Turning Drains Into Sponges and Water Scarcity Into Water Abundance

by Brad Lancaster

www.HarvestingRainwater.com

www.DesertHarvesters.org

What is the story of this place?

What is the story of its water?

Tucson, Arizona, USA
304 mm average annual rainfall

1904

1904
Watershed acting as a sponge

2007

2007
Watershed acting as a drain

Evidence of a hydrophobic society

- dehydration infrastructure

- dysentery infrastructure

Floods that occurred every 100 years begin to occur every 10 years -

after development paves the watershed and increases the rate and volume of stormwater running off site

pollute our local waters then import ever more distant water

Distance is energy

The largest consumer of electricity (and single source producer of carbon) in Arizona is the pumping of water

This landscape is irrigated with imported water high in salt.
This increases salt levels in the soil and decreases soil fertility.

Irrigating with on-site rainwater, which has almost no salt reduces salt levels in the soil and increases soil fertility.

A degenerative ruin.
Is that the story of this place?
Is that its purpose?
Its calling?

Water consumption in Amman

The average water consumption per person in Amman, Jordan is 130 liters per person per day

Free rain falling on Amman

Average annual rainfall (272 mm or 272,900,000 liters/ square km) multiplied by surface area of Amman (1680 sq km) divided by 365 (days of the year)
divided by population of Amman (2,919,000 people) equals 441 liters per person per day

A different story

Path to Scarcity

Drains local resources

30 to 70% of the potable drinking water consumed by the average single family household in the western U.S. and Australia is used for landscape irrigation

Path to Abundance

Harvests local resources

- Rainwater is primary water source
- Greywater is secondary water source
- Municipal/well water only a supplementary source

Rain garden - a living sponge

Here it is a level-bottomed, mulched and vegetated infiltration basin

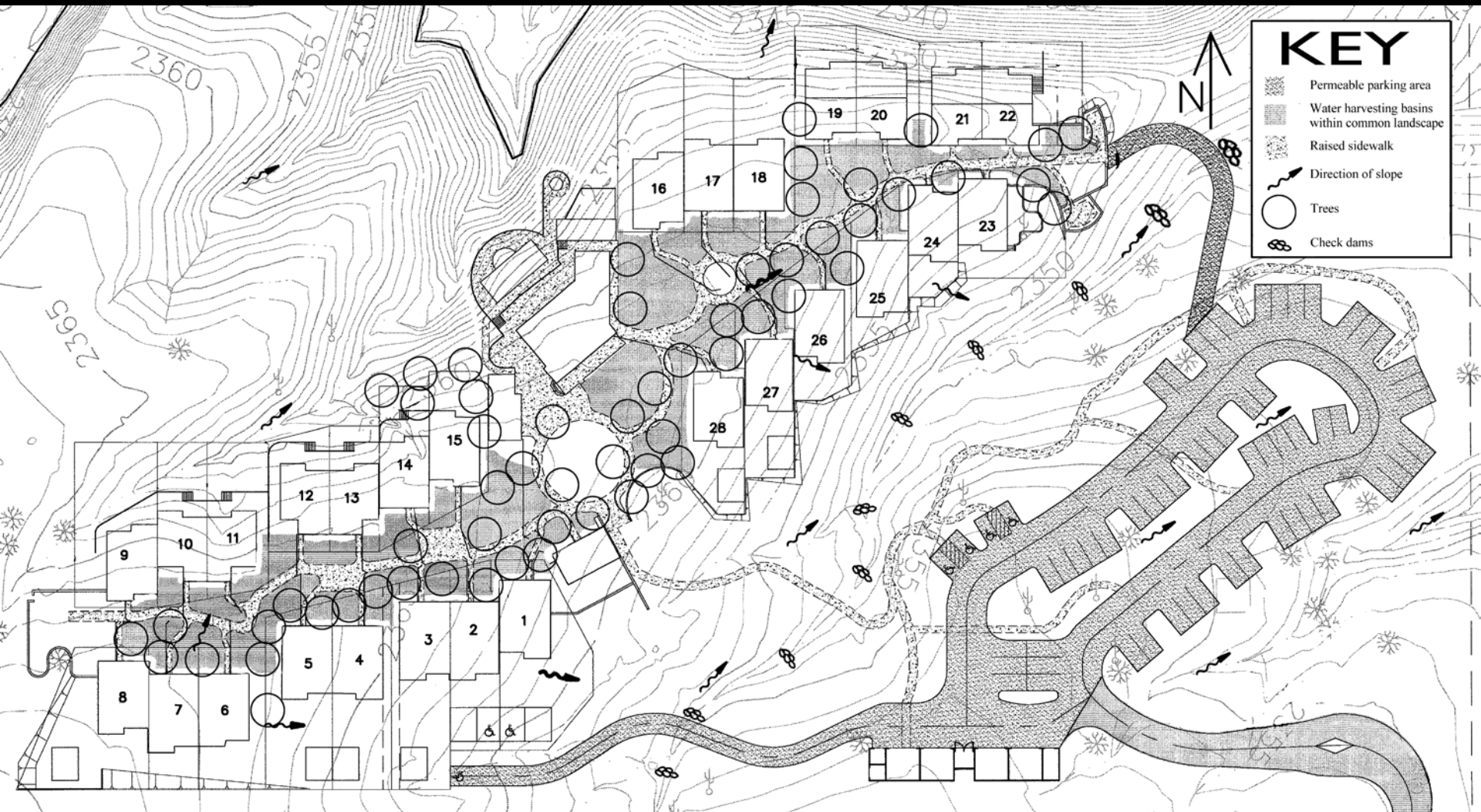
Before sponge

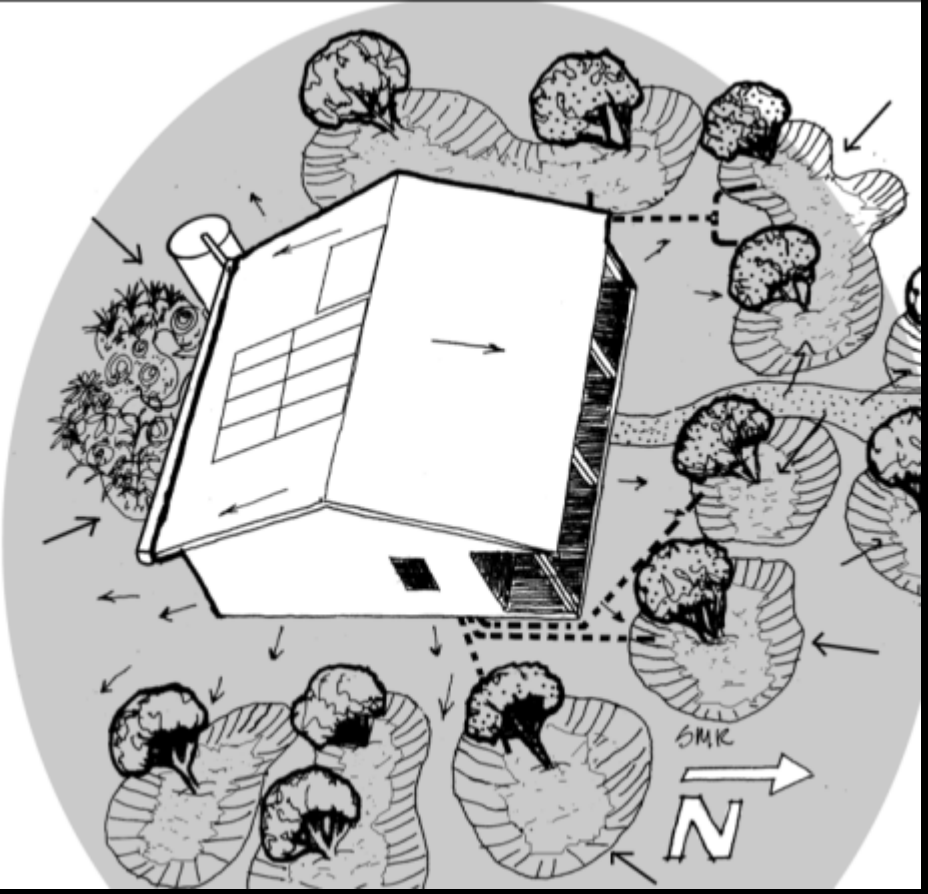
of mulch and vegetation placed within water-harvesting earthworks 60 cm deep

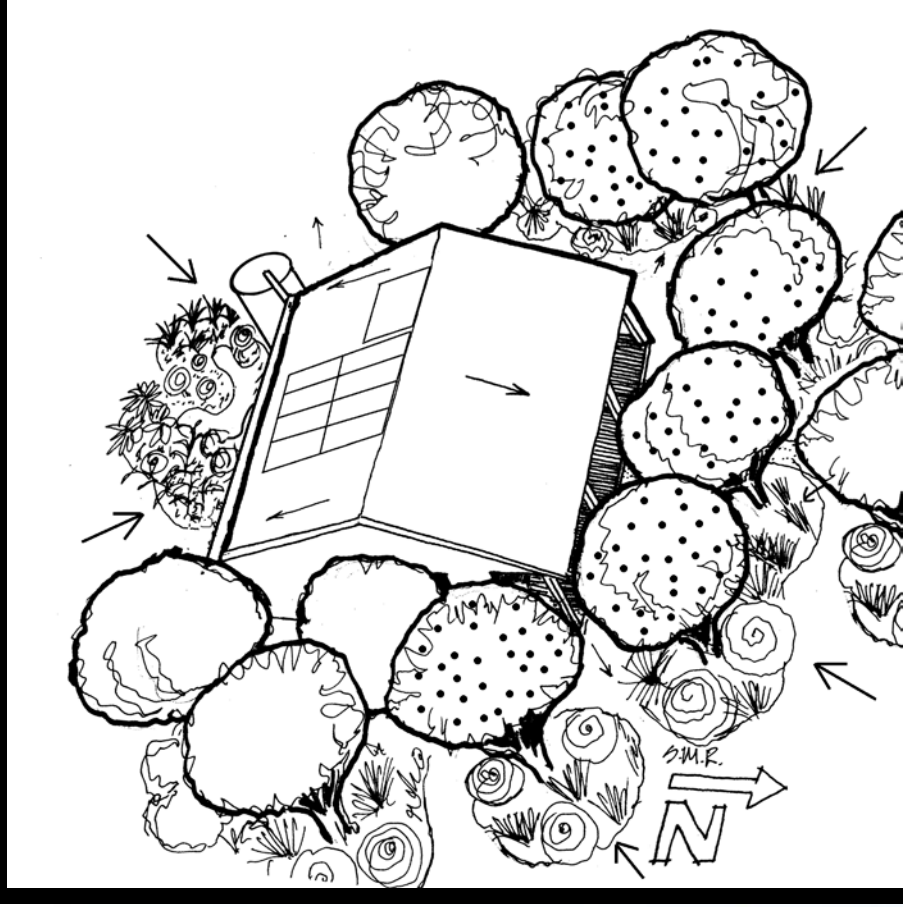
After sponge

is planted. It is irrigated only with harvested rainwater and household wastewater - no drinking water

Integrated water harvesting has 10 times the flood control capacity of a conventional system







Harvest and utilize water as close as possible to where it falls

within the oasis zone - within 10 m (30 ft) of catchment surface

condensate harvest to courtyard Jeddah, Saudi Arabia

Air conditioning condensate harvesting

DRY CLIMATE/SEASON:

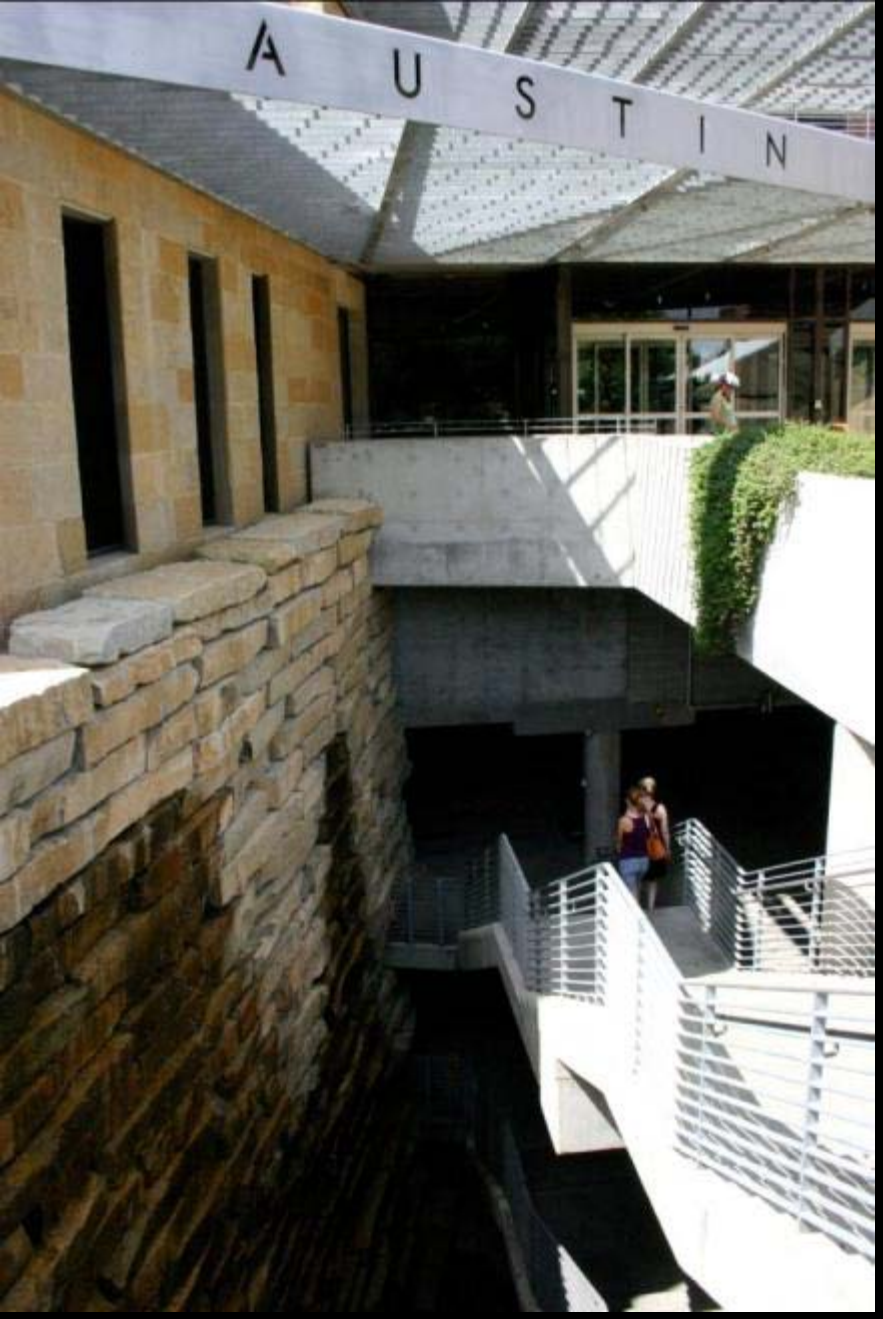
a home air conditioner can generate 1 liter (0.25 gallons) of condensate per day

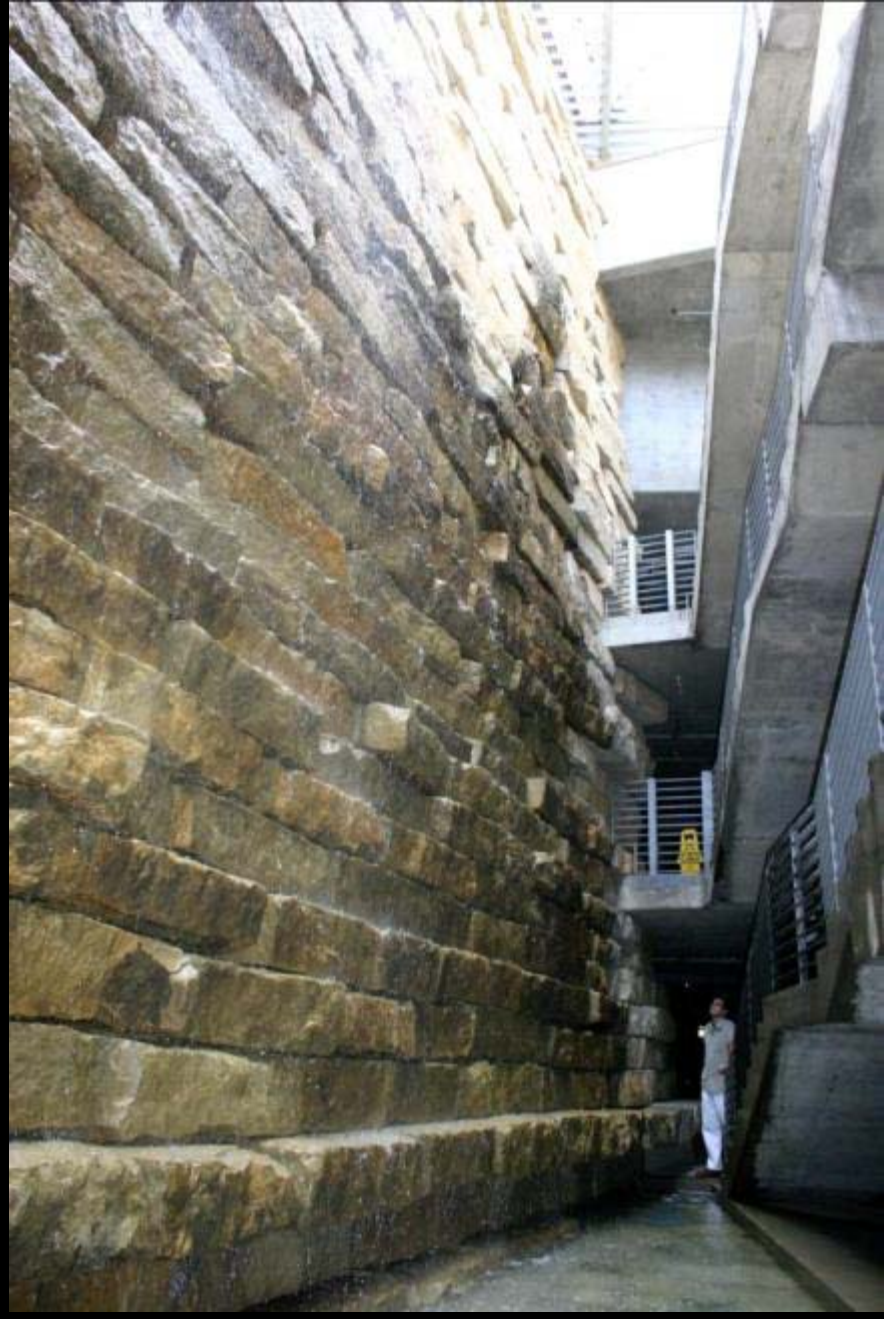
a large commercial air conditioner can generate 1,900 liters (500 gallons) per day

HUMID CLIMATE/SEASON:

a home air conditioner can generate 68 liters (18 gallons) of condensate per day

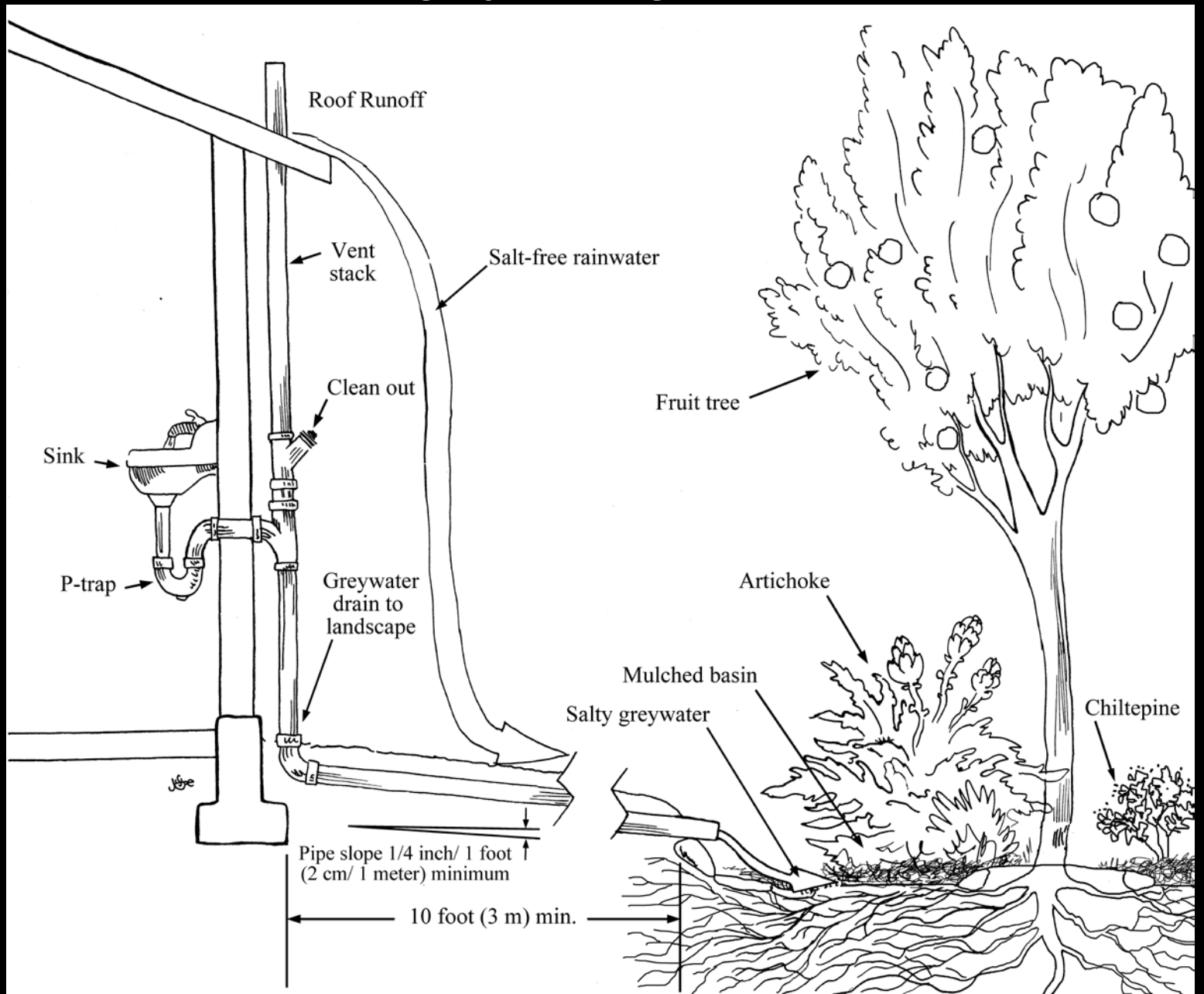
a large commercial air conditioner can generate over 7,500 liters (2,000 gallons) per day





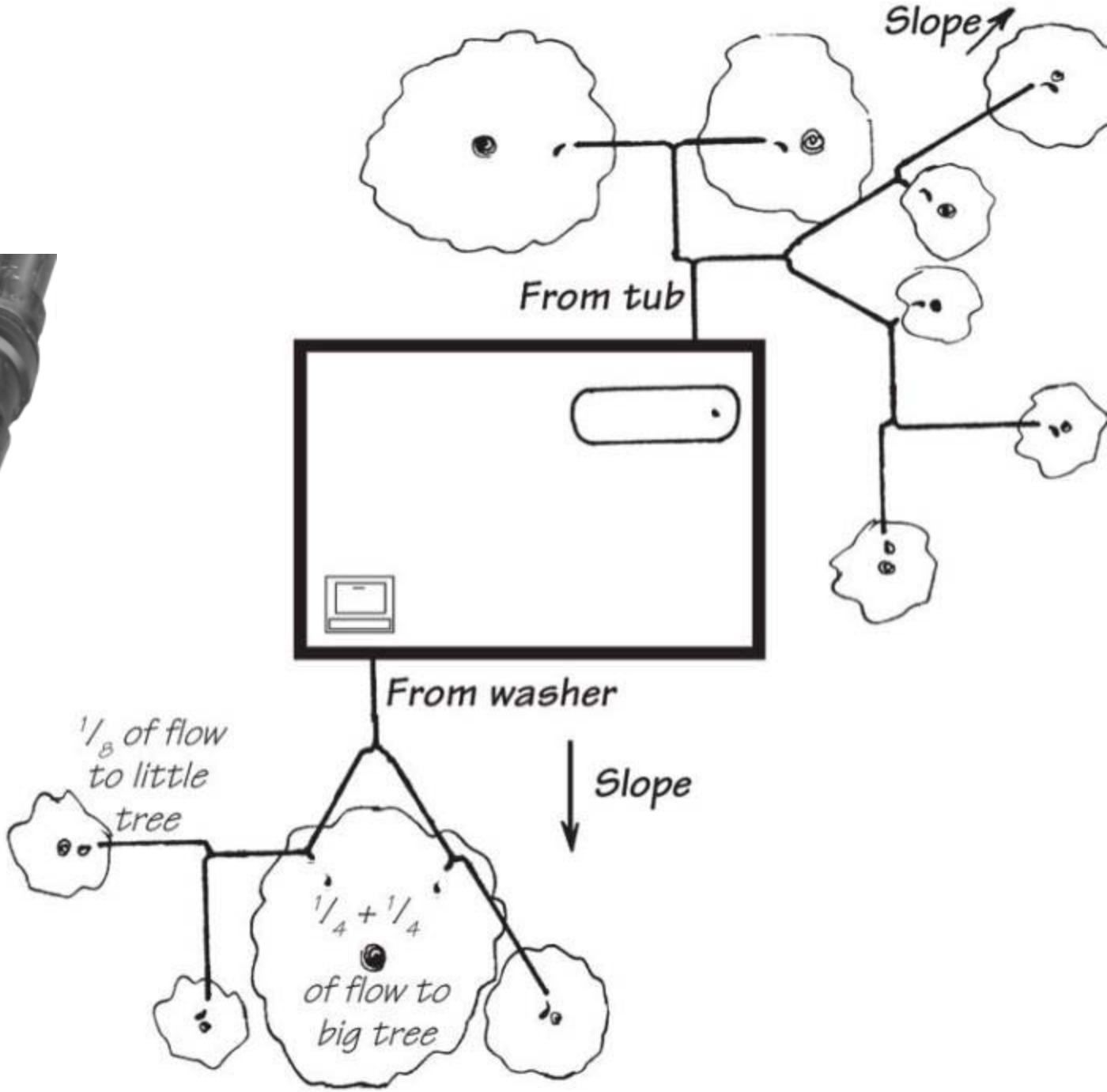
Air conditioning condensate waterfall, City Hall, Austin, Texas

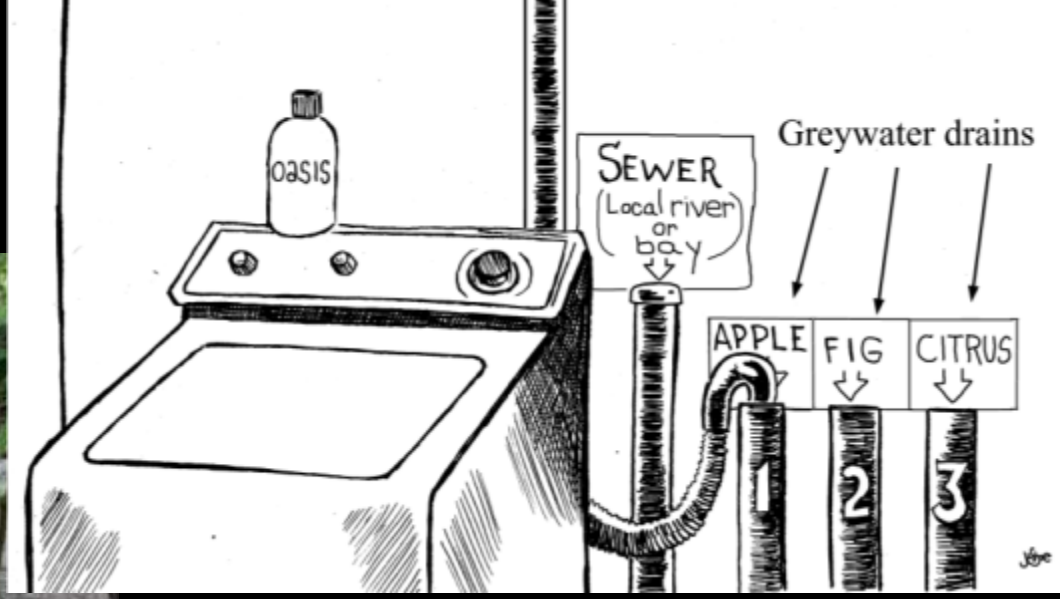
Gravity-fed greywater harvesting into rain garden doubling as a greywater garden



Split or distribute the flow

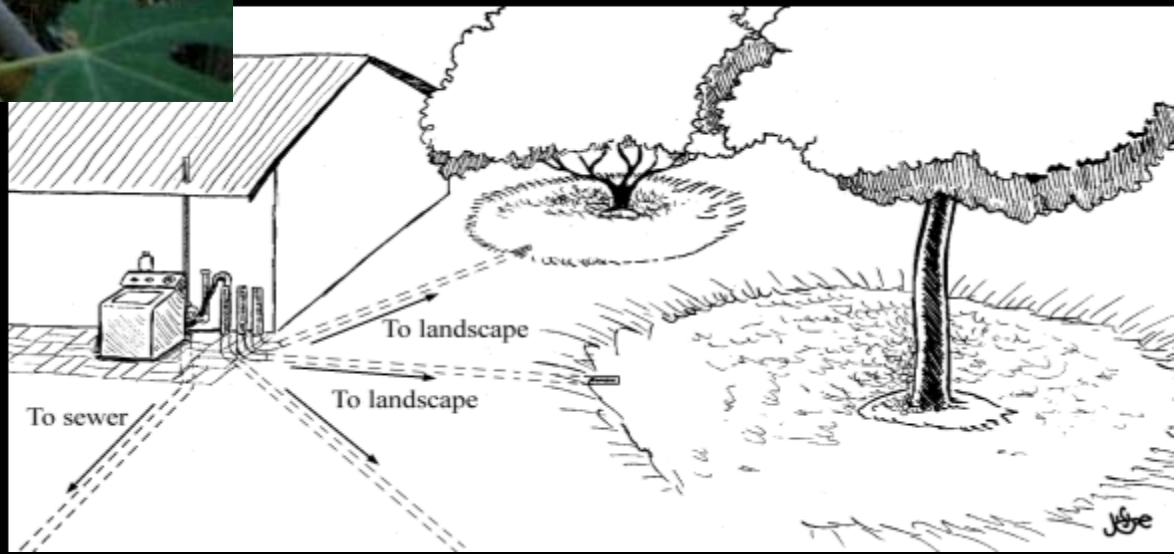
Gravity-fed, branched drain greywater system



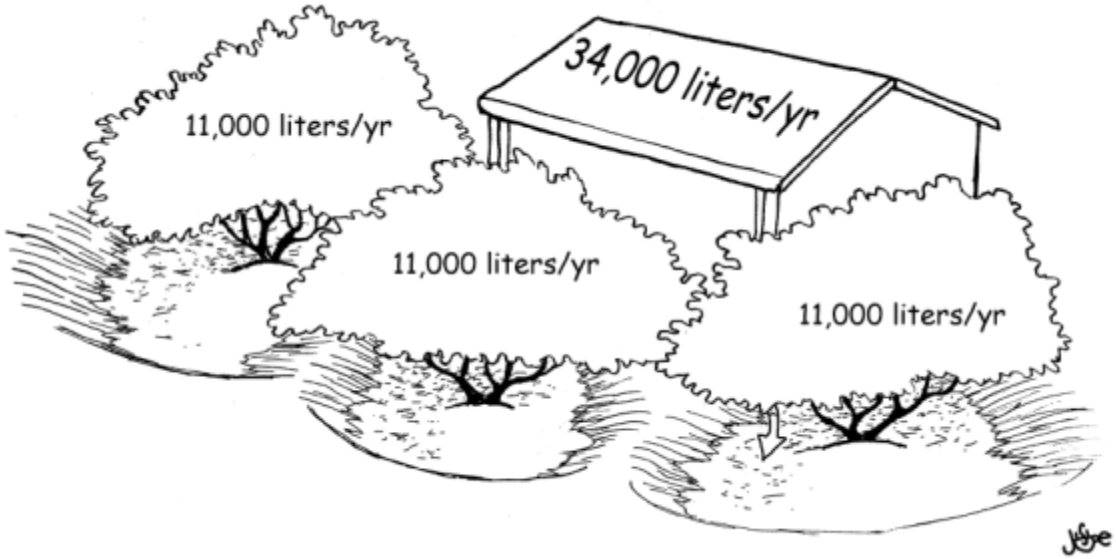


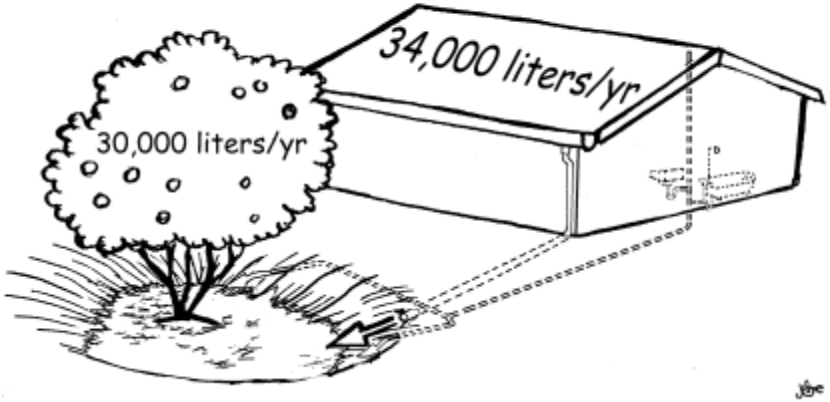
Multi-pipe laundry greywater system

see Greywater chapter of
Rainwater Harvesting for Drylands
and Beyond, Volume 2
for more



Landscape in Tucson, Arizona (304 mm annual rainfall)
irrigated only with passively harvested rainwater and greywater
- no drinking water used in landscape





34,100 liters of water from (330 m^2 roof) equals:

- 5,625 toilet flushes (6 liters per flush)
- 750 loads of clothes washing (45 liters per load)
- 900 five-minute showers (37.9 liters per shower)

Australian rainwater harvesting tank (4,500 l)connected to outdoor faucets, washing machine, and toilet

Water truck pumping water up to rooftop tanks
downtown Amman, Jordan

17% of the national energy production in Jordan used for pumping water.

Water is pumped 330 km from Disi to Amman and an elevation rise of 1,300 m from Jordan Valley to Amman

Sameeh Al-Nuimat of Care International
Village of Bayudah Al Shrquia, Jordan
Rainwater tea

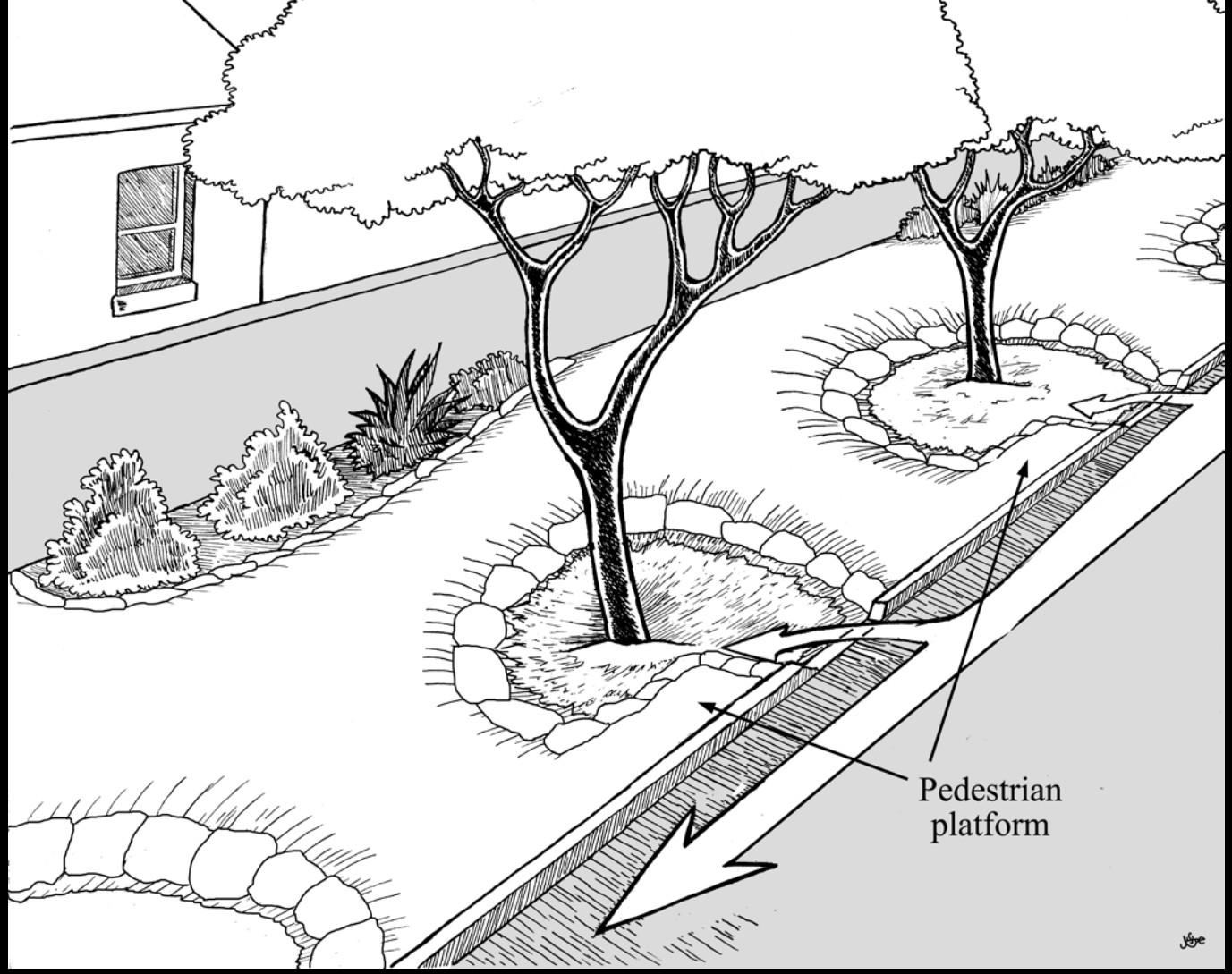
Mercy Corps - funded
Roman era cistern
rehabilitation
northern Jordan

Before - the planting of rainwater, stormwater, and trees - 1996

Lancaster household, Tucson, AZ, USA (304 mm annual rainfall)

After - the planting of rainwater, stormwater, and trees - 2006

Lancaster household, Tucson, AZ, USA (304 mm annual rainfall)



My neighborhood street receives over 3 million liters of rainwater per kilometer

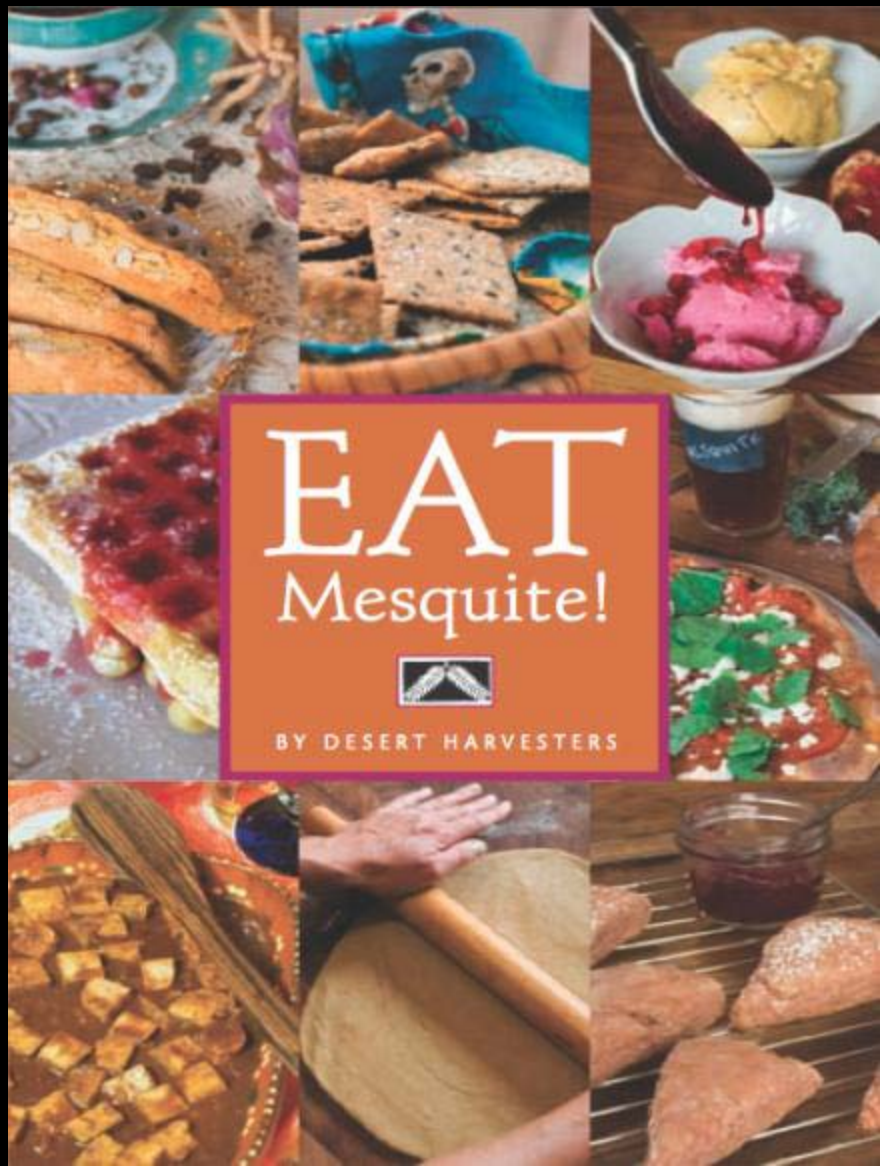
That is enough rain to passively irrigate trees spaced every 8 meters on both sides of the street

For every 100 mm of rainfall…

- A 3-m wide paved street will drain 300,000 liters of rainfall per 1 km
- A 6-m wide paved street will drain 600,000 liters of rainfall per 1 km
- A 9-m wide paved street will drain 900,000 liters of rainfall per 1 km

Growing local food with local rainwater

DesertHarvesters.org

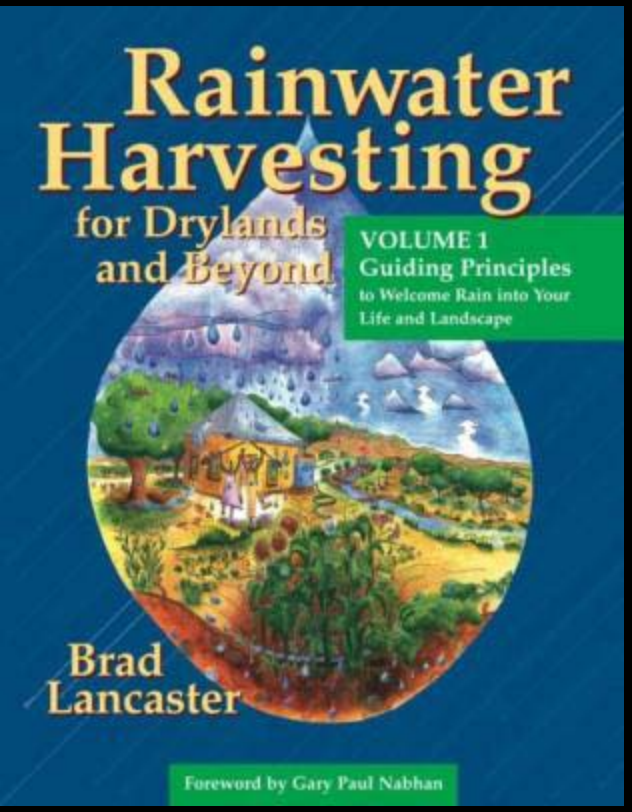


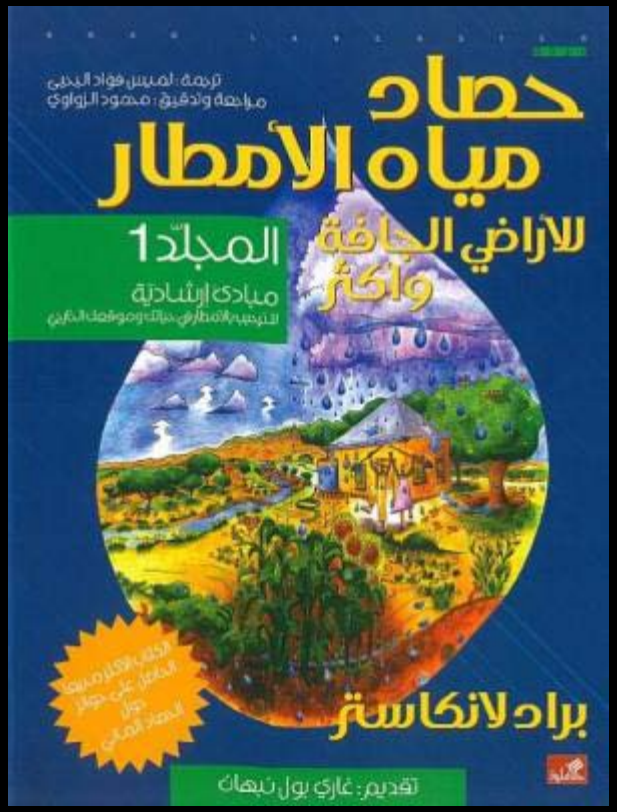
Spring created by a loose rock check dam
slowing, spreading, and sinking flow of water

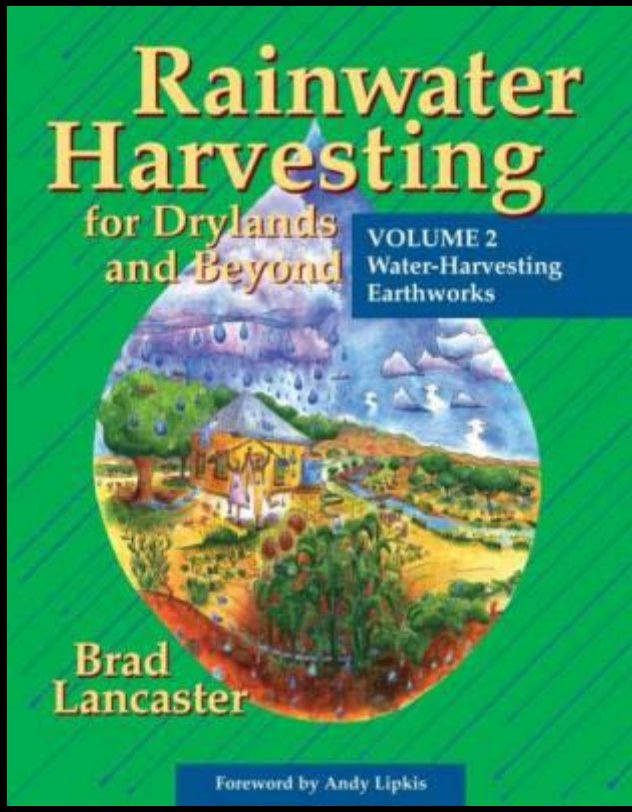
What is the story of this place?

What is the story of its water?

What is your role in this story?







www.HarvestingRainwater.com

Arabic Edition: Al Ahlia Publishing & Distribution
King Hussein Street, Amman, Jordan
Email: alahlia@nets.jo

Tucson, Arizona USA in 1904
304 mm annual rainfall. Watershed working as a sponge

Tucson, Arizona USA in 2007
304 mm annual rainfall.
Watershed working as a drain

Crew of four builds 35/year.

In clay soil excavation takes 8 days,
in rock it takes longer

"Rainwater is the best, it tastes better, and it is the water that comes from Allah."

- Ali Flahmohammad Khtatabh, Whadneh village Imam, Jordan

JOHUD funded revolving community loans funded cisterns, greywater, composting, gardening, and small livestock.

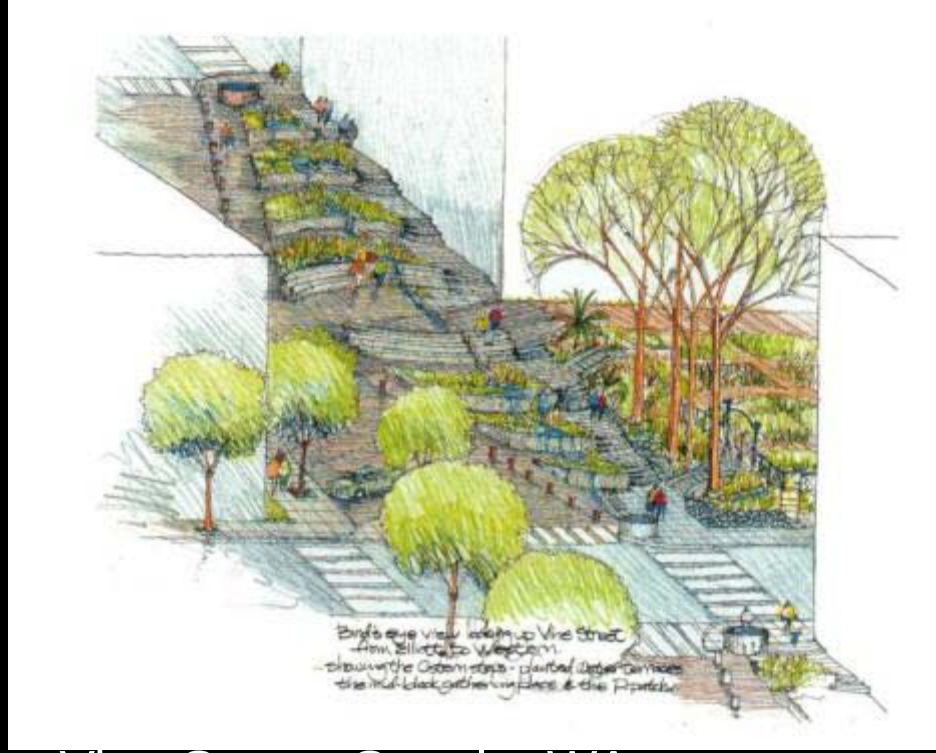
Cisterns cost $2,500 JD

Utilizing local waters,
Ten millimeters of rain...

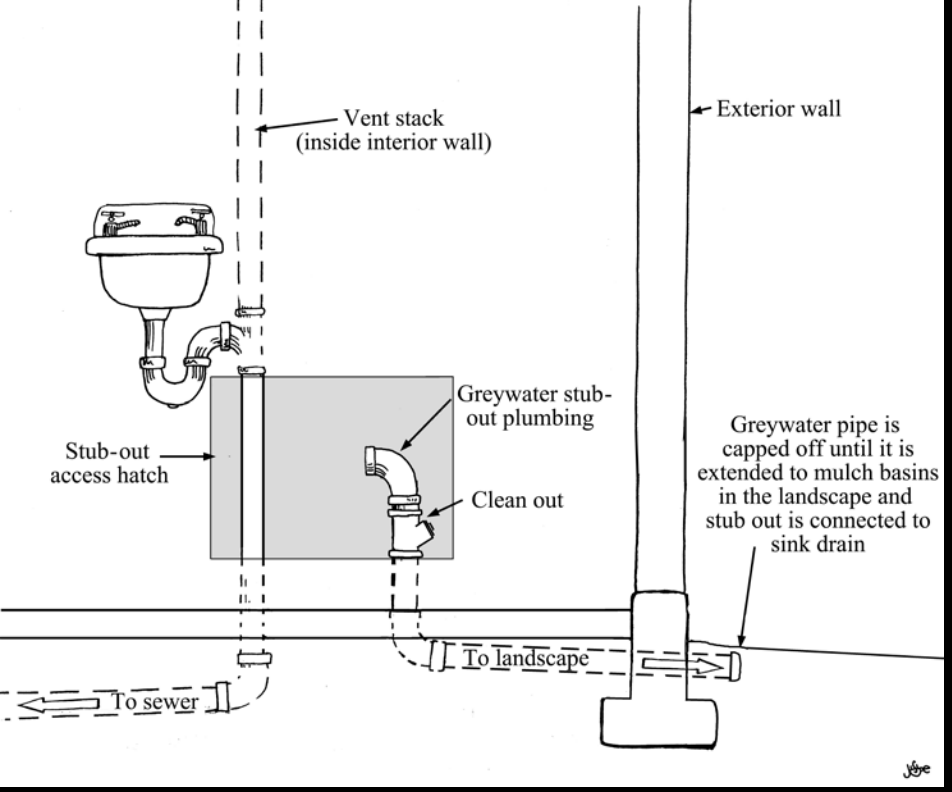
- falling on a 100 m^2 catchment surface = 1,000 liters of water
- falling on a 1 hectare catchment surface = 100,000 liters of water
- falling on a 1 square kilometer surface = 100,000,000 liters of water

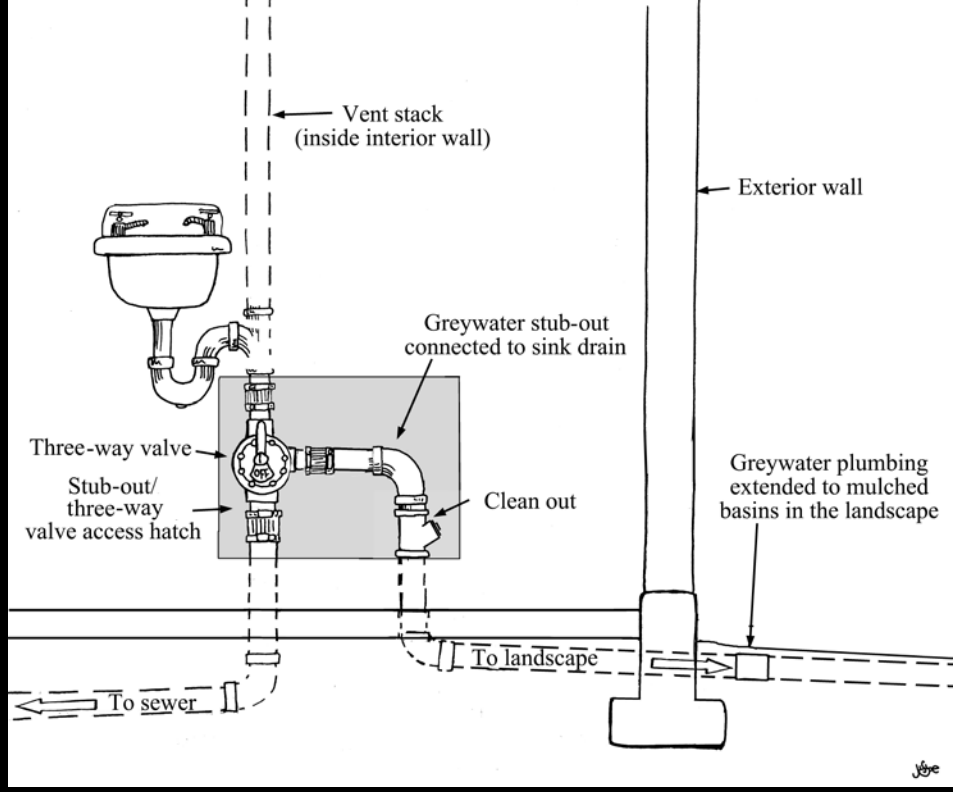
304 mm/year of rainfall on Tucson = 228,934,000,000 liters

Water consumed annually by residents of Tucson = 181,321,000,000 liters



Public urban water harvesting, Vine Street, Seattle, WA





Greywater stub out and 3-way valve

Tucson, Arizona, USA

1904

Watershed as a sponge

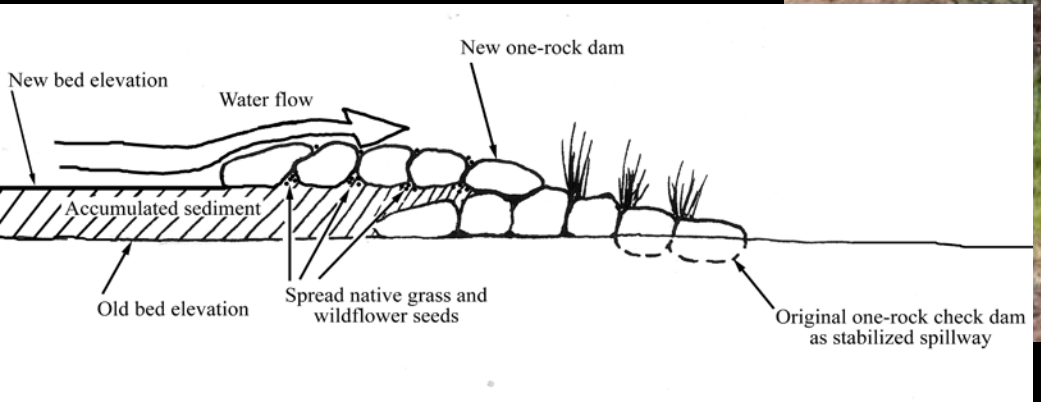
2007

Watershed as a drain

One-rock check dams - more appropriate where there is no bedrock

free publication on Education and Outreach/ publications page at:

www.QuiviraCoalition.org



Greywater compatible soaps
- no salt/sodium, no boron, no chlorine

Dr Murad Bino, Executive Director for the Islamic Network on Water Resources Development & Management developed a sodium-free soap in Jordan

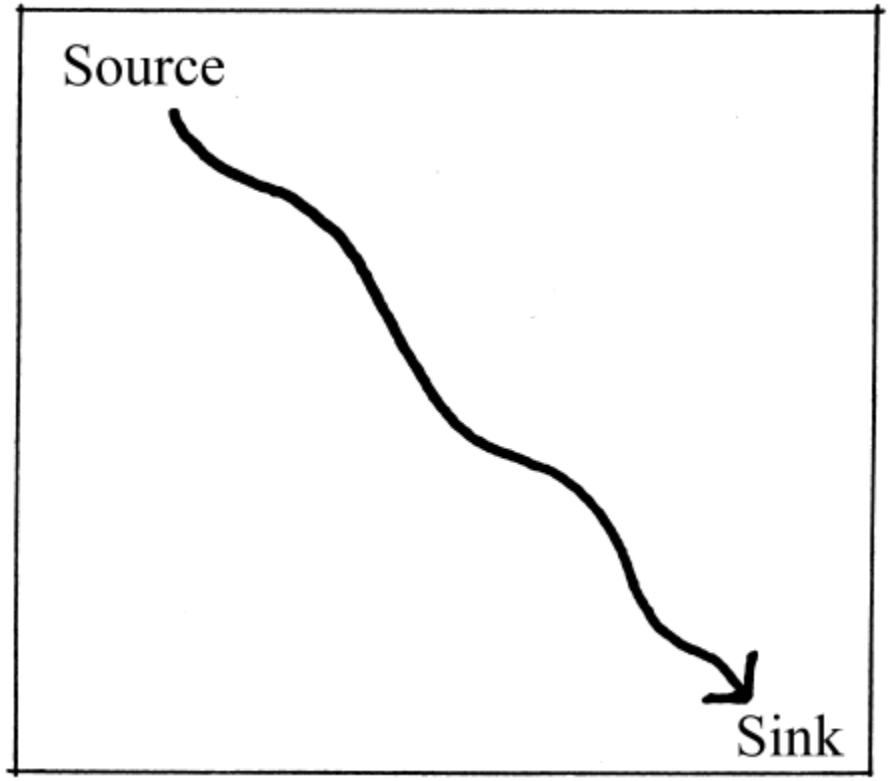
Eight Principles of Successful Water Harvesting

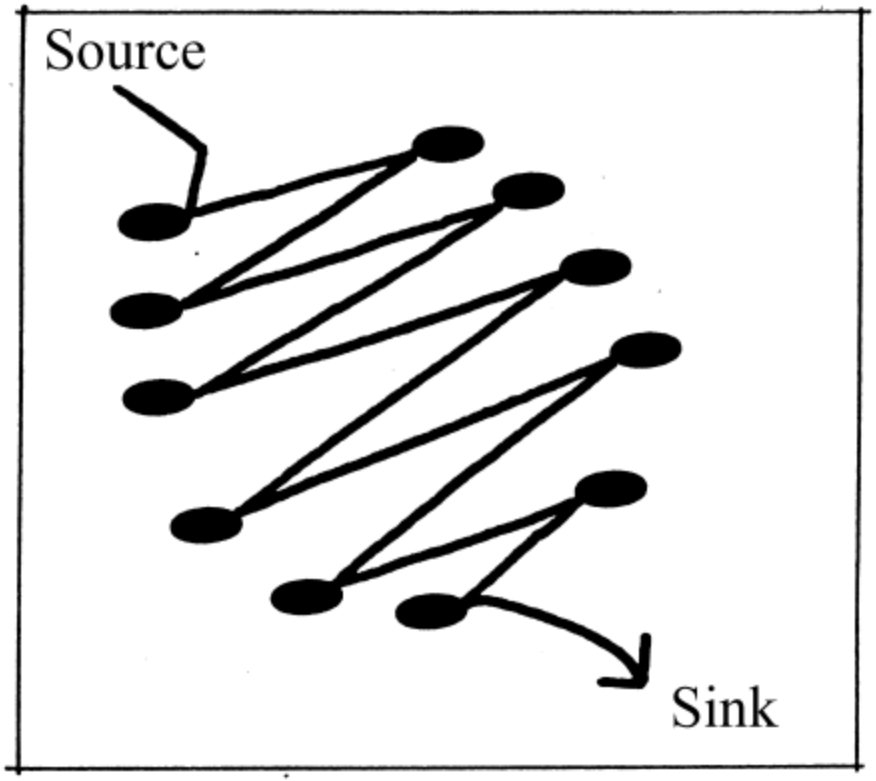
1. Long and thoughtful observation

2.Start at the top of the watershed and work your way down

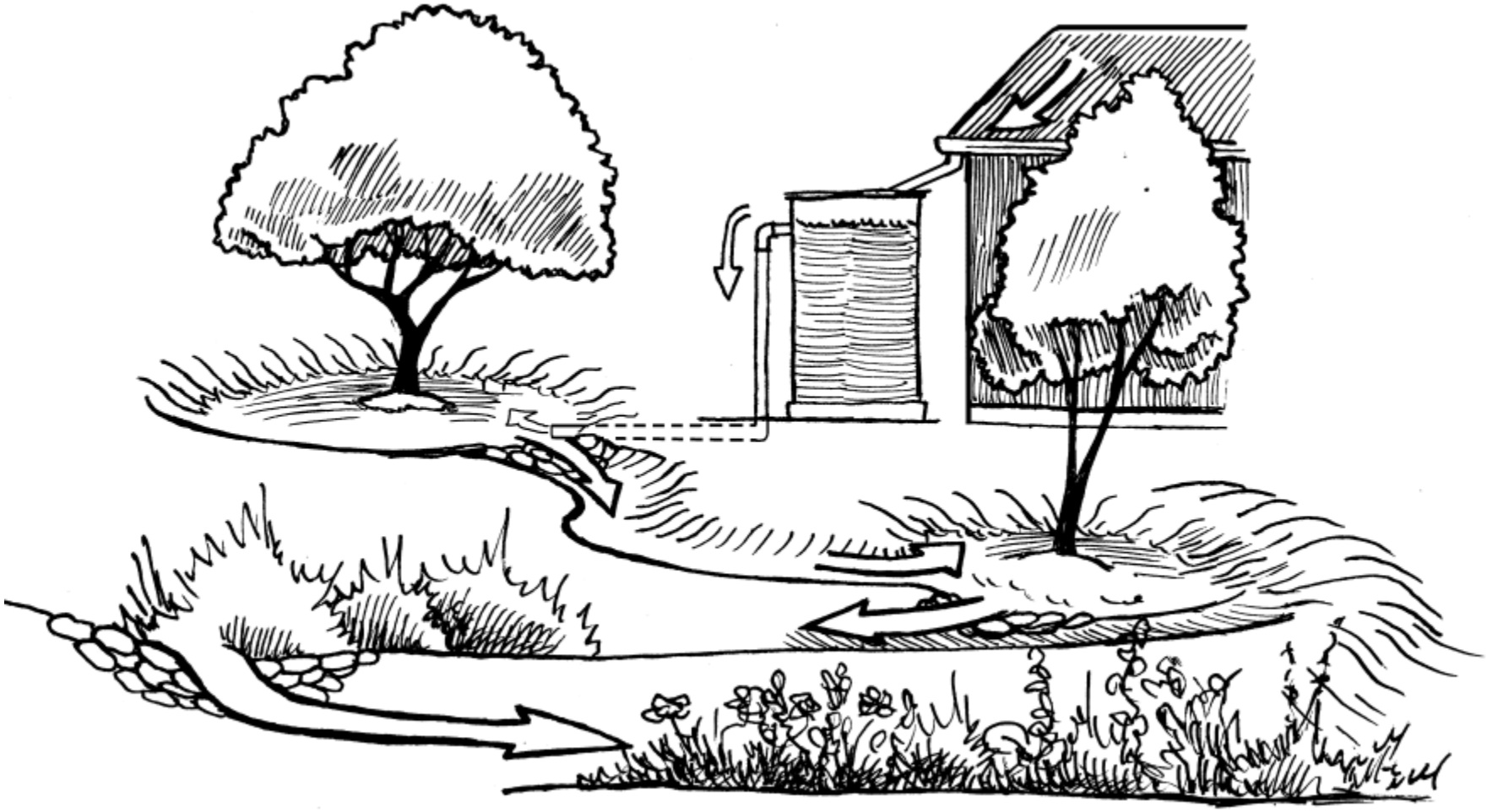
3. Start small and simple

4. Slow spread and infiltrate



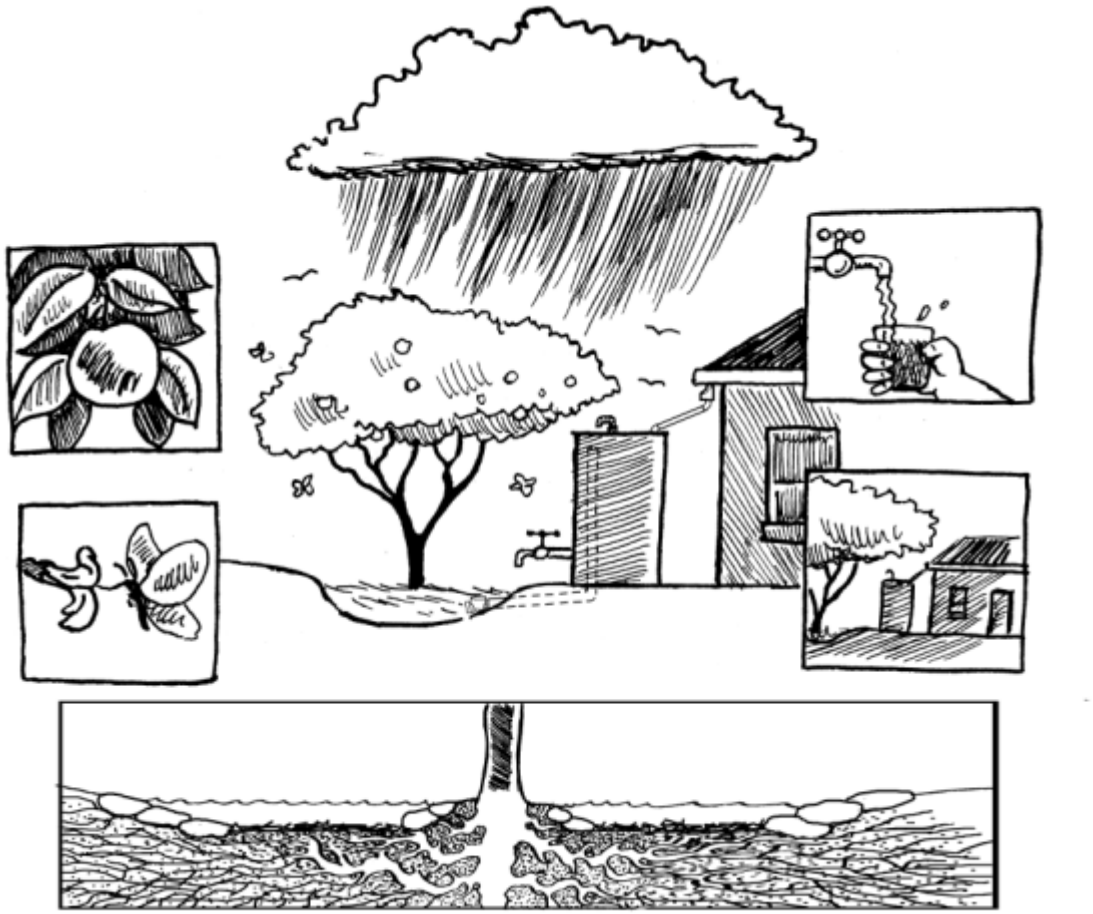


5. Always have an overflow and use it as a resource

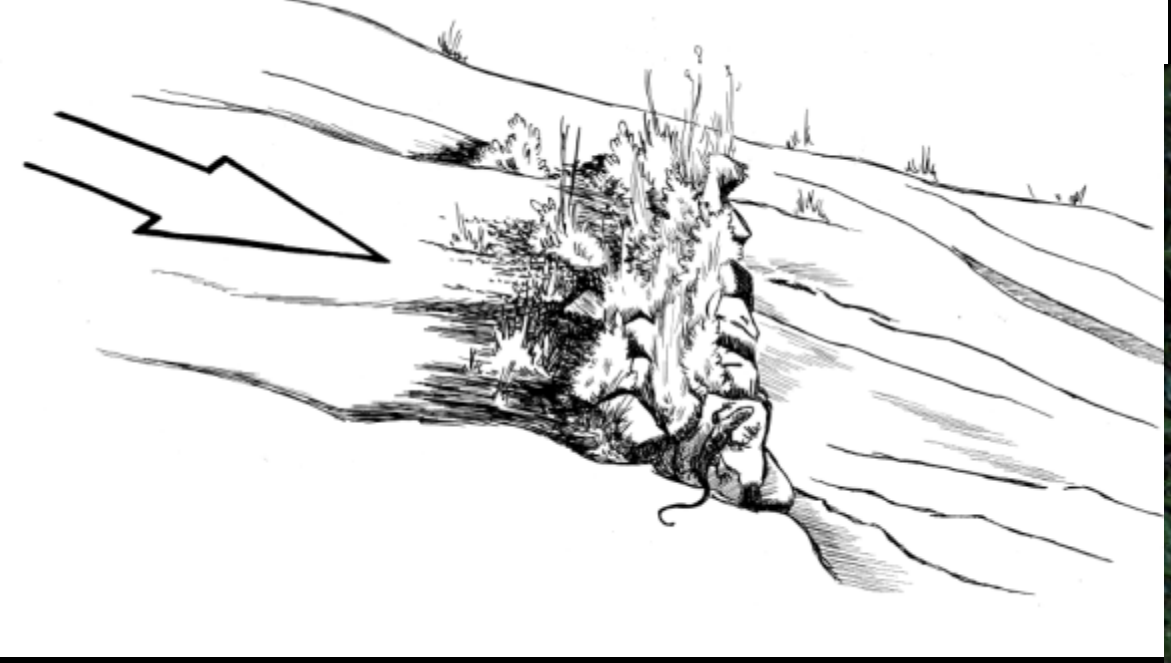


6. Maximize living and organic groundcover - the sponge

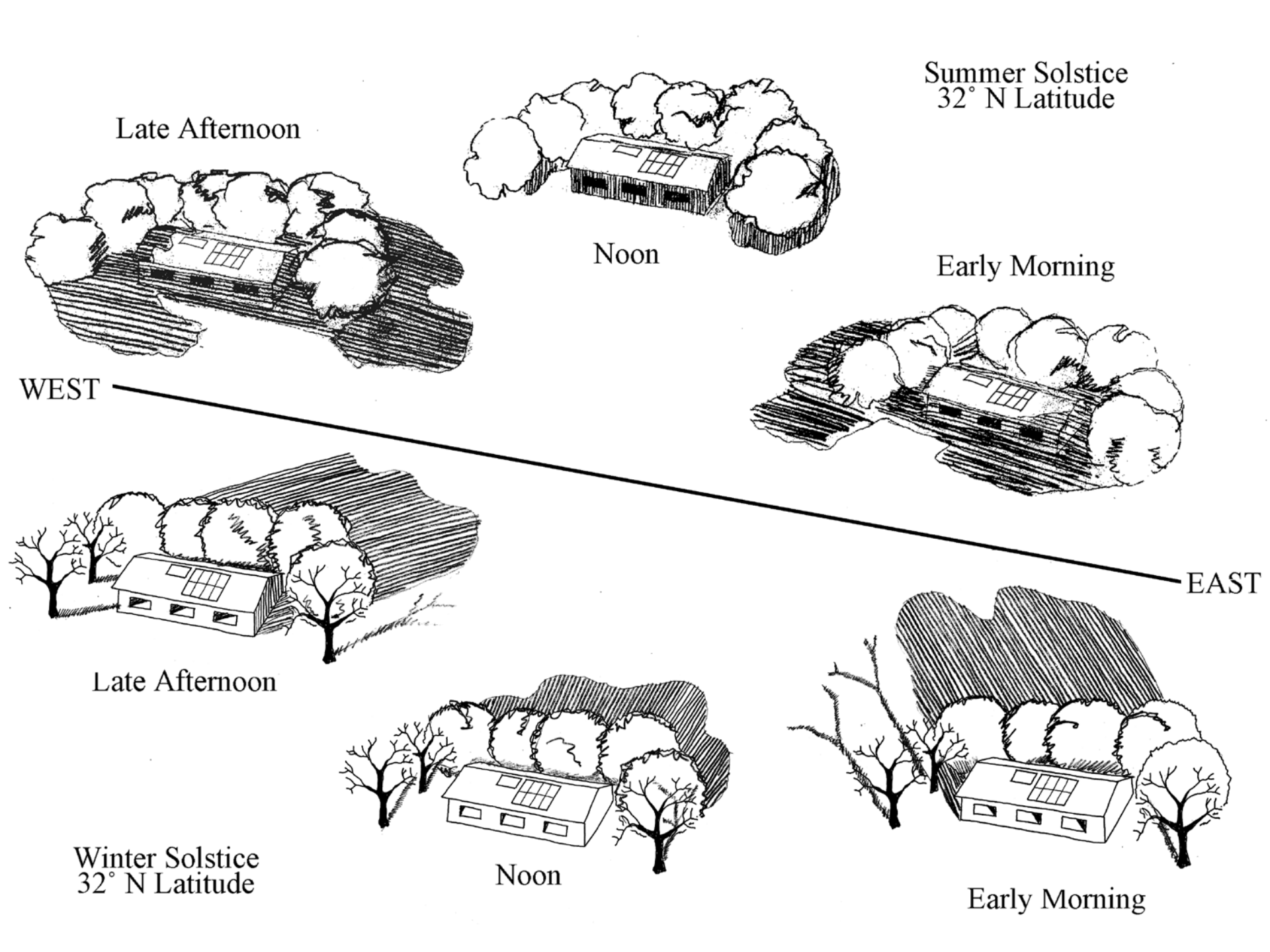
7. Maximize beneficial relationships and efficiency by “stacking functions”

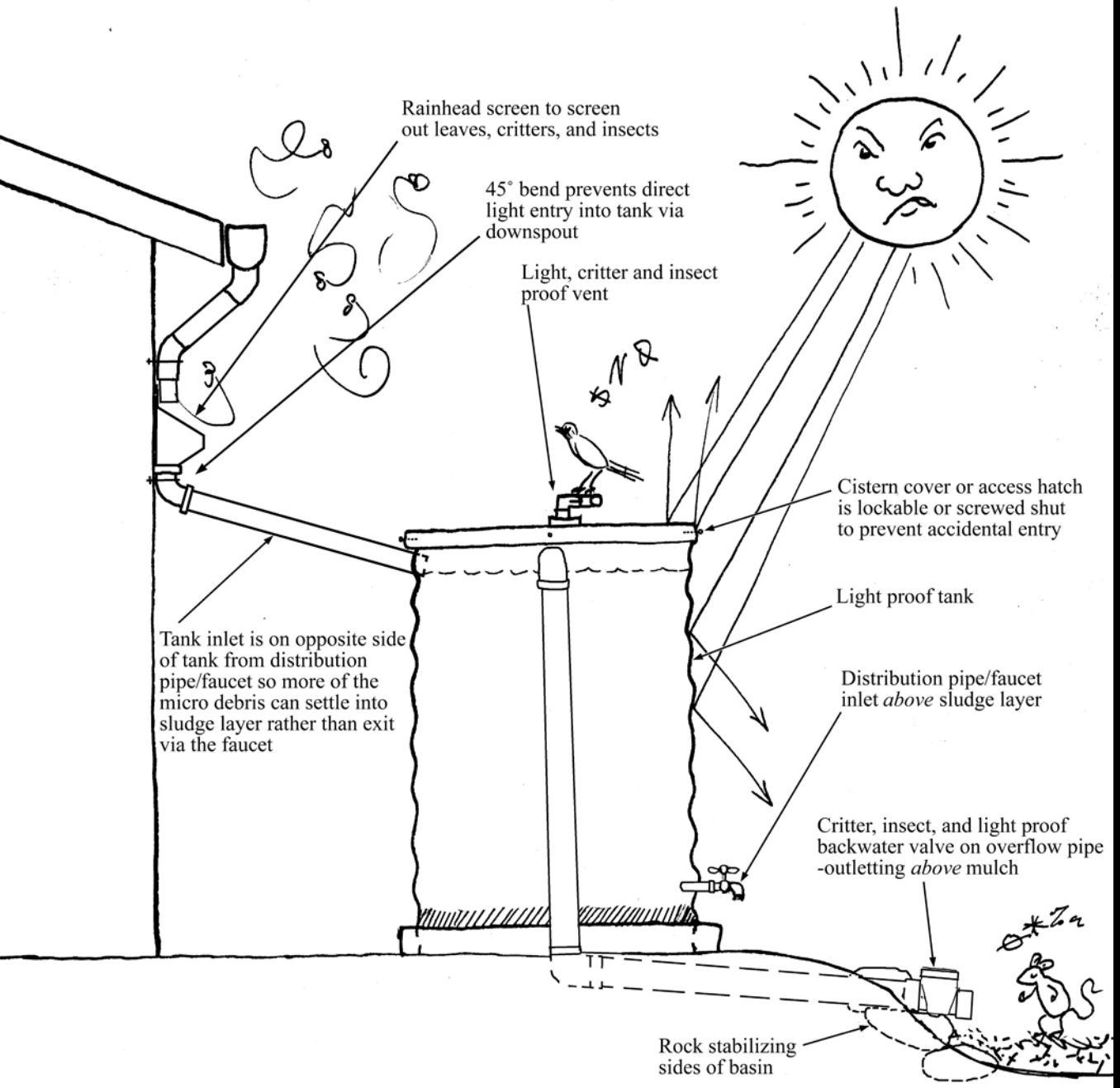


8. The feedback loop: long and thoughtful observation



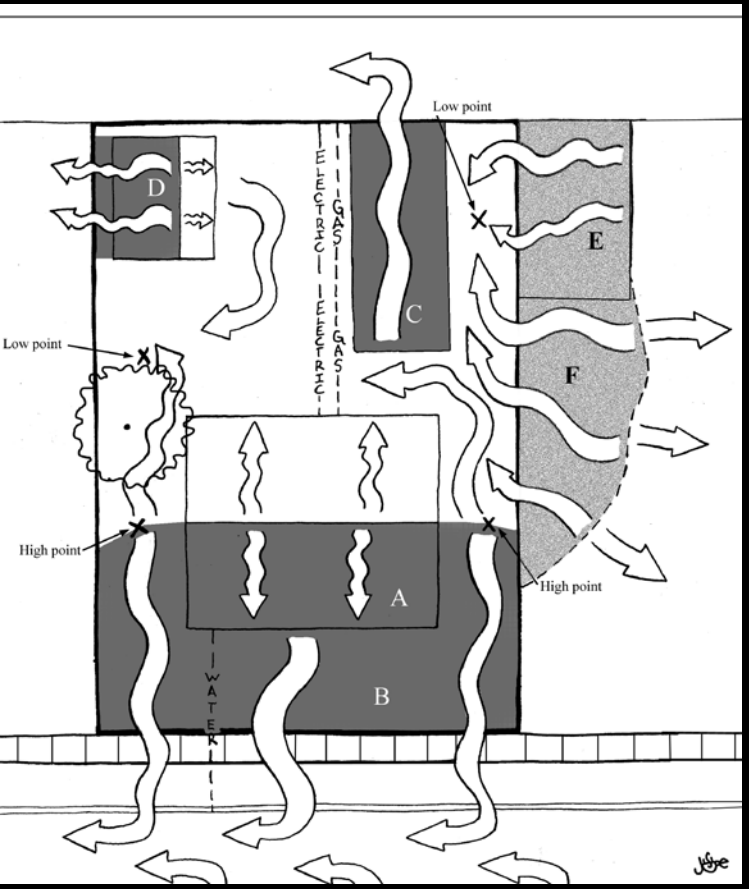
Zephaniah Phiri Maseko,
Zvishavane, Zimbabwe

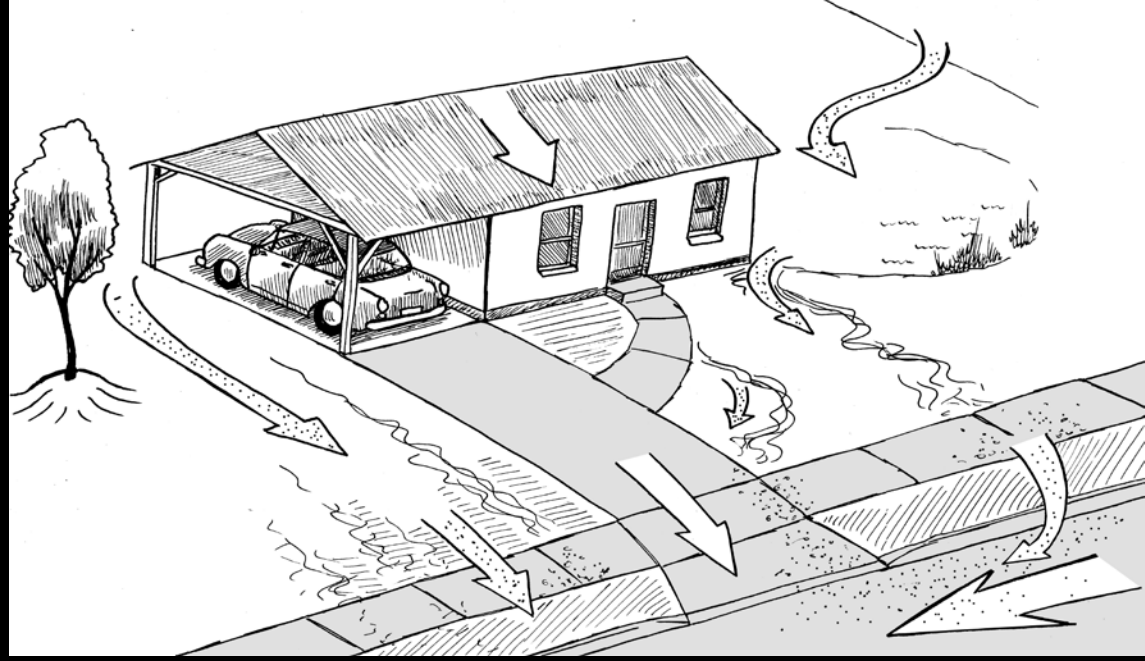

Summer Solstice
32˚ N Latitude
Late Afternoon
Noon
Early Morning
WEST
EAST
Late Afternoon
Noon
Early Morning
Winter Solstice
32˚ N Latitude



Leaf Eater Advanced rain head from RainHarvesting.com


NEW SEASONS





OceanFriendlyGardens.org

Living Building Challenge

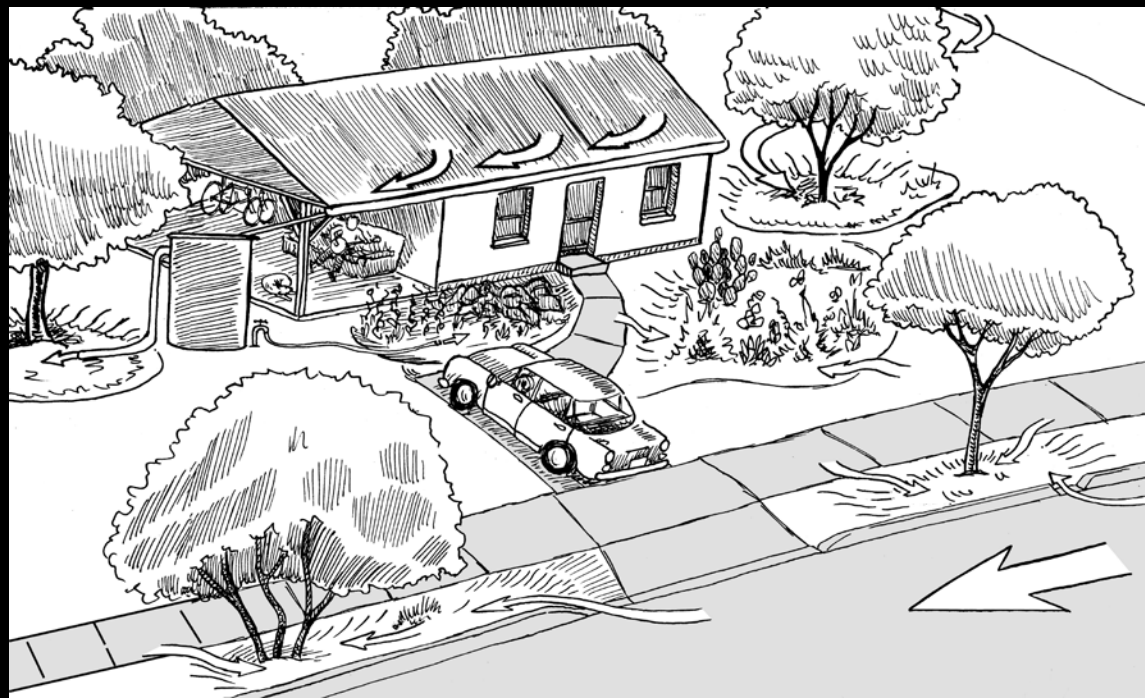


Fig. 132. Pomegranate tree in a 500-m² plot (1967).

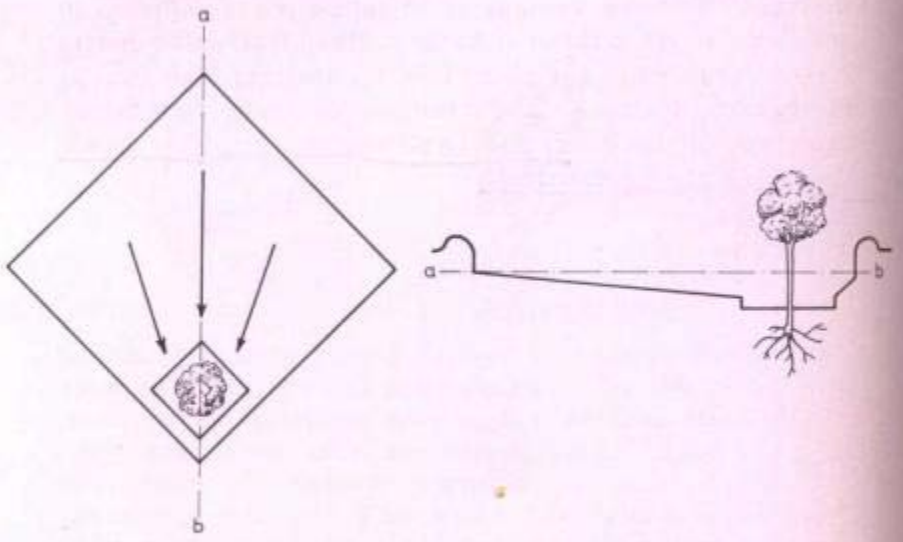


Fig. 131. Plan and cross section of a negarin plot. The arrows indicate the direction of runoff flow.

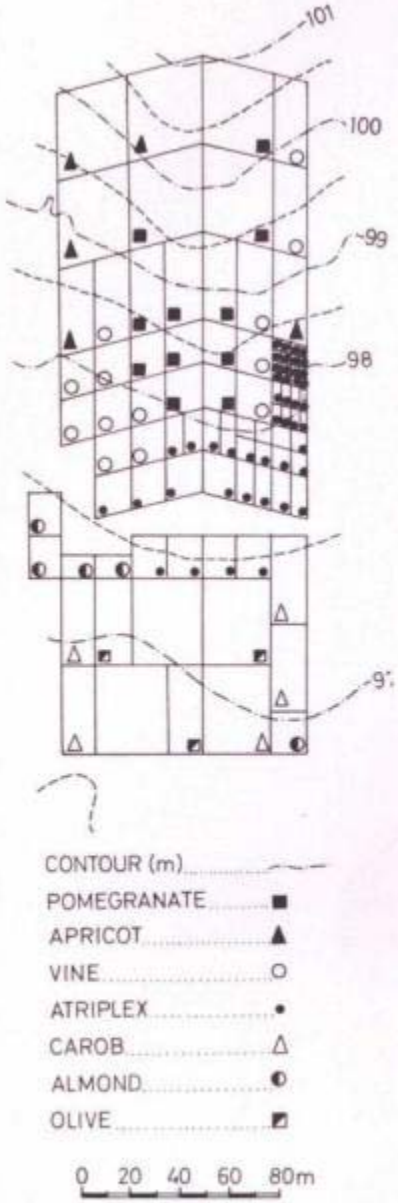
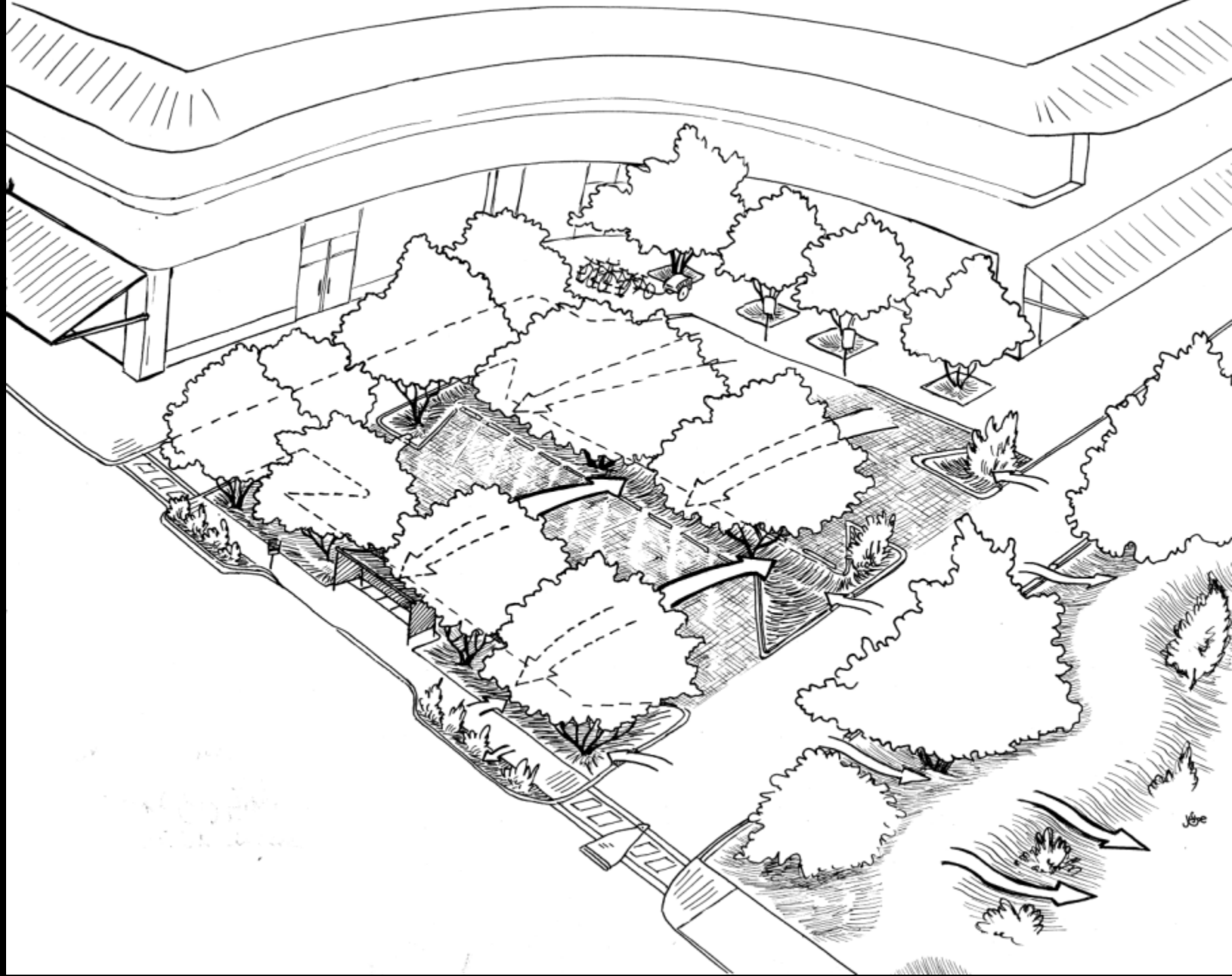


Fig. 130. Plan of negarin microcatchment plots; the largest are 1000 m² and the smallest 15.6 m² in area.

Urban drool harvesting, Los Angeles

Tujunga Wash Flood Control Channel between Vanowen Street and Oxnard Avenue, Los Angeles, CA


Tujunga Wash



Rainwater irrigated greenhouse
Paul Cross, Charybda Farms,
Arroyo Hondo, NM

Watergy - The Water / Energy Connection

42% of the energy consumed by the City of Tucson is used to pump and distribute water

(does not include additional energy consumed to get water from Colorado River to Tucson through CAP canal)

- Tucson City Energy Office 8-21-2009.

How to Estimate the Energy Embedded in Your Water Supplies

www.rivernetwork.org

Roman era cisterns of 10,500-gallon (40-m^3) capacity
northern Jordan

PATTERNS OF CLIMATE, WATER PER CAPITA, WATERGY, & SUN: AMMAN, JORDAN

CLIMATE

AVERAGE HIGH & LOW TEMPERATURES: 1976 - 2005 — Source: met.jometeo.gov.jo (note #1)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
°C HIGH	12.2	13.5	17.0	22.7	27.6	30.5	32.1	32.1	30.5	26.5	19.7	14.2	23.2
°C LOW	3.9	4.5	6.6	10.2	14.2	17.5	19.7	19.4	17.6	14.5	9.3	5.5	11.9
°F HIGH	54.0	56.3	62.6	72.9	81.7	86.9	89.8	89.8	86.9	79.7	67.5	57.6	73.8
°F LOW	39.0	40.1	43.9	50.4	57.6	63.5	67.5	66.9	63.7	58.1	48.7	41.9	53.4

HIGHEST TEMP ON RECORD: 44 °C / 111 °F — Source: mherrera.org/temp.htm

LOWEST TEMP ON RECORD: -6.5 °C / 20 °F

WATER PER CAPITA

AVERAGE RAINFALL: 1923 - 1990 — Source: www.worldclimate.com

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
mm	63.3	62.6	43.6	17.3	3.5	0.0	0.0	0.0	0.3	6.1	28.2	48.0	272.9
INCHES	2.49	2.46	1.72	0.68	0.14	0.00	0.00	0.00	0.01	0.24	1.11	1.89	10.74

WETTEST YEAR'S RAINFALL: 450.34 mm / 17.73 INCHES — Source: met.jometeo.gov.jo (note #2)

DRIEST YEAR'S RAINFALL: 98.0 mm / 3.86 INCHES

LONGEST PERIOD W/ NO MEASURABLE PRECIPITATION: — Source:

AREA: 1680 km² / 649 SQ MILES (Wikipedia)

POPULATION: 2,919,000 — Source/Year: Wikipedia / 2010

RAINFALL INCOME: 430 ℓpcd / 114 GPCD

WATERGY

Percentage of Jordan's total electricity consumption used to pump water in 2001[4]: 15.3%

Daily shortage in liters of city of Amman's water supply[5]: 90 million

# of avg Jordanian citizens whose kWh usage would be needed to desalinate that water[6]: 48,291

MUNICIPAL USE: 130 ℓpcd / 34 GPCD

Source/Year: see note #3

SUN

LATITUDE: 32 — Source: Google Earth

ELEVATION: 790 m / 2591 FT

WINTER-SOLSTICE SHADOW RATIO:* 1: 1.45

	ON MAR 21	ON JUN 21	ON SEP 21	ON DEC 21
^ DEGREES N or S of DUE E THE SUN RISES:	0	27N	0	27S
^ DEGREES N or S of DUE W THE SUN SETS:	0	27N	0	27S
B # of DEGREES SUN IS ABOVE THE SOUTHERN HORIZON AT NOON:	58	81	58	35

To find current magnetic declination for location: HarvestingRainwater.com/books/volume1/volume-1-resource-pages-appendix-6/#magdec

**Object height:length of shadow cast at solar noon (Dec 21's is longest noontime shadow of year). The ratio is 1:x, where x = 1/(tangent(90-(latitude+23.44))*

Notes: 1. Site accessed 27 Feb 2008 per Wikipedia // 2. Site accessed 2 April 2009 // 3. Individual share of water supply in Amman Governorate, per dos.gov.jo. Date not given. Site accessed 2 May 2011. // 4. *Electric Energy Access in Jordan, Lebanon and Syria*, Sami Karaki (American Univ of Beirut) et ali // 5. www.jordanembassyus.org/new-/lib/factsheets/environment.shtml#water // 6. Per Energy Recovery Inc (www.energyrecovery.com/tools/power_model.php4) reverse osmosis desalination consumes 2.33 kWh per cubic meter of water treated); per Karaki et ali, *annual* per capita kWh usage in Jordan in 2002 was 1585 kWh; 90,000x2.33x365=76,540,499, divided by 1585=48,291

A. Rainwater Harvesting for Drylands & Beyond, Vol 1, or www.esrl.noaa.gov/gmd/grad/solcalc/ // B. RWHDB Vol 1, or Mar 21 =90–latitude, Jun 21 =90–(lat–23.44), Sep 21 =90–lat, Dec 21 =90–(lat+23.44)

Available online at: www.harvestingrainwater.com/watergy-climate/water-conservation-and-climate-overview-data-sheets/