Storm Water as a Resource

How to harvest and protect a dryland treasure

City of Santa Fe, New Mexico

200 Lincoln Avenue, P.O. Box 909, Santa Fe, N.M. 87504-0909

Larry A. Delgado, *Mayor*
Jim Romero, *City Manager*

Councilors:
Carol Robertson-Lopez, Mayor Pro Tem, Dist. 4
Patti J. Bushee, Dist. 1
David Pfeffer, Dist. 1
Karen Heldmeyer, Dist. 2
Rebecca Wurzburger, Dist. 2
Miguel M. Chavez, Dist. 3
David Coss, Dist. 3
Matthew E. Ortiz, Dist. 4

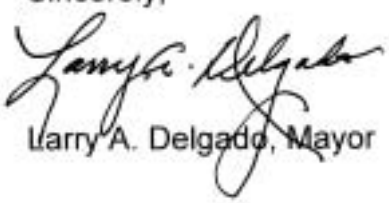
April 8, 2002

Dear Fellow Santa Feans:

It's hard to overemphasize the importance of water conservation as we enter another dry springtime here in Santa Fe. I think we're all aware how much we need to save water and make the best possible use of the water we do have. Water harvesting - keeping rainwater and snowmelt on our properties and letting it soak into the ground - is one of the best ways to do this. It helps reduce the outdoor water we need in dry weather, and it also helps recharge our aquifer and reduce flooding danger when it does rain.

Water harvesting is an important part of my four-point plan for sustainable water management in Santa Fe, and this booklet illustrates lots of good ways to do it. There is something in here that will work almost anywhere, and if we all pitch in and use these methods, it will make a real difference for our community. Harvesting rainwater is a great way to do yourself a favor and make a real contribution to Santa Fe's water future at the same time.

Sincerely,



Larry A. Delgado, Mayor

STORM WATER AS A RESOURCE

TABLE OF CONTENTS

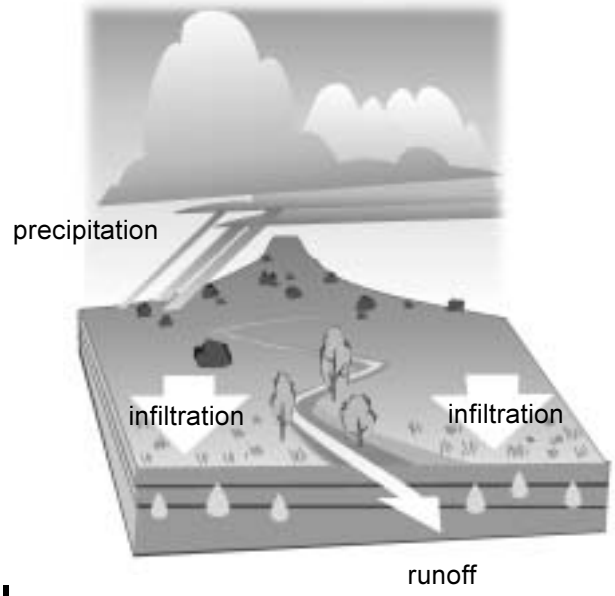
The terraces, mulch, vegetation, and permeable outdoor areas in these photos are great ways to catch water and take advantage of precipitation. As you can see, they also contribute to a very attractive landscape.

Photographs and landscape design by Clemens and Associates

Introduction

If you could save money on your water bill, make your yard look better naturally, prevent erosion, improve water quality, save tax money, and help increase Santa Fe's water supply, *would you be interested*?

We hope so. You can do all these things, right now, relatively easily, with a great deal of benefit for you and the whole Santa Fe community. The key is capturing rain and snow that falls on your property instead of letting it run off uselessly to cause erosion and flooding. Here's why we need to do it:

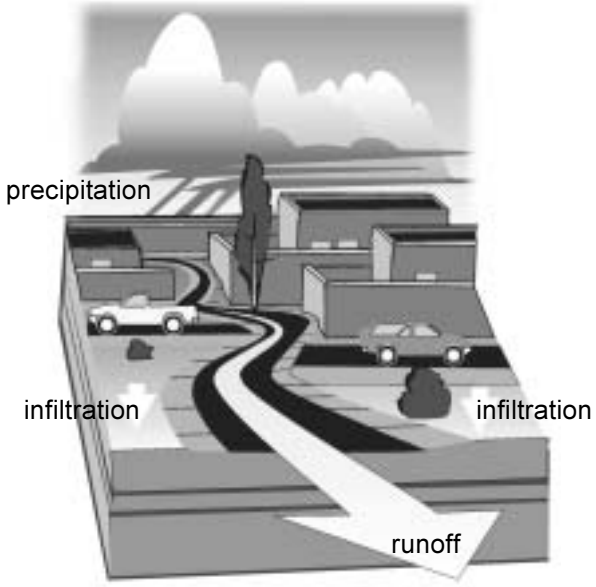


In an undisturbed environment, even here in the arid Southwest, almost all the rain and snowmelt soaks into the ground very close to where it falls. This gentle, sustained infiltration:

- supports plant life
- maximizes ground water recharge
- minimizes flooding and erosion.

Only the heaviest thunderstorms produce surface runoff - everything else soaks in to the ground.

Plants do use water, but ground cover plants, especially native grass, let more water soak in than they use. As a result, ground water recharge is generally greater with a vegetated ground surface.



Things are very different in an urban setting:

- Much of the land surface - roofs, driveways, roads, and so on - is impervious to water.
- Water runs off the impervious surfaces almost instantly, so gullies and arroyos fill up quicker and have to carry much more water.
- The extra water in the arroyos moves faster, increasing erosion and property damage. Eroded soil fills reservoirs and causes water pollution.
- The additional runoff makes flooding worse.
- All the additional runoff is water that can no longer soak in to help recharge ground water.

It may come as a surprise, but much of what we think of as undisturbed or natural landscape around Santa Fe is in fact seriously degraded. Increased grazing, interrupted fire cycles, agriculture, roads, land clearance, and neglect have left even the non-urbanized landscape around Santa Fe in poor condition. It's important to realize that undeveloped land would naturally support much healthier vegetation than it usually does now. The good news is that it's not that hard to get there from here! Good water harvesting is a great way to start.

Urban areas don't have to lose all their runoff water and suffer from erosion and flooding. This handbook is a guide to many different ways to keep that water around and let it soak into the ground.

Section 1 **Site Planning and Design** suggests how to think about working with your land to take advantage of its natural features and runoff patterns.

Section 2 **Water Harvesting Techniques** describes how to catch and use water in many different situations.

Section 3 **Erosion Control and Repair** deals with how to prevent and repair erosion problems, including how to keep soil on-site and prevent erosion during construction.

Stormwater is a valuable resource!

The beautiful landscape in this photo is supported by water "harvested", or captured before it could run off. It's a good illustration of how to put stormwater to very attractive use.

It's the ultimate win-win situation. As individuals, we can have:

- Thriving landscapes and gardens using less water
- Lower water bills
- Erosion damage prevented or repaired
- A new connection to our beautiful landscape

As a community, we get a lot of important benefits too:

- Increased water supplies, from more infiltration as well as less irrigation demand
- Protected and improved water quality
- Reduced flooding
- Less tax money spent on repairing erosion damage and treating water pollution
- A healthier urban ecosystem

We often think of rain and snow as just a nuisance. But did you realize that all the water we'll ever have comes from precipitation? Even the deepest ground water originally fell as rain or snow – it's just stored underground. The only way we can ever replace any of the water we pump and use is to allow precipitation to soak back into the ground and recharge the ground water. However, since a lot of Santa Fe is paved or roofed, a lot of water is running off uselessly and very little is soaking in to recharge our ground water supplies.

How much water falls on Santa Fe?

There are about 23,885 acres within the Santa Fe City limits. Our average precipitation is 14 inches, or 1.17 feet, per year. So:

23,885 x 1.17 = 27,945 acre-feet per year

To put this in perspective, our total water consumption in Santa Fe last year was less than 13,000 acre-feet – that's for everything: homes, watering yards, commercial and industrial use, hotels, car washes... In other words, more than twice as much water as we use falls out of the sky for free, just within the City. We can't capture it all, but we could save and use a lot more than we do – and it would make a big difference!

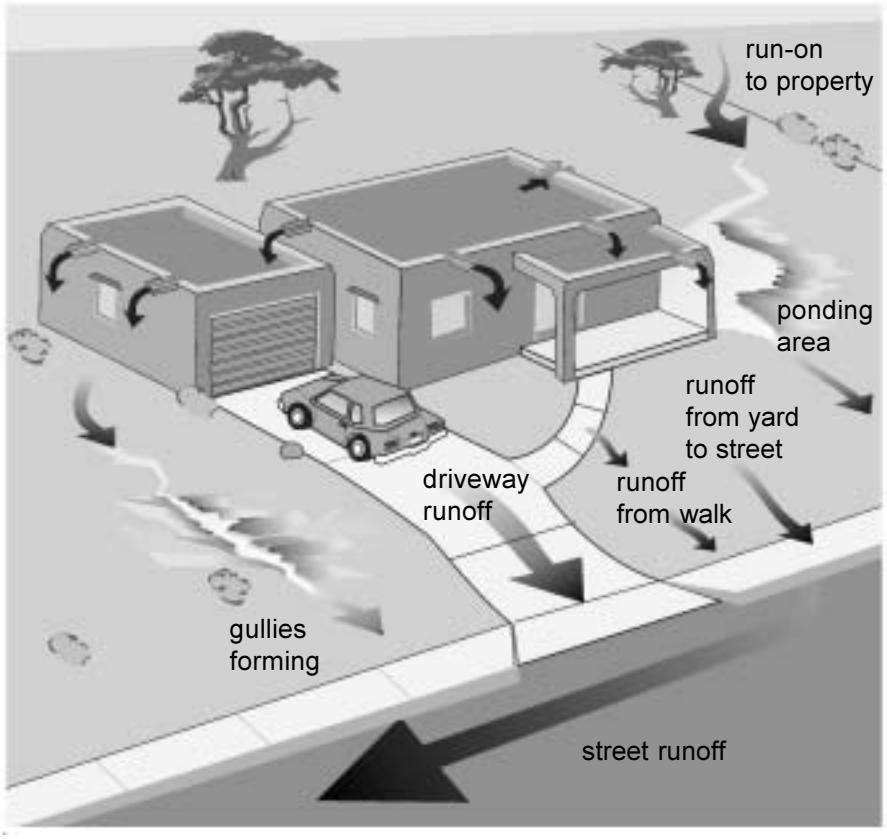
1. Site Planning and Design ~ *think like a raindrop*

These three basic principles are the keys to water-wise planning and design:

1. **Know how water moves on your property.**
2. **Keep as much water on your property as you can.**
3. **Protect your soil.**

Know how water moves on your property

The best way to start conserving and making better use of precipitation is to follow the raindrops - notice where water goes on your property. Take advantage of opportunities to contain it, slow it down, and soak it in. Don't let it get away!



After (or better yet, during!) the next rainstorm, take a good look at your yard.

- How does water flow across the land? Look for pine needles or leaves moved by water as it flows over the land.
- Where does it collect or puddle?
- Where does it soak into the ground?
- When water flows off the roof, driveway, walkways, or other hard surfaces, where does it go?
- Are there rills, gullies, or other signs of erosion?
- Does water run onto your property from elsewhere?
- Where does it run off your property?
- Does it already collect or pond too much somewhere?

Water is a valuable resource - know what happens to it on your property!

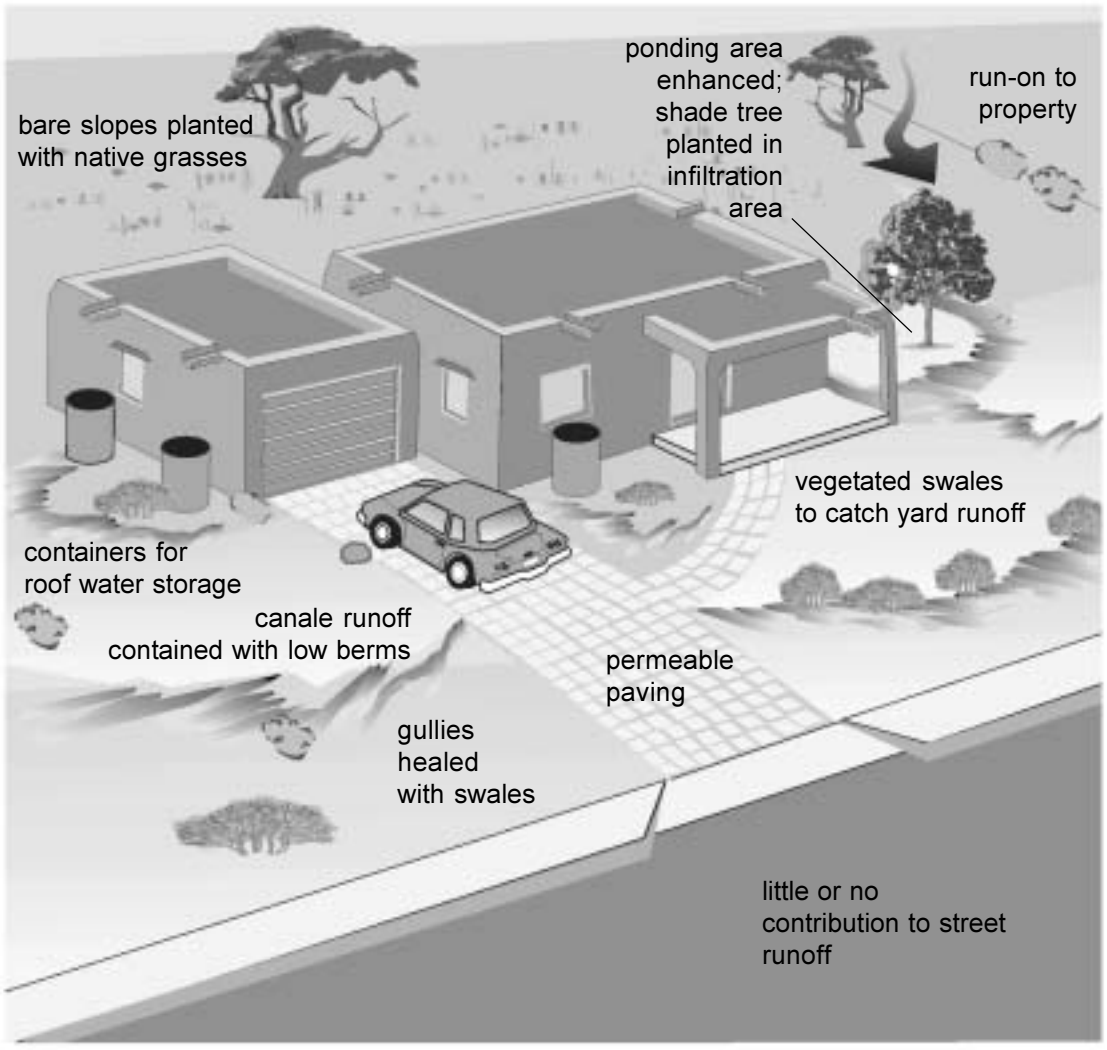
It's just as important to follow the path of water whether your house is already built or not. You'll have more options about lot layout if you're building from scratch, including locations for building and garden areas, paths, and driveways. But whether or not your house is already built, understanding how water moves on your property and designing with it will help integrate your buildings and landscape better and make your home more beautiful - as well as using water more efficiently.

Keep as much water on your property as you can

Here are some of the best ways to keep water on your land:

- **Maximize permeability and opportunities for infiltration**
- **Minimize impermeable surfaces**
- **Keep the water as close to where it falls as possible**
- **Provide physical containment wherever there's a good opportunity**

These ideas can inspire the design and layout of the outdoor spaces around your home. Most outdoor surfaces don't have to be completely waterproof. Sometimes a grassy or gravelled surface will work fine, and even be more attractive. Flagstone, bricks, or other paving materials that come in individual pieces and leave room in between for water to soak in will do the job and still allow water to stay on-site. Even vehicle surfaces - driveways and parking - can allow water to infiltrate.



Remember that plant roots help keep the soil porous and absorptive. Unless there's a good reason otherwise, plant cover is a good thing.

And even if there are places where you don't want plants to grow, don't cover the soil with waterproof plastic or similar coverings! Instead, use commonly available landscape fabrics that will keep weeds from growing but still let water soak in. Use them under gravel, for instance, rather than polyethylene or other kinds of waterproof plastic.

On most properties in Santa Fe, virtually all the rainfall and snowmelt could be retained to support plants and recharge our aquifer. The techniques on the following pages will help you use natural precipitation and water movement throughout your landscape and exterior design. Take advantage of free water from the sky - you'll be amazed at how beautiful the results can be!

Protect your soil

It's hard to overstate how important it is to protect the surface of the soil. Bare soil around Santa Fe does a bad job of allowing water to soak in. Unprotected soil becomes compacted in some places and washes away in others, while any water that does manage to soak in evaporates right away. Vegetation plays a crucial role in getting water into the soil, keeping it there, and preventing runoff damage. Good soil-protecting vegetation, especially drought-tolerant grass, will:

- Slow the movement of any water that collects on the ground
- Allow much more water to infiltrate into the soil
- Protect the soil surface from compaction
- Shade the soil and protect it from the wind, greatly reducing evaporation
- Make the soil more porous and let it hold more water, because of the effects of roots

Healthy native grass cover in Santa Fe.

Rapidly eroding unprotected soil

Even though plants use water, more water soaks into the ground with good plant cover than without it. Mulch like straw, bark, or gravel is much better than no ground cover but mulch by itself doesn't offer all the advantages for the soil that good native grass or ground cover plants do. These photos show what native grass cover can look like in the Santa Fe area, compared with all-too-typical unprotected soil surfaces that erode rapidly and absorb almost no water.

Rainfall here is enough to support healthy grass and wildflower cover, once it gets established. It does take time, attention, and usually some extra water at first to get native grass started on bare soil. Santa Fe has many local nurseries and landscape professionals who can provide expert advice, as well as the right seed. It's not usually that difficult, but there are important points about timing and care.

It's important to realize that trees aren't always helpful when you're trying to infiltrate water and prevent erosion. We've all heard how "deforestation causes erosion", and there are places where that's been true. But here in Santa Fe, we have a lot of places where piñon and juniper trees are growing so thickly that they prevent grass or any other soil-surface ground cover plants from growing. The result is that all the rain that falls between the trees hits soil like concrete and runs off almost instantly, digging gullies as it goes.

Trees crowding out grass and letting soil erode

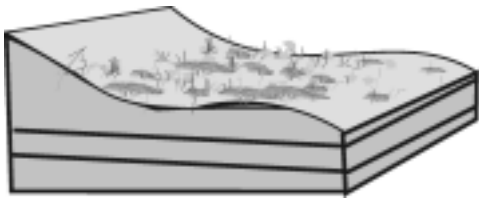
During construction activities, or other times when soils are disturbed, it's especially important to provide extra protection for the soil to keep it from washing away. Several ways to protect disturbed soil are described below in the Erosion Control and Repair section.

2. Water harvesting techniques

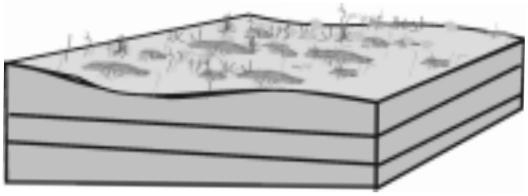
Water harvesting just means keeping precipitation on your land so you can use it. An important part of water harvesting is catching water from hard surfaces, like roofs, parking areas, or rocky places, and using it for landscape irrigation. Water harvesting is the nitty-gritty of putting the principles from the last section – soil protection and keeping water on your property – into practice. In this section we'll look at several ways to do this, and show how you might combine techniques for a successful water-wise landscape.

Swales

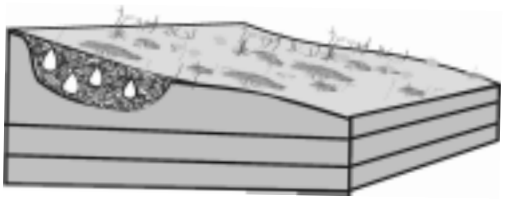
A swale is a level or gently sloping trench that collects, slows down, and diverts runoff water. Swales can vary greatly in width and treatment from small ridges in gardens to multiple long trenches graded across many acres of sloping land using heavy equipment. Swales are most often dug along slope contours, or perpendicular to the way water flows. Swales may be the single most versatile way to harvest water.



Generally a swale has a mounded ridge of soil – a berm - on the downslope side, that helps retain water that would otherwise run off. The berm can be strengthened with a stone border.



Some swales have no berm at all; they're just a shallow excavation. The gentler the slope, the better this works.

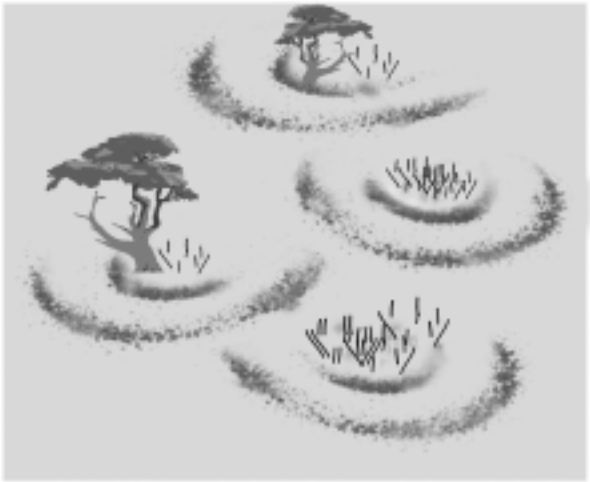


In fact, some swales are hardly even visible on the ground surface - they are really trenches filled filled with gravel or pumice so that water will soak in better.

Water harvesting helps do many things:

- Reduce landscape water bills
- Increase water availability for trees and other vegetation
- Reduce dependence on City water
- Keep valuable planting alive during water use restrictions
- Recharge aquifers
- Reduce erosion
- Keep plants healthier, since rainwater is low in salts and contains nitrogen.

"Eyebrow" swales work well with trees and on irregular slopes.



Soil in Santa Fe is often not very permeable. Even if you don't dig a trench and fill it with pumice or gravel, water will soak in faster if you add pumice, compost, or other amendments to the soil in the bottom of swales. Plant roots also help make soil more permeable.

In principle, if you have enough swales they shouldn't completely fill up with water unless there's an exceptional storm. But just to be sure, the top of contour swales should be level, so water will run over evenly instead of concentrating in one place. Better yet, provide a stone-armored spillway so any overflow won't erode your swale.

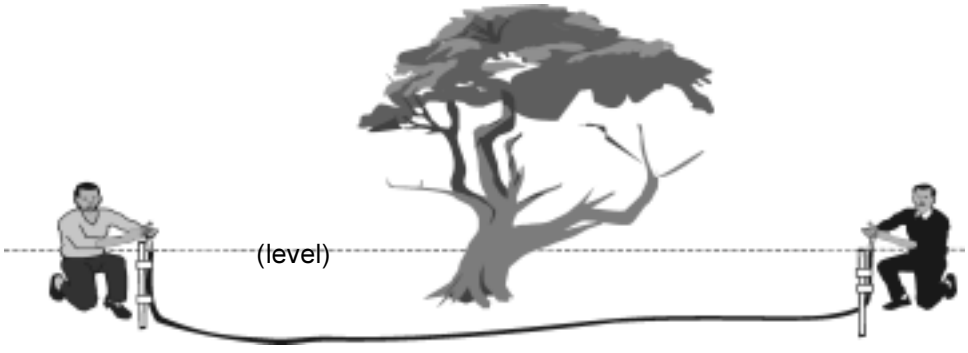
How to build swales

Swales should be spaced about every 20 to 30 feet, starting as near the top of a hill as possible, to catch the runoff originating above each swale. If the swales are any more widely spaced, Santa Fe's intense thunderstorms are likely to produce more runoff than the swales can handle and the swales may wash out, especially if vegetation isn't well established or good spillways aren't provided.

Unless you intend a swale to gently convey water to another area (such as a detention basin), it should be built on contour. One good way to plan a swale before you start digging is to use an easily constructed water level. The materials required for a water level are two yardsticks, a length of clear plastic tubing (about fifteen feet long is good), and some strong tape to attach the tubing to the yardsticks. First, fill the tubing with water. Try to eliminate any bubbles. Clips are handy to temporarily close the tubing off to keep the water inside. Then attach the tubing to each yardstick, at two places near each end of the tubing. The tubing should run along most of the length of each yardstick. Next, two people take the yardsticks and one person places each yardstick vertically on the ground. When the clips (if they were used) are removed from the tubing, the water finds the same elevation at each end of the tubing.

One person stays at the place where the swale will start, while the other walks a few yards away and finds a place that looks close to the same level as the starting point. The people at either end of the tubing take turns calling out the height of their water lines (read from the yard sticks), and the person walking out across the slope keeps moving their yardstick slightly until the readings are the same. The levelled spot on the contour is marked with a rock or other handy object and then the next point on the future swale is surveyed.

Once the moving person reaches the end of the tubing, the first person (who stayed at the starting point) moves to the last surveyed level spot, and they repeat the procedure until the leading person gets to the end of the future swale. Then they move up or down slope to the start of the next swale.



If you encounter an obstacle like a tree while you are laying out a swale, you can route the swale around either side of the obstacle. The bottom of the swale doesn't have to be perfectly level (on contour), but the top of the berm should be as close to level as you can make it. The best tool for this is a line level (available cheaply, with instructions for use, from builder supply stores) laid out along sections of the nearly finished swale. Once the line level is laid out and verified level, the top of the berm can be visually inspected, or the height to the line level can be measured at several places with a ruler, to see that the berm is level. The idea is that if the swale ever filled up, it would start to overflow along much of its length rather than at one point, which would then erode. In addition, it's a good idea to build spillways protected with stones, brick, or something else that will keep them from eroding, as illustrated above.

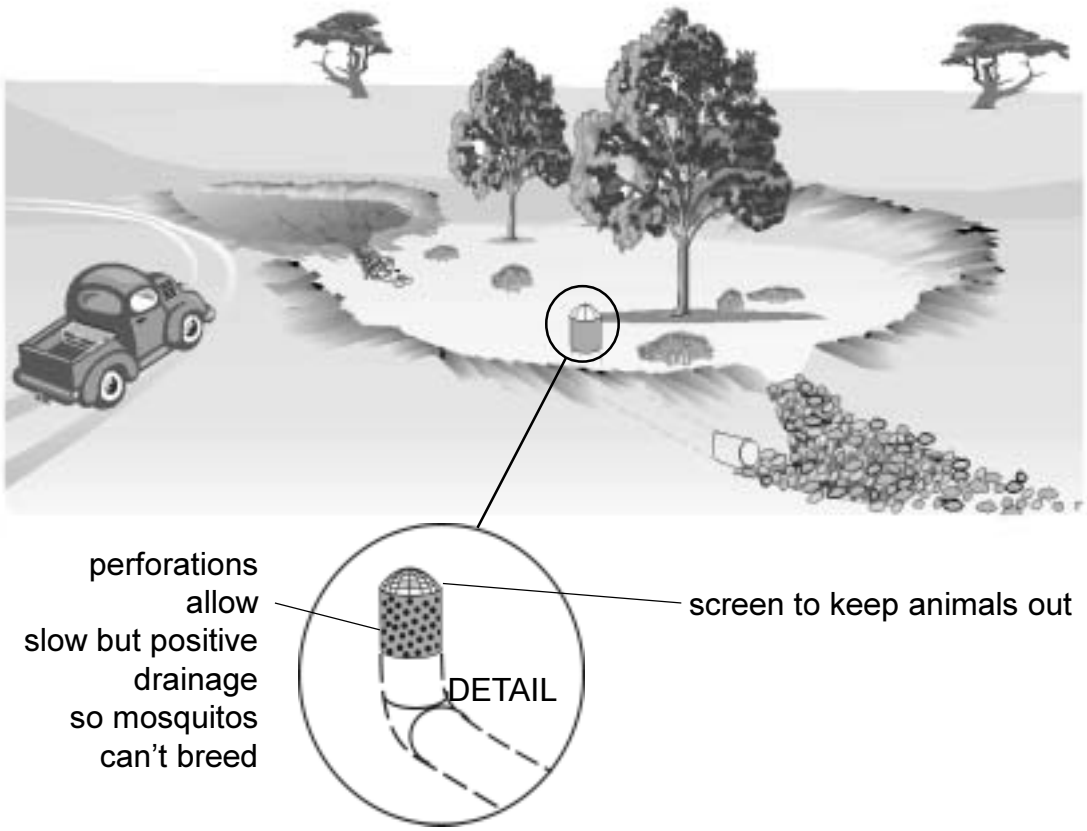
Terraces

Terraces are a similar idea to swales, and are what swales evolve into when slopes get steep enough (slopes steeper than about 3 horizontal feet to 1 vertical foot result in downslope swale sides that are too steep to stay in place without structural support like a retaining wall). Terraces have been used for millennia all over the world for keeping soil and water in place, and they're a good idea here, too.

Infiltration Basins

Basins collect and infiltrate stormwater on gently-sloping or nearly flat land. Basins should be sited to take advantage of naturally occurring level spots or depressions. Basins, like swales, contain water and allow it to soak into the soil. Both basins and swales can support attractive planting and garden areas and be a focus for your landscape rather than just utilitarian water containment structures. Basins should also have armored or reinforced overflow spillways.

If water can pick up sediment, you need to provide some way to remove the sediment so it doesn't fill up your basin. Often the best way to do this is to provide a smaller upstream settling basin with an easily-cleaned bottom and vehicle access, so you can remove mud and sand from the settling basin and protect your main basin. This kind of dual basin is illustrated in the drawing below.



One of the important benefits of basins, swales and any other water retention structures is that they are great places to get grass or other vegetation started, and the extra water they concentrate allows for more verdant plant growth with less irrigation.

Storage Tanks and Cisterns

Storing water in containers of some kind offers more control over when and how you can use the water. Generally it requires some plumbing and perhaps pumping, in addition to the container or containers. A storage tank can be as simple as a salvaged 55-gallon drum (be sure it's clean!) or garbage can; or as sophisticated as a large site-built underground cistern collecting all your roof runoff. Large cisterns can be equipped with a submersible pump, filter, and pressure tank to supply an automated drip irrigation system.

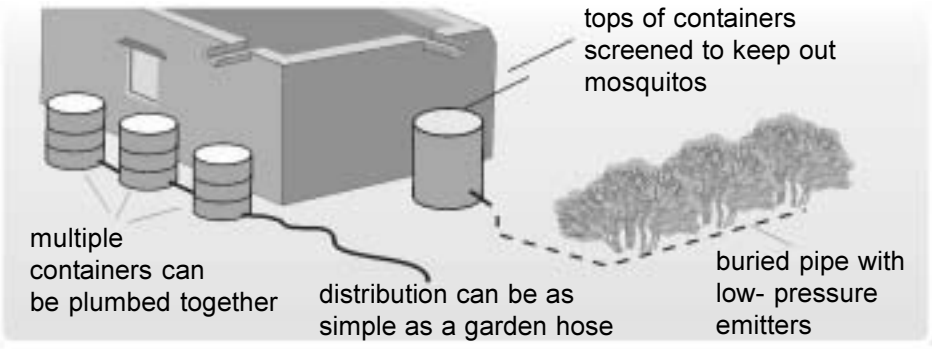
The quickest and easiest way to contain rain water is to put rain barrels under all your canales or downspouts. You should realize, however, that a single 1-inch rain (not unusual for a good summer thunderstorm) on a 1500-square-foot roof will yield almost a thousand gallons of water – that's more than 30 garbage cans!

Around the world, including many parts of the United States, people have collected water in cisterns for centuries. Around the Mediterranean, for example, towns and villages are built atop a honeycomb of deep cisterns that contain most of the total annual rainfall. In Texas and along the Gulf Coast, many older houses have underground cisterns the size of large rooms.

Of course, it can also go a long time without raining here, too. If you're serious about saving runoff water in containers, you'll want to invest in a bigger tank or multiple tanks. A rough rule of thumb is to provide at least 1 gallon of storage for each square foot of roof or collection area. There are many options, including plastic barrels already equipped with spigots, larger plastic water tanks holding several hundred gallons, plastic or concrete septic tanks holding a thousand gallons or more which can be buried, and large reinforced concrete or concrete-block cisterns custom-built to any size in excavations on your site.

Cisterns provide the most control and flexibility in saving harvested water, but generally also cost the most per gallon saved.

Water from rainwater cisterns is not safe to drink unless it's been treated! Treatment and domestic use are possible, but can be complex and are beyond the scope of this handbook.



Mulch

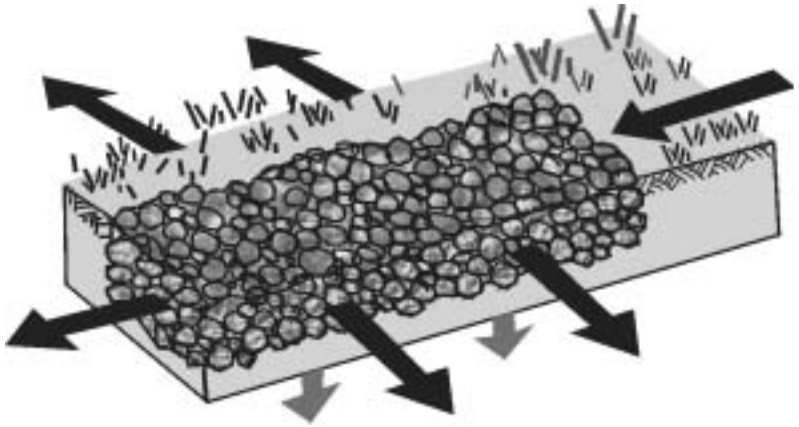
Mulch is a covering for the soil surface that protects the soil from the evaporative effects of wind and sun. Mulch can be plant material, like bark, straw, wood chips, and nutshells; or it can be gravel or other non-living material. Mulch helps optimize water harvesting by holding water in the soil, and makes it much easier to get plants started and keep them alive. Mulch will:

- Reduce evaporation
- Increase infiltration by slowing runoff and giving it more time to soak in
- Reduce erosion from bare soil
- Make plant establishment easier and more successful
- Moderate soil temperature by reducing summer heat and winter cold
- Make it harder for weeds to sprout
- Supply nutrients and organic matter to soils
- Enhance habitat for earthworms and other important and beneficial soil dwelling animals

No matter what other water harvesting (or gardening) techniques you use, mulch will help them work better and save even more water. Free mulch (made from chipped tree limbs) is often available from the City solid waste transfer station. Call 955-2220 for details. Other kinds of mulch available in Santa Fe include straw, which works well but often contains seeds from the plants that made the straw; and various kinds of mulch including nut shells that are sold at garden supply stores.

French drains and pumice wicks

French drains are rock-filled excavations that contain water and encourage infiltration into the soil. They are sometimes called soakaways or dry wells.



- Gravel or stones should be evenly sized, so that small material doesn't fill up the spaces between larger pieces and reduce the room left to contain water.
- Filter fabric should be placed on top of the gravel, and anywhere else that water enters the French drain.
- Several inches of sand, soil, or gravel can be placed over the filter fabric and stone fill to match the original grade.
- It's also important to keep French drains at least six feet away from your house foundation - more if possible.

Hold on a minute!

French drains are a good way to infiltrate water, but unfortunately they can also give pollutants a head start into our ground water. Collecting roof runoff poses little risk of pollution, but runoff from a parking lot, or even a driveway, where gasoline and other things could spill, is a different story. Because of this, French drains and similar underground infiltration structures may require a Discharge Permit from the New Mexico Environment Department. Better safe than sorry! Contact:

New Mexico
Environment Dept.

Ground Water
Quality Bureau

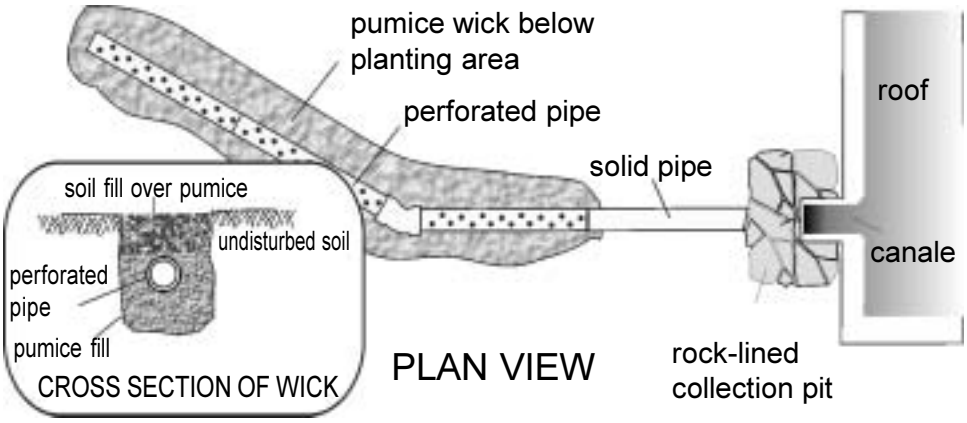
1190 S. St. Francis Dr.
Santa Fe, NM 87501

827-2918

It's very important to keep all mud and sediment out of a French drain. Sediment will fill up the spaces between the stones and clog the soil where the water goes. This will drastically reduce infiltration and make a French drain almost useless. If all the water going into the drain is from a roof or other clean surface, this may not be a problem. On the other hand, if water can run over the ground and pick up sediment before it enters the French drain, it is vital to remove the sediment.

Better yet, for water that could contain sediment, use swales, basins, or other structures that are open to the air and can be vegetated. Sediment can be removed if necessary (for instance from a settling basin), and plant roots will help counteract the tendency for the soil to become clogged by fine mud.

French drains, if not clogged, do help soak excess runoff into the ground. This reduces erosion and helps with aquifer recharge, but often keeps the water out of reach of plants. You can have the water absorption advantages of a French drain and still use the water for plants with a pumice wick.



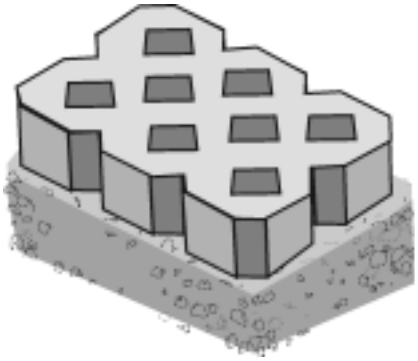
Pumice wicks, like French drains, are excavations filled with stone - but unlike ordinary stone or gravel, pumice is porous and the stone itself absorbs a lot of water. This water is available to plant roots. So, water can be routed from a collection area (like the bottom of a downspout or canale) to where it's needed in a pipe, and then allowed to soak in to the pumice and surrounding soil.

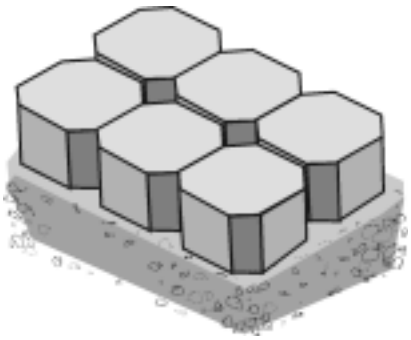
Permeable Paving

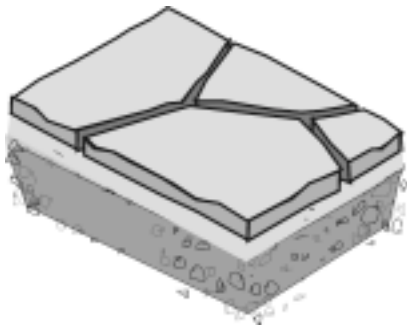
Gravel can be a suitable paving surface for driveways and parking areas that allows water to soak into the soil below. A well-constructed gravel driveway can remain relatively smooth with minimal maintenance because it is lightly used by slow moving vehicles. Crushed stone aggregate such as 3/4" to 1-1/2" granite is more suitable than rounded stones like pea gravel, because the angles of the crushed stone interlock to form a matrix that stays in place and supports weight better.

While gravel is much better than asphalt or concrete for letting water soak in, the soil underneath the gravel often tends to suffer some compaction over time, and ruts may develop in the gravel surface. There are specialized structural products on the market that help support the weight of vehicles and contain gravel, prolonging the life of a gravel drive or parking area and enhancing its absorptive capacity. For example, a plastic honeycomb matrix can be buried underneath a gravel layer to distribute the weight of traffic while keeping the gravel in place. Engineers and landscape professionals can provide up-to-date information on this and other water-friendly paving surfaces best for your situation.

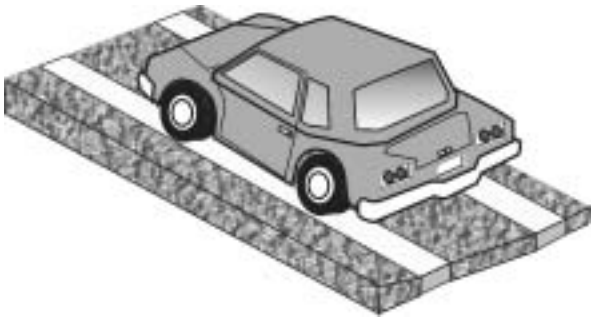
Another alternative is concrete or brick unit pavers, which can make an attractive driveway or patio surface that is still somewhat permeable. A pavement of brick or paving block on sand, or turf-block, can make the driveway more integrated with your landscape or garden, rather than a hard and intrusive extension of the street penetrating deep into the garden space.







Paving only under the wheel tracks is a good, inexpensive design if your driveway is fairly straight. By leaving the center strip open for native grass, groundcover plants, or gravel, a driveway of two wheel tracks can reduce impervious surface coverage by 60% compared with a conventional concrete driveway.



Check Dams

Check dams are a great way to capture sediment in gullies and arroyos to reduce erosion. At the same time, they capture water and make it available for plants. The sand and sediment caught upstream of a check dam is usually very permeable and it's easy for water to soak in. The additional level area in the arroyo channel increases the area for infiltration, and water stored underground is less vulnerable to evaporation. This all means that check dams can be great places to get trees, shrubs, grass, and other vegetation to grow. The vegetation, in turn, helps further encourage infiltration, slow runoff water, and structurally reinforce and protect the check dam.

BEFORE

AFTER

Vegetation

In Section 1 on site design we emphasized how important it is to keep the soil protected and let plants help keep water from running off or evaporating. Even plants we're used to thinking of as "weeds" are generally better than bare soil. It's a good goal to try not to have any bare, unvegetated soil on your property.

Unless you have other plans for an area, consider native grass and wildflower cover. That's mostly what would be growing here naturally, and it offers all the advantages we've mentioned for soil protection and water infiltration. Native grass (and there are many varieties) can grow quite thick and become beautiful vegetation all by itself. Be aware, though, that it's not supposed to be green all the time! No matter how much water you put on native grass, it won't look like a turfgrass lawn. It has a beauty, and diversity, all its own.

Native grass may seem tricky to get started, but it's mostly just a matter of timing and making sure new seedlings stay moist when they're small and vulnerable. You can do this with mulch and/or irrigation, as well as planting to take advantage of natural winter or summer precipitation patterns. Most dryland seed mixes contain seeds of both "cool season" and "warm season" grass species. The cool season grasses (like Indian ricegrass and streambank wheatgrass) germinate in the early spring as the snow melts, and warm season grasses (like galleta, which every good dryland mix should have, sideoats or blue grama, little bluestem, alkali sacaton, and sand dropseed) germinate and grow best in warm weather following summer thunderstorms. The cool season or spring growers have the benefit of low evaporation rates, but the summer or warm season growers require repeated rain events (or irrigation) to survive past the seedling stage. Once established, these grass species, all perennial, will survive dry times and will green up again during moister periods.

If your soil is sandy, you might choose a sandy soil dryland mix. These are likely to include some combination of seeds of galleta, Indian ricegrass, alkali sacaton, sand dropseed, and sand lovegrass.

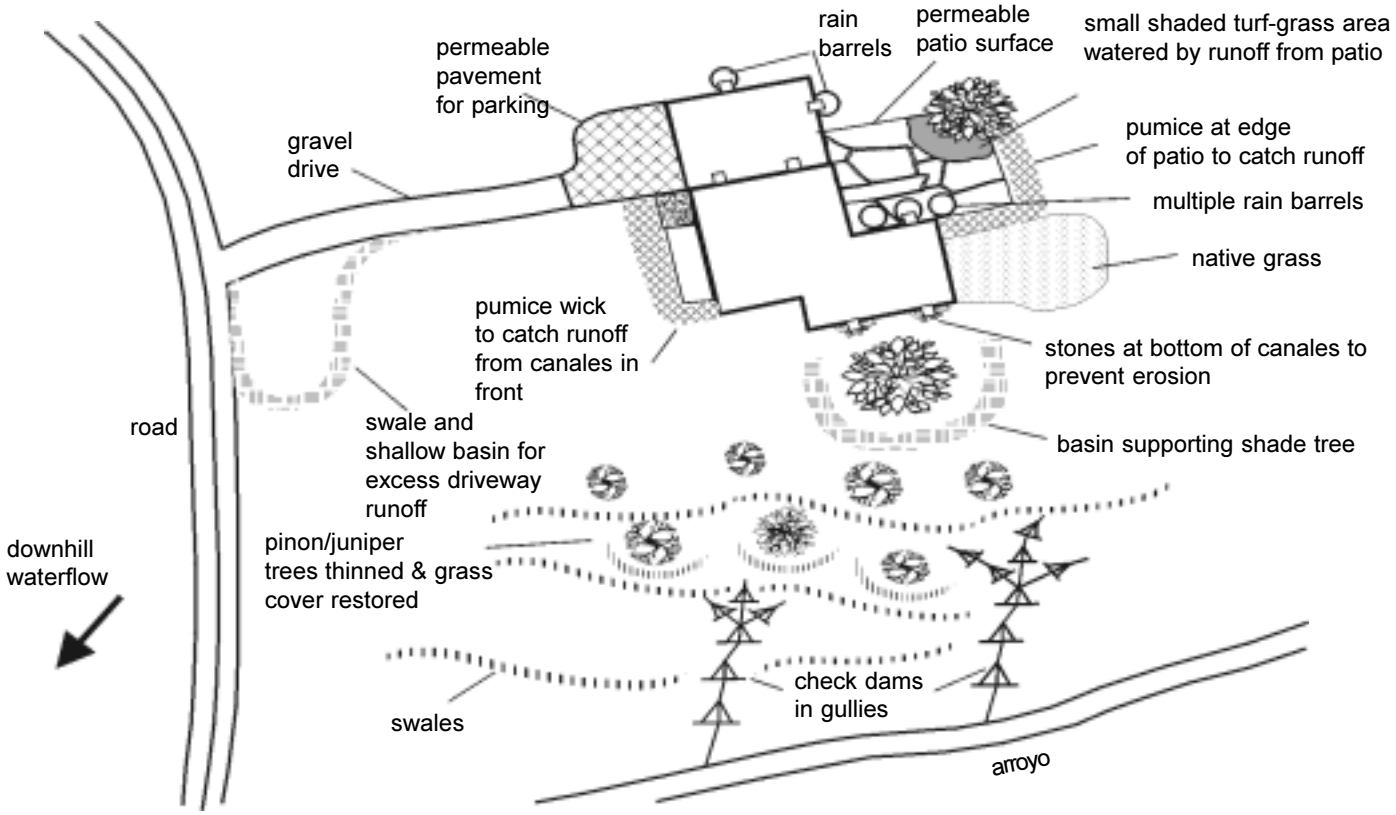
There are also broadleaf plants - wildflowers - that bind the soil well and are desirable for their beauty, but they are generally not included in dryland seed mixes because of their expense. Seeds of these species are more often purchased separately. The standouts among them are the annual purple aster, chocolate flower (a perennial), pepper grass, evening primrose (several species), *Ratibida* (one of a couple plants called "coneflower"), buckwheat, sunflower, penstemons, and "perky Sue". Buffalo gourd is a large and dramatic native plant that may be appealing. It provides soil cover as well as adding some organic matter to the soil when its huge taproot decomposes after the plant dies.

Where trees are too thick for grass to grow, like the situation pictured on page 5, what's needed is to thin the trees so there's water and sunlight available for grass in between. There should be at least 20 to 30 feet between trees. Then heal the gullies with check dams if necessary (see page 14 below), put in some swales to keep the water in the soil until grass can get started, and plant appropriate native grass seed at the right time, with mulch and/or some irrigation to get it started. There are documented instances where this kind of treatment, over large areas, has allowed dried-up springs to flow again.

The places where water concentrates from roofs or hard surfaces and soaks in can be quite a bit wetter than surrounding areas that just get average precipitation. These are the places to put more water-loving plants, while places with no additional water will still support native grasses, shrubs, and wildflowers. By organizing your planting to work with water flow like this, you can have more verdant spots and a very attractive overall landscape, with little additional water beyond what naturally falls from the sky. Even here in Santa Fe! Swales and infiltration basins are the perfect places to get plants started and support relatively water-loving ones.

Putting it all together

This example of a hypothetical home and yard illustrates many of the ideas from the previous pages. Techniques can be combined and put to use in ways that reinforce their effectiveness and contribute to an attractive landscape that retains and uses most of the precipitation it receives. Remember, water is valuable. Don't let it get away!



3. Erosion control and repair

Keeping water close to where it falls and letting it soak in to support natural vegetation will almost always keep erosion from getting started in the first place. Often, however, native plant cover has been disrupted and unprotected soil is rapidly eroding. The key to preventing and repairing erosion, just like water harvesting, is to protect the land surface and slow down the water so it can soak in. Appropriate plant cover is one of the most effective ways to do this.

Erosion is pretty obvious in Santa Fe's more dramatic arroyos, and overwhelming in the "grand canyon" of the Santa Fe River below St. Francis Drive. To prevent erosion on a grand (and very expensive) scale, we have to stop it while it's still easily manageable, on our own back yards and construction sites. Can you recognize an erosion problem before it gets out of hand? Here are a couple of examples:

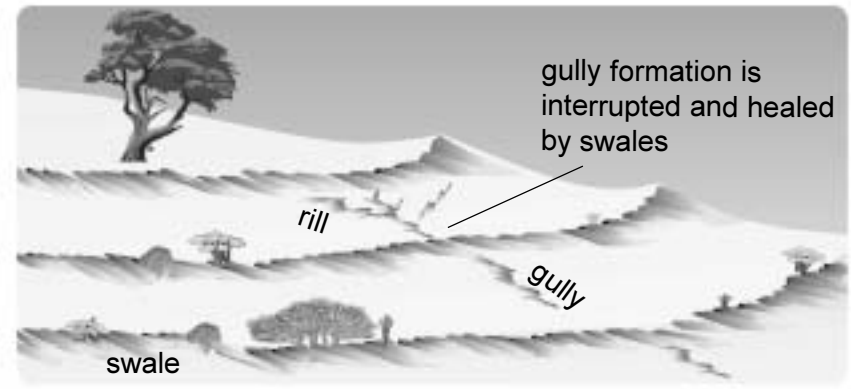
Unprotected soil is washing away around the clumps of grass, which are left on ever-increasing pedestals as the soil around them is eroded.

Bare soil is always erosion waiting to happen. Water will run rapidly off unprotected soil, and soon concentrates to form little channels called rills that join to form gullies. These are bleeding wounds that need attention!

Always start at the top, if you can. The higher up on your property or on any watershed you can work to prevent or repair erosion, the easier and more effective it will be. A little digging or revegetation will work wonders before runoff has a chance to concentrate and build up volume and momentum.

Bare soil between the trees is eroding into gullies. It will be much easier to get good grass cover established if the trees are thinned, since they now get most of the sunlight and water.

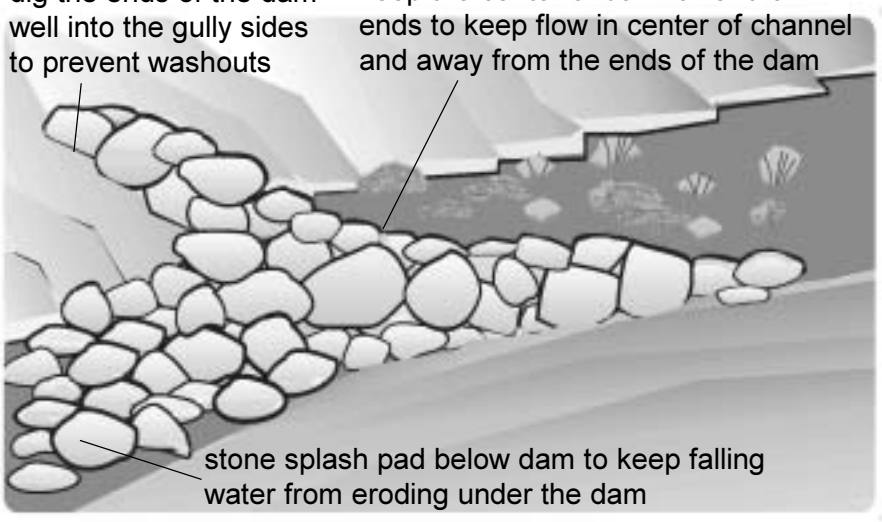
Swales

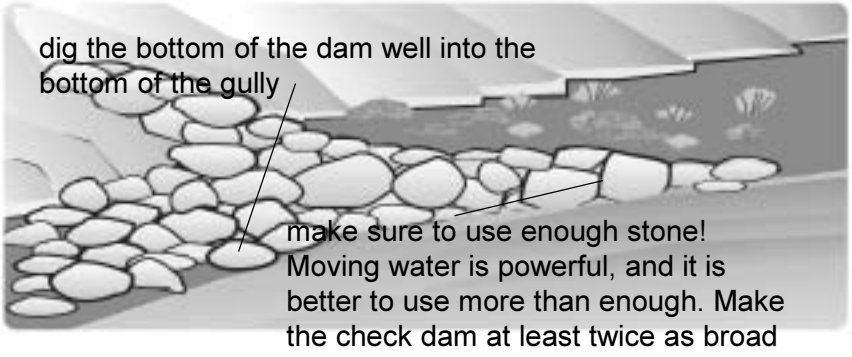


The same simple and effective swales that work for water harvesting because they slow the water down, let it soak in, and provide great places to start plants, also prevent the formation of rills and gullies. Containing runoff with swales at the top of a slope will reduce or eliminate the need for bigger, more labor- and material-intensive structures further downstream.

Check dams

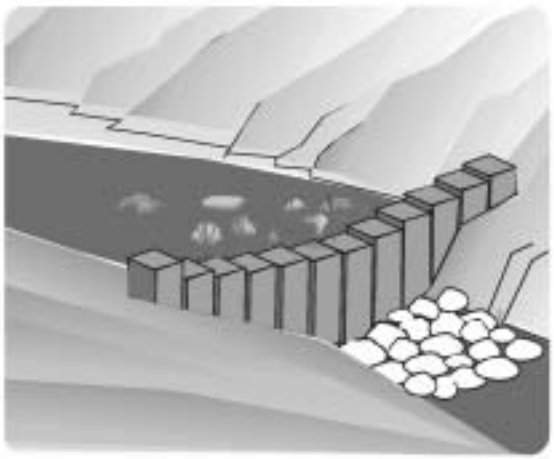
Sometimes you can't start at the top of the watershed. Maybe you have gullies running onto your property from somewhere else and can't do anything about the land upstream. If you need to work in a gully or channel of any size, the main tool you have is the check dam - a low dam that is designed primarily to slow water flow and collect sediment. The sediment is a great way to store water and support a plant community that further protects and stabilizes the soil above the check dam. Small gullies, less than a foot or two deep and less than four or five feet across, can often be repaired with a series of simple check dams made of nearby stone, piled by hand into the channel. There are a few important points to remember, though, as illustrated to the right and below.





Sometimes one or two check dams will stabilize an eroding gully, but often it will take several to do the job. You want the slope of the gully channel to be as nearly level from the bottom (or "toe") of one dam to the crest of the one below it as possible.

You can also make check dams out of cut railroad ties, set vertically into the bottom of the gully deeply enough that they won't wash out (say a foot or more). Railroad ties laid horizontally are easily washed out by the force of flooding water, and usually don't work in the long run.



If you prefer not to use railroad ties because of the creosote used to treat them, there are non-toxic alternatives available, including posts the size of railroad ties made of recycled plastic, and naturally rot-resistant wood like juniper.

It's not a good idea to make permanent check dams out of straw bales, brush, or ordinary lumber because when these materials rot or give way, the gully will rapidly wash away all the sediment caught above them, undoing all your hard work in a single storm. Perishable materials should only be used for temporary erosion protection (such as on construction sites), or where you are sure that plants you can grow on captured sediment will be dense and strong enough to keep all the sediment in place by themselves. Generally in the Santa Fe area there is not enough water available for this.

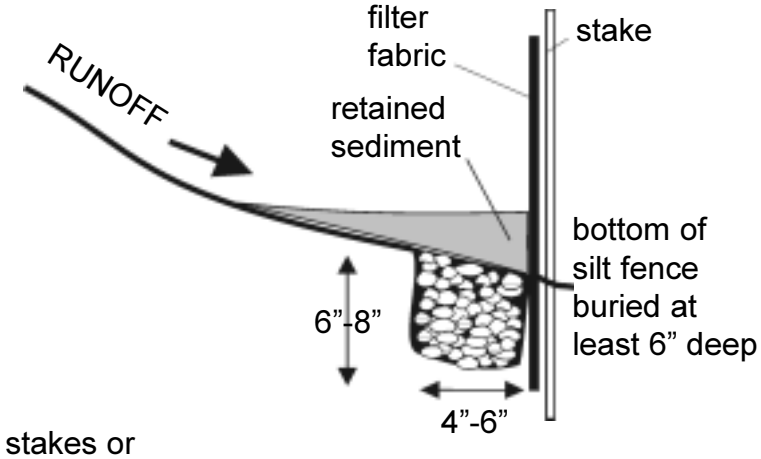
In general, check dams for gullies or arroyos more than a foot or two deep, or four or five feet across, will need to be stronger than just hand-stacked stone. They may need the reinforcing wire baskets called gabions, or other engineering design. It's a good idea to consult with an erosion control or engineering professional in these situations.

Temporary erosion and runoff control

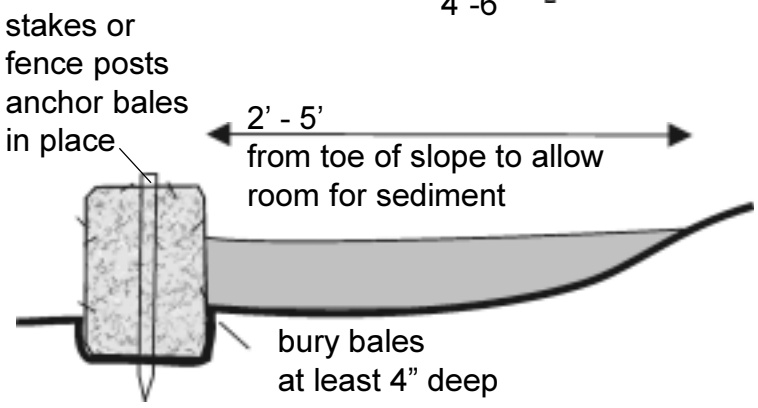
Soil is most vulnerable when it's recently disturbed and has no protective vegetation at all - and a construction site is a great place to find soil like this. Soil needs extra protection during construction activities or similar disturbances, and there are more and more legal requirements to do this.

Once again, the key is to follow the path water will take across and off your construction site, to make sure it can't just run off unimpeded carrying soil with it. There are many ways to keep water under control and keep soil from leaving a building site. Here are some of the most common techniques.

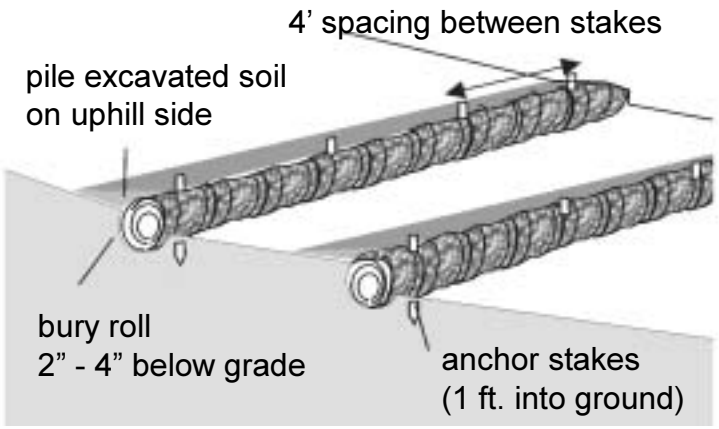
Silt fencing is one of the quickest, cheapest, and easiest ways to retain sediment on a construction site. This is the black fabric that you've seen on highway projects, standing up about a foot high. It lets water filter through but slows it down so silt drops out. Perhaps the most important thing to remember about silt fencing is that it won't do any good unless it extends down firmly into the soil. Don't let the water just run underneath it!



Straw bales can also be used to keep soil on a construction site. Like silt fencing, they can enclose a disturbed area or protect a slope. If they're used as check dams, build them the same as rock dams: dig them well into gully banks, make sure water can't wash under or around them, and slope them gently down in the middle.

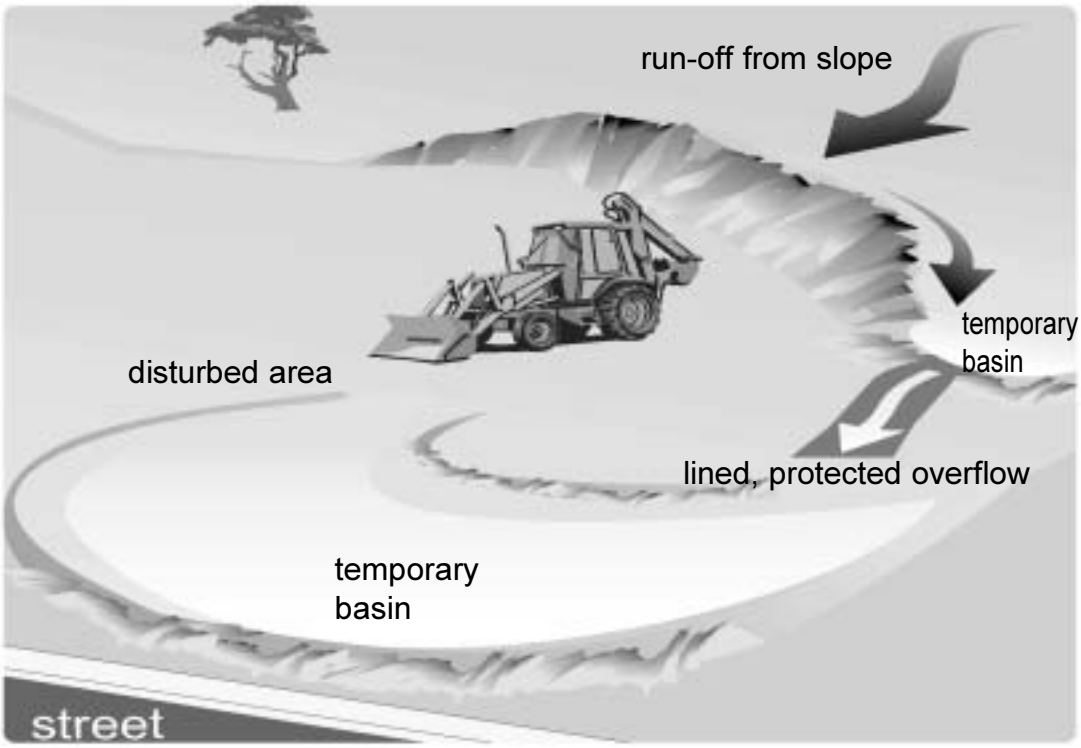


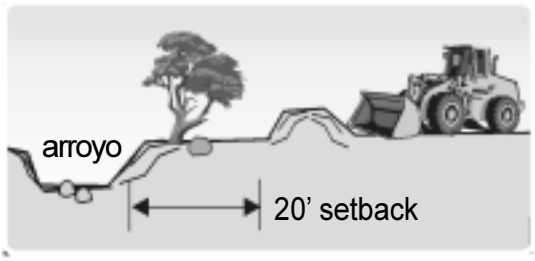
Fiber rolls, also called sediment rolls or wattles, are biodegradable fibers rolled inside open netting. They work like straw bales to allow water to filter through while keeping sediment behind and slowing runoff. They may be more convenient than straw bales where longer lengths are needed.

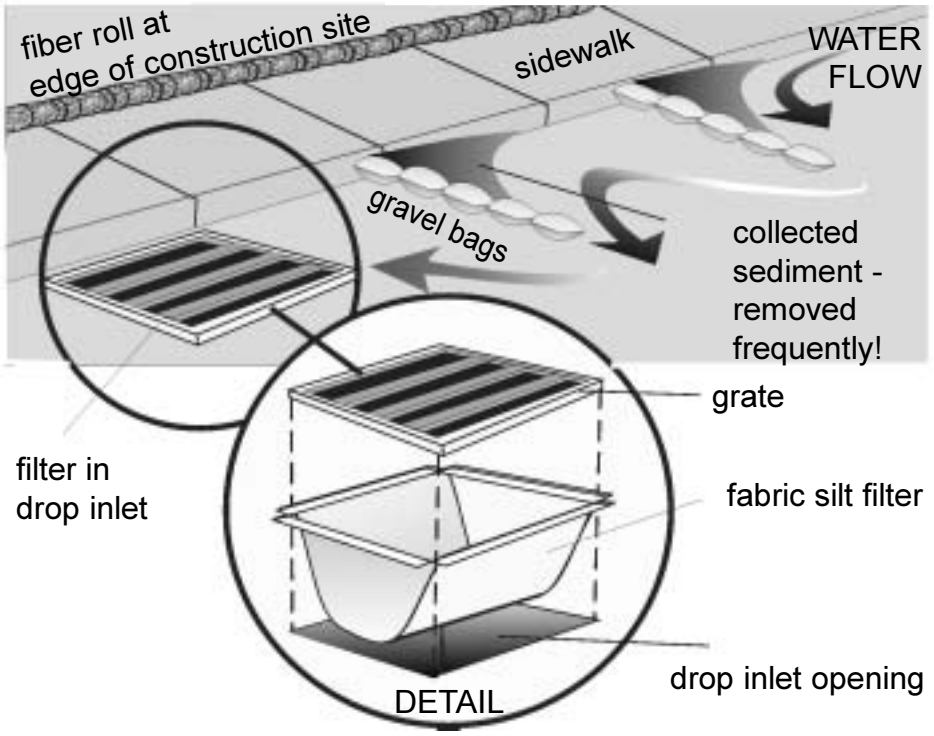


Berms and basins can help keep water on site during construction activities. You may also need to divert water away from disturbed areas to keep them from being eroded or flooded.

Sand and gravel bags can be useful for controlling water and sediment on construction sites, too. Gravel is better, since if the bag breaks the gravel doesn't wash away and contribute to the sediment problem itself.







It's important to keep soil stockpiles and other material far enough away from arroyo banks that they won't wash in, even if the arroyo runs enough to meander, change course, or enlarge its channel. A good rule of thumb is to keep the nearest edge of any soil piles at least 20 feet from the banks of an arroyo. If this isn't possible, it becomes even more important to use additional protection like straw bales or silt fence to keep sediment out of the arroyo.

It's also important to keep silt and sediment, or other pollutants, from washing into storm drain inlets. But at the same time, you have to let storm water drain into them. Here's an example of some good ways to do this. Just like in this example, you'll often need to combine techniques to get the job done.

Many of the following publications were useful in the preparation of this handbook and are recommended reading for more in-depth information about water harvesting.

- *Harvesting Rainwater for Landscape Use*. Patricia H. Waterfall. Arizona Department of Water Resources, 1998.
- *Introduction to Permaculture*, Bill Mollison. Tagari Publications, 1988.
- *Natural by Design: Beauty and Balance in Southwest Gardens.* Judith Phillips. Museum of New Mexico Press. 1995.
- *Rainwater Harvesting: Supply From the Sky*. City of Albuquerque. 2001.
- *Start at the Source: Residential Site Planning & Design Guidance Manual for Stormwater Quality Protection.* Bay Area Stormwater Management Agencies Assoc. January 1997.
- *Sustainable Landscape Construction: A Guide to Green Building Outdoors.* J. William Thompson and Kim Sorvig. Island Press. 2000.
- *Texas Guide to Rainwater Harvesting*, Second Edition. Wendy Price Todd and Gail Vittori. Texas Water Development Board, 1997.
- *Water Harvesting Guidance Manual.* (Public Review Draft). City of Tuscon, Arizona, September 2001.
- "Water Harvesting Traditions in the Desert Southwest," Joel Glanzberg. *Permaculture Drylands Journal*, #30, pp. 25-27. Permaculture Institute. Summer 1998.

The following web sites also have interesting information relating to water harvesting.

- *Harvesting Rainwater for Landscape Use*, listed above, is available online at http://ag.arizona.edu/pubs/water/az1052/
- Amounts of precipitation likely for different probabilities of storm (i.e. "2-year", "10 year", and so on) can be found at http://www.wrcc.dri.edu/pcpnfreq.html.
- Materials and other details of cistern construction are discussed at http://www.ca.uky.edu/enri/pubs/enri204.pdf .
- A description of how to build a ferrocement tank can be found at http://www.lboro.ac.uk/well/resources/technical-briefs/36-ferrocement-water-tanks.pdf .
- The Center for Science and the Environment in India has information on water harvesting at http://www.rainwaterharvesting.org .

Acknowledgements

This handbook was produced as part of the Arroyo de los Pinos Project, a collaboration between the City of Santa Fe and the College of Santa Fe. It was funded in part by a Clean Water Act Section 319 grant administered by the New Mexico Environment Department and U.S. Environmental Protection Agency Region 6.

New Mexico Environment Department

Surface Water Quality Bureau

COLLEGE OF SANTA FE

Text was written by David Morgan and Sandy Trevathan

Graphic design and illustrations were done by Bob Hill,
City of Santa Fe Graphics Division.

Photo credits:

Front Cover: Photograph by Charles Mann
Landscape design by Susan and Walter Blake

Back cover: Photograph by Charles Mann
Landscape design by Julia Berman

"If there is magic on this planet, it is contained in water."

-Loren Eiseley, *The Immense Journey*

Water can
indeed work magic,
especially here
in the arid Southwest
- and a little help
from us
can make a big difference.