squares to the inch. You can pick up several sizes at an art supply store, the larger the better. Look for plain paper graphing paper, as there are special

drafting or vellum types that are quite a bit more money. The extra expense is unnecessary for line plots.

Picking a Scale

The scale is how many feet in the cave are equal to inches on the map (or kilometers to millimeters, or furlongs to hectares, or whatever). What you are going to be looking for is the total range of the cave, so that you can figure out a scale that will show the cave to its best advantage, but keep the whole cave on the page. I like to pick a large scale, and work on a large piece of paper, and then reduce it later. However, watch out, if you get too large  and reduce to 8.5x11 it may get too small to read detail!! (note: large scale means <u>less</u> feet to the inch, so the map is less compressed and more data shows)

This can be done with the X,Y,Z data you have generated. The range is the distance from the farthest east to the farthest west and likewise south to north. You find these by finding the smallest X and the largest and subtracting them, likewise with north and south. This gives you the total range of the cave.
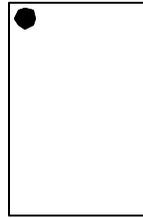
Example:

| Station | X | Y |
|---------|-----|----|
| A1 | 0 | 0 |
| A2 | 10 | 25 |
| A3 | -5 | 35 |
| A4 | -15 | 30 |

In this example the cave runs from -15 to 10 in the X (east - west) plane, and 0 to 35 in the Y (north - south) . Therefore you need to make sure you have room to scale your map for 25 feet in X and 35 in Y. If this was the extent of the cave I might pick a scale of  5 feet to the inch, then the map would be 5 inches by 7 inches, and it would fit on a normal page without reducing. But hopefully the caves we map will be a (little) larger then this, after all this isn't New York caving. I normally use scales of 20feet/inch, 50 feet/inch, 100 feet/inch. These are good picks because you can scale it easily on 10 squares to the inch graph paper.

Entrance Location

You want to make sure that you have a large enough piece of paper, and that the cave is set on the paper so that it does not run off one side (funny how some of my early caves used to end right where it ran off the edge of the paper)

Using the data you looked at to scale it with above, it will give you an idea of how the cave is roughly shaped. You want to place the first station (usually the entrance) in on the sheet so that there is room for all the passages around it. In the example above, in the X (east - west) direction, there are points on both sides of the first station. In the Y (north - south) it just goes up. So I would place the point on the middle of the bottom part of the paper. This leaves room for passage on both sides of the entrance east - west, and allows the cave to climb up the page.
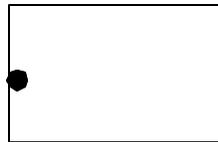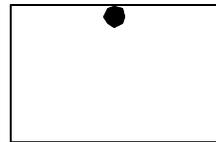
Large Neg Y
Pos X

Large Pos Y
Mixed X
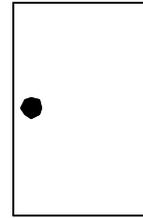
Mixed Y
Large pos X

## Examples of Entrance Locations based on X and Y

Small Mixed Y
Large Pos X

Large Neg Y
Mixed X

If you screw up, or if you find more cave that does not fit on the current page - don't panic! Celebrate that extra cave, and just tape another sheet of graph paper on. Match the grid lines and carry the scales over.

Graphing

After all these decisions, the graphing is the easy part. Put a point at your picked location for the first station, usually 0,0 - this is A1. Because you can graph only two dimensions at a time, we usually pick X and Y. Add the scale along the bottom and side, marking the distances every 20 or 50 or 100feet (depending on your scale) for reference.

Put the next point at the X and the Y for point A2. Then draw a line from A1 to A2 (a thin ruler or old credit card works great). Put the next point in and repeat. Make sure to label you points with the survey station. This will help you in the working sketch, associating points to the survey notes.
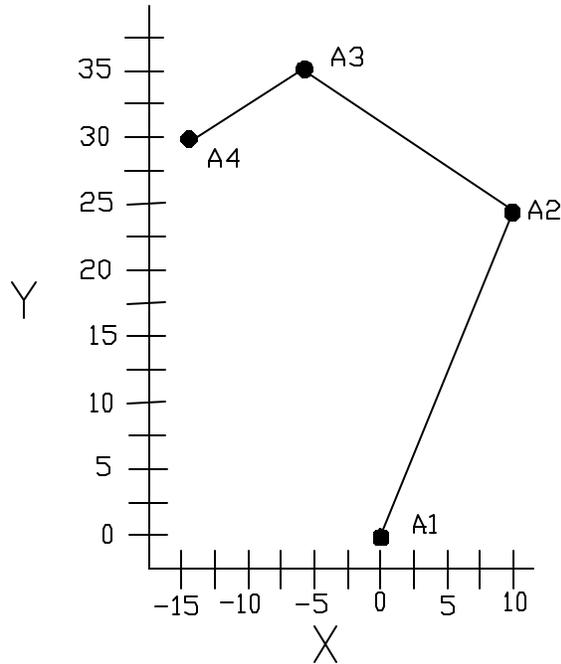
## Chapter 4  The Working Sketch

The working sketch is the heart of the map. It is the first time you start taking details from the survey notes and (try) to assemble them into something that looks like a map of the cave. To me this is both the most frustrating, and the best part of drawing a map. Take your time, and enjoy it. The better you do here, the better the final map will be!

Material
First I lay a sheet of mylar over the completed line plot. mylar is little more then plastic paper. You can buy it in several thicknesses and sizes. It can also come with one, both or neither sides frosted. I usually get one side frosted - it seems to hold the pencil marks better.
There are several reasons for using mylar. First, it is easy to see through, thus you can see you line plot through the mylar. Second, it stands up to abuse - lots of abuse in my case, as you can erase, and erase and erase…… To much erasing on paper, and eventually you will wear right through the paper. But you can erase to your hearts delight on mylar and never wear through. Third, because the paper is translucent (means you can see through it, dummy), it makes it easier when comes time for inking.
There are other materials you can use, such as vellum. Vellum is a fine translucent paper. I never use it at this stage because it is fragile and easy to erase through and rip.

Set-up
Place the mylar over the line plot. Make sure your piece covers the entire line plot, plus a little, to sketch out on. If the cave survey is not completely done yet, you are going to have to guess

approximately where the cave will go and make sure you have enough o cover that section. Adding mylar is not as easy as adding graph paper, but it can be done.

Secure the mylar down with tape so that it will not move relative to the line plot (it helps to have both pieces secured to a drafting table, a board, or a dining room table (if you don't mind NOT eating on it for a while). I use drafting dots - these are little dots of tape sold precut in art supply stores. They are quick to work with and are not as sticky as regular tape, so they are easy to remove and reposition. Regular tape work just as well, but take care removing it from drawings and sketches.

Place registration marks on the mylar. These are just crosses marked in a few locations on the mylar (away from the cave area), with the location (from the scale on the line plot below) marked next to it. These are invaluable if you have to remove the sketch map from the line plot and then later replace it. This can happen if you have to add more passage after the map has been started.

## Pencil Sets, and Leads

You can buy sets of drafting pencils. If you are going to do a lot of this, go ahead and splurge, buy a good set of pencils, a little heavy, but balanced, with metal grips.

I use different type of lead for the sketch map. Plastic lead, made for drafting on mylar, gives a crisp clean line and doesn't smudge, but can be harder to erase. It can be hard to find nowadays, so a hard pencil lead will work just as well, just watch you don't smudge it

## Line Weights

The line weight discussion normally takes place in the inking chapter. Line weight means using different width pens to make some lines stand out better then others. For example, cave walls should be the first things you see, so you will use the heavier line weight (meaning the thicker line)

Because we use pencils on the sketch map, we don't have nearly as much control over line weights as we do with inking pens. However we can use at least 3 weights in pencils. As the pencil point wears, or different pressures are used, this will cause variation, but We should be able to at least see a difference. I tend to use .7mm for passages, .5mm for dome and important features and .3mm for details. Don't be upset if it doesn't look a lot different, but it usually helps
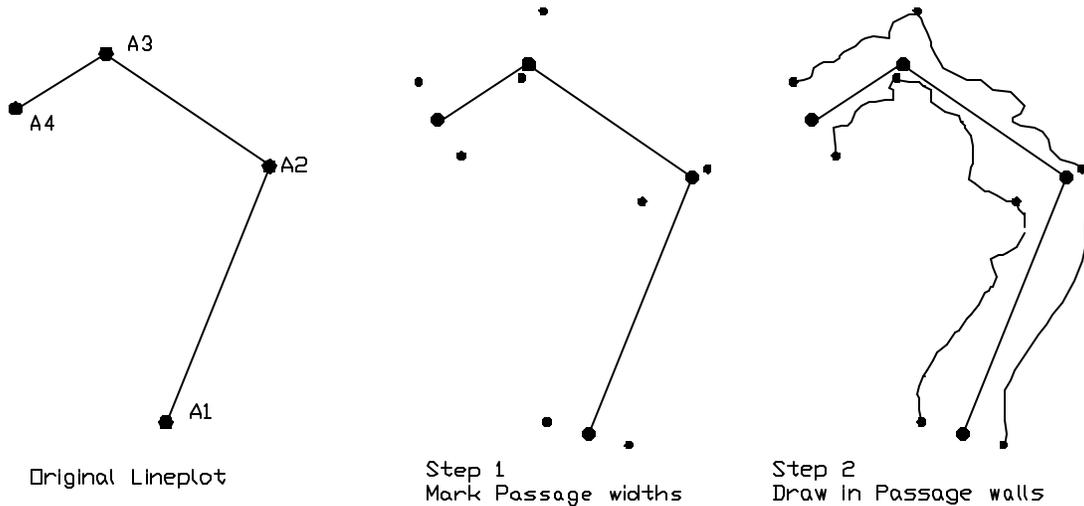
## Sketching the map

Here comes the fun but hard work - the actual sketching.

Haul out all those muddy slips of paper, now is the time to get the rest of the info off of them. Go through, and at each station, mark out the passage width. With an engineers rule (scaled at scales like 10,20,40,50 division to the inch) put a little dot to the left and right of the station where the passage wall is. Try to do it at right angles to the shot as marked on the lineplot below, but you are going to have to interpret.

When these are done, start sketching in the walls. Take your time. Keep looking at the survey notes for shape, features, and trends between points. If you don't like it, erase it and start over. This is why we use mylar. Keep at it until you think it represents the passage, and you like it.

Make sure one section of wall blends in correctly with the others, this is especially important a the junctions.

There is always discussion about whether the lines should be smooth or a little jagged. This is a matter of choice and is up to you - do what you think is good. (Personally I think this is a case of do you crumple, or do you fold, your choice entirely, they both get the job done)!



Original Lineplot

Step 1
Mark Passage widths

Step 2
Draw in Passage walls

Now start adding in details. This is another case of 'take you time and make yourself happy'. Add as many of the details as are on your note. Add those you remember (a good case for sketching the map soon after you leave the cave!) Try to make the large features look exactly like they did in the cave. Even try to make the rocks look like they do!



Step 3
Add Details
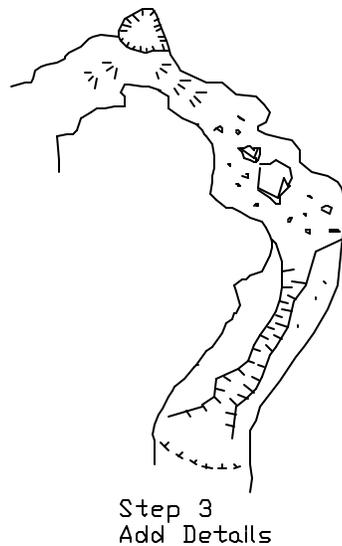
At some point in time, you will get to a point where the cave is so complicated or does something so strange that you aren't quite sure how to represent it on the map. Because you are trying to represent a 3 dimensional cave on a two-dimensional piece of paper, this happens all

the time. And because it happens all the time, you can be sure someone has tried something to represent it.

Right here the book 'On Station' excels. It has a whole chapter on drawing up difficult passages. You can also pull out various guidebooks and newsletter to check out what other mappers have done. Its a little beyond the scope of this article to go into depth on these. However, a good rule of thumb is, if it is understandable, it will do the job.

## Symbols

Cave mappers use symbols to represent features or items we see in a cave. Most folks understand the basic symbols, but there are literally hundreds of symbols that can be used. Try to stay with a smaller, standard list of symbols. Again 'On Station' has a complete list. It is ok to use symbols you make up, but they HAVE to be included in the Legend (more on this later).

## Garbage

Right about now - when I am adding in features, I get thoroughly disgusted with my work. Everything I do looks like GARBAGE. This is a good time to take a break and come back later. You get too close and you are blinded by the (hopefully) small errors.

Two things to remember here:

First, like keeping book in the cave, drawing a map is an art. But it IS a learnable art. The more you do, the better you get, but you need to keep at it. I personally have improved greatly over the period of time I have been drawing. Of course there are those people who are naturals, like Jeff Streba and Dennis Englert, these guys started good and improved (assholes). Keep at it. Second, you are you own worst critic. You know exactly where the mistakes are, and you can't help but stare at them (kinda' like looking at that traffic accident on the side of the road). If you are at the point where you want to shitcan the whole thing - let someone else take a look at it. You may be surprised at their comments.

## Cross Sections

When you are done with the plan view, it is time to start on cross section. You probably took quite a few in the cave, but you may not use all of them. Pick the ones you want to use.

You want to accurately portray the cross section of the cave but you don't want to clutter up the map. Look at the cross sections - if a passage stays basically the same over a long stretch, put in one or two, but not every one you drew in the book. Put more around major changes, or where the information is important. If you have some interesting cross sections, put them in, but do not overpower the rest of the map.

If you can put two passages in one cross section (where one passage goes under another), do it as it looks good. But use the Z data (vertical elevation) data of the passages to keep it in scale and realistic distance between the two.

Scale in relation to plan view is important. You can use any scale you like from 2X to half. If you have room on the map, try to use full scale. However if you are using a large scale, the cross sections may end up being too small, so you might have to double cross section scale. Sketching cross sections is similar to sketching passages. Using the data from the book put little dots at right and left walls, also ceiling and floor. Then sketch in the walls as shown in the notes.

Make sure the cross section looks like the plan view it is supposed to be showing. If the map shows a slot in the floor at that point, the cross section should reflect it.

You can place the cross section either near the location it represents, or place all the cross sections together in a location away from the main body of the map. It really depends on how complex the map itself is and how much room you have for the cross sections. The goal is to not make the map to cluttered and hard to read.

Cross sections have lines drawn from the cross section to the area it represents. The lines have ticks (small lines at right angles to the main line, or little insets that suck you blood. You figure out which is used here) that represent UP near the cross section, and direction the section was drawn from near the map. Most cross sections are drawn as if you are facing into the cave. This makes a difference, as you could draw the cross section opposite hand and or represent it reversed

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Step 4
Add Cross Sections
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<u>Summary</u>

Take your time, what you do here will define how the final map looks. You will be directly copying this for your inked copy. Keep at it until you are (mostly) happy.

When you are done with these steps, you end up with what looks like a cave map, except it will not have titles, names, legends, and so on. More on these later.

Sketch maps have several uses. I usually have several sketch maps going at any time, waiting on more survey data. They can help in the exploration of the cave. You don't have to wait for the whole thing to be surveyed.

And you can copy the sketch map and bring the copies into the cave to check the map against the original (the cave, stupid).

# Chapter 5 Inking

Inking is the process of generating a final copy of the map in ink. It is generally done by shining a light through the working copy and a clean sheet of translucent material and copying all the details from the working copy onto that clean sheet of paper.

At this stage al lot of people ask "Why Ink?" Why not just use the working copy as the final map? Good question - here are my reasons:

First - The line control is much better. You don't get the varying line weight you often see as a pencil point gets duller and duller. Also you get better definition at lower line weights, you can really make some fine detail lines. Inked lines tend to reproduce better on copying machines because of this.

Second - It looks neater. You can usually tell the difference between an inked map and a penciled map.

Third - it gives you a permanent copy that cannot be changed or altered.

Fourth - It gives me something else to write about!

Inking is not simple, but not real difficult. It takes a fair amount of practice and the right equipment. Mistakes made when inking are pretty much permanent. But it really improves the quality of the map, and does not take a large amount of time.

This is also the point where several people will be leaving us to go to computer aided drafting. You can now take your sketch map and scan it into the computer and produce the final map digitally. You can have pretty much the same control on line weights and detail.

However, I find I enjoy the inking and the resultant map, and also have found it can take a little longer on computer. Whichever way you decide, lets get started!

Equipment

Inking pens are the one thing few people own, but are necessary for the job. You can buy the pens from art supply stores. Recently a lot of drafting supply stores have been reducing their prices as more and more offices go over to CAD. You can buy the pens in sets or individually. I only use three or four sizes, so I tend to buy mine one at a time. I use .18mm (0000), .30mm (00) and .5mm (1). Like pencils, choose line weights that are easily distinguishable. Stay away from the disposable types, they are a little expensive, and when the tips jam, there is nothing to do but throw them away. I prefer Rapidograph or Rotring for reliability, but they do not have interchangeable parts. If you can afford it buy tungsten points - they seem to last longer. Paper and vellum can wear the tips over time, leading to a wider line.
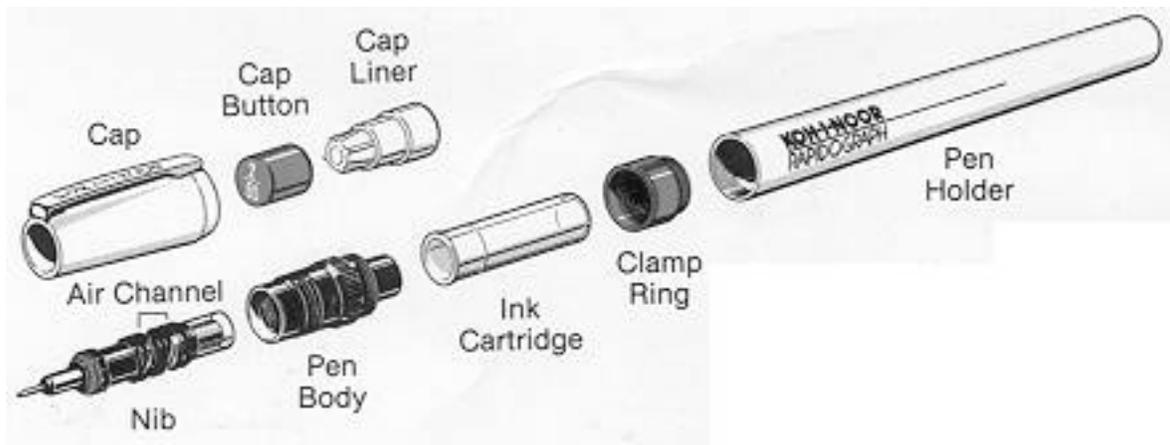
They are fairly easy to use. You fill a reservoir with the correct ink for the job (depending on the material you are drawing on), shake the pen up and down (over a piece of scrap paper) a few times, and off you go! The pens have a reservoir, a weight with a wire attached, and a tip - very little else.

Care and feeding of these beasts is very important. Store them upright with the tip down while using; this keeps the ink in the tip from drying out. Always clean the pen after use. If you get the tip blocked with dry ink, you are pretty much screwed. You can try to clean with air pressure, water, or ultrasonic cleaners, but I have never had too much luck. A small hint; do not take the weight with the wire out of the tip. The wire is so small, you will never get it back into the tip, and you will bend and break it.

Materials
There are a few different types of materials you can ink; each has positive and negative points.
 Paper (bond) - Cheap and easy to obtain, but does not work well because it is hard to see through. Also may not stand up to erasure.
Mylar (Plastic Paper) - Rugged and easy to erase, you just scrape the ink off). However, my experience is that the ink does not sink into the mylar, just sits on top until it dries, so it stays wet for ever, and tends to run. There are special inks and pen tips (made to score the surface so the ink does not run) made especially for mylar, but I have not been that happy with them
Vellum - This is the classic, it is really just high-grade tracing paper. It is cheap, and you can see through to ink. It absorbs ink well, and can stand one or two erasures. This is what I use.

Light
The first thing you really need is a light table. This shines light from below, through the working copy and the paper you plan to ink on. This makes the details from the working sketch stand out well, so you can easily see them. You can buy these professionally, but most folks I know just build their own. They are little more then a box with a light fixture on them, and a piece of glass or plexiglass on top.

However, for folks that have neither the time, money, or space, there are other tricks. For years I stole the glass front to my stereo cabinet and put it up on a few books, and positioned a light to shine up through it. Although the glass is not frosted (it does not spread the light evenly), it does a good job. Any type of glass or translucent plexiglass (thick enough to support some weight of you leaning on it) will do the job.

If your table is not large enough for the whole map, you are going to have to work in sections. This is not to hard provided you tape the inked copy to the sketch in such as way that they always stay registered.
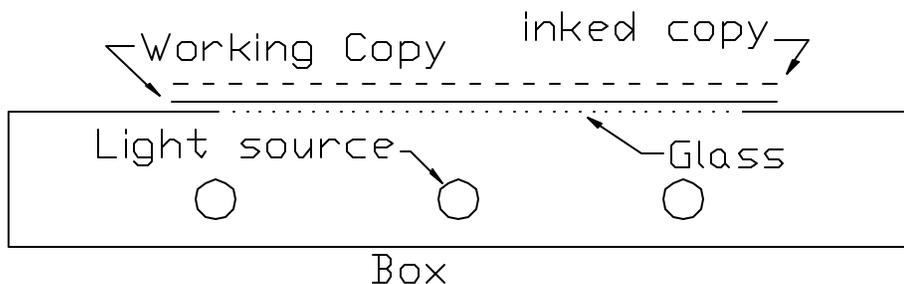


## Setting it up

First, clean the surface of your light table (or what ever you will be using). Clean it well and let it dry. If a pen hits a hunk of dirt (from the notes, the dogs, or your beard) it will deflect it and the pen will run off course (and suddenly the passage will have a little bend there that you just remembered)

Then tape down the working copy so that the entire area to be inked is in the lighted area. If the table is too small, or the map too big (we should all be so lucky), pick a section to work on and make sure it is all in the lighted are. Use drafting dots, or drafting tape to avoid tragedies.

Tape your chosen materials over the working copy. Make sure you have enough to do the whole map. You really don' want any splices on your final map.

Turn on the light. You should be able to clearly see the detail of the working map through the material for inking.

## Ink that Map!

Now you are ready to begin! Fill your pen with ink - do this AWAY from the light table (and not over any white carpets either!). It usually takes only a small amount of ink to complete a map. I only fill the ink cartridge about 1/8 to ¼ full. On a piece of scrap paper, get the ink flowing. Shake the pen up and down, not violently, just enough to move the weight. If you shake too hard ink will come out the air holes and go flying ( I know this to be true). Sometimes

touching the pen to your tongue helps, and sometimes this just gives you a black tongue (and a really bad taste in your mouth). Eventually, if the tip is not plugged, ink will flow.

Start with the passages. Make sure you use the right size pen (larger for passages) Start away from you, drawing the pen towards your body. Work in long, continuos strokes, trying to keep the pen to the paper as long as possible (the less you pick it up, the less gaps you may leave). Watch where you put your hands and arms, if you hit wet ink it will smear.

Now, put aside the passage pen (leave it capped and standing up, with the tip down), and take up the detail pan. Follow the same rules. Take your time. Occasionally turn off the light to see how things are going, and see if you missed inking anything.

All in all, if you have a good working copy, the inking is simple. It goes very quickly and can be done in an hour or two. You are really just tracing, not much brainwork involved, but you can see why it is important to work hard on the working copy.

Inking Straight Lines

You are going to ink straight lines occasionally, either for cross sections or for leader lines. I have found you cannot draw them straight enough by hand to look good (or at least I can't). I use a ruler. But you have to be very careful when inking along a straight edge, or a template. If you lay it flat on the vellum, and run the pen along side of it, capillary action will draw the ink in under the ruler, and blotch. Looks like hell, especially when you were trying to draw a straight line to begin with. You'll have to try to erase it.

But there are ways to get this doe without blotching. Inking rulers come with little bumps on one side to raise ruler off the surface. If you don't have one of these rulers, tape a dime to the bottom of the regular ruler and it will do the same thing.

OOPS

You made a mistrake. It happens. Can you blame someone else? No? Well then you will have to try to fix it.

First though, do you really have to fix it? Is it inconsequential? Do you suddenly remember the passage did take that little funny urn here anyway? This one is up to you; if it really does not inaccurately portray the cave, or you can live with it, leave it.

You can try to erase. Use either a hard eraser, or a sharp blade. Rub over the area (after it is dry) many times with medium pressure. With either an eraser or a blade, you are removing the paper the ink is on, not just the ink. Most sheets will allow you to do this once or twice without ripping. BE CAREFUL.

After erasing, DO NOT REINK. The paper where you have erased is now much more porous. Reink in the same place and you are bound to leave a blotchy mess.

I have usually managed with the last two methods. Other options include white-out, and pieces of paper glued into position. Both of these work, however I favor the paper over white-out, as it takes ink better. Watch the edges with extra pieces of paper; the pen may want to follow it. Worse come to worse - start over. It really does not take that much time to re-ink

# Chapter 6 – Finishing the Map

OK! Stand back. Look at that inked map in all its' glory – it's DONE.

But wait!?! Where is the cave name? The legend? The names, the north arrow? I guess it isn't done yet.

Finishing the map can be one of the more tedious parts. But it is the last, and it really makes a difference between a professional looking map, and one from Indiana (sorry, just kidding). As you put the last parts together, you will be amazed at how much of a difference it will make.

## Working with a copy

Work with a copy of your inked map to begin with. This way you can practice paste-ups, write notes on it, correct it, and decide how you want things to look. Copy it – Kinkos can run anything up to 2x3 for a buck or so. Make sure you handle the original carefully. Might as well run 2 while you are there, just in case. Take the original home and store it – you won't need it for a while.

## Corrections

Post your copy on your worktable and take a close look at it. First, start looking for errors. I usually find errors like lines not meeting, or some details left out. Look to see if the map needs more detail to balance out. Mark these in red ink; we will take care of these later.

## To Compete or Not to Compete, that is the question

Right about now, you need to ask yourself a question. Do you want the map to compete in the Cartography saloon at the NSS conventions, or is just a map to publish in your grotto newsletter/guidebooks?

I often compete, but it is a hard process. First you get to post your map on the wall, next to maps that look like works of art. Then you get to watch it ripped apart by judges. And usually you walk away with little more then a "good job but…"

If you can go into this as a learning experience and walk away with a ton of valuable information on how to improve your future maps, go for it. If you are thin skinned – be warned.

The reason this becomes important is because there are two standards for what to put on the map. If it is for your consumption alone, only put on what you want. Add enough data so that people will be able to understand and use the map, but not so much that the map appears busy. Try to get sizing and locations correct but this is not an absolute.

If you choose to compete, there is a host of things that HAVE to go on the map. Often winning maps make the grade by putting all the required info in and still not appearing cluttered.

This is your choice, but I will list most of the requirements and let you choose.

## Choosing what to label and letter

Regardless of what you choose to add to your map, you want it to look as neat and balanced as possible. Take a pencil and draw those things right on a copy of your map, which is what the copy is for. Try and get sizing and locations about right, but getting it exact is not important.

When you are done, step back and look at it, does it look good? Do you have room for more?

Should you leave things out? Cross out, draw arrows, do whatever to make it look the way you like. Go wild on this copy.

Sudden Left Turn – Computer generated maps (again!)
Before you go on with typesetting and gluing stuff to your inked copy, right here is another spot where you can choose to hop on the digital bus. Kinkos can digitize the inked map into any graphics program. Inked maps tend to digitize real well due to the high contrast of the dark ink. Instead of adding all the text by hand, you can do this with computer.
This way you have the feeling of a hand drawn map, but seamless typesetting. Try this if it interests you. You will still have to add the elements detailed in this chapter.

Elements
  Title Block

# Bighola Cave
## AKA Jerrys Humming Buttcrack Cave
## RockCastle County, Kentucky

### Suunto and Tape Survey Sept 94 - Sept 00

This is the most important information and should be mounted in a central location
Name – the most important, and should be the largest font on the map. I used to underline is, but now this is a no-no. Use the most common name and add other names if they are in general circulation.

Cave Location – Along with the name, this is also important. We normally add only county and state. You can add more information, up to exact location, but we normally do not do this, as there is no way to tell whose hands the maps will fall into.

Survey grade – There is a ranking on survey grades from pacing to tripod mounted Brunton. I normally state type of compass and 'Tape'. This can also be denoted as a grade 5 survey.

Date – approximate dates the cave was surveyed

## Major Components

There are other major components that need to be added. These can basically be added anywhere on the map, as long as the map looks balanced. Add them to the map now, with a marker, and we will talk later about moving them around.

### Compass Rose
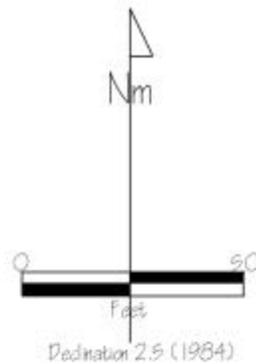


This shows the direction of North. Always mark whether you are using true north, or magnetic north. In competition maps this needs to be long enough to scale off of and the amount of declination needs to be displayed.

### Scale

This shows the scale that the map was drawn at. Do not use scales that say "1 inch = 1 foot". This would be OK for your original, but as maps get copied, blown up, or reduced, it would no longer be true. Unit less scales are much better, as they blow-up/reduce correctly with the map and stay in scale.

Make this scale easy to read and make sure you add what units of measurements you are using. In this case we are using feet. Notice how the scale does not say 100 feet to the inch. If we were to reduce the map 50% that statement would no longer hold.

### Survey Crew
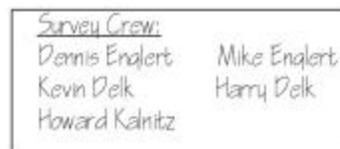


If you want your friends to remain your friends (and survey with you again), list their names. If you want them to hate you, leave them out. If you really want them to hate you, spell it wrong. Take care. Place it in a small block; it shouldn't take up too much room. If you have too many names, consider only using initials.

Legend/Key



This is one of the most important areas of the map. This shows the map-reader exactly what you meant when you put this squiggle, or that dash on the map. Without it the map-reader may not have a clue of what you are trying to represent. But in caving today, we generally use a set of symbols that everybody is familiar with and can identify.

So we have a choice. You can either note on your map that you are using a certain group's symbols (such as NSS or CRF or AMCS) or you can ad a legend. I tend to add the legend for a few reasons. First, it usually looks good on a ma. Second, it gives beginners, or those without access to symbols lists, a clue to what is going on.

Get ready for the big secret - You can use any symbol you want, as long as you identify it on the key! If you want to make one up that fits your particular circumstances go right ahead. Just as long as it is identified. In mapping Great Saltpetre Cave, I was faced with a lot of saltpeter trailing dumps (or alien burial piles take your pick). I could use the symbol for a pile of dirt, but that wasn't clear enough for me. So I combined two symbols and made a newer symbol, and I clearly identified it on the legend. Map judges will crucify you if you use an unknown symbol and don't include it on the legend.

Make sure your legend is clearly readable, and remember it will most likely be reduced, so don't start too small. There is always a controversy on whether you put the symbol first and then the description, or the other way around. I usually put the symbol first but here is another secret – it doesn't matter!

When you get done, make sure you have all the symbols on your map listed!

Cross Section Lines and Identifiers
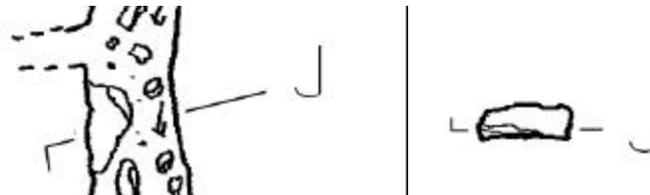


These are the lines you draw from the cross sections to the areas in the cave they represent. These are important to add to make sure you can match cross section with area. Try to keep them straight. Don't let them run into passage walls – keep a gap between the line and the passage. If you have set the cross section off to one side, you have to label the location on the map with an identifier usually just a small script latter) and match that identifier with the cross section

Just for the anal oriented – the letter should be on the same side as the in the passage drawing as the cross section. Don't forget to add your direction ticks either.

Passage Names

These are important too! How else can we refer to a passage if we don't have the passage name? These should be straightforward. Add what names you prefer, but don't go overboard and name every small section. Place them close enough to the area they represent so there is no confusion. Use leader lines – small lines that go from a name or a number to the area they represent. These can cross the passage lines if needed. Make sure you use a smaller line weight then the passage.

Passage Heights, Drop Depth, and Depth Below Surface
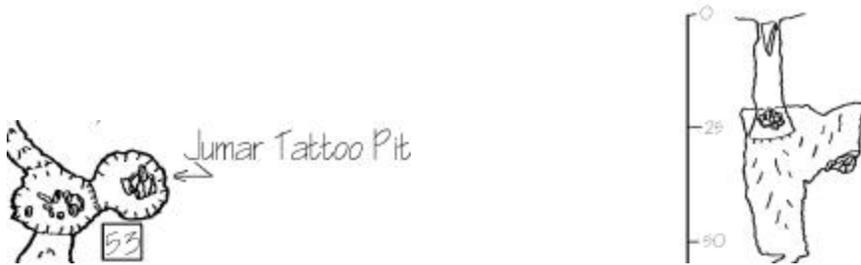
Start marking these in also. You get these numbers from your notes and the reduced data. Use the same rule as before, add enough to show information, but not so much you clutter the map. Make sure you label your zero datum for the depth.

Other Things to Add

- Cartographer - How are they going to know whose great work this is if you don't add your name?
- Copyright - good idea if the map may be published
- Total length and depth – needed in judging
- Date of Drawing
- Grotto Affiliation
- Survey number, such as Alabama cave survey number.

# Chapter 7 Typesetting and Labeling, and Paste-up

OK! Now you should have a copy of your inked map, scribbled all over with numbers, names, legends, and the like. It's not done yet, but at least you have a clue of what it might look like! What's next? Typesetting and applying the labels!

## Typesetting

There are many different ways to produce good-looking labels for your maps. Books are full of them. I use one or two exclusively, but I want to share the others and problems I have seen with them:

> Hand Lettering – If you are good enough to do this, I hate you. Most mortals cannot hand letter well enough to make it look good. If you are one of the few – have at it.
>
> Rub On Letters – These come in sheets and you rub them off onto a piece of paper to make words and sentences. They are getting harder and harder to find, and they are hard to keep in a straight line as you apply them. This is rapidly becoming a lost art. Besides, you always run out of the letter you need, leaving you with sheets of Zs', Fs', and Qs'
>
> Inking Templates – Inking templates are pieces of plastic with guides for sticking your pen through to produce letters. This too is becoming a lost art. There are alignment problems, not a lot of good fonts, and I always seem to smear something. Want to really piss yourself off? Ink an entire map, and then have to trash it because you screwed up inking a word (smear OR misspelled!)

There are really only two ways I would recommend, and they both involve computers:

## Computer Generate the Labeling

Once the map is done, and you know where you want all of your labels and text, you can jump to computer and finish the rest. As I have explained before this involves going to Kinkos or the like, scanning in your map, and then adding the rest of the data via a computer application such as Photoshop, or Illustrator.

This has the benefit of a hand drawn map and computer labels and can look good. There are some problems with getting the right sized fonts and positioning, but these are overcome with time and experience. Make sure you have access to the applications needed for this, and when the work is done, a full bed printer/plotter to generate the completed map at the size you want (again – Kinkos can usually do this)

## Computer Generated Labels and Paste-Up

This is the way I have done it for years. You generate the labels via computer, print them out, cut them apart and glue them to the map. This takes some time, but is fairly easy to do and low tech!

### Generating the labels

First, write down everything you hand labeled onto you map in the last section. Put into the computer in a word document type application. Once all the data is in you can start playing with Font types and Sizes. Keep playing around till you have one that looks good. You may

have to use a drawing program for things such as the north arrow and the scale, but these are straightforward. Jam them all onto one page. Print out a few with different fonts and sizes so you can pick. Use a laser printer. If you don't have one at home or work, find a friend with one, or go to Kinkos. They are getting a lot easier to find in the last few years.

Final Check.
First, take one of those printouts of your components and start cutting it up. Don't worry about straight lines now, this is just for checking. Tape each component to the map (you can use the one you wrote on) in the location it is supposed to be in (don't worry about some of the minor components such as ceiling heights). Step back. How does it look? Do the sizes look correct? Not too big or small?
How about the layout? This is you last chance to change things. It is easy to change size and fonts on the computer.
Check the balance. It shouldn't be too cluttered, but it shouldn't have too much white space. Move things around, try different arrangements. Nothing is set in stone, yet.

Paste-up
This is the part I like the least. I always end up gluing my finger to my ear or something worse (Guys – use the restroom BEFORE this step).
When you are finally happy with the working copy, put it where you can see it and pull out the original inked copy. It is time to start pasting!
First, put some graph paper under the inked map. Make sure the map sheet is straight with the graph lines on the paper (as much as you can make it). This will allow you to place the labels straight in respect to each other and the edge of the map. The paper you inked on should be translucent enough to see the lines through it.
I use a glue stick to paste with because it is easy to control, and gives you a little time to move the label before the glue sets up. On the other hand it can ball up and leave glue boogers (do I have to explain?) on the paper. Be careful.
Cut the label from your print out. Trim close to the letters, but do not cut into them. A straight line helps placement. I usually use a small set of sharp succors, or an Exacto knife here. Turn it face down on a scrap of paper and completely coat it with glue, over shoot it a little to make sure you have glue on the edges (or else they will peel up and bend). Be care full not to set the next pices doen in the glue from the overshoot –I throw out the scrap frequently.
Place it on the inked map. Using your fingers, position it correctly. Make sure the letters are straight, not just the edge of the paper as you may have cut it a little skewed. Make sure the paper does not cover any inked features. Make sure your fingers are clear of any glue boogers (or any other kind) before touching the label to position it.
When you use really small labels (such as passage heights, names, or cross section identifiers) I trim real close and place the blank side right on the glue stick. Wipe it off to the side and place it. Be careful not to get glue on your fingers, it will pick up dirt and transfer to the paper where you touch it.
This process can seem like it takes forever, but only needs to be done once, and really gets over quickly.

OOPS
If you notice a mistrake after the glue has set, there are one or two things you can do. You can re-label right over the mistake, or try to peel it (very slowly and carefully) from the map with a sharp blade to help peel it. The sooner you notice the problem, the softer the glue will be – but it sets up strong enough to rip in a matter of minutes.

Leader Lines.
You can't add leader lines until the labeling is done, because you don't know exactly where the labels are going to end up, and you don't know how much paper you are going to leave on the label. The exception is lines required for cross sections. Because the sections are inked, you can add the lines at the same time.
So you need to add them after the labeling. This is not a problem. I usually fire up the ink pen – at a small line weight and add them in. Careful when using the ruler and careful where the paper edge is. If your pen hangs up it will blotch, so go from the paper to the vellum.
You can also use the pen at this time to make your final corrections.

Strip it.
Good-looking maps usually have a border. The easiest way I found is strip chart. It is sticky tape in varying widths that you can find in art stores. Pick a width, unroll some, and stick it to your map. Take care it is straight; it is easy to see if it is crooked. If it is wrong, peel it up and do it again, this stuff is forgiving. Take care not to stretch it too tight, it will cause the map to buckle!

ALL RIGHT – it is done!

# Chapter 8 Copying and Reducing
Well the map is technically done. But it really doesn't look all that nice – it has all these paper strips on it, and it really doesn't roll well. You need to make copies.

Photocopying
There are really three types of photocopying for large documents and one is better then the other for what we are doing. For years the best you could do with a large map was to have it photo reduced, in other words have a picture shot of it and have it photographically reduced. We are lucky now we have a few options which are quicker and a whole lot cheaper!
Roll type Photocopiers
This is the old standard. You would feel your map in ovr a roll and it would copy at the same time. These were problematic with paste-up maps because two things tend to happen. First, it can peel off the paste-ons, rip them, or at least bend back an unglued corner. Also, because the light is only on one side, and the copying element on the other, the paste ups tened to cast small shadows, and it was obvious they were there.

Scanner Bed Photocopiers

When I started mapping these were only found in large blueprint companies. But now-a-days Kinkos has them in most of their stores and they are well worth it!!! These units are really just high quality large scanners. They scan your map over a flat piece of glass and send it either to a computer file or another piece of paper. It doesn't show the paste-ups at all and you have a good looking final production. What's more these units can also automatically reduce the map to standard size pages (you will want to do this for publications!)

Go in and scan you map. Have a few large size copies made on the large scanner and at least one of the small ones. Take the smaller one and bring it to the regular machine and make some more copies. It will cost a few bucks (I think Kinkos charges by the output inch) but again it is well worth it.

You may also consider getting a scan on disk to play with later, or have a permanent record of!

Make sure you make enough of the large copies to give one to each person on your survey crew – you couldn't have done it without them and they will appreciate it (maybe you will be able to suck them in for more trips).

Take your original home and put it somewhere safe. Keep it warm, dry, and happy. Try to store it flat if possible, the paper patches won't fall off as quick that way. Make sure you permanently store a good final copy also to reproduce later if needed. Take care of it – it is a work of art!!

Summary

That's al there is to it. Sounds complicated but it really isn't. The real trick is to START. Get off your butt and do it – that's the only way it will ever get done!

Disclaimers

If you think this is all my original work, thank you, but it isn't. I have unashamedly stolen from the best sources I could find, and rewritten to fill the gaps, blanks, and to make it easier to understand.

   I have stolen from:

       On Station George Dasher (available from the NSS)

       MSS Survey Special Published by the Missouri Speleological Survey (also available from the NSS)

       CRF Personel Handbook

For advanced data on all surveying subjects, please consider these volumes

Howard Kalnitz nss20678