Appendix 1

Water Levels, A-Frame Levels, and Laser Levels

TOOLS FOR MEASURING SLOPE, ELEVATION RELATIONSHIPS, AND DETERMINING THE PLACEMENT OF WATER-HARVESTING EARTHWORKS AND ASSOCIATED PLUMBING

Professionals typically use a laser level or transit/surveyor's level to measure slope, elevations, and/or define how they want to shape the land. These tools work well, but they are expensive. So we begin with two effective and inexpensive alternatives you can make—a "*bunyip*" *water level* and an *A-frame level*.

THE "BUNYIP" WATER LEVEL

The "bunyip" (fig. A1.1), as this water level is called in Australia, is a simple tool that enables you to find a land "contour" (a level line on the landscape), determine elevation differences between two points, and determine the slope of the land.

You can use this tool to mark the locations for contour berms, slopes of diversion swales, end points of boomerang berms, depths of basins, and appropriate locations for overflow routes. In addition, you can determine how much a gravity-fed greywater pipe will need to drop in elevation as it maintains a minimum 2% slope from where it exits a house to the point it outlets into the landscape.

A bunyip consists of a long clear vinyl tube, with each end attached to a tall stake that is marked in inches or centimeters. When the two stakes stand vertically, the tube becomes "U" shaped. Water is then poured into the tube, and air bubbles and kinks are removed so the water flows freely within (box A1.1). The bunyip works on the principle that still, standing water is level across its entire surface, as you would find on a calm lake. A bunyip is basically a lake in a tube.

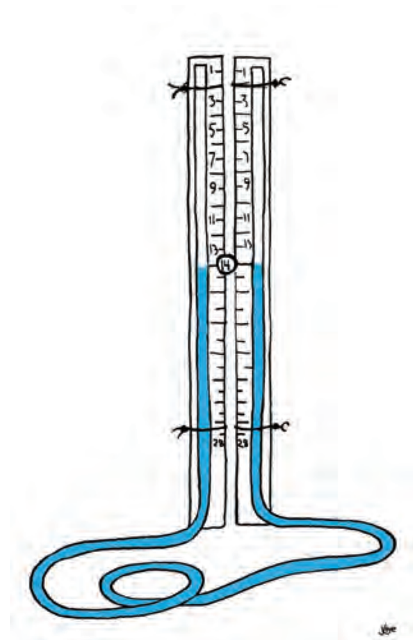

Fig. A1.1. Bunyip water level

The tube is filled with enough water so the surface of the water reaches about halfway up each vertically held stake. If the stakes are standing right next to each other on level ground, the water level will be the same in both ends of the tube, and the measurement reading on each stake will be the same. If one stake is raised while the other stays where it was, the water level will stay straight across, but the measurement readings on

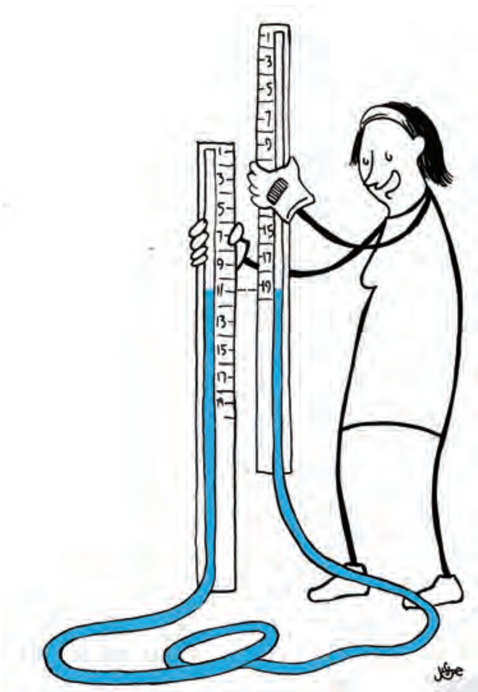

Fig. A1.2. Testing the bunyip level; the water is level.

the stakes will be different, reflecting the elevation difference of the bottom of the stakes. It takes two people to use a bunyip water level—one to hold each stake. Bunyips are easy to make using the materials and instructions below.

WHAT YOU NEED TO MAKE A BUNYIP

- Two 5- to 6-foot (1.5- to 1.8-m)-tall, straight stakes (2 x 2s work well)
- 30 feet (10m) or more of 3/8-inch (10-mm) interior diameter thin-walled clear-vinyl tubing (thick-walled tubing kinks more and is a waste of material), available in the plumbing section of most hardware stores
- 3 feet (90 cm) of wire, string, or duct tape to bind the tubing to the stakes
- Yard (meter) stick or tape measure
- Permanent ink marker
- 2 to 3 gallons (9 liters) of water
- Funnel to pour water into the tubing

• Optional: 2 corks and 2 strings. Corks are used to plug the tube ends when moving the water level around, then removed during use. Wine bottle corks can be whittled down to fit the tubing. Tie one end of a string to the top of the bunyip stake and the other end to a cork so you don't lose the corks.

HOW YOU MAKE A BUNYIP

Lay the stakes beside one another on the ground with the bottom ends even. Measure 5 feet (1.5 m) up from the bottom of each stake and mark this point. These marks should be level with one another since the bottom ends of the stakes are even. Starting from the upper mark of each stake, use the measuring tape or yard stick and permanent marker to mark each inch (or centimeter) going down for 30 inches (or 75 cm). Check the accuracy of the marks by standing the stakes next to each other on level ground to confirm they line up. Starting with zero at the top, number the marks from top to bottom on each stake so the numbers also correspond.

Bind the tubing near the top of each stake using wire or string. Lash it tight enough to hold the tubing in place, but not so tight that it significantly pinches the tubing. Pull the tubing straight down along the stake and lash it in the middle, then near the bottom of the stake.

Fill the tubes with water in one of two ways:

Method 1: *Pour the water in*. With both stakes in an upright position, carefully pour water into one end of the tube until water overflows the tube. Any air bubbles that become entrained in the tubing will prevent accurate water level measurements. Remove air bubbles from the tube (see box A1.1 for instructions), and add more water until the desired water level is attained.

Method 2: *Siphon the water in*. Lay one stake on the ground. Set the other stake upright against a table that has a bucket of water standing on it. Release the upper tubing from the upright stake and stick the end of the tubing in the bucket of water. Wash the end of the tubing of the stake laying on the ground, then suck on the end of the tubing to initiate water siphoning. Air bubbles typically do not get entrained in siphoned water running from the bucket into the tubing.

With the air bubbles removed, hold the stakes upright next to one another on level ground. Check

Box A1.1. Getting Rid of Air Bubbles in Bunyip Tubing

To ensure accurate water level measurements, enlist a friend to help you remove air bubbles in tubing. First, pour water into bunyip tubing. Next have your friend hold the two bunyip stakes upright next to each other. Then stretch the intervening tubing out along the ground. Where the tubing "folds" back on itself (the bottom of the "U"), pick up both parts of the tubing 2 feet (0.6 m) from the bottom of the "U," using one hand. Make sure the tubing is not pinched anywhere. The bottom of the "U" will hang down forcing any air bubbles in that length of tubing to rise toward your raised hand. Now slowly slide your hand up the tubing, always keeping the bubble-free section of tubing lower than the tubing in your hand. Tap the tubing with your free hand to help free any bubbles sticking to the side. When your hand gets to the stakes, drop your hand slightly or lift the stakes slightly so the collected air bubbles can escape out the open ends of the tubing (fig. A1.3).

You may need to add more water in the tubing to fill the space the bubbles occupied. After you've put more water in, check for bubbles again.

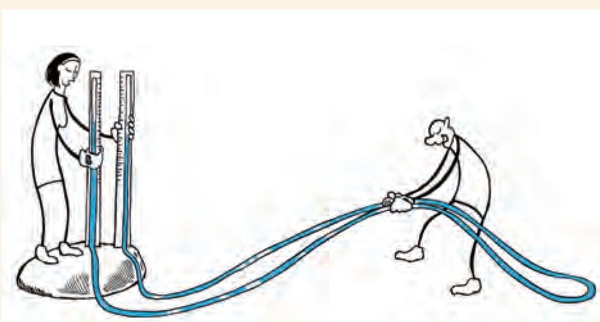

Fig. A1.3. Removing air bubbles from tubing

that the level of water is about halfway up the stakes. Drain or add water as needed to get water to the right level. Water should move freely up and down in the tubing when you move the stakes. If water does not move, check the tubing for kinks, remove the kinks, and verify that water moves correctly. Once the water becomes calm after moving the tubes, check that the water level lines up in both tubes, and that the measurement reading is the same on both stakes. If the water levels are not at the same height when the stakes are standing next to each other on level ground, check again for air bubbles or a kink in the tubing. If the measurement reading is not the same, check for mismarked stakes.

Now your bunyip is ready to use. While carrying it around, use the corks or your thumbs or fingers to plug the tubing to keep water from spouting out the ends. Remove corks or thumbs when you are reading water level measurements. During a long project, it's a good idea to periodically set stakes on level ground next to each other to verify no new bubbles or kinks have formed.

USING YOUR BUNYIP—TWO HYPOTHETICAL EXAMPLES

Marking a level line for a contour berm

Al and Bonnie want to mark a level contour line on their land where they plan to dig a contour berm later that day. They get out their bunyip water level and Bonnie holds the two stakes upright as Al fills the tubing with water and gets rid of air bubbles. The water is about halfway up their stakes and is level, so they are ready to start.

To refamiliarize themselves with the water level, Bonnie holds one of the stakes a few inches (cms) higher than the other. When the water stops moving, the water in the higher stake reads "19" while the lower stake reads "11", with both stakes vertical (figs. A1.2 and A1.4), so they are reminded that the stake that reads the higher number is also higher in the landscape than the other stake.

As they walk to where they want to begin measuring the contour line, they each hold a stake with their thumb over the open end of the tube to keep water from spilling out. Bonnie sets the bottom end of her stake down where they want to begin the berm. Al walks 5 to 20 feet (1.5 m to 6 m) along what he thinks is the contour line (20 feet if the land is relatively flat, closer if the land is more undulating). Al puts his stake down in a spot he feels is on the same contour line as Bonnie's stake. Standing in these positions, they each gently tap the top of their end of the tube with their thumb to stop the water sloshing around within the tubing. When the water is still, and they've removed their thumbs from the end of the

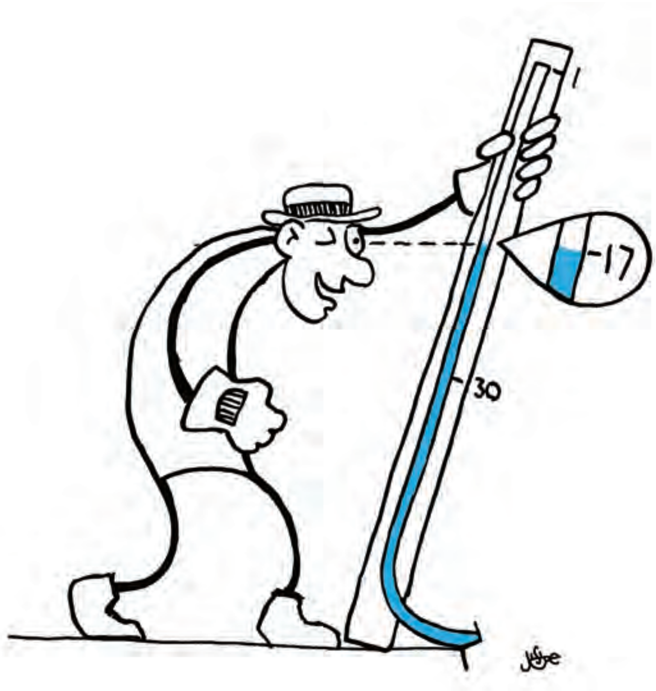

Fig. A1.4A. A non-vertical bunyip stake will give a lower, incorrect reading

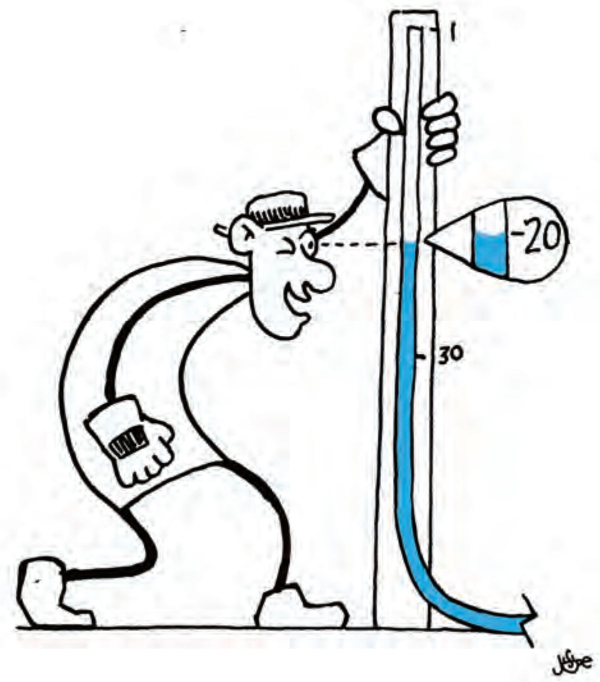

Fig. A1.4B. The bunyip stake must be vertical for a correct reading

tubing, they tell each other what water level measurement they have. Bonnie reads 13 while Al reads 17.

"I have the higher number, so my stake is higher than yours," says Al. "So I'll move my stake downslope a bit. You stay where you are since you're in the spot where we want to begin the berm." After moving his stake several times, Al and Bonnie each read 15 on their stakes, so they are now at the same elevation. They scuff a line in the dirt connecting Bonnie's point to Al's. With that done, Al keeps his stake in place and puts his thumb on the top of the tubing. Bonnie plugs her end of the tubing and walks her stake beyond Al ("leapfrogging him") to a point she thinks is level with his stake (fig. A1.5).

As Al and Bonnie find a series of points on the same land contour, they continue to connect the dots by scuffing the contour line into the dirt. They could have marked the contour line with wooden stakes or other markers, but since they planned to dig a berm 'n basin along the contour line right after lunch, scuffing is sufficient. They keep going until they reach the full length chosen for the contour berm. If they had encountered a landform that presented a natural barrier, they would have stopped there instead.

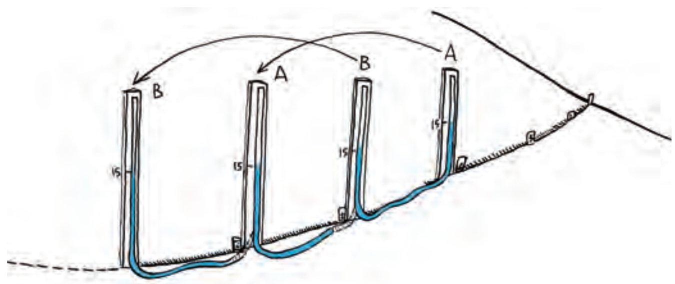

Fig. A1.5. Leapfrogging the bunyip to mark a level contour line on the land. Here the contour line is marked both by scuffing a line in the dirt and with stakes.

With the contour line marked, they prop the bunyip water level against a tree to keep water from running out of the tubing, call some friends, and dig a contour berm along the line they just marked (see chapter 2 on berm n' basins for more information about construction). By four o'clock that afternoon, the contour berm is complete.

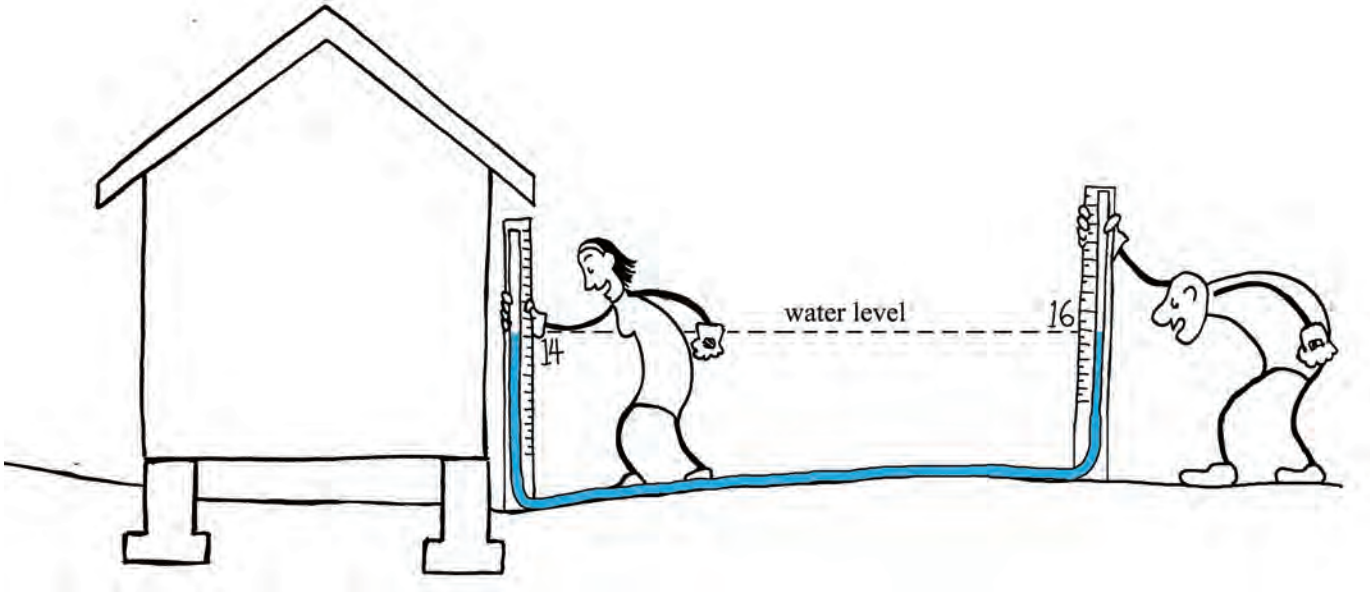

Fig. A1.6A. Bunyip shows land slopes toward house

Using a bunyip to determine a difference in elevation and measure slope

In the middle of a record-breaking drought, friends of Bonnie and Al decide to make use of the rain that does eventually fall by putting in a water-harvesting basin in front of their house. To make sure they don't dig into and damage underground utility lines they call their free local utility-marking service (in many states, dial "811") to have buried lines marked between the public right-of-way and the meters. Then they hire a private utility-marking service to continue marking buried lines from the utility meters to the house. Once all utility lines are marked, they ask Bonnie and Al to bring their bunyip over and help them figure out the direction water naturally drains around their new home.

Bonnie and Al look at the relatively flat lot and try to eyeball the way water would flow, then get out their bunyip water level to see if they are right. "OK," says Bonnie, "I'm putting my stake by the house." Al places his stake 10 feet (3 m) away from the house at a point he thinks is directly downhill from Bonnie. When the water stops moving within the tubing, Al and Bonnie tell each other the water level readings they have (fig. A1.6A).

"I've got 14," says Bonnie. "My stake reads 16," says Al, "and with our bunyip that means you are a full two inches lower than me, so water will drain toward this house…which is bad news!"

Al, Bonnie, and their friends decide to dig a shallow basin about 15 feet (4.5 m) from the house to intercept rainwater, and to move the soil from the basin to the house foundation to deflect rainwater away from the house. They dig out a level-bottomed basin 6 feet (1.8 m) wide and 8 feet (2.4 m) long, and put most of the fill dirt next to the house, making sure the dirt is at least 4 inches (10 cm) below the top of the foundation's stem wall (as recommended by local building codes to keep termites and/or soil moisture from entering the home). They rake the area between the newly dug basin and the house so the grade slopes away from the house and into the basin. Then they use the bunyip water level to check their work. Bonnie again stands by the house and Al places his stake about halfway between the house and the basin on the new slope they created.

"My stake reads 16," announces Bonnie.

"And I read 14, so we did reverse the slope and water will now drain away from the house," cheers Al. "Bonnie, stay up against the house while I move my stake to the bottom of the basin to see how much deeper it is than the soil by the house."

Al moves to the bottom of the basin and reads 6 on his stake (fig. A1.6B).

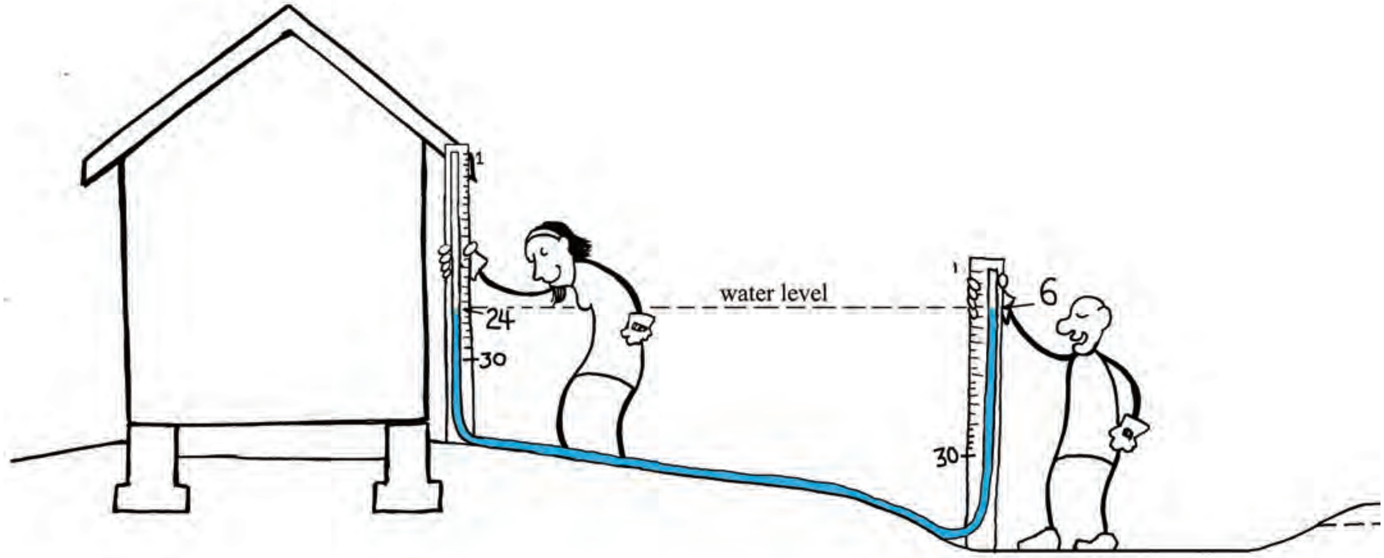

Fig. A1.6B. Using a bunyip to measure how much lower the bottom of the basin is than the area near the house, confirming that the slope now drains away from the house

"I've got 24" exclaims Bonnie. "Subtract your 6 from my 24 and that tells me you are 18 inches lower than me. We did a good bit of digging!"

"This basin will catch a lot of rainwater! Let's make sure when it fills up, any surplus water will overflow away from the house," says Al.

They take land-surface readings all around the edge of the basin using their bunyip water level. They learn from the readings that if water flows out the lowest point around the edge of the basin, it will drain water toward the neighbor's house. To change this, they pick up the shovels and alter the dirt level of the basin's rim slightly so the lowest point on the basin's edge will now direct overflow into another basin on site.

Checking their work with the bunyip as they go along, they dig several more basins, this time located in the public right-of-way (public land located between their property line and the street). These basins will harvest even more rainwater and will receive overflow from the basin they dug in front of the house. So this series of basins will direct overflow water all the way from the house to the street. The edges, bottoms, and general slope of the basins are checked using the bunyip one last time.

The basins were constructed so that while the overflow spillways that move water from one basin to the next are at the same elevation, that elevation is well below the soil level abutting the house. This way the house will stay high and dry. The elevations of the level bottoms of the basins varied, but were all lower than their respective overflow spillways, so some water will be retained in each basin. The depth between a basin's overflow spillway and the bottom of the basin determines the storage capacity of the basin.

Bonnie and Al's friends are delighted with their new water-harvesting basins. After taking a break, they plant the basins. Hardy native trees go in along the street in the public right-of-way basins. The basin in front of the house is planted with a drylands-adapted peach tree to provide fruit for future pies. Along with it, they plant a wolfberry, a chuparosa, and native flowers that produce native foods and medicinals and attract hummingbirds. This basin will receive direct rainfall, harvested runoff, and greywater from the home.

Bonnie and Al's friends are so inspired, a week later they dig several more basins near their house. A vegetable garden goes into the basin on the equator-facing side of the house where it will receive winter sunlight. A native mesquite tree is planted in a basin west of the house to fix nitrogen in the soil and screen the vegetable garden from harsh summer-afternoon sun. Once all the basins are dug, planted, and well-mulched, Bonnie and Al's friends dance together to entice the rain (fig. A1.6C).

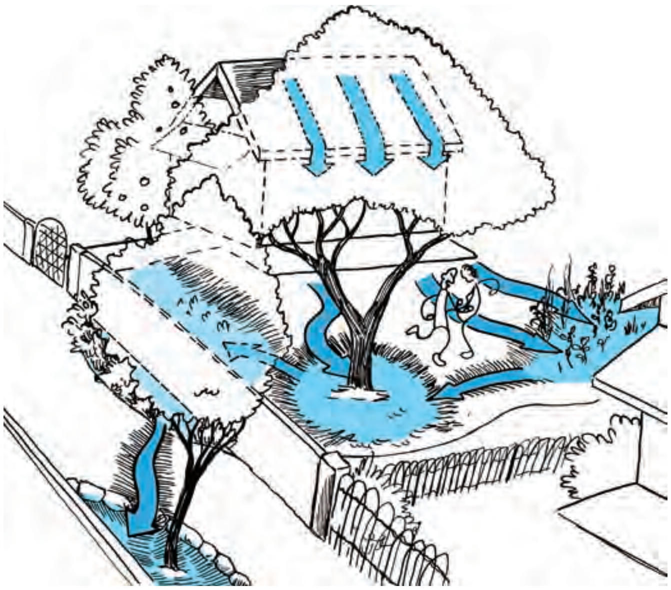

Fig. A1.6C. Celebrating completion of a water harvesting landscape

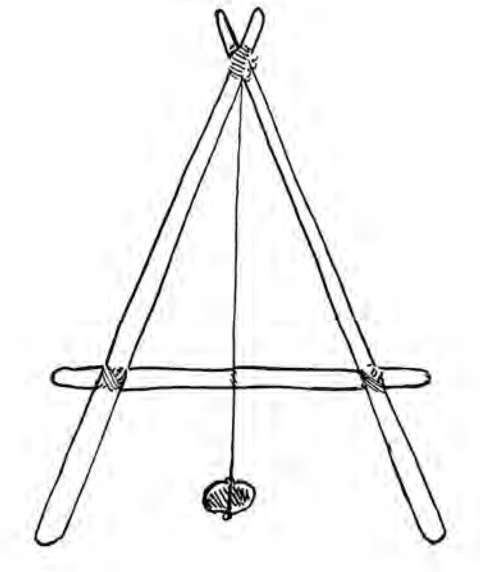

Fig. A1.7. A-frame level

For more information see chapter 2 on infiltration basins, chapter 11 on vegetation, chapter 4 in Volume 1 on integrated design, and the video page at HarvestingRainwater.com.

THE A-FRAME LEVEL

The A-frame level (fig. A1.7) is even simpler to construct than the bunyip water level. No tubing or water is needed, and you can use it all by yourself. An A-frame level can be used to find a contour line on the landscape, but unlike the bunyip, you cannot measure the elevation differences between two points at different levels, nor can you measure the slope of the land. It does come in very handy for marking the line on which to construct contour berms and for checking to see if the two ends of a boomerang berm are level.

The A-frame level is made of three poles or sticks tied or fastened together to form a capital "A" (thus the name). A weighted string is hung from the top of the "A" like a plumb bob. When both "feet" of the "A" are level with one another the weighted string will hang alongside a center line marked on the horizontal stick of the A-frame. If the two feet are not level with one another, the string will hang to one side or the other of the center mark, depending on which foot of the A-frame is lower.

WHAT YOU NEED TO MAKE AN A-FRAME LEVEL

- 3 straight poles, pipes, sticks, or something similar. They must be long enough so that the top of the "A" is about as tall as you are and the feet of the "A" are at least 3 feet (0.9 m) apart. The feet can be closer together, but the narrower the "A" the longer it will take to mark a level contour line on a slope.

- Rope, cordage, nails, or screws to securely fasten the poles, pipes or sticks together at 3 points

- A piece of string about 4 feet (1.2 m) long and a weight of some sort (stone, horseshoe, etc.) to tie to one end of the string

- Marker, knife, or paint

HOW YOU MAKE AN A-FRAME LEVEL

Lay your three stakes, poles, or sticks on the ground in the form of a capital "A." Tie or screw the

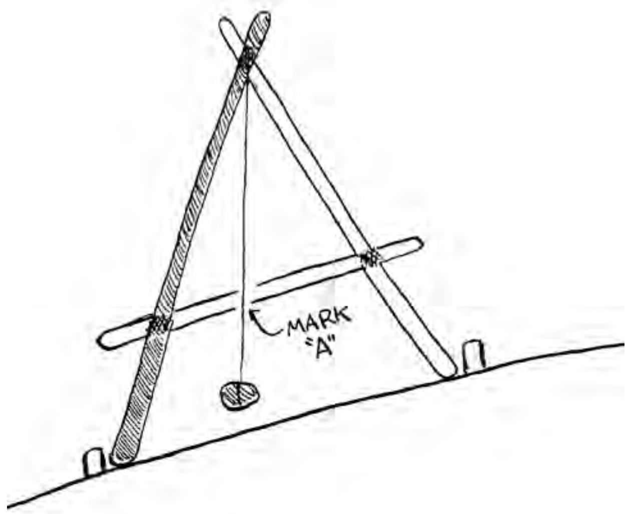

Fig. A1.8A. Calibrating the A-frame, step one

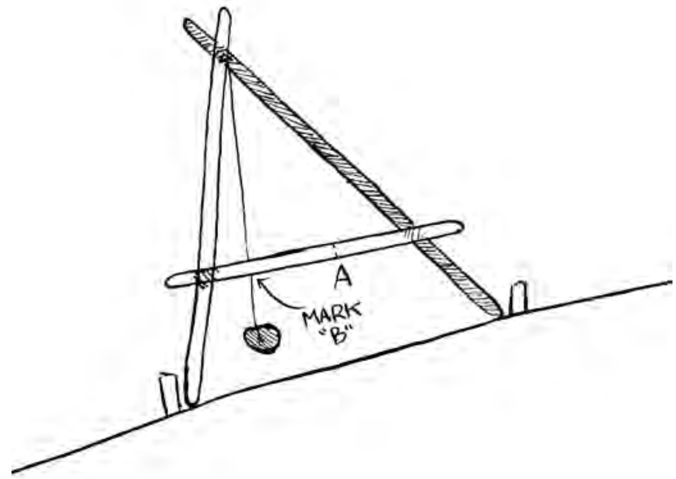

Fig. A1.8B. Calibrating the A-frame, step two

three stakes together in the three points where they touch. This is a great opportunity to live out your Boy Scout or Girl Scout knot-tying fantasies with clove hitches and lashing! Make sure all bindings are tight so that your A-frame level won't come apart and the joints don't loosen, as that would result in inaccurate readings.

Once bound, set the A-frame upright and tie one end of the string to the top of the "A." Tie the weight to the other end of the string. The heavier the weight, the less likely it will get blown around on a windy day. The weighted end of the string should hang below the cross stake (the stake parallel with the ground). To make the center mark on the cross stake, place the feet of the upright A-frame on a section of unlevel ground, so one foot of the A-frame is a little higher than the other. When the weighted string comes to rest in a spot alongside the cross stake of the A-frame, lightly mark that spot (fig. A1.8A).

Now, mark the two points where the A-frame is standing on the ground. Lift the A-frame, rotate it, then set it back down with the "feet" switching places. When the weighted string again comes to rest alongside the cross stake, lightly mark that spot (fig. A1.8B).

Now you have two marked spots on the cross stake. Permanently mark the midpoint between these two spots on the cross stake (fig A1.8C).

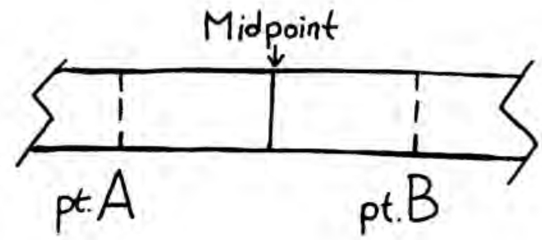

Fig. A1.8C. Calibrating the A-frame, final step

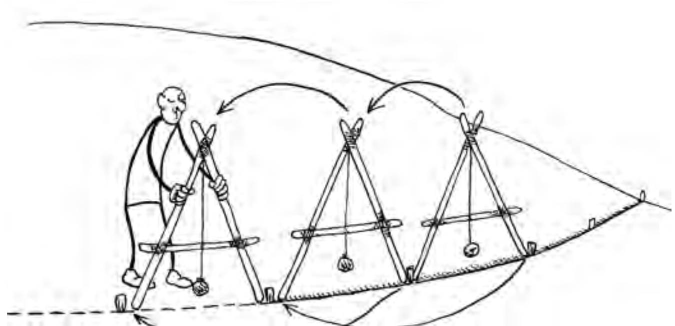

Fig. A1.9. Using an A-frame level, finding and marking a level contour line

From now on when the weighted string comes to rest alongside this permanent mark, you will know the two feet of the A-frame are standing on two points level with one another.

Your A-frame will read accurately as long as it does not loosen up and change shape. You can quickly test it by going through the steps just described. If the heavy mark is still at the midpoint when you test it on level ground, then your A-frame will read correctly. If the mark is not at the midpoint, retighten the joints and make a new midpoint mark.

HOW TO USE AN A-FRAME LEVEL

Go to a spot where you want to mark a level contour line across the landscape. Place the A-frame upright with its "feet" on what you think is level ground, and see where the weighted string comes to rest along the cross bar. If the string comes to rest alongside the permanent mark, the feet of the A-frame are on a level line. Now mark a straight line in the dirt from one foot of the A-frame to the other. Rotate the A-frame 180° with one foot left standing on the end of the line you just marked and the other foot moved to a new spot you think will be level with the first (fig. A1.9). If the weighted string comes to rest to either side of the permanent mark, the A-frame is not on a level line. Move the newly placed foot slightly up or down the slope until it rests on a spot that is level with the other foot. Again, mark this straight line in the dirt. Continue finding and marking the level contour line by rotating and stepping the A-frame across the landscape. Repeat this process until you have marked the contour line length needed for your project.

Once finished, the marked contour line may be rather zig-zaggy, but you can smooth out the line within the zig zags to a more curvilinear shape when you plant the contour line or construct a structure such as a berm 'n basin or sheet flow spreader atop it. Just make sure the top of the structure remains level.

AN A-FRAME VARIATION FOR WINDY SITES

On very windy days the weighted string of the A-frame will blow around. A variation used by Chris Meuli on his windblown New Mexico land was built by lashing a line-level tool to the horizontal cross stake instead of using a weighted string (fig. A1.10). If you construct this type of A-frame, you'll need a line

Fig. A1.10. Chris Meuli's line-level A-frame. A bubble level tool is lashed to horizontal bar (look below Chris' toes). Chris bolts his A-frame together with wing nuts so he can disassemble and fold it up for easy storage. His A-frame is only as tall as his waist, which allows him to use the tool under the branches of trees.

Fig. A1.11A. Omar is using a laser level to take an elevation measurement at the curb cut inlet of a street-side rain garden's water-harvesting basin. This is the reference elevation: we want to know how much higher or lower all other points are in relationship to this point where water will enter the basin.

Fig. A1.11B. Next, Omar is taking an elevation measurement at the bottom of the infiltration basin. The deeper the basin bottom is in relation to the curb cut inlet, the greater the basin's water-harvesting capacity. If the basin bottom is higher than the inlet, it won't work. In this case, the basin bottom measured *beneath the mulch* was 8 inches (20 cm) deeper than the inlet. This will work, but it's not ideal. I prefer a depth of at least 12 inches (30 cm) measured beneath the mulch, and a minimum 8 inch (20 cm) depth if it's measured from the *top of the mulch*.

See chapter 7 for how a *vertical mulching* strategy could be used to increase the water-harvesting capacity of this basin.

level, a *straight* cross stake, and a level place to build the device. With both feet of the "A" on level ground, secure the cross brace so the line level's bubble is right in the middle of the cross brace reading "level."

LASER LEVELS

One person can operate a rotating laser level. This device consists of a self-leveling, rotating laser-beam transmitter attached to the top of a tripod plus a separate elevation measuring rod with a laser receiver/reader bracketed onto it. A laser level is very accurate and easy to use, but it is the most expensive tool presented in this appendix.

Ideally you keep the laser level's transmitter (and the tripod it sits upon) in one position while taking all your measurements, because the laser's elevation will be your reference elevation (at different locations you'll be measuring the vertical distance between a point in the landscape and the laser). The laser transmitter projects a laser beam in a full 360° circle, so position it atop the tripod in sight of all the locations you want to measure, making sure no trees, buildings, or other objects will obstruct the laser beam.

When you position the laser transmitter, adjust the tripod's legs so the top of the tripod is close to level. Next, turn on the laser and wait for the transmitter to make the needed final adjustments to become truly level. If the transmitter makes a warning sound, the tripod position is too far out of level for self-adjustment. In that case, turn off the level before the transmitter's motor burns out, readjust the tripod to get it closer to level, and try again.

With the laser turned on and spinning, turn on the laser receiver/reader, attach it to adjustable measuring rod, place the rod where you want an elevation measurement, then slide the receiver up or down the rod until the laser receiver starts to beep. An arrow on the laser receiver points up if you need to move the receiver up to find level, or points down if you need to move the receiver down (fig. A1.12). The closer the receiver is to the same elevation as the laser transmitter, the more quickly it will beep. When intermittent beeps become a single continuous sound, the laser receiver is level with the laser and a flat bar appears on the display.

Fig. A1.11C. Omar is taking an elevation measurement on the planting terrace of the rain garden's infiltration basin. Ideally, the top of the terrace is built *no higher* than the elevation of the curb cut inlet so storm-captured runoff will rise to the top of the terrace, saturating it and the plants' root zone.

Do not look directly at the laser—it can hurt your eyes.

Note that most laser levels have the number "1" located at the bottom of the measuring rod—this is the opposite of most bunyip water level's elevation rods, which have the highest number located at the bottom. So when you take elevation readings at different locations using a typical laser level, the higher the number, the lower that location is in the landscape. This is not intuitive to me, so when I use a laser level, I constantly remind myself that *the higher the number the lower the elevation, and the lower the number the higher the elevation*.

Take measurements throughout the planning, placement, and building of an earthwork. One person can do this—though it can be helpful if one person holds the rod and reads the laser receiver, while another writes down measurements at different points in the landscape.

In fig. A1.11A-D and A1.13, laser level measurements were taken after construction to determine how well this earthwork basin was built by others.

In this case, the terrace was found to be 2 inches (5 cm) higher than the curb cut inlet. Not ideal because in small storms water flowing along the street curb will be just 1 to 2 inches (2.5 to 5 cm) deep, and will be unlikely to rise to the level of the terrace and its plantings. But the terrace can work in a big storm when flow will be deeper—typically 4 inches (10 cm).

Fig. A1.11D. Omar is measuring the elevation of the rain garden's top zone on its downstream side. Ideally, this point should be at least 4 inches (10 cm) higher than the curb cut inlet of the *eddy basin* shown here (or the curb cut outlet of a *flow through basin*) to ensure that water will not overflow and erode the dirt pathway. In this case, the top of the rain garden's downstream side is 7 inches (18 cm) higher than the curb cut inlet, so all is good. Note, for easier pedestrian access, the top of the dirt path should not be higher than the sidewalk elevation, nor more than 2 inches higher than the top of the street curb. See chapter 8 and (5 cm) fig. 8.43 for more on *eddy* or *backwater* basins and important considerations for this elevation relationship.

Fig. A1.12. The arrow on the laser receiver's display signifies that the receiver must be moved down to become level with the laser transmitter. As needed, you can slide the receiver itself up or down on the measuring rod, or slide the adjustable section of the measuring rod up or down; or move the base of the measuring rod to a higher or lower point in the landscape if you are trying to find a point that is level with a section of the landscape previously measured.

A1.13. This much less expensive laser level only points in one direction at a time. Check bubble in level's vial to make sure it is level, then observe the elevation differences of various points to the elevation of the laser. Here Omar is checking elevation of a planting terrace in relation to the basin's curb cut inlet.

To give me a quick visual reference when I build such a basin, I find and mark a spot on the basin bank for the planting terrace that is no higher than the curb cut inlet (to maximize water capacity). I then shape the basin's dirt banks into the terrace at desired elevation, and check levels again. When all is correct I can then do the rockwork.

See chapter 11 for more on a rain garden's three planting zones—bottom, terrace, and top.

TOOL BOX LEVEL

Gravity-fed plumbing should be constructed and maintained with a minimum slope of 2% (1/4-inch drop per linear foot or 2-cm drop per linear meter). My favorite tool for measuring pipe slope is a 12-inch Empire Magnetic Tool Box Level, with Vari-Pitch vials that read slope in 1/8th-inch increments (figs. A1.14A, B, C).

The level's vials can be turned to change the direction from which their markings—and the slope of what the level is measuring—can be read. The body of the level has a grooved side that fits snuggly along a pipe, and a magnetic side that can conveniently adhere to metal pipe or gutters.

For additional photos and info check out the "Greywater Harvesting" page at HarvestingRainwater.com and its subpages "How to Get Slope Right on Gravity-Fed Greywater Distribution Plumbing" and "Greywater-Plumbing Options and Tips."

Fig. A1.14A. 12-inch Empire Magnetic Tool Box Level positioned with magnet side up and grooved side down to fit on the pipe, so slope measurements can be read from the side of the level. See fig. A1.14B for close up.

Fig. A1.14B. Close up of level reading drop/slope of 1/4-inch drop per linear foot. Note how the right edge of the bubble on right vial touches and reads 1/4-inch slope.

Fig. A1.14C. Tool Box Level with its grooved side up and its magnetic side down. Vari-Pitch vial has been turned so slope measurements can be read from above. Here it reads level. Note how the edge of the bubble in the vial touches and reads "0."