Water: You Can't Live Without It!

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"We must listen

the water sings life

the water tells us

we are one."
- John Trudell

Between August 10-20 I had the pleasure of attending an Advanced Permaculture Design & Keyline Water Management course held at Seven Seeds Farm in Williams, O.R. The course was facilitated by Tom Ward and Randy Carey of Siskyiou Sustainable Designs. Tom is a long time permaculture teacher and counselor and Randy is a farmer and president of the Williams Creek Watershed Council. Together they brought a wealth of knowledge and experience to this 10 day event.

As our usable water resources dwindle and become more polluted every day, water conservation seemed a fitting topic in a place where the watershed is flowing at 1/3 of its normal capacity. The course immersed us in philosophies and techniques that showed a way of living with the land that doesn't pit the needs of farmers against those of fish and wildlife habitat. By letting our problems become solutions (roads as water catchment), seeing our waste as resources (graywater) and taking our lessons and designs from nature, we truly are faced with "insurmountable opportunities" and "overwhelming abundance." This essay is taken from my notes and is an attempt to pass along these important ideas and techniques.

What is Keyline Water Management?

Keyline systems of water and soil conservation were developed in Australia during the 1950's by P.A. Yeomans as a response to increasing desertification and erosion of the landscape. His book Water For Every Farm (see "Resources" below) is an important

resource on holistic farm design. Keyline is a set of principles and techniques based on a whole systems approach that works with natural patterns to restore or increase the depth and fertility of the soil, while increasing its water holding capabilities. Keyline integrates terraces, ponds and cultivation techniques with the natural landscape to infiltrate water into the soil efficiently and hold it on the land as long as possible. In order to truly work with nature, implementing a Keyline system requires careful observation and assessment of a site.

Permaculture Assessment & Keyline Order of Permanence

The backbone of a permaculture assessment is a holistic understanding that recognizes an ecosystem as a complex of compounds in dynamic interaction that maintains its existence through the mutual inter-relationships of its parts. When working on a site we need to remember that anything we do may affect the whole system, that systems can change unpredictably, and that even a small adjustment can have major effects. It is with this in mind that we begin our observations and try to read the landscape.

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Start with the big picture. Ask questions such as: What is the climate like? What is the elevation? What is the latitude? What is the precipitation? What is the slope and solar aspect of the land? Where am I in the water shed? What is happening upstream? What is the vegetation? What's dying? What's coming in? What's growing where? What is the geology? What is the history? What are the sectors for energies and flows that affect the site, but that come from off the site? Things to consider may include: wind, frost, fire, wildlife/animals, people, access and utilities. What are the "invisible structures?" (i.e. zoning, codes, water rights, etc.) What is the water doing? What are the sources: streams/rivers, springs, ponds/lakes,

run off, city water, ground water-is it artesian or perched? What are the existing catchments? What is the health of riparian areas?

Some useful tools when doing an assessment include: maps, (topographical, geological) aerial photographs, a compass, a clinometer, (to determine solar angles and slope), a sight level or an A-frame level (for laying out contour lines), field guides of various sorts, well drilling records and of course your neighbors.

Yeomans developed what he called the "Keyline Order of Permanence" which lists elements of a site in order of changability, beginning with the most permanent. This can be helpful to keep in mind when determining what you have to work with.

Order of Permanence:

Climate

Land form

Water

Roads

Trees

Buildings

Fences

Soil

Before we make any changes to a system we should compare our observations and brainstorms to some permaculture principles. These include:

Protracted thoughtful observation rather than prolonged thoughtless action.

Hold water and fertility as high on the land as possible.

Utilize wasted resources and locally available materials.

Work with nature, rather than against it.

Start small-harvest your mistakes.

The problem is the solution.

Stability through diversity.

Whatever we take, we must return.

Distribute surplus.

Think globally, act locally.

Stack functions. Every element in a system should serve multiple functions, and every function in a system is served by multiple elements.

Make the least change for the greatest effect.

Plan for small scale, energy efficient and self-reliant systems.

Design systems that self manage.

Etc. (see Permaculture literature below)

Our assessment, these principles and what we want to do on the land give us a solid foundation to begin from. By applying Keyline principles we can provide for our water needs and those of the land.

Keyline Principles

Insure the rapid application and infiltration of water to the landscape, while paying close attention to salinity, over saturation and related problems. This is achieved by improving soil structure and the strategic use of terraces, swales and ponds.

Use specific pattern cultivation methods that combine soil aeration and water control.

Choose earth moving principles that are economical and effective. Making the least change for the greatest effect.

Our goal is to make the greatest use of the water as it flows through the land. Things to consider are: How many ways can I use the water

before it leaves the site? (washing-irrigation-aqua-culture-irrigation) What is the longest route that the water can take through the site?

Key Points

Every watershed has a primary key point. This point is the interface between collection and distribution, and is characterized as the point where the ridge meets the valley. Where springs flow together to form a stream, or where water infiltrated into the top of a ridge resurfaces, are key points. Key points are good places to begin our collection and distribution systems. Typically, surface water above the primary key point is potable quality, and the water below it is nutrient carrying and is best used for irrigation and infiltration to charge the water table.

Most of us live farther down the watershed and are unable to steward the primary key point in our landscapes. However, a watershed will encompass several key points. Secondary key points can be found at slope changes in stream beds or where two streams converge- anywhere that water is concentrated. For those of us in urban settings, the key point we work with in the "watershed" of our yards could be the point where our rain water converges into a cistern.

Water Harvesting, Storage & Conservation

The three main elements of water catchment are: sources, storage and distribution. Whatever water source you choose to develop, losses will be minimized if the water is caught and stored close to the source. There are many possibilities for storage, including tanks, ponds and the soil. How you plan to distribute the water may influence the placement of your storage, particularly in regard to gravity.

The cheapest place to store water is in the soil and in vegetation, and there are a number of tricks to do this. Most importantly your soil will be able to infiltrate and hold water more efficiently if it has good structure and a high organic matter content. This should be a focus regardless of what other strategies are used, and can be done through composting, cover cropping and Keyline ripping (see below). Also burying large woody debris in the soil will create a sponge effect

and hold moisture where it is available to plants. Swales, terraces, pattern cultivation and brush dams can all be used to infiltrate water into the soil and hold it there as long as possible.

Swales (ditches laid on contour) can be dug across slopes to slow down and infiltrate over land flow and run-off. These can be shaped to fit in with other management objectives by being shallow and wide enough to be grazed or mowed, or they may be little more than a trench cut by a mould-board plow or shovels. Regardless of shape and size, the soil dug out of the swale can be piled on the down slope side to form a low berm that should be planted to trees and other plants to make use of the water concentration. The infiltration capacity of a swale is greatly improved by ripping the bottom with a sub-soiler or other implement.

Swales can also play a role in water purification. If the bottom is dug deeper than usual (>1 ft) and then filled with some sort of organic debris (wood chips work well), the organic matter actually acts as a filter. The surface area of the material supports a colony of organisms that traps and absorbs harmful bacteria and toxins, biologically treating the water before it is used by plants or penetrates into the water table. This type of treatment can be used on road run-off, zinc contaminated water (from galvanized roofs) and graywater.

Keyline terraces are what connect all the elements of a Keyline system. They can be used to carry water from a key point, a brush dam, a pond or a swale spillway, or to a pond or a swale, or to carry water for flood irrigation. A Keyline terrace is basically a swale slightly off contour. They are laid out to have a slope that falls between 1 ft in 50 ft (sandy or forest soils) and 1 ft in 300 ft (clayey or compacted soils), depending on the soil. The slope of the terrace prevents blowouts that can occur in swales that don't have a spillway. They serve two main functions: one, like swales, is to infiltrate water into the soil; the other is to transport water from a source to a storage or from a storage to where it is needed. Newly constructed Keyline ditches tend to leak, but settle in, becoming compacted and water tight through use. As transportation systems they are preferable to ditches that run downhill and cause erosion. When designing access roads and paths on your farm, using these principles to lay them out on the appropriate slopes enables them to double as catchment, infiltration and water moving systems. While doing some surveying exercises during the course, we found that the paths used by deer and other animals often run on these keyline slopes.

One of the uses for Keyline terraces is efficient flood irrigation. Up to 80% of water dispersed through conventional overhead sprinklers does not actually penetrate the soil. Most of it is lost to evaporation, puddling and "bounce back". Flood irrigating with a Keyline terrace is one of the most efficient ways to water. Most of the water released from the Keyline terrace flows through the soil along channels created by Keyline pattern cultivation and "sub-irrigates," reducing loss considerably. This is done by leap-frogging two "flag dams" (a flag dam consists of a long narrow piece of canvas with a bar at one end to hold it up on the banks of the terrace, and a chain on the other to anchor it on the uphill end) down a terrace so that, while one is holding back the water so that it spills out and flows down the slope, the other one is placed down hill from it to catch the water when it is released from the first dam. This system of stopping and releasing the water is continued until the desired area is covered. This may seem like a lot of work, but consider that an irrigation set like this would only need to be done a couple of times a month. Another benefit is that the whole thing can be done without electricity or gas for pumping the water and without plastic hose. This irrigation technique is most suited to perennial plantings such as trees, bushes and pasture.

Pattern cultivation is another method of spreading and holding water in the soil. This technique uses the same gradual keyline slopes, but places them always falling away from the gully out onto the ridge, thereby holding the water on the land as long as possible. The way this cultivation is done is by cutting channels through the soil following the appropriate slope. This should be done sequentially over time beginning by ripping just below the plant roots and going successively deeper over time, ripping the channel too deep to start may actually send the water deeper than the plant roots. These channels allow air, as well as water, to penetrate the soil. This helps develop soil structure and organic matter, thereby increasing the overall water holding capacity of the soil. Yeomans actually developed an implement called the "Keyline plow" for this very purpose. It's sort of a sub-soiling-chisel-plow with very narrow shanks so that no turning of the soil occurs when the channels are cut. The concept, however, could probably be applied by either using, or modifying existing farm equipment.

Brush dams can be built in gullies to slow down the water as it moves through the land. These are constructed by keying a long branch or log into the banks, pounding stakes into the ground along it and lashing piles of brush in place along the framework. Brush dams can

be designed using cuttings of willow and cottonwood for stakes that could over time root and anchor the dam in place. Digging keyline terraces from these out onto the ridges also spreads the water out. Designing brush dam placement and terracing is much like fulfilling the role that the beaver once played in the landscape. Before white people came to the Northwest there were 100-400 million resident beavers, today there are only 9 million left. It used to be that the beaver dams (up to one every 100 ft.) were what held water on the land and prevented erosion and siltation. Restoration stategies that include reintroducing beavers have proven successful.

Tanks are most suitable for storing water for household use. There are many designs and materials to choose from and they may be stored either above or below ground. Again, consider relative placement and gravity flow. (See "Drinking Water" below)

Ponds, depending on your soil, are a good way to store water that is accessible above ground. For the potential volume of storage they are more economical than tanks, however to build a sound earthen dam you need at least a 40% clay content in your soil. Ponds have several advantages in the landscape, including water storage for irrigation and stock watering, aqua- culture (a pond will be the most biologically productive zone on your site), wild life habitat (floating "islands" increase habitat without sacrificing holding capacity), production of biomass for composting and/or fuel production, recreation and fire protection.

A series of small ponds will lose less water to evaporation than one large pond. Shade and wind shelter help reduce evaporative loss from any pond, this can be achieved through hedgerow plantings around the pond. Avoid deep rooted species on the dam itself, as these will open passages for leakage and failure. Floating vegetation in the pond itself greatly reduces evaporation, inhibits weed growth and keeps the water cool and fresh. A good floating guild is Azolla (water fern) and Lemna (duck weed). Both these plants reproduce quickly and can be harvested periodically for compost. A type of small fish called Gambusia can be added to ponds to eat mosquito larvae. To maintain maximum storage capacity natural ponds should be dredged every 5-15 years depending on size, because it will fill with organic matter (great compost resource). A natural pond left to self manage will, over time, turn into a wetland or marsh.

Pond placement is critical to both longevity and water holding capacity. Ponds should not be placed in gullies because there is

typically very little material available to build the dam with and they tend to fill up with silt faster. There is also a greater risk of dam failure due to the lack of a spillway. Ponds built on "flat" ground have a greater storage capacity for less work than ponds on slopes.

Ponds or any large earth works often require the use of heavy equipment that is highly energy intensive to use and to produce (embedded energy). Resorting to these big machines brings up some ethical issues for people trying to live on the land in a sustainable way. This is why the initial assessment is so important. Can we outweigh the harm caused by construction with the long term benefits for ourselves and for the land? Projects of this scale should be made to last and designed to be able to be maintained by hand.

Other strategies for water conservation include: mulching, growing drought-hardy crops, growing more over wintering crops, watering less frequently and more thoroughly (this encourages plant roots to go deeper into the soil where water is available longer), and knowing your crops (many people actually over-water). Planting hedgerows provides shade and wind protection, reducing evaporation, and the tree roots hold the water table higher in the soil. On a broad scale, a massive effort to reforest and de-pave the landscape is what is truly needed to restore a healthy hydrologic cycle worldwide.

Drinking Water

Again we're looking at sources, storage and distribution. Potential sources include springs, wells and rain water.

When assessing a spring it is important to know whether it is a hard rock spring or a perched spring. Rock springs are usually drinking quality, but a perched water table has more potential for contamination as they flow through the soil above the bedrock. Rock springs have a constant flow and temperature (aprox. 4'C) year round, while perched seeps fluctuate. Even a seemingly slow flow can provide ample water coupled with adequate storage - 1 cup/minute will add up to 96 gallons/day. Remember to be thankful for what you have, as people have "lost" their springs by trying to over-develop them.

Wells can be a good source of potable water, however they should be tested periodically for bacteria and toxic contamination due to

agricultural run-off etc. Some of the drawbacks that I see are: the use of electricity to pump out of the well, and the unpredictability. Once your out, your out.

Rain water is probably our most frequently wasted resource as it usually flows unused into storm water diversion drains. Rain water is generally good for drinking despite having a low pH (acid rain). Maintaining its purity through catchment and storage is the trick. The first few gallons collected each rain should be kept separate due to dust and leaf litter contamination. (see Permaculture literature for "roof washer" designs) Also what your roof is made of is important. Tile, wood shingled and baked enamel are the best, beware of galvanized metal, as it contains high levels of zinc which can be toxic, and asphalt composite. Galvanized roofing can be treated by applying a layer of primer and two layers of non-toxic weather proof latex paint. It should be stressed that even if your roof water isn't potable quality, it is still a valuable resource for other household and irrigation uses.

As far as storage goes, there are several cistern/tank designs to work with. Some of the more common ones are: Ferrocement, (either make your own, or they are commercially available, a 2,000 gallon tank costs about $1,000.) With plastic tanks, polyethylene is less toxic than PVC. 55 gallon metal barrels are usually available used for free or cheap, and can be plumbed together to increase capacity. Make sure you know what was in them before you drink out of them. Old bathtubs and other dumpstered/ reused goods may be adapted and used. Clay plaster and wood (white oak, red wood, alder and western red cedar will all hold water) are a couple of natural materials that may show potential, however the wood leaks if not kept wet and the clay may crack if allowed to dry out. Don't be afraid to experiment and be creative!

Watershed Councils

Back to the big picture. When we look at these strategies of water use it becomes clear that we need to make friends with our upstream neighbors. Who is stewarding our upland water resources? All too often what we find when we look upstream is missing and/or degraded forests, roads, pollutants, erosion, siltation, over-grazing, compaction and over-allotment of the water, often to people that don't take good care of it. Many of the principles and techniques

discussed here help us to address these problems and offer tools for restoration; they simply require implementation. From a watershed perspective, this implementation needs to start at the headwaters.

In Oregon, Governor Kitzhaber initiated the Oregon Watershed Enhancement Board that distributes funds to local Watershed Councils for watershed assessment and restoration. These are self appointed, non-regulatory, broad based groups, formed by citizen initiative and approved by the county commission. They provide assessment, materials and cost sharing to land owners involved in restoration work, including reforestation, erosion control and fencing live stock out of riparian areas.

Starting a group focused on restoration or education, organizing a skill share, talking to your neighbors, watching how water moves and experimenting are just some examples of how we can begin to address some of these issues. We need to begin conserving and restoring our water now, because we can't live without it!

Resources

Water For Every Farm. by P.A. Yeomans. ISBN 0-646-12954-6.

Permaculture Designers Manual. by Bill Mollison. ISBN 0-908228-01-5.

Living Energies. by Callum Coates. ISBN 0-46551-97-9.

Earth Ponds. by Tim Matson. ISBN 0-88150-155-7.

Tom Ward and Randy Carey are available in southern O.R. for professional counseling in site assessment, development and pond building. They may also be able to help import Keyline plows. Randy is a good resource on Watershed Councils. Randy Carey P.O. Box 292 Williams, O.R. 97544. Tom Ward P.O. Box 1282 Ashland, O.R. 97520.