GROUNDWATER PUMPING EFFECTS ON NATIVE VEGETATION IN OWENS VALLEY

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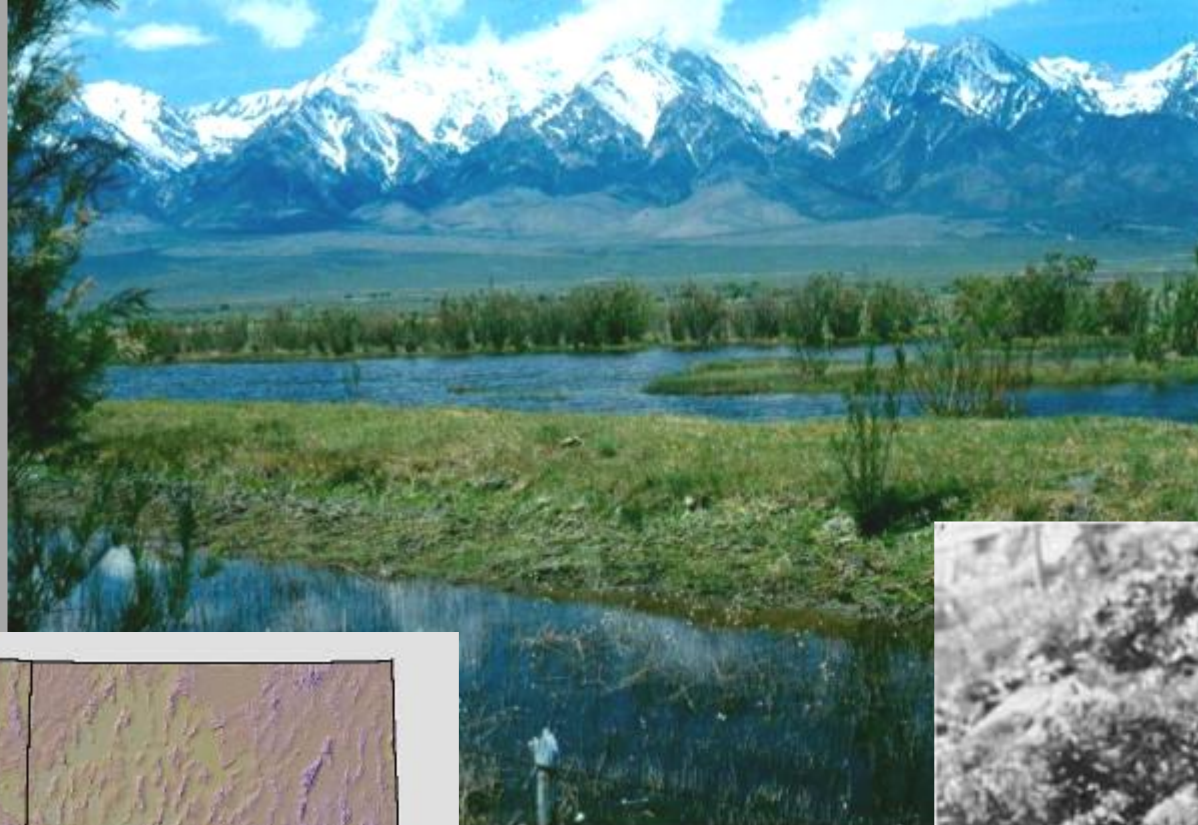
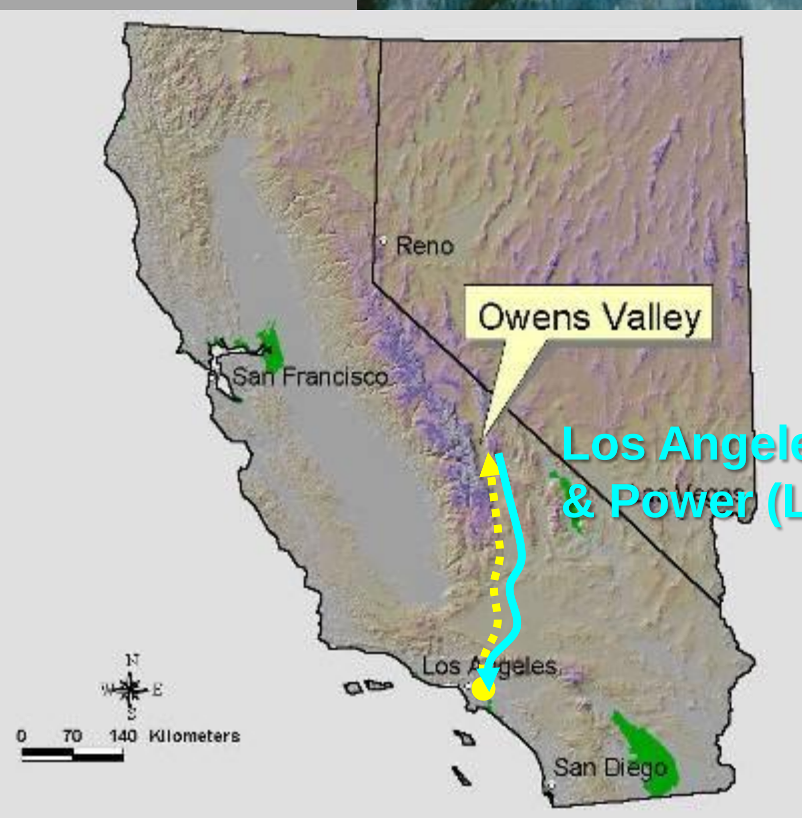
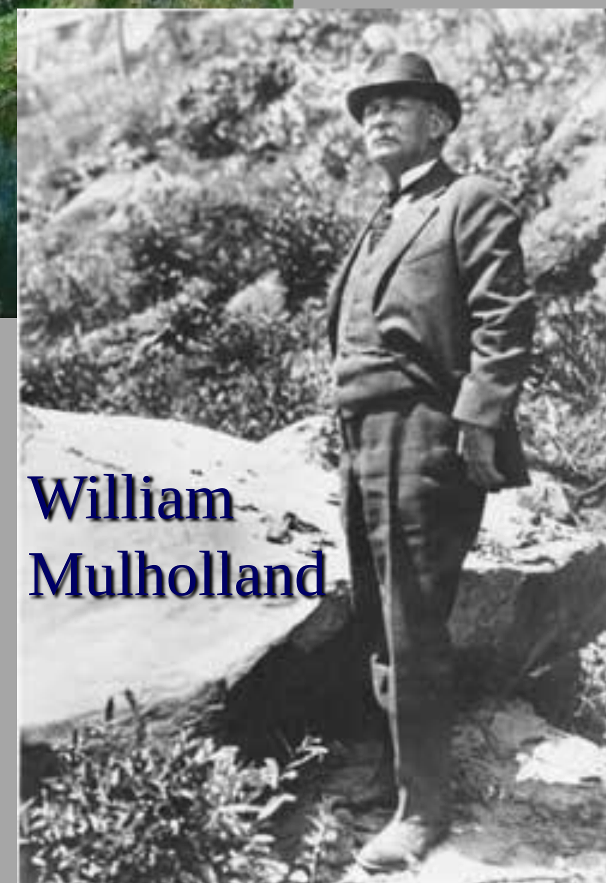
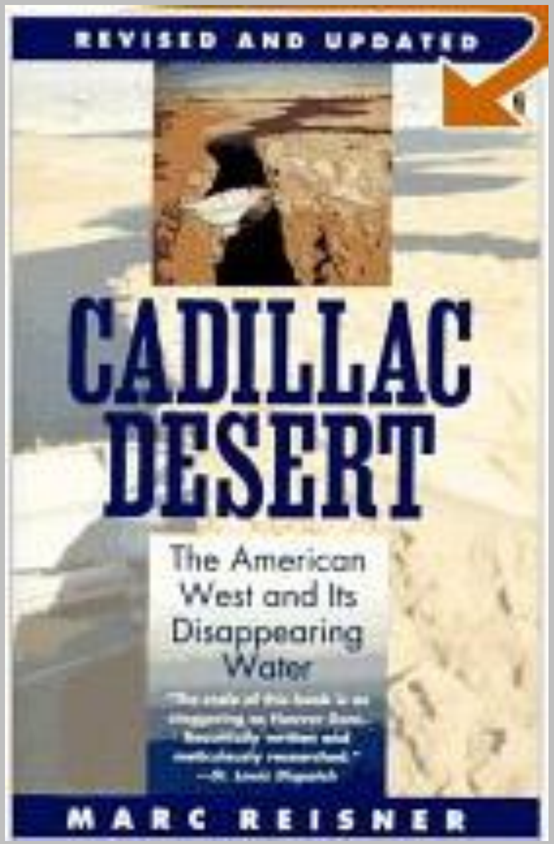


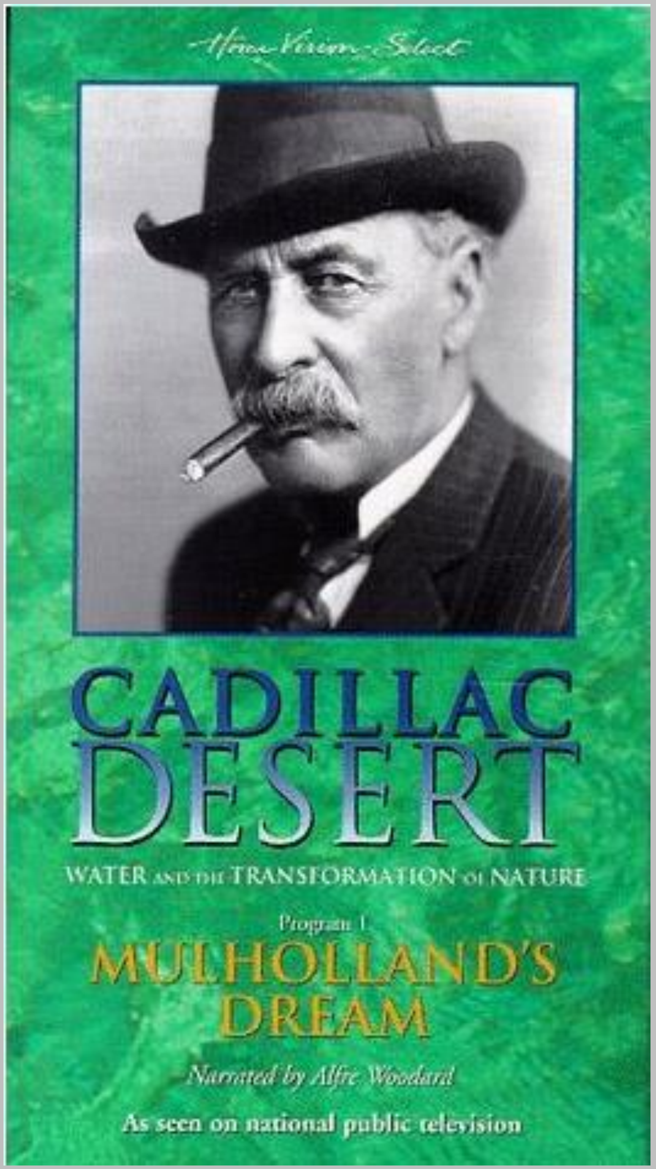


Los Angeles Dept. of Water & Power (LADWP) Aqueduct

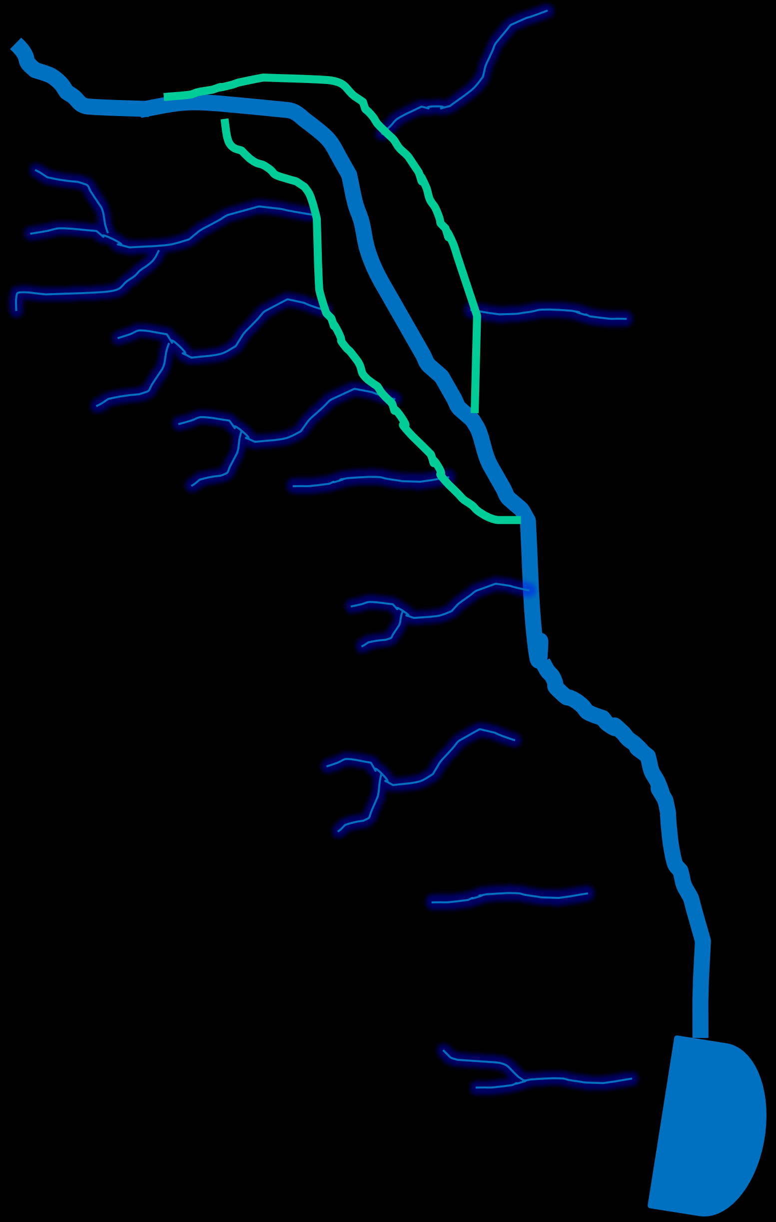


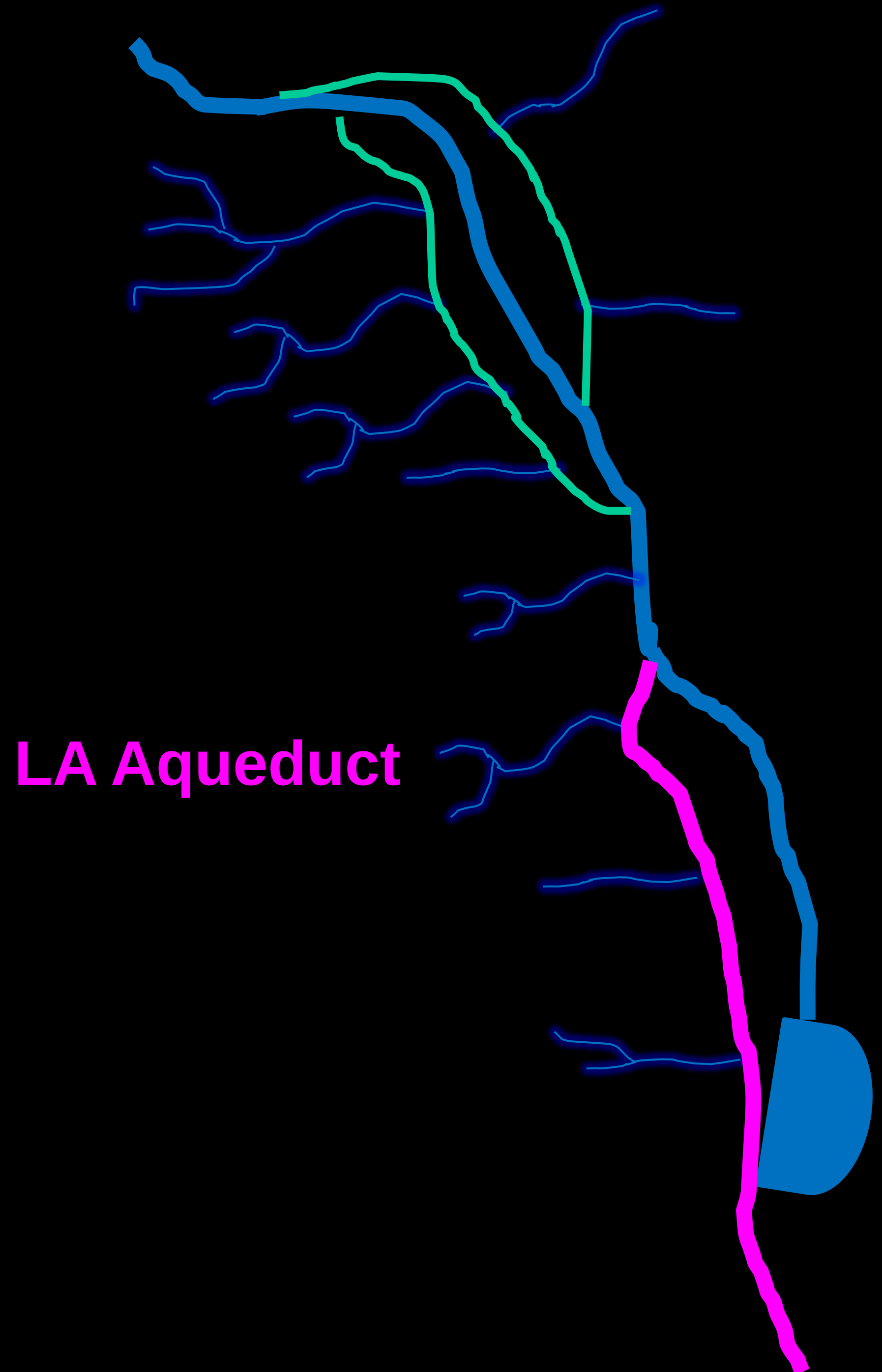
William Mulholland

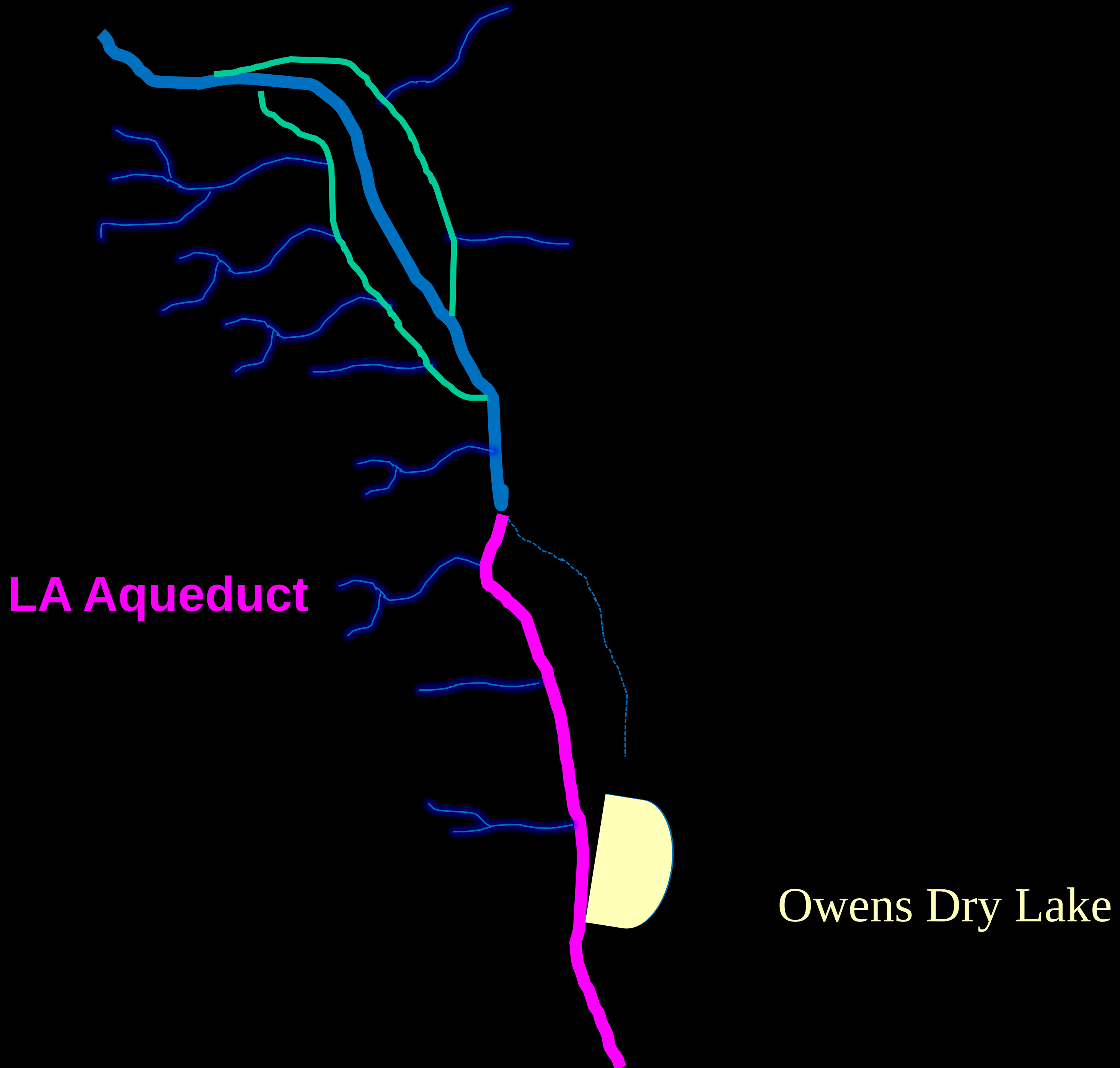

REVISED AND UPDATED
CADILLAC DESERT
The American West and Its Disappearing Water
MARC REISNER


Home Vision Select
CADILLAC DESERT
WATER AND THE TRANSFORMATION OF NATURE
Program 1
MULHOLLAND'S DREAM
Narrated by Alfre Woodard
As seen on national public television


Daniel Pritchett
June 10, 2006




LA Aqueduct


LA Aqueduct
Owens Dry Lake

Owens Valley is in the
GREAT BASIN

No Outlet to the Sea

-Low Precipitation
5 ½ inches
¾ in winter
-Cold Winters
-Hot Summers

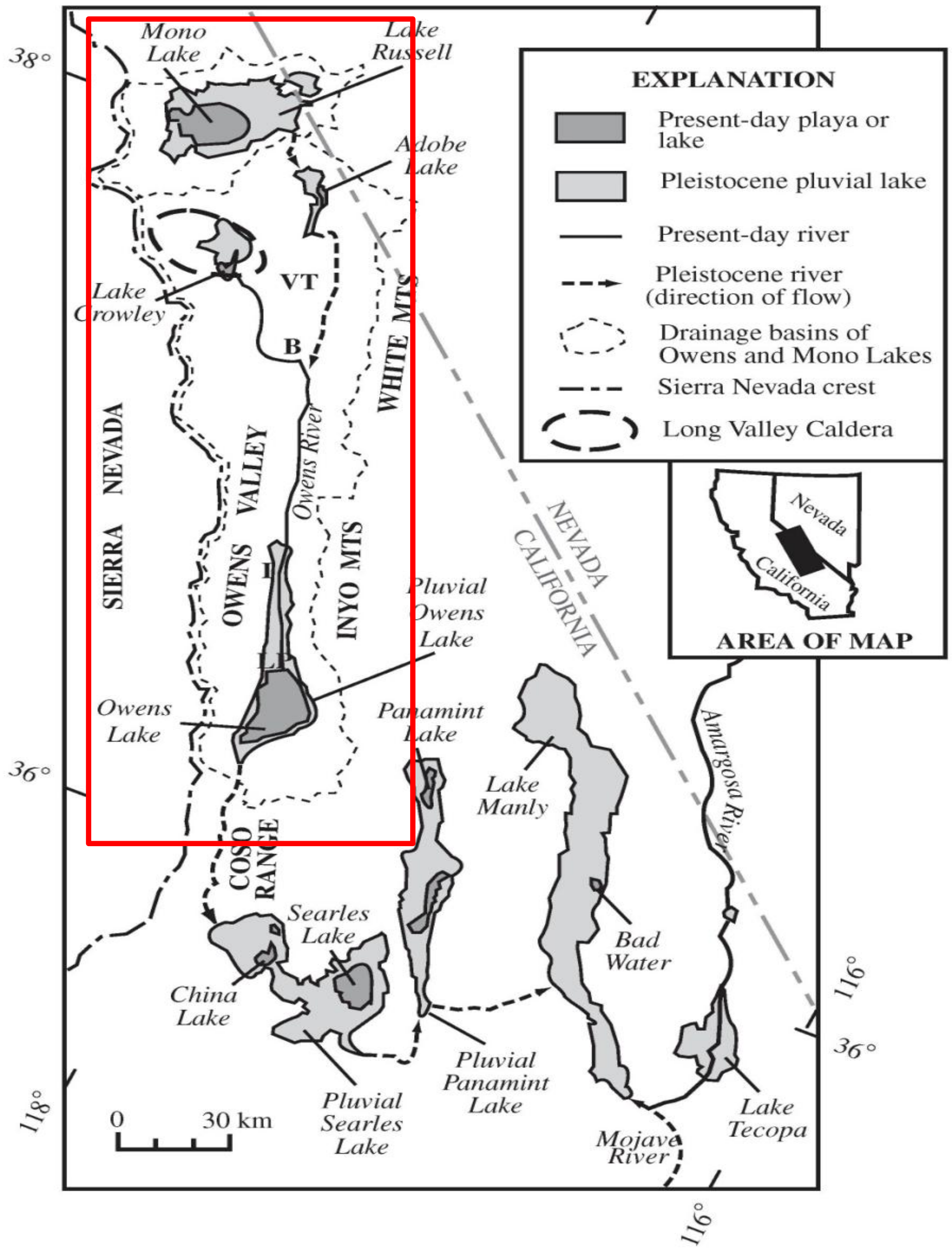
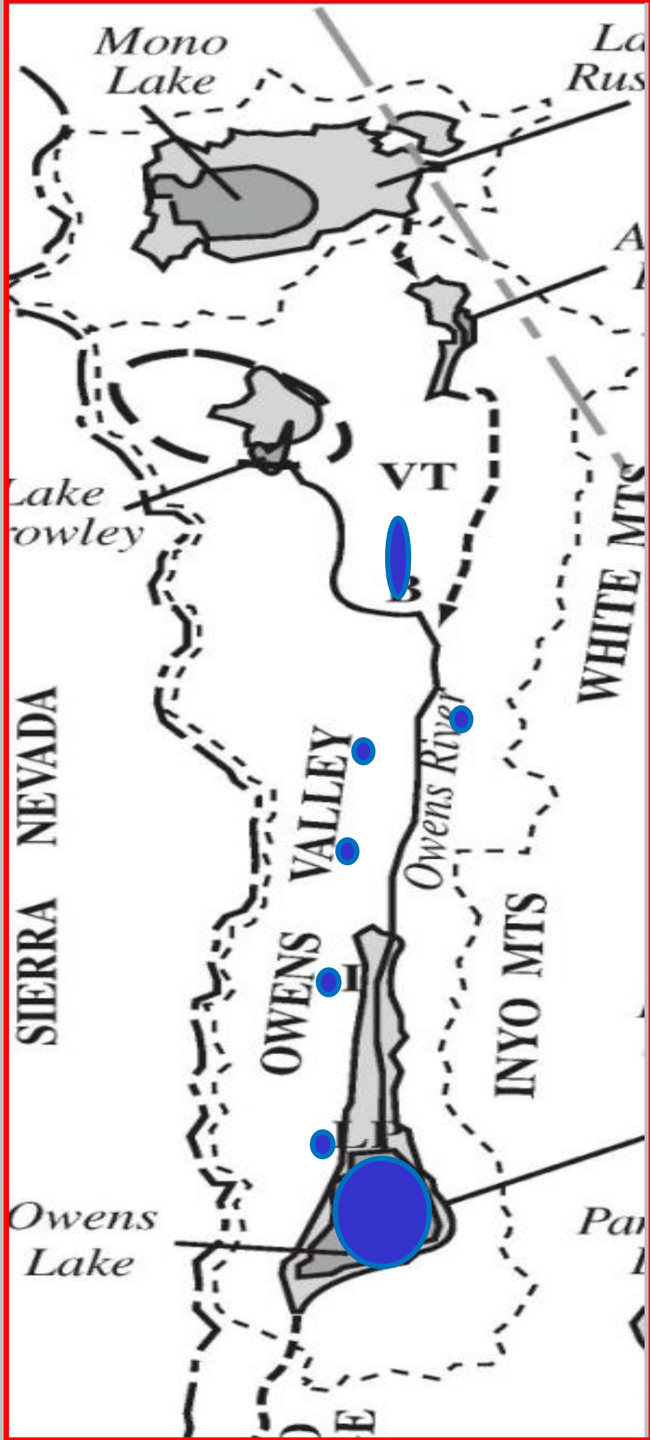
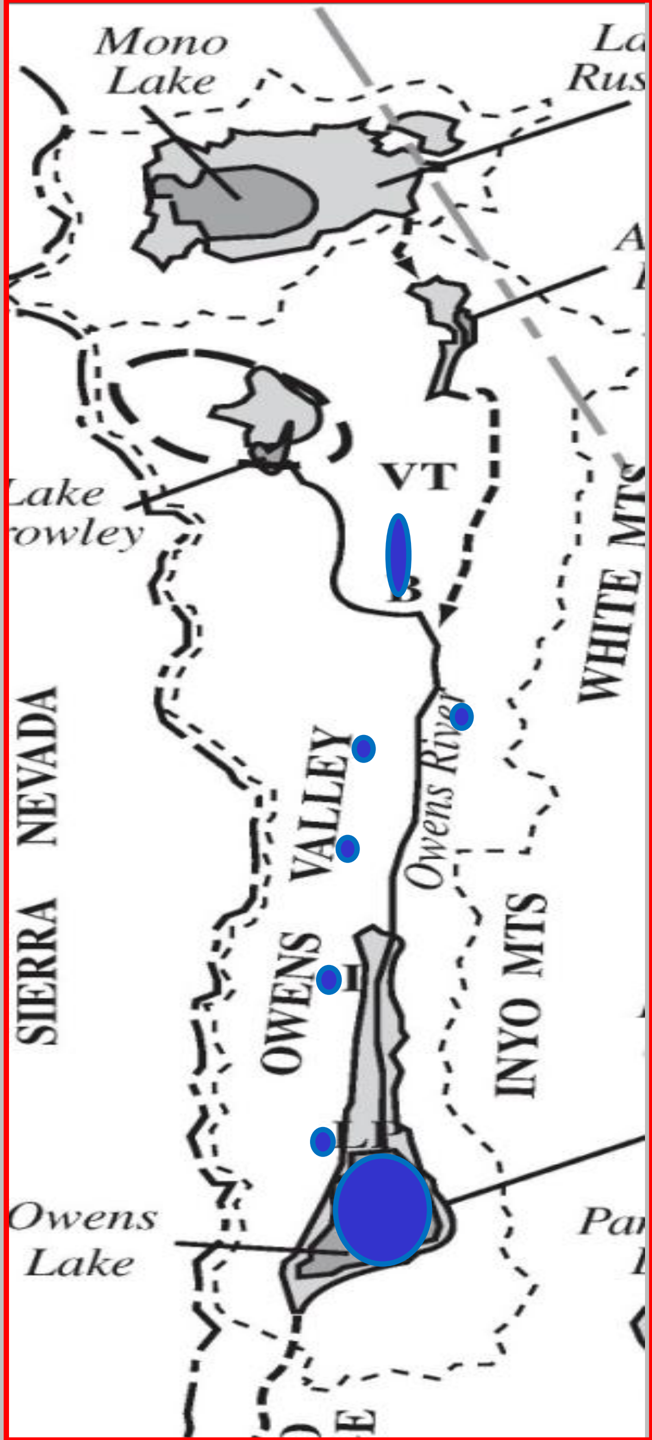


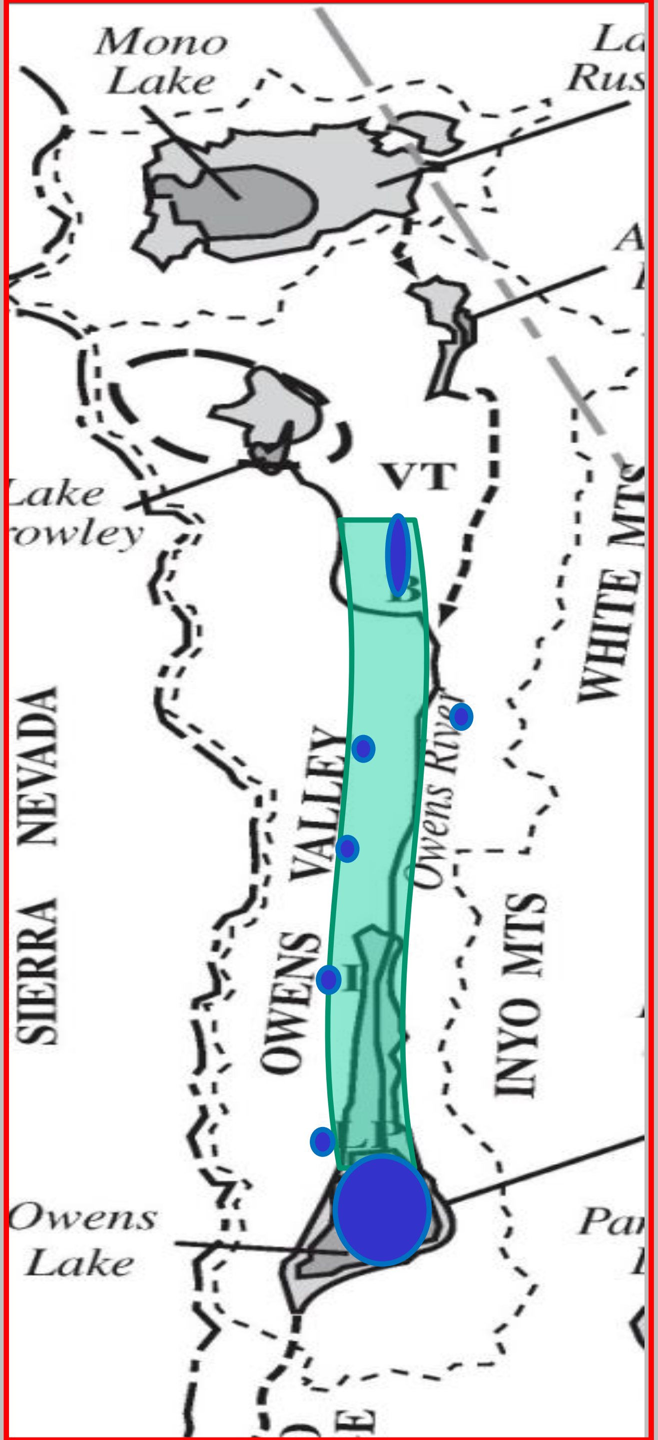
Fig. 1. Map of present day and pluvial Owens Lake, and other lakes hydrologically connected upstream and downstream from it during pluvial periods of the Pleistocene. B, Bishop; I, Independence; LP, Lone Pine; VT, Volcanic Tableland (figure modified from Smith and Bischoff (1997)).



Mono Lake
VT
B
SIERRA NEVADA
OWENS VALLEY
Owens River
WHITE MTS
INYO MTS
OWENS
LP
Owens Lake

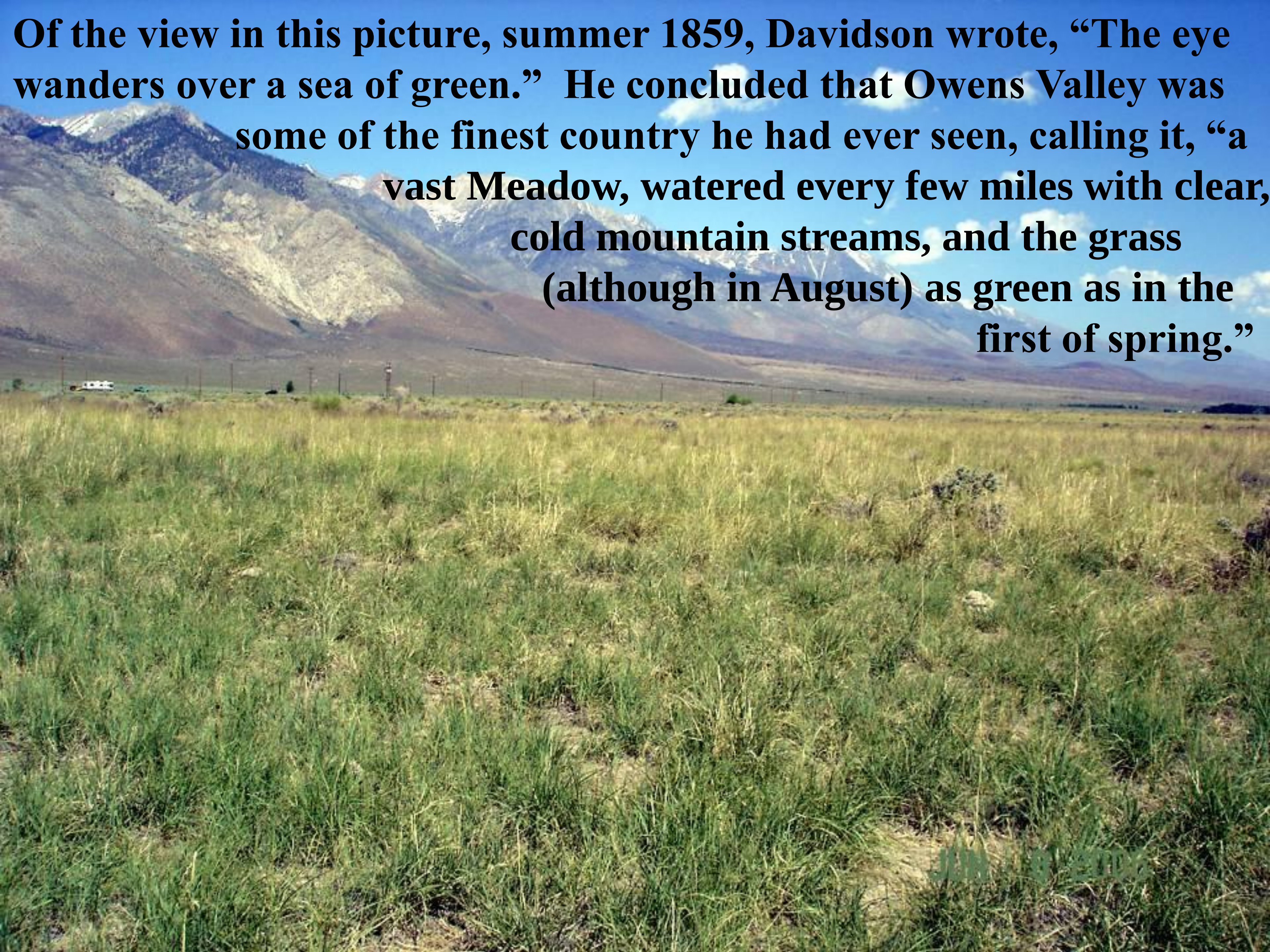


Wet Places = REFUGIA



Wet Places = REFUGIA

Alkali Meadow


Of the view in this picture, summer 1859, Davidson wrote, “The eye wanders over a sea of green.” He concluded that Owens Valley was some of the finest country he had ever seen, calling it, “a vast Meadow, watered every few miles with clear, cold mountain streams, and the grass (although in August) as green as in the first of spring.”


JUL 14 2006

Dominant Grass Species

Sporobolus airoides, **alkali sacaton**

Distichlis spicata, saltgrass


Calochortus excavatus
candidate for listing

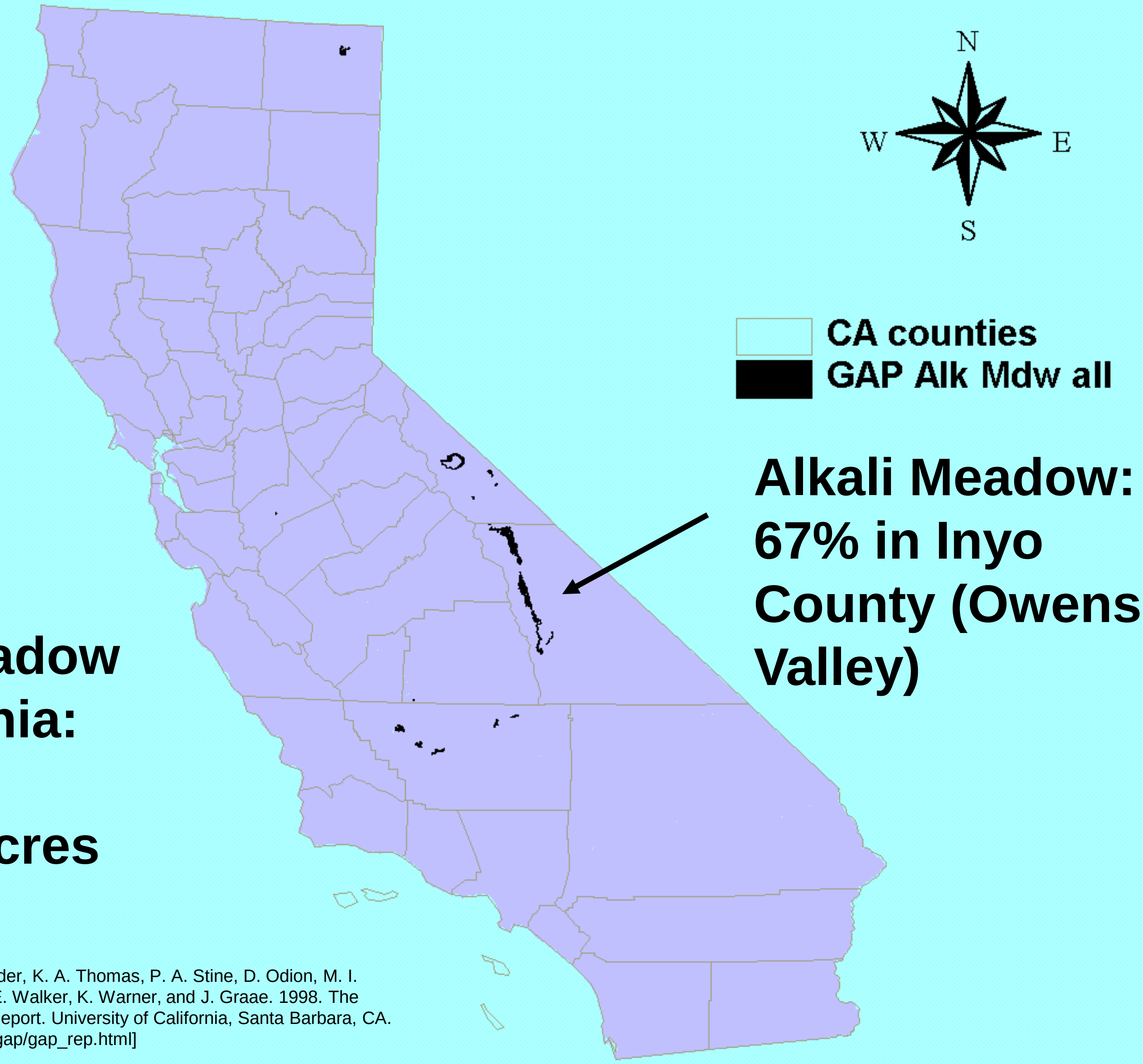

Sidalcea covillei
state listed

Also Habitat for Other Species

Western Meadowlark, nesting
Sturnella neglecta

"Owens Valley" vole, an endemic
Microtus californicus ssp. *vallicola*

Other California Species of Concern,
birds, invertebrates, plants



Alkali Meadow: 67% in Inyo County (Owens Valley)

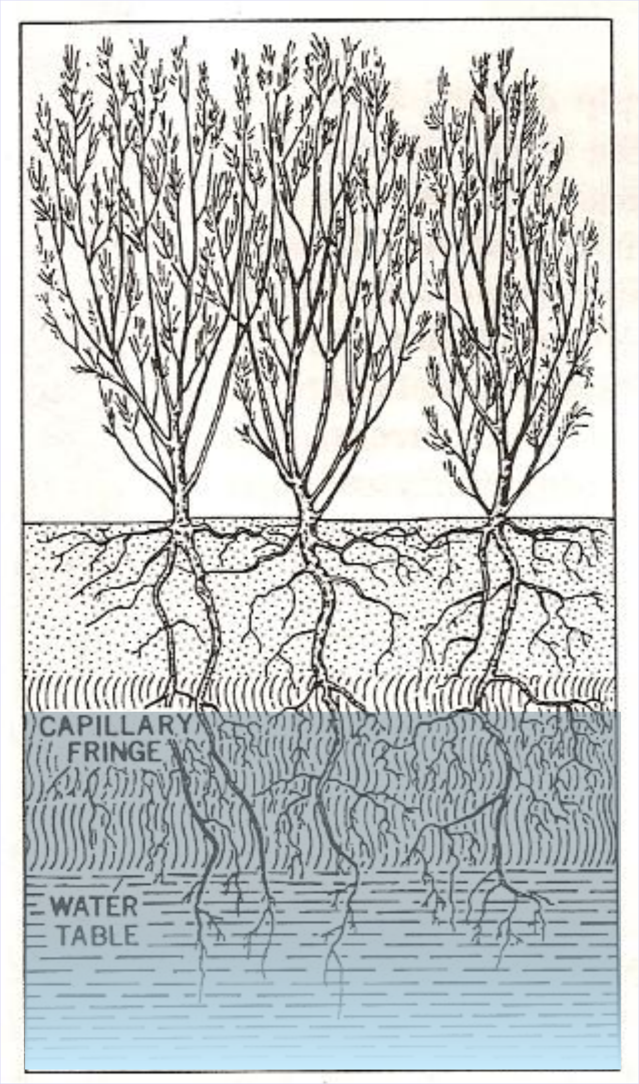
Alkali Meadow in California: 61,114 ha 150,900 acres

Davis, F. W., D. M. Stoms, A. D. Hollander, K. A. Thomas, P. A. Stine, D. Odion, M. I. Borchert, J. H. Thorne, M. V. Gray, R. E. Walker, K. Warner, and J. Graae. 1998. The California Gap Analysis Project--Final Report. University of California, Santa Barbara, CA. [http://www.biogeog.ucsb.edu/projects/gap/gap_rep.html]

Shallow Groundwater

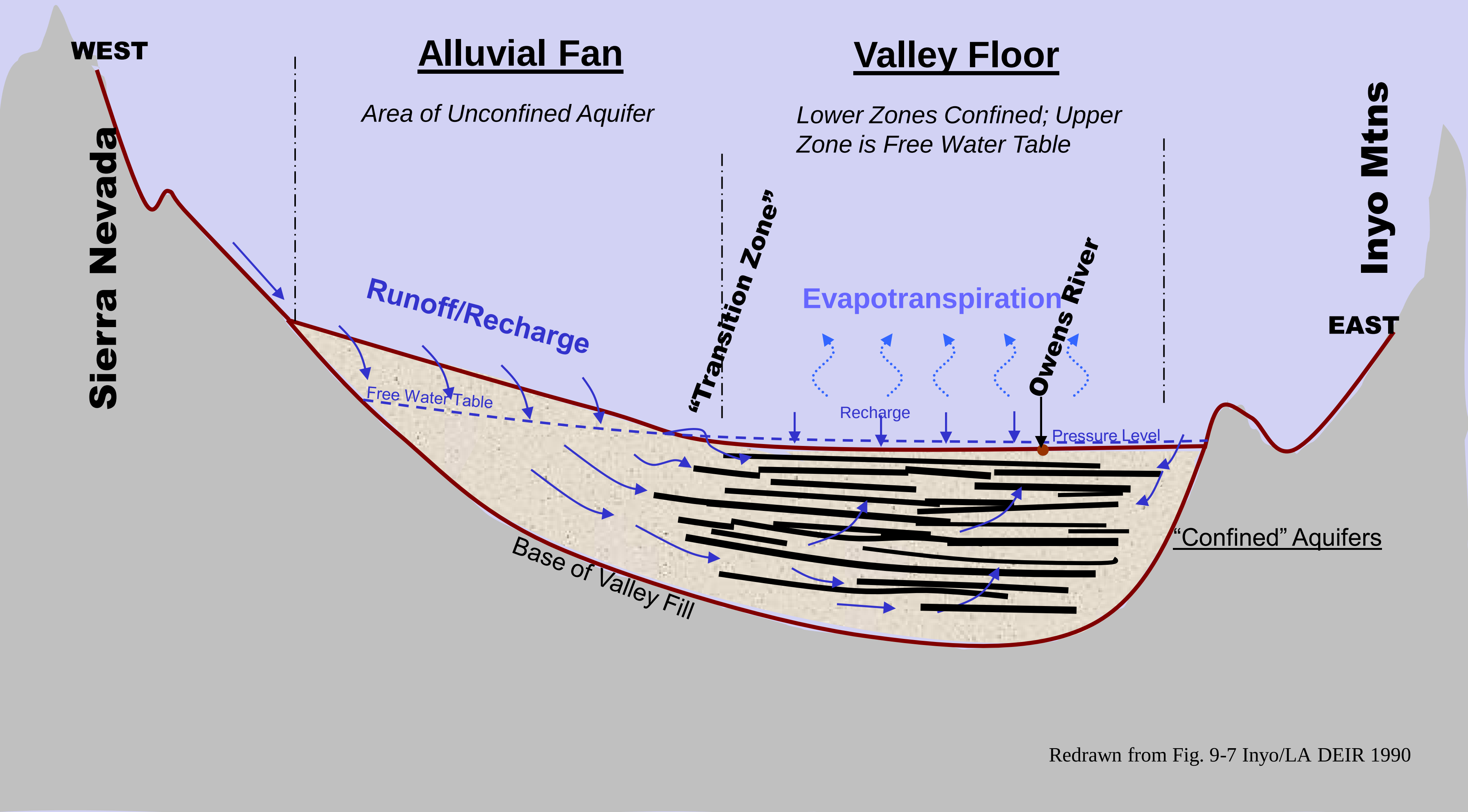
Roots of meadow plants tap into shallow groundwater. Our meadow grasses grow roots down to ~2m (~8ft)

Plants that tap groundwater are known as *phreatophytes* (“well plants”).



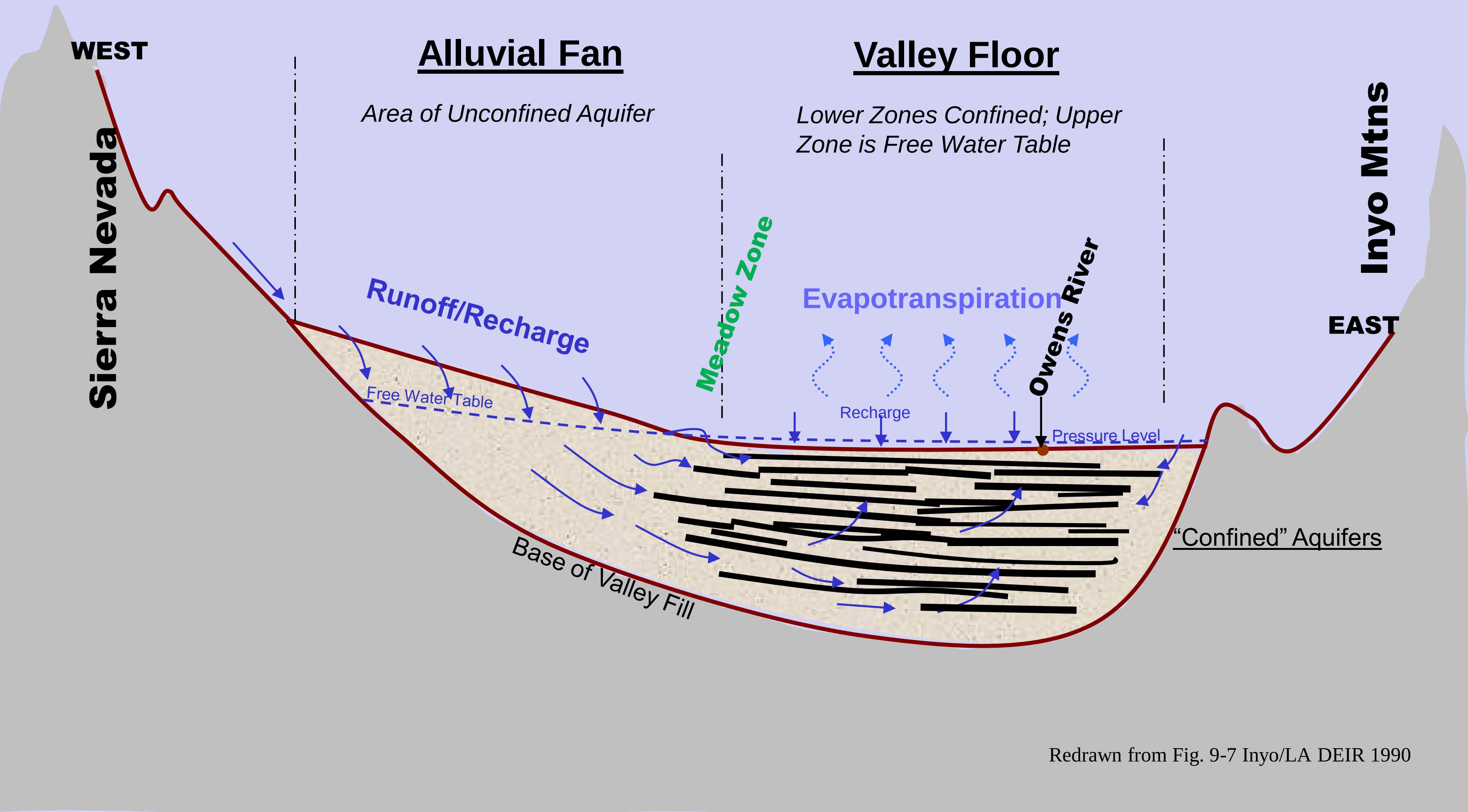
from Robinson, T.W. 1958. Phreatophytes. USGS Water Supply Paper 1423, pg. 10

Conceptual Illustration of Owens Valley Aquifer System



Redrawn from Fig. 9-7 Inyo/LA DEIR 1990

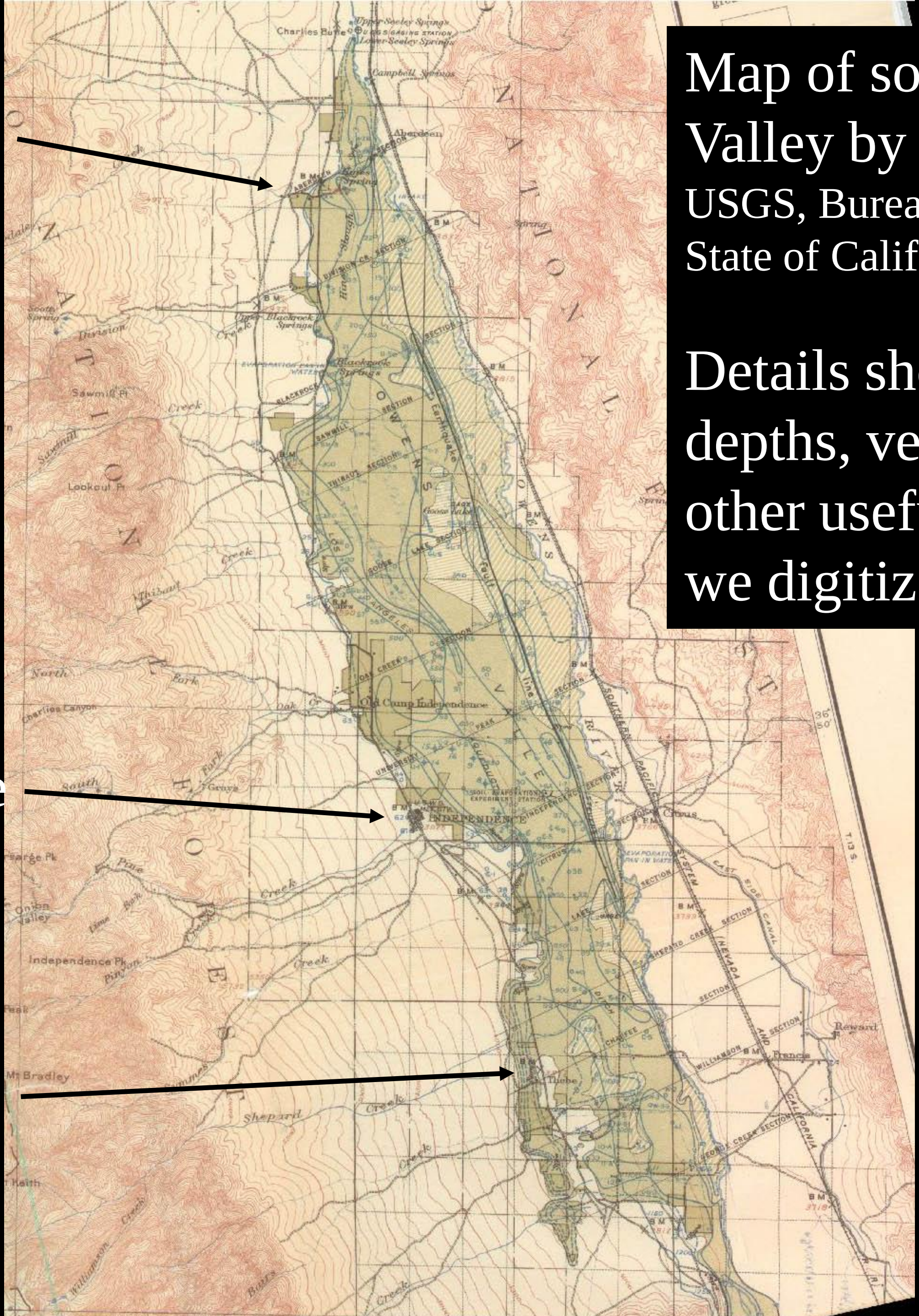
Conceptual Illustration of Owens Valley Aquifer System



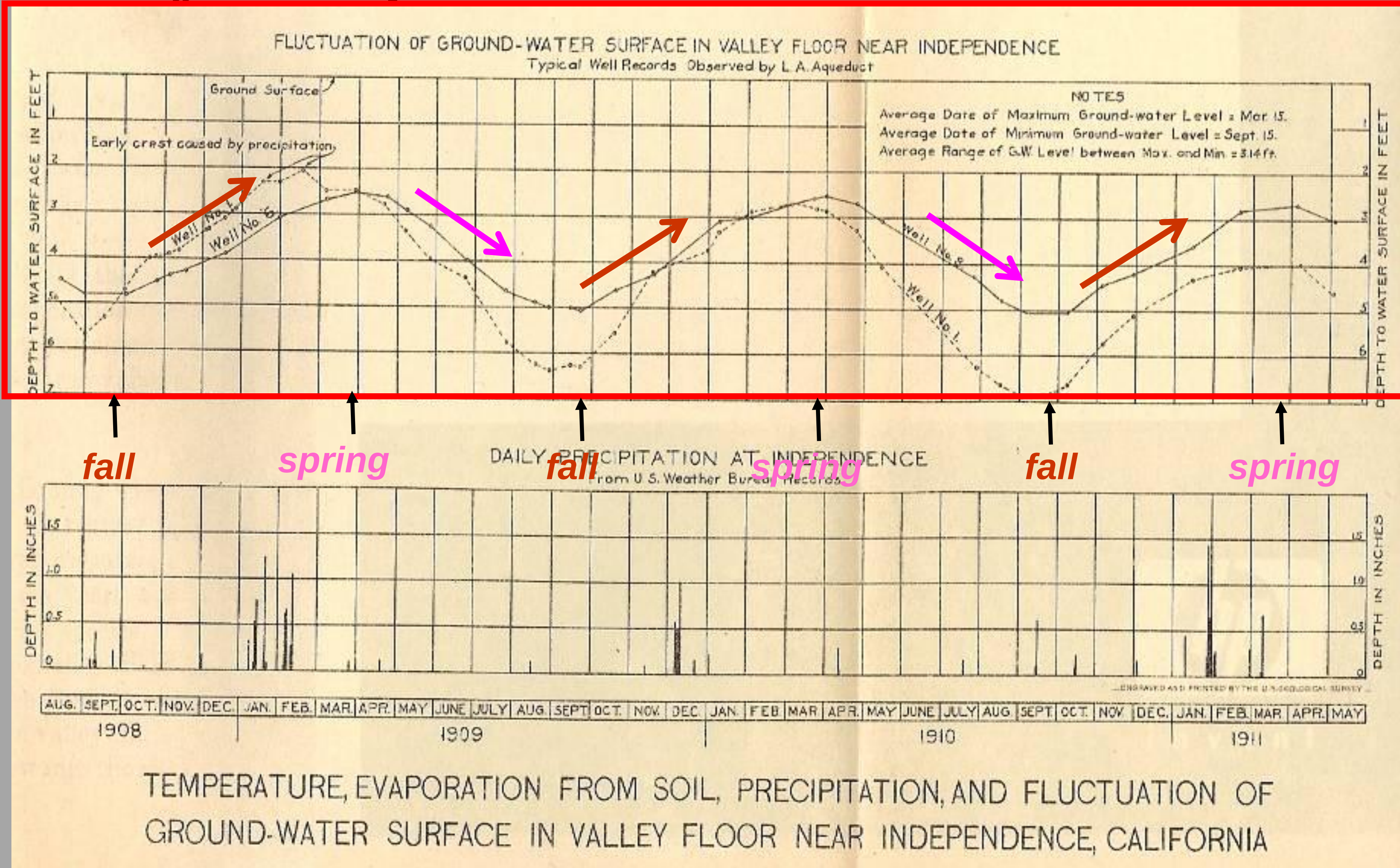
Redrawn from Fig. 9-7 Inyo/LA DEIR 1990

Map of southern Owens Valley by C. H. Lee, 1912.
USGS, Bureau of LA Aqueduct, and State of California.

Details show groundwater depths, vegetation types, and other useful features, which we digitized in GIS.

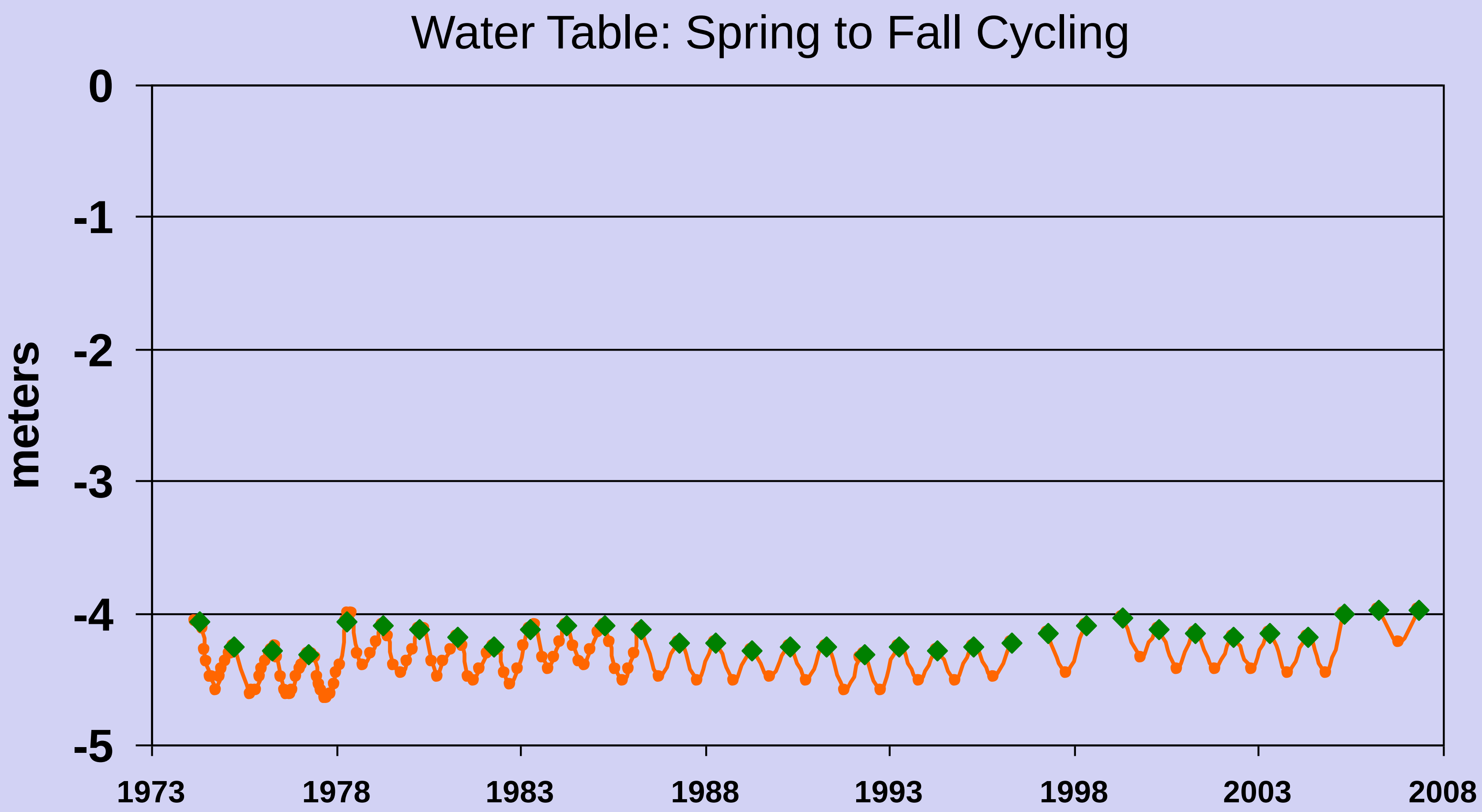


Aug. 1908 – May 1911: Seasonal Water Table Fluctuation due to ET

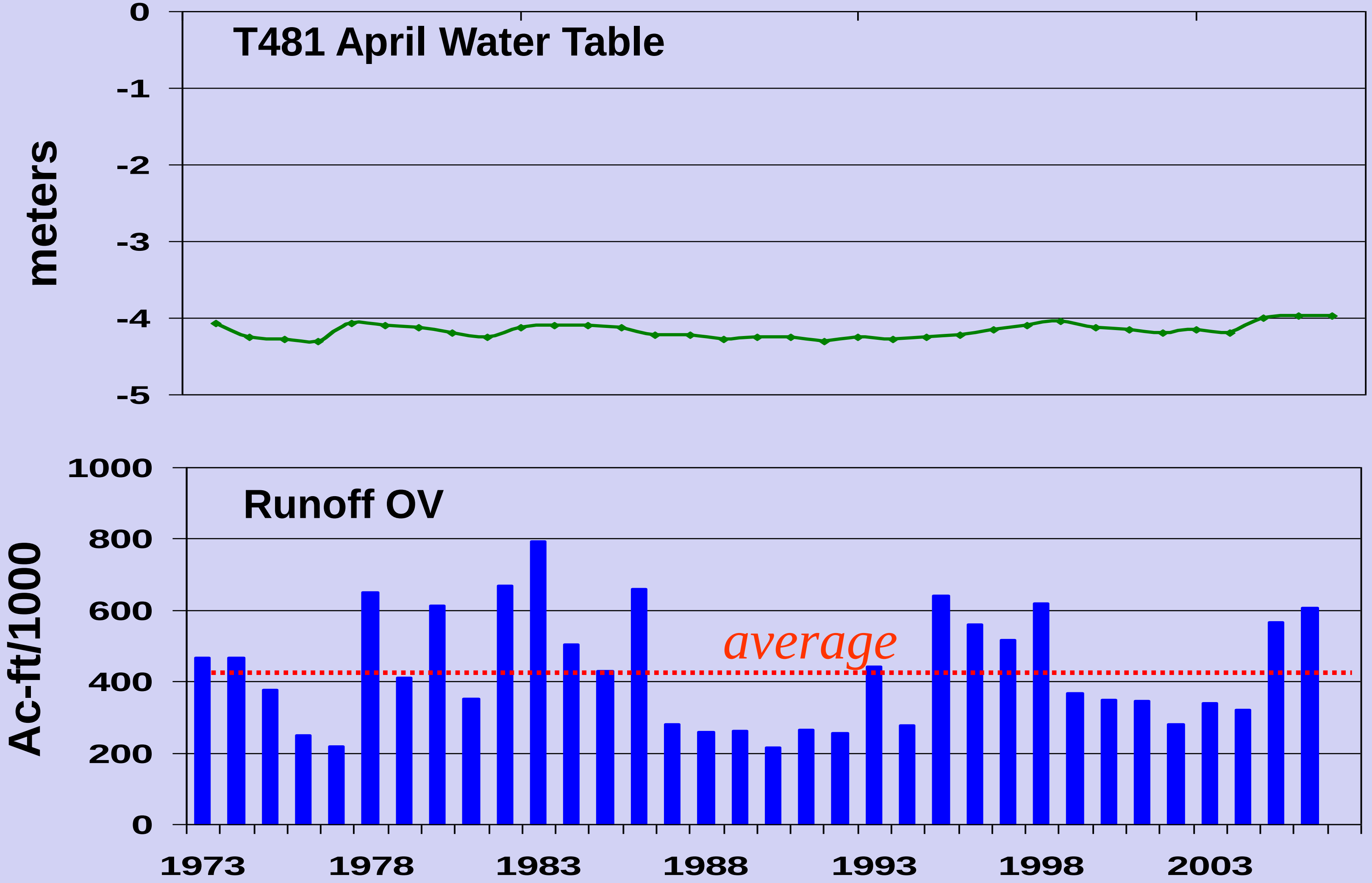


Lee, C.H. 1912. An intensive study of the water resources of a part of Owens Valley, California. United States Geological Survey Water Supply Paper 294. Government Printing Office, Washington, DC.

T481: 1974 - 2007

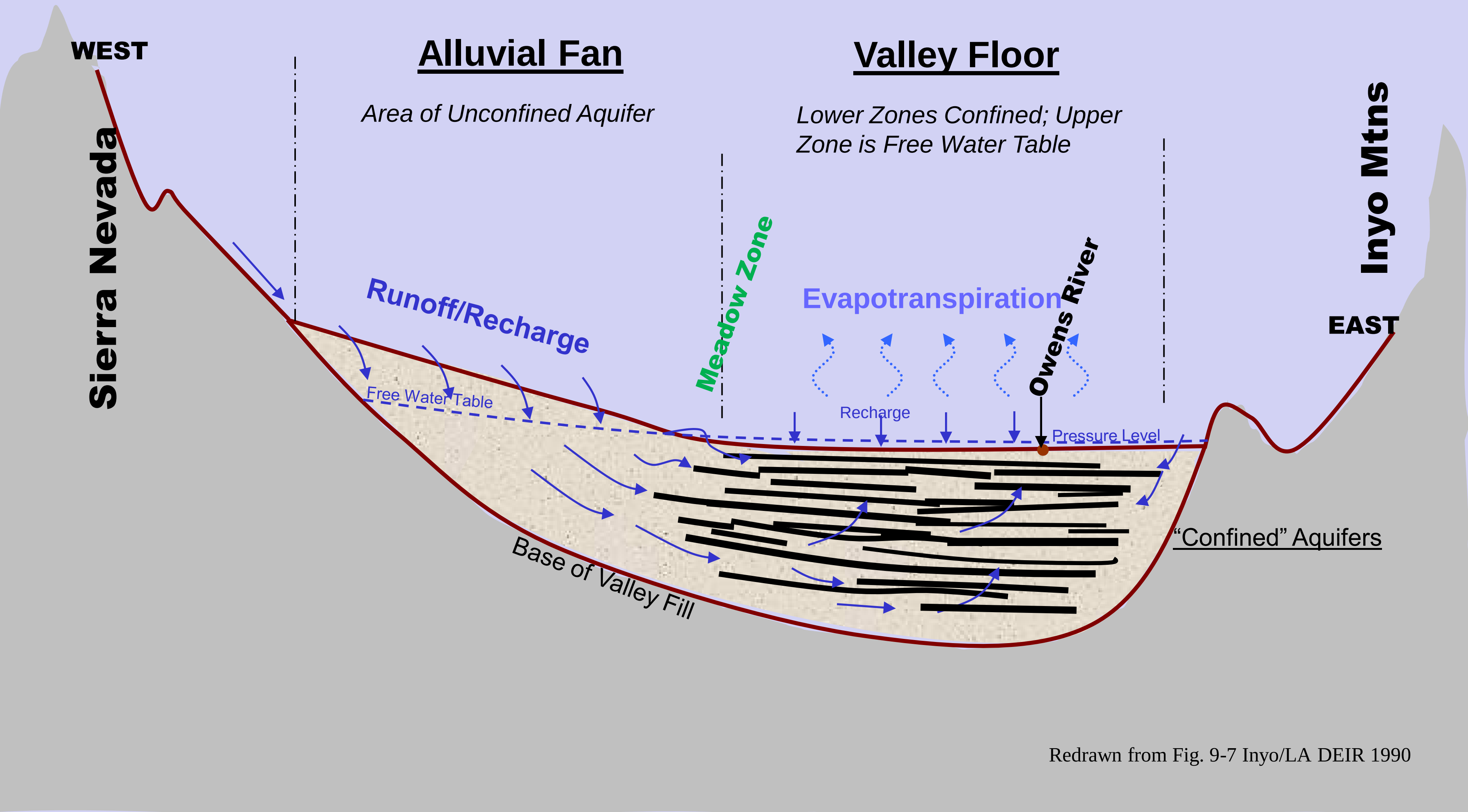


Effect of Runoff Variability on Groundwater



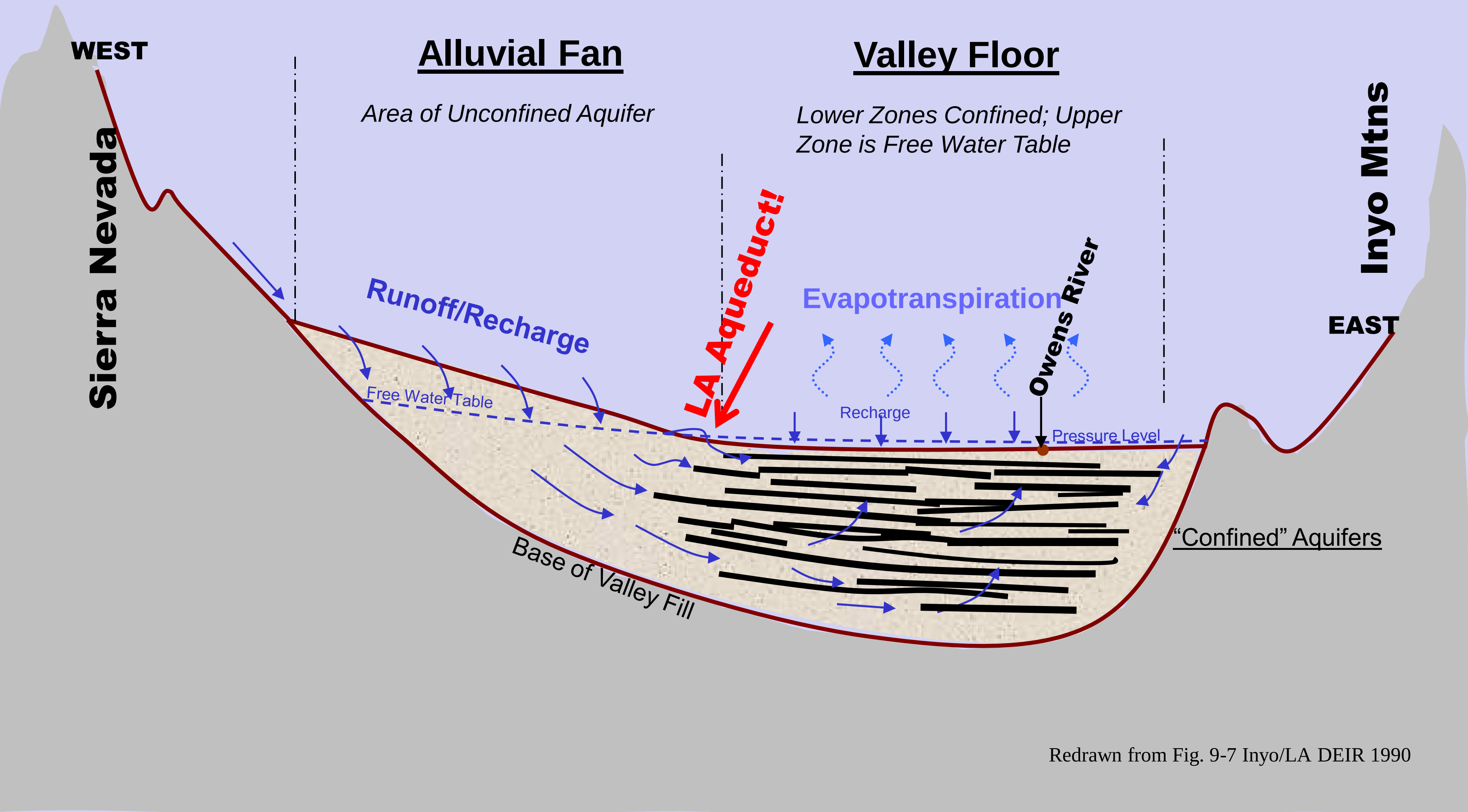
This hydrology – the stable, reliable water table,
gave rise to and sustained meadows, wetlands, and their plants and animals. The hydrology and biology were in balance.

Conceptual Illustration of Owens Valley Aquifer System



Redrawn from Fig. 9-7 Inyo/LA DEIR 1990

Conceptual Illustration of Owens Valley Aquifer System



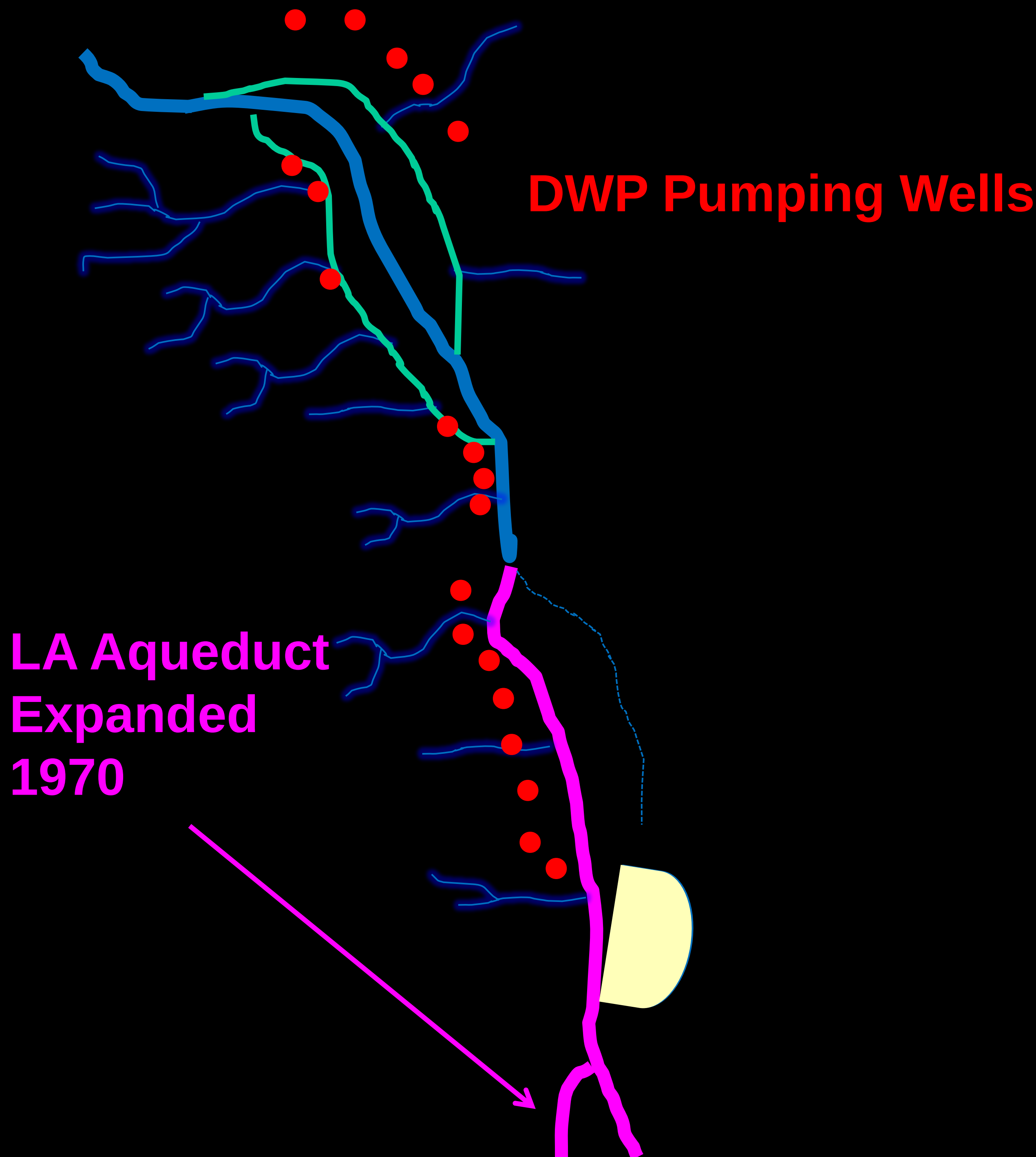
Redrawn from Fig. 9-7 Inyo/LA DEIR 1990

DWP recognized the abundance of water and commenced to systematically drain it from the watershed.

Export ***began*** 100 years ago with completion of the LA Aqueduct. Neither the extraction nor its environmental consequences have reached an end point.

Besides taking the Surface Water

Groundwater Pumping


DWP Pumping Wells
LA Aqueduct
Expanded
1970

Inyo County
Water Department

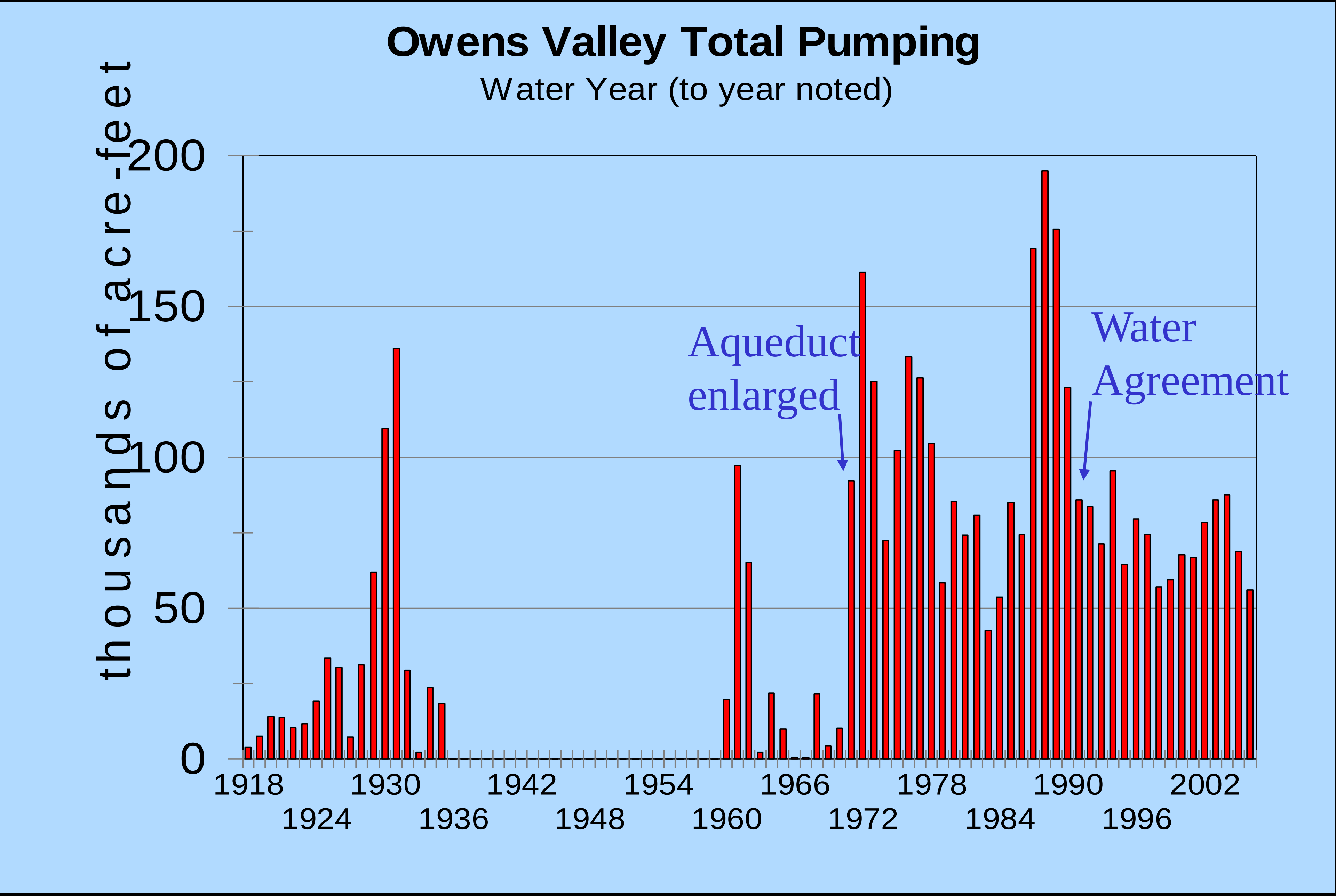
- **Implement Long Term Water management Agreement between City of Los Angeles and County of Inyo**

- **Monitor environmental conditions for changes due to LA’s water management activities**

Inyo/LA Water Agreement (1991):

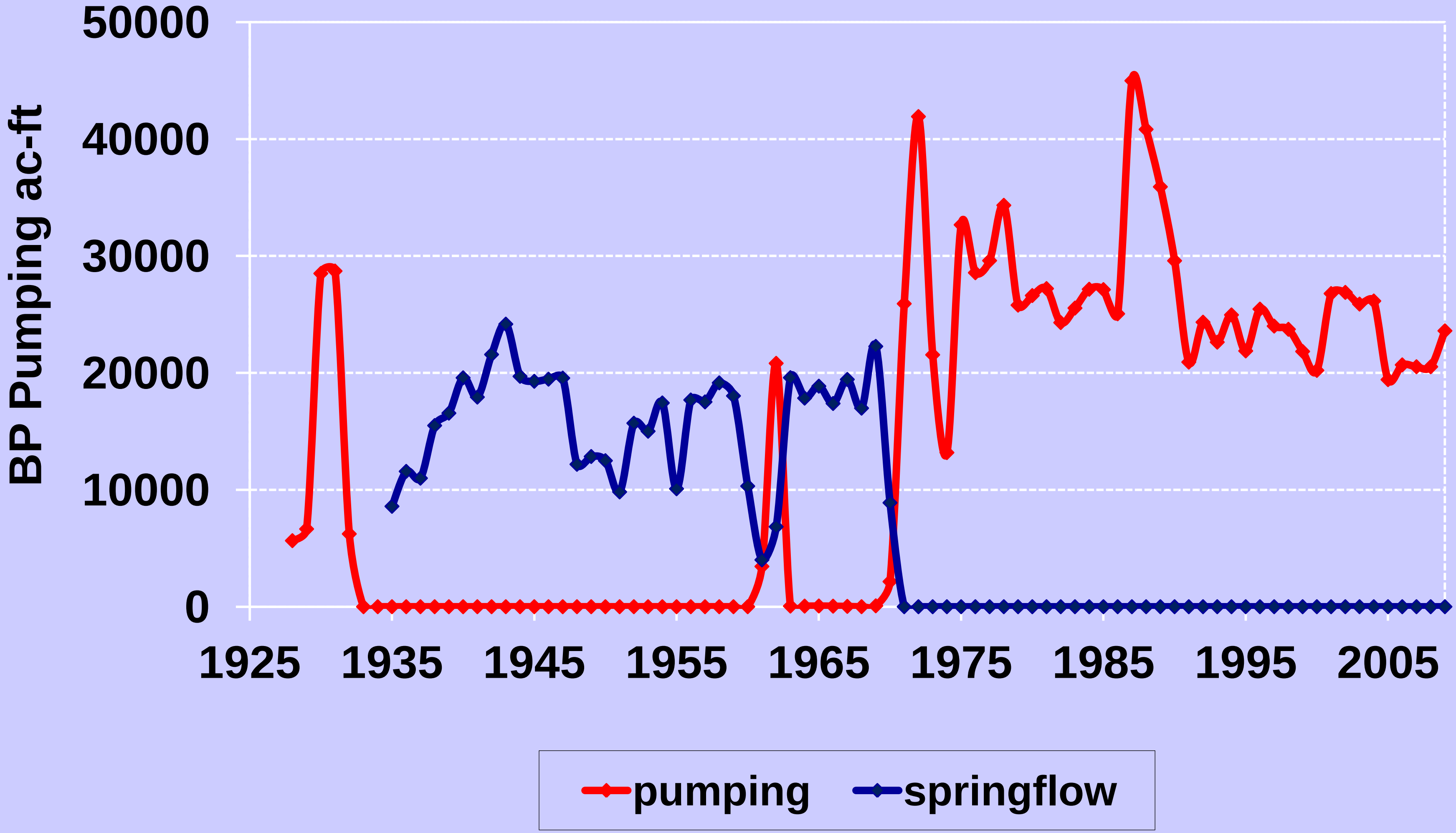
The overall goal of managing the water resources within Inyo County is to avoid certain described decreases and changes in vegetation* and to cause no significant effect on the environment which cannot be acceptably mitigated while providing a reliable supply of water for export to Los Angeles and for use in Inyo County.

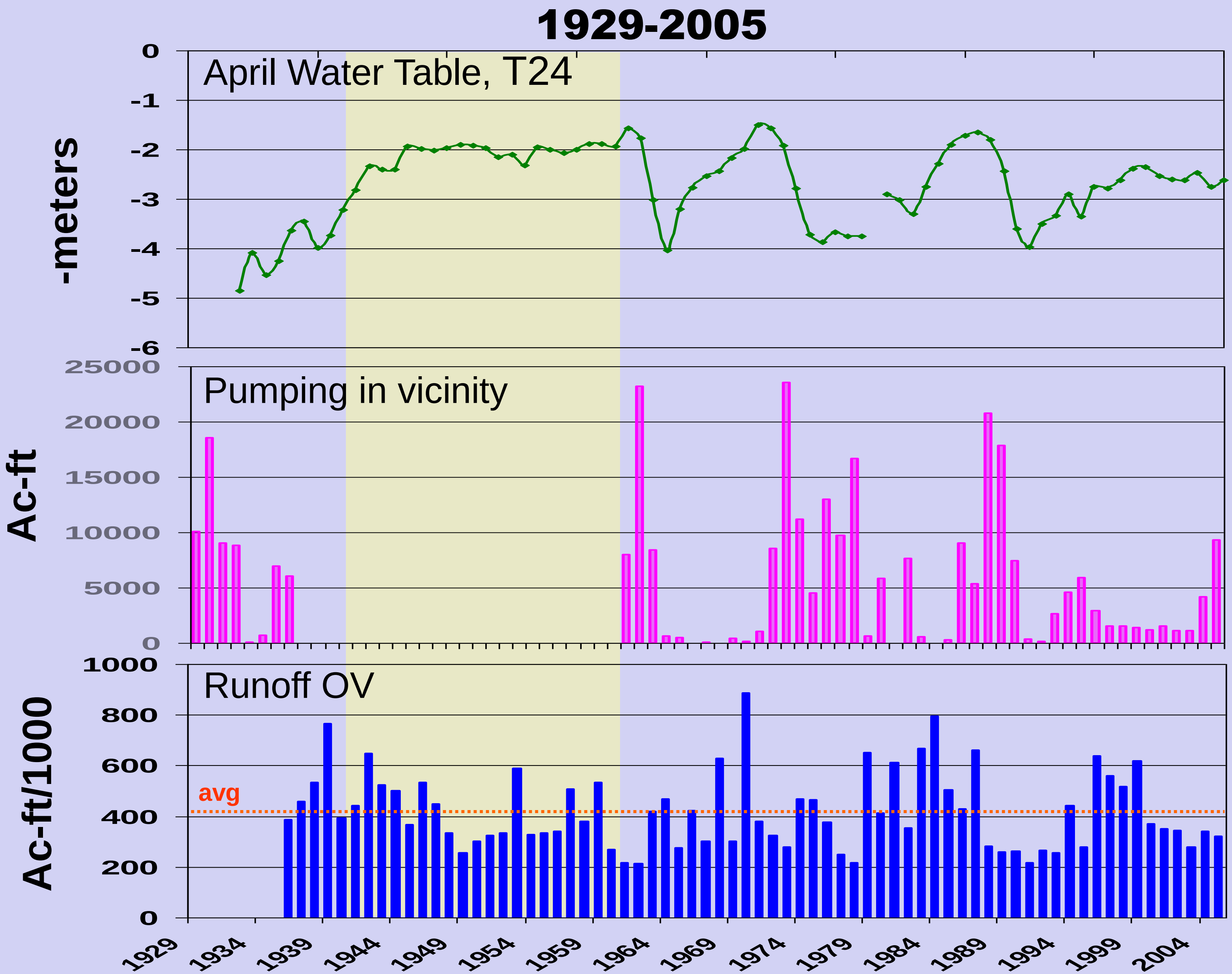
* "baseline" defined as mid 1980s

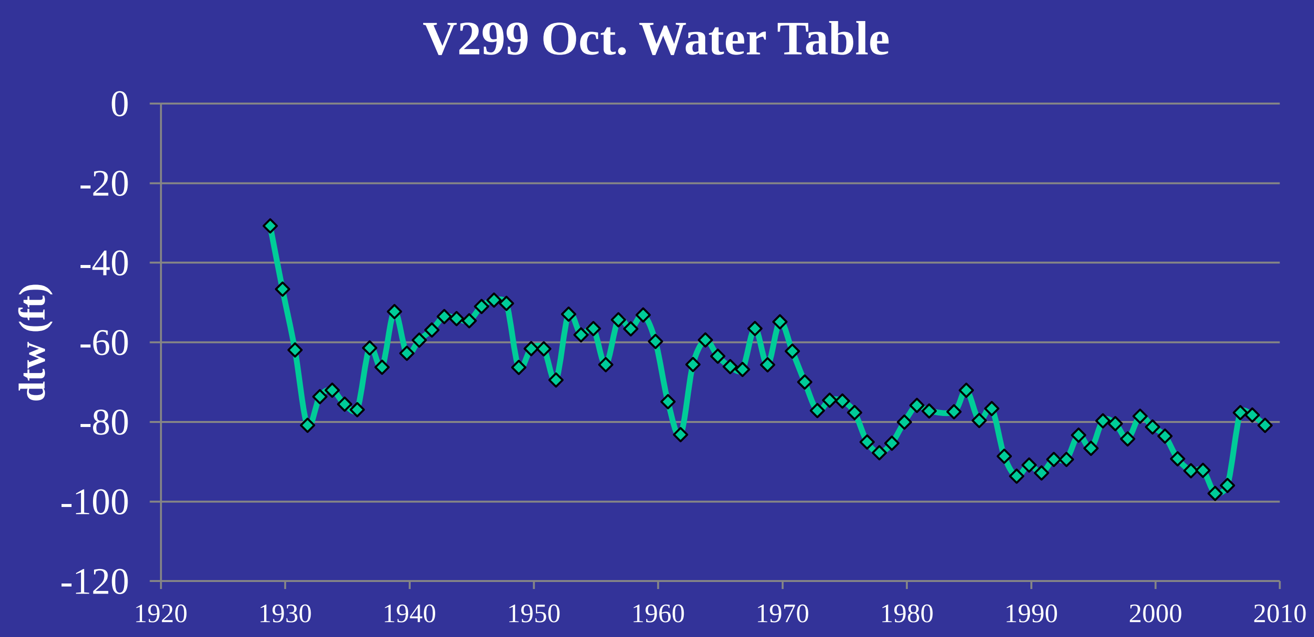


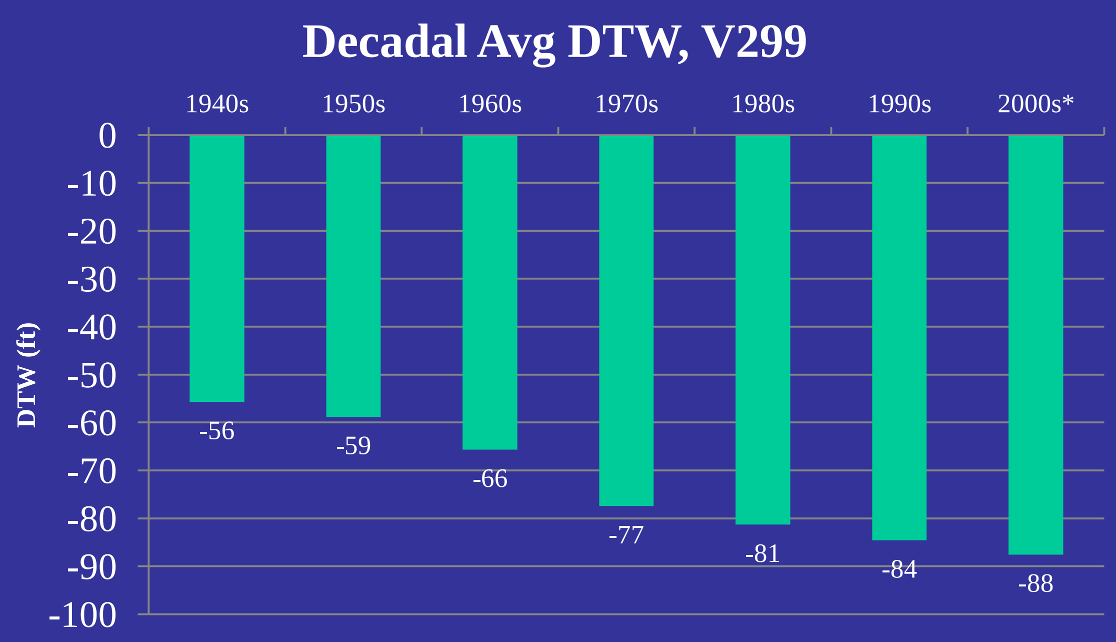
Owens Valley Total Pumping
Water Year (to year noted)
thousands of acre-feet
200
150
100
50
0
1918
1924
1930
1936
1942
1948
1954
1960
1966
1972
1978
1984
1990
1996
2002
Aqueduct enlarged
Water Agreement

Big Pine-area pumping 1929-2009
and flow from Fish Springs1935-2009

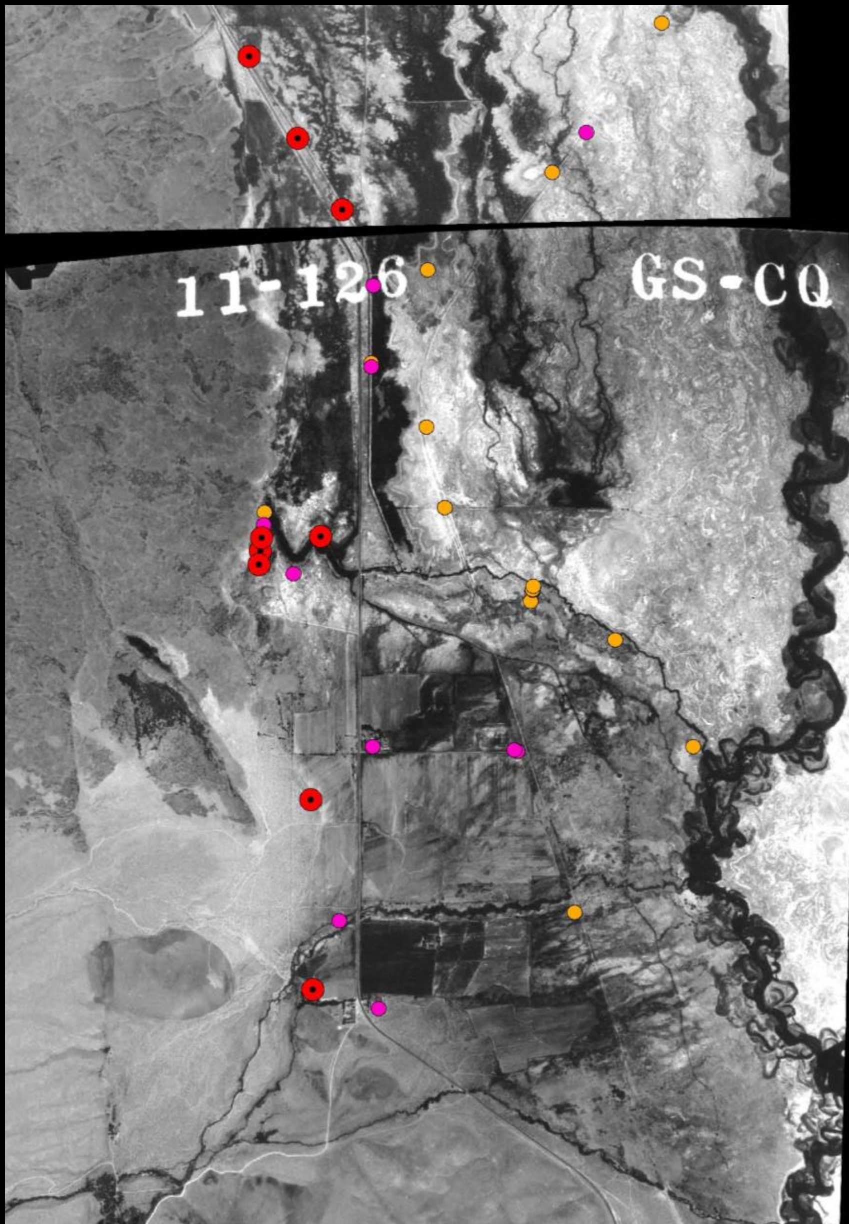


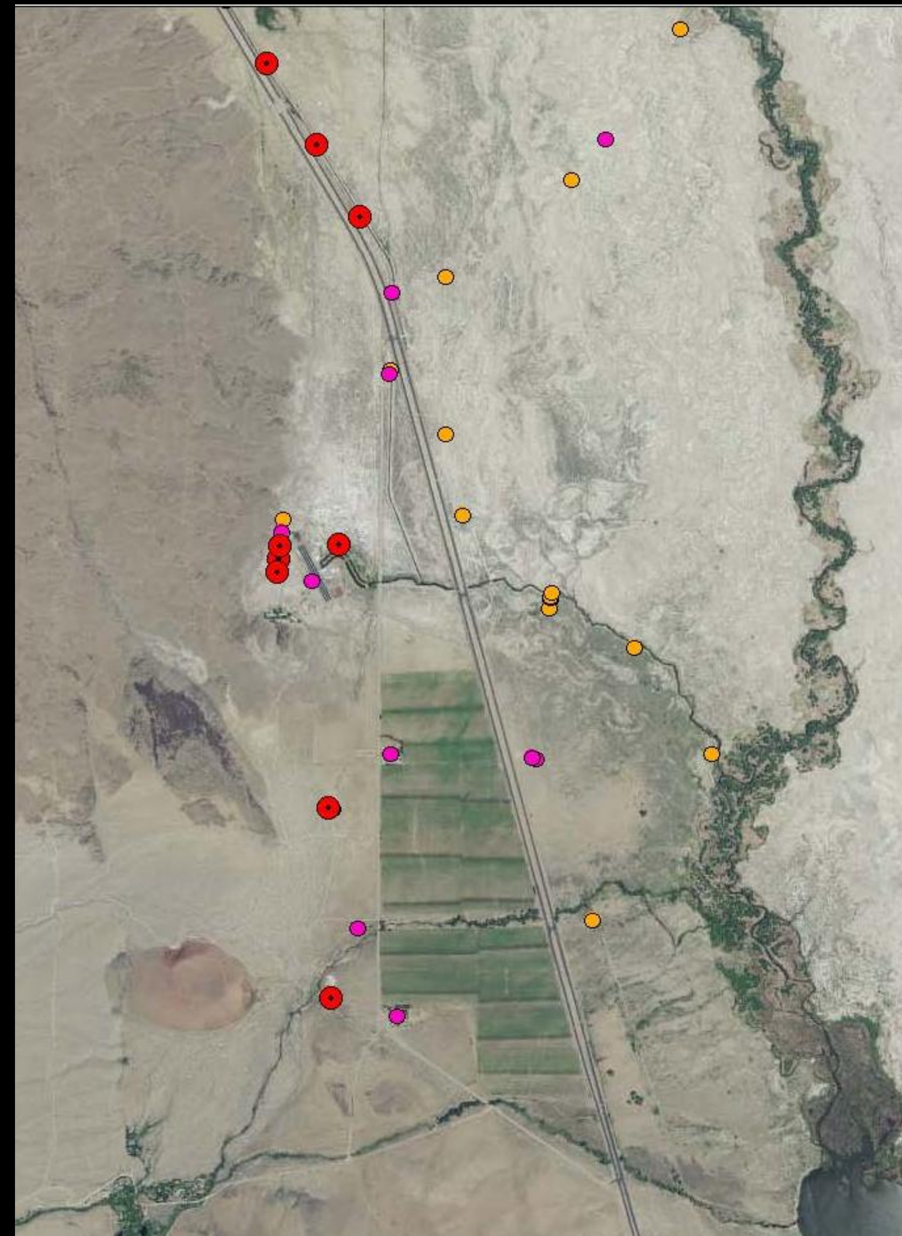

1929-2005
April Water Table, T24
-meters
0
-1
-2
-3
-4
-5
-6
Pumping in vicinity
Ac-ft
25000
20000
15000
10000
5000
0
Runoff OV
Ac-ft/1000
1000
800
600
400
200
0
avg
1929
1934
1939
1944
1949
1954
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004


V299 Oct. Water Table
dtw (ft)
0
-20
-40
-60
-80
-100
-120
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010

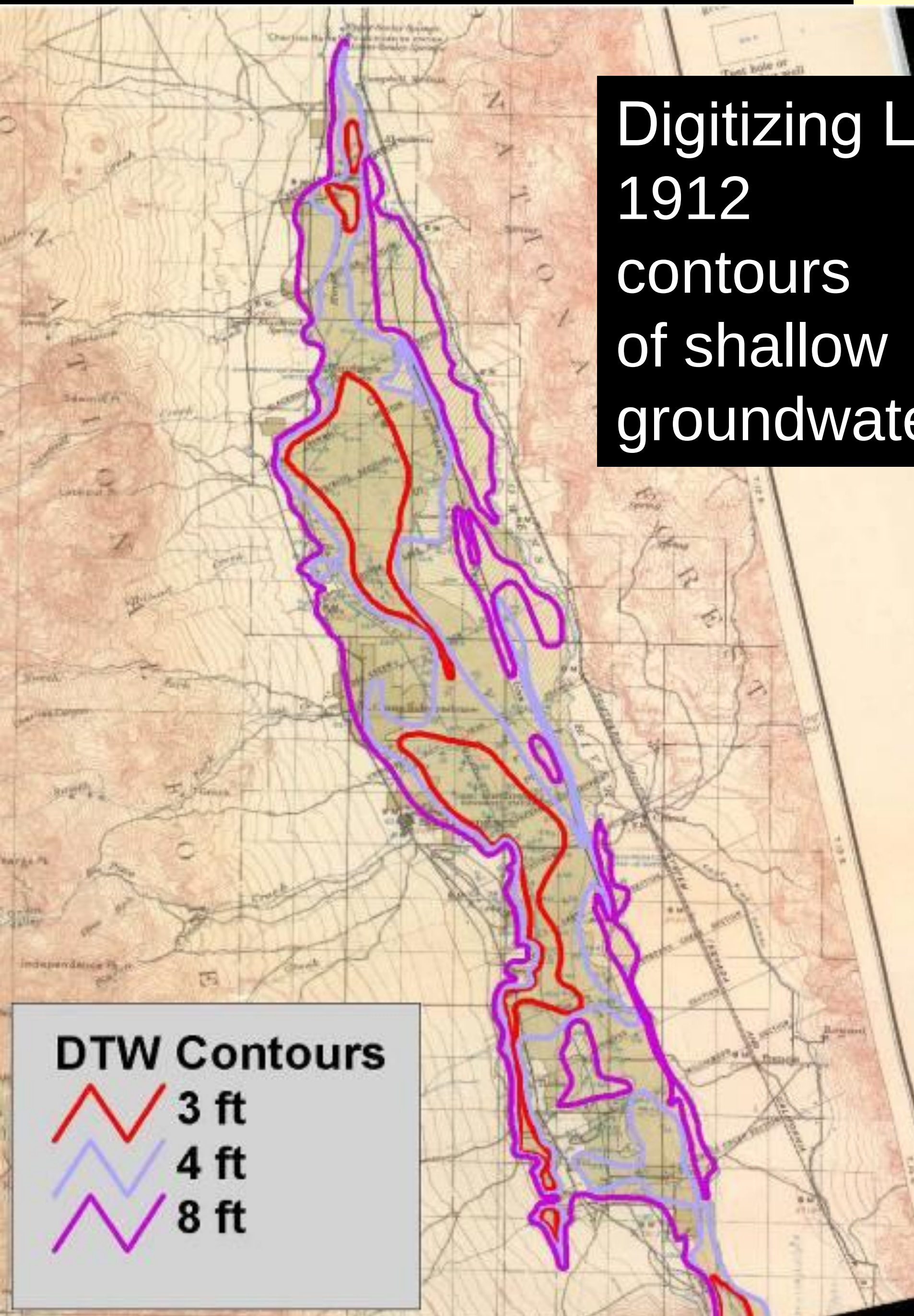

Decadal Avg DTW, V299
1940s
1950s
1960s
1970s
1980s
1990s
2000s*
DTW (ft)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-56
-59
-66
-77
-81
-84
-88

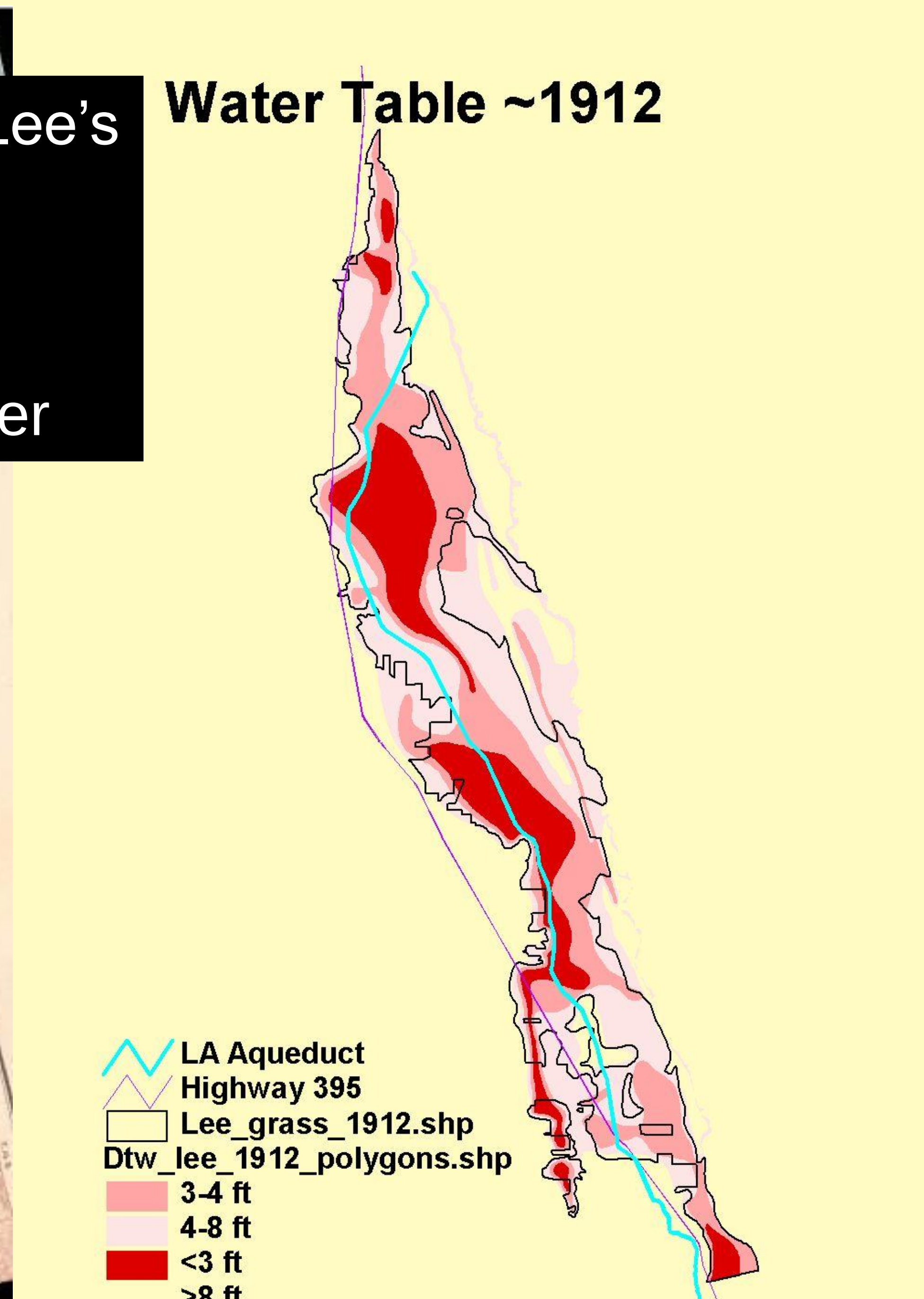
Fish Springs Area, 1947 and 2009

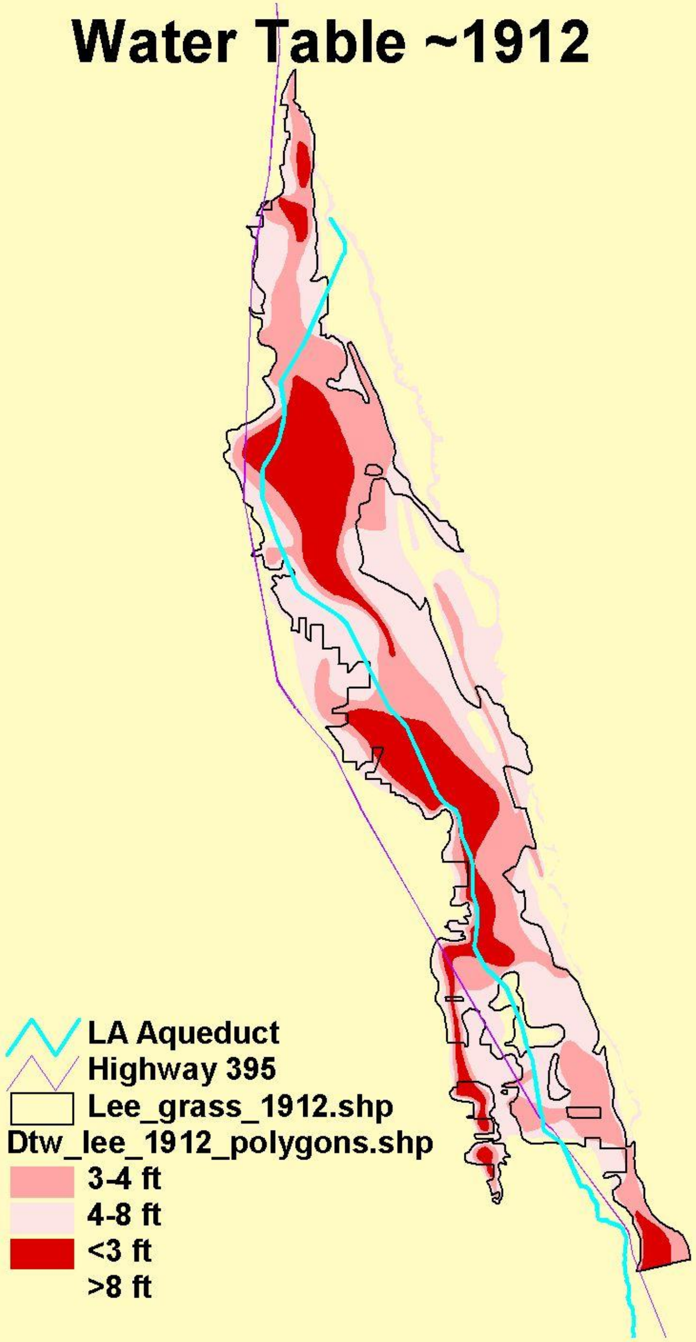




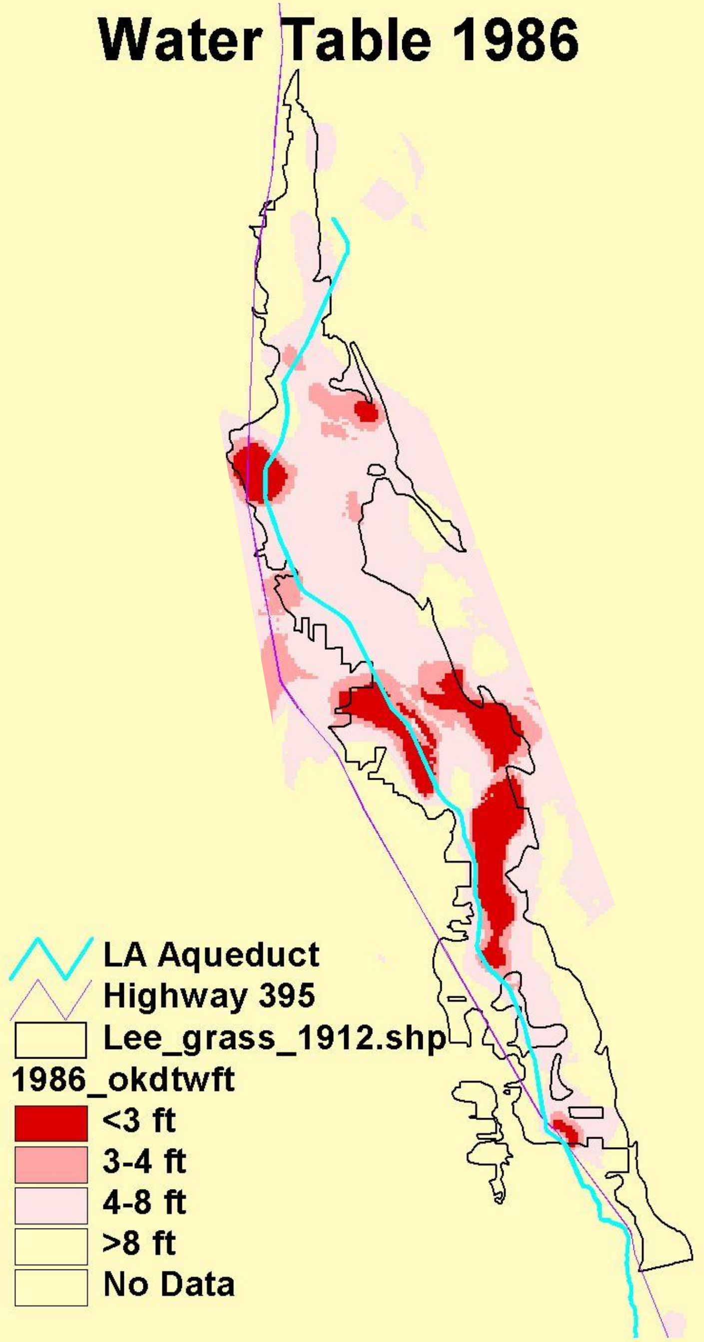
Digitizing Lee's 1912 contours of shallow groundwater



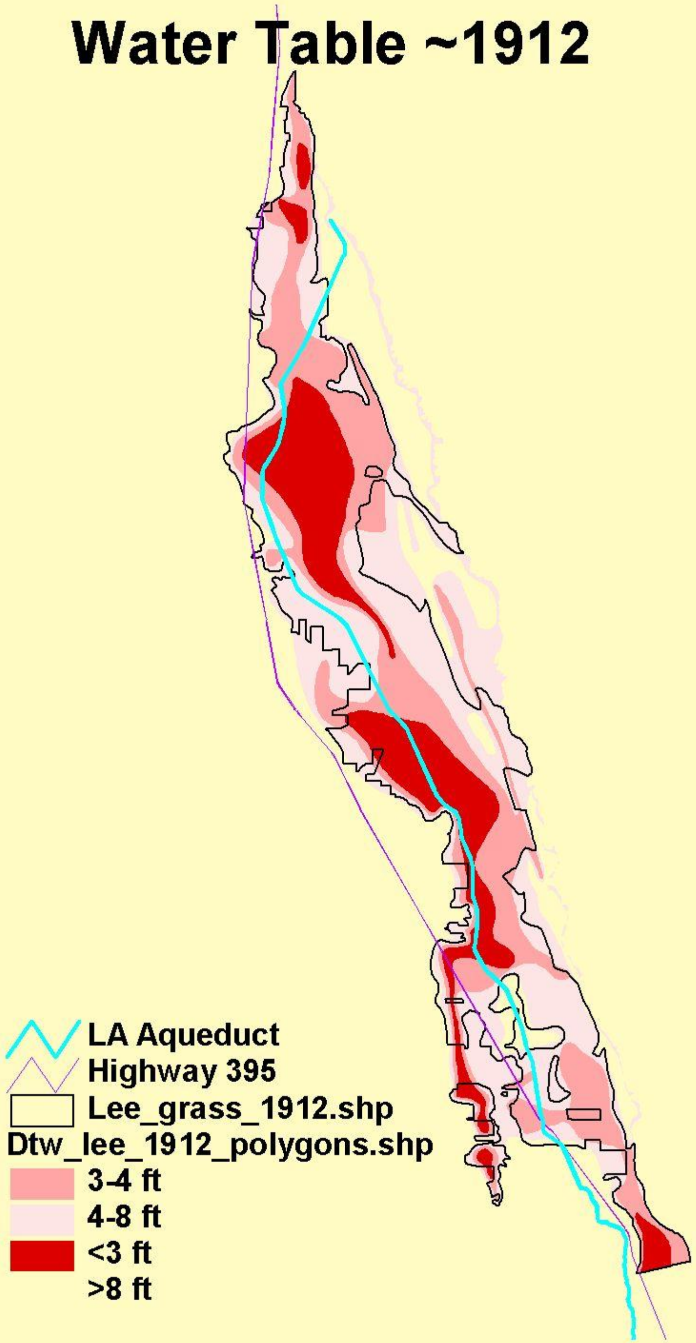


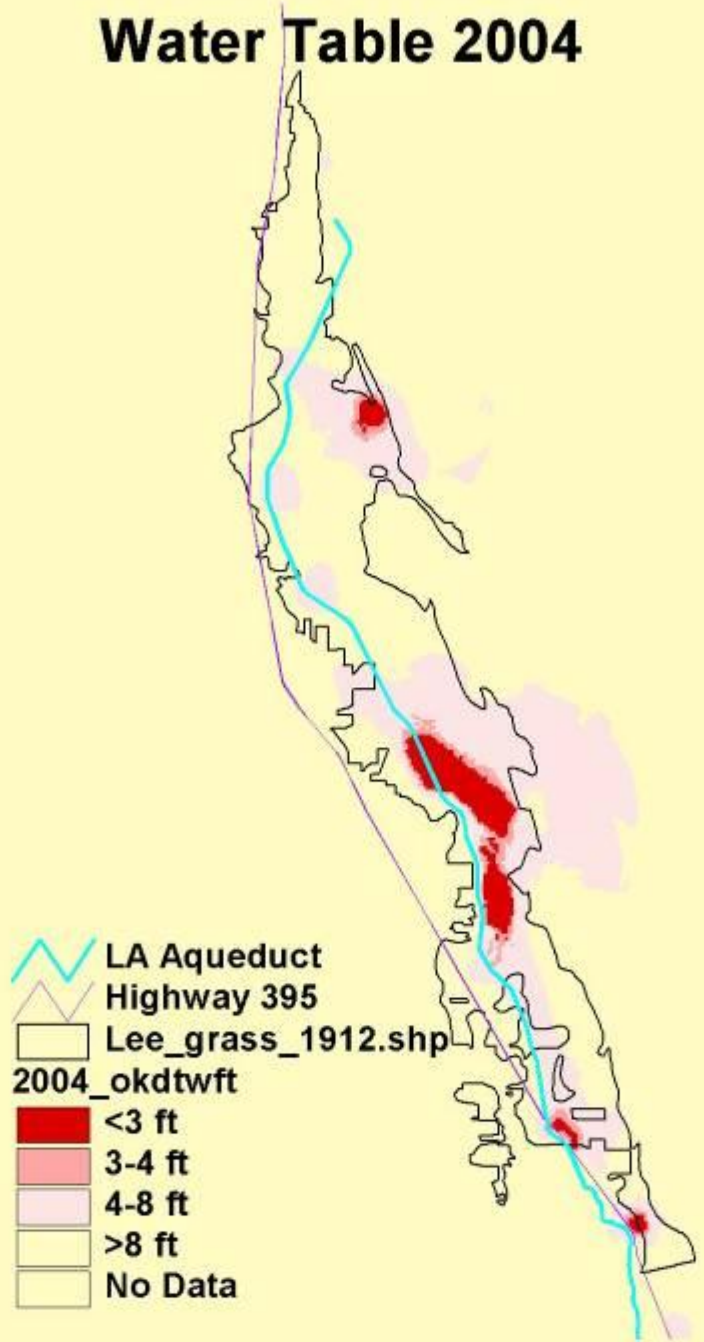


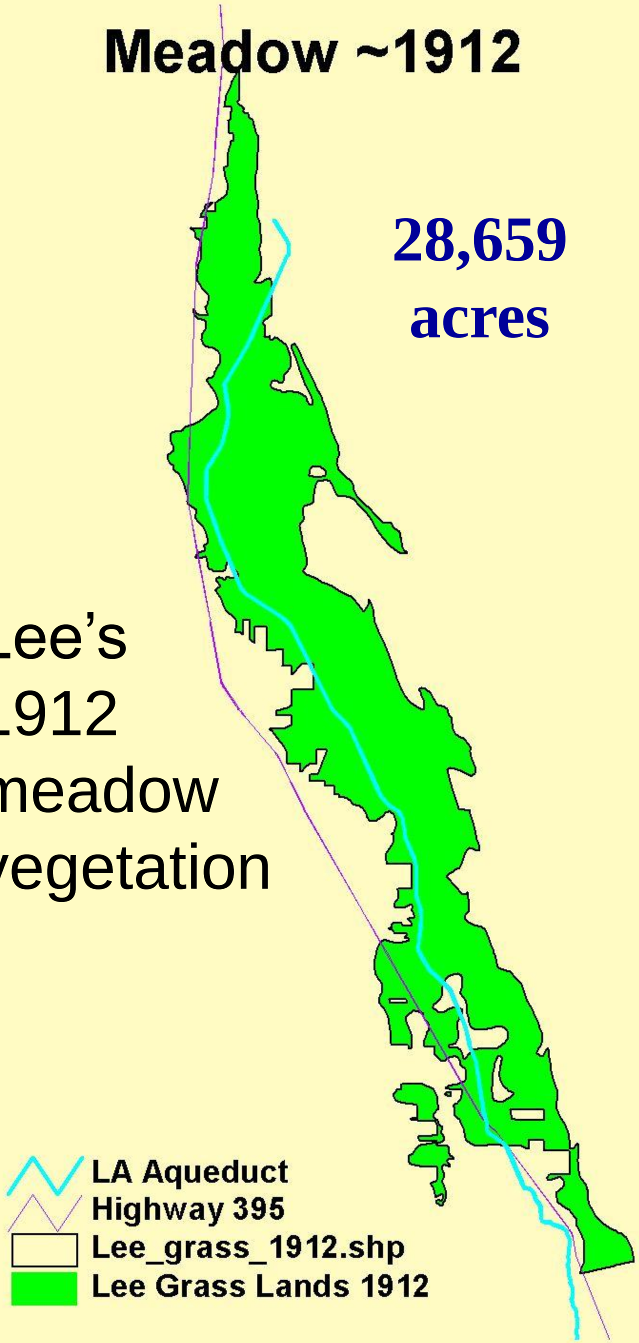
Water Table ~1912
LA Aqueduct
Highway 395
Lee_grass_1912.shp
Dtw_lee_1912_polygons.shp
3-4 ft
4-8 ft
<3 ft
>8 ft



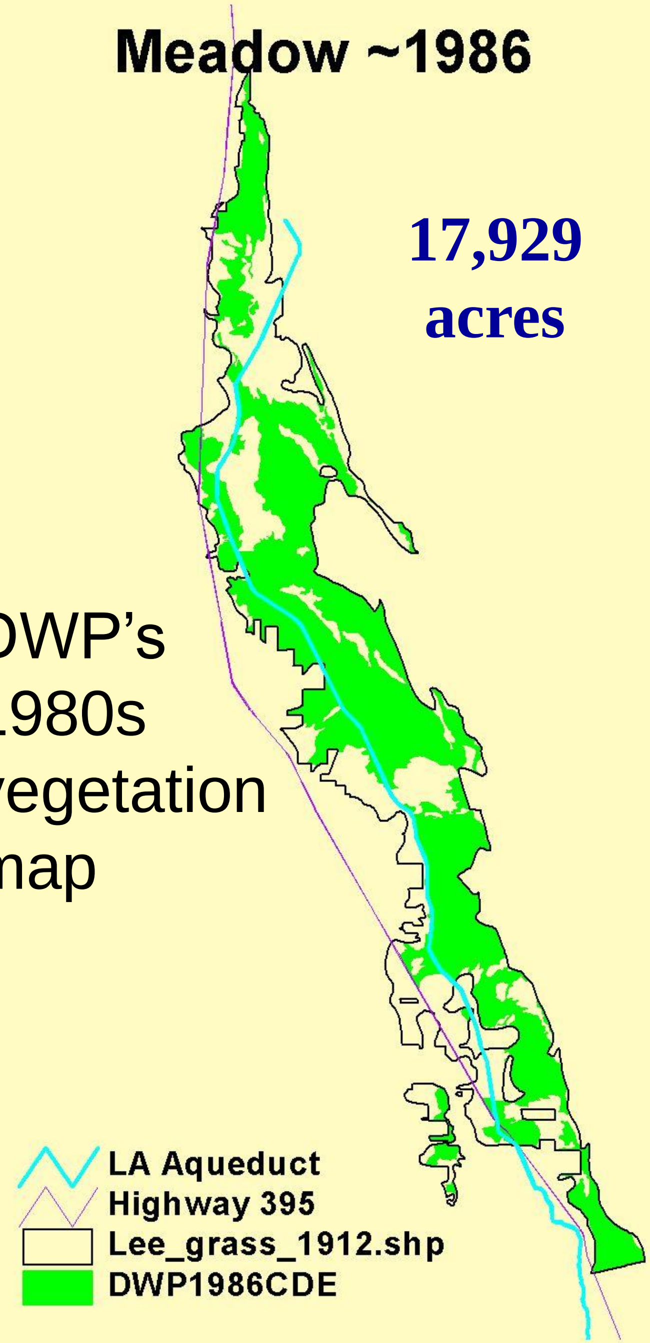
Water Table 1986
LA Aqueduct
Highway 395
Lee_grass_1912.shp
1986_okdtwft
<3 ft
3-4 ft
4-8 ft
>8 ft
No Data


Water Table ~1912
LA Aqueduct
Highway 395
Lee_grass_1912.shp
Dtw_lee_1912_polygons.shp
3-4 ft
4-8 ft
<3 ft
>8 ft


Water Table 2004
LA Aqueduct
Highway 395
Lee_grass_1912.shp
2004_okdtwft
<3 ft
3-4 ft
4-8 ft
>8 ft
No Data

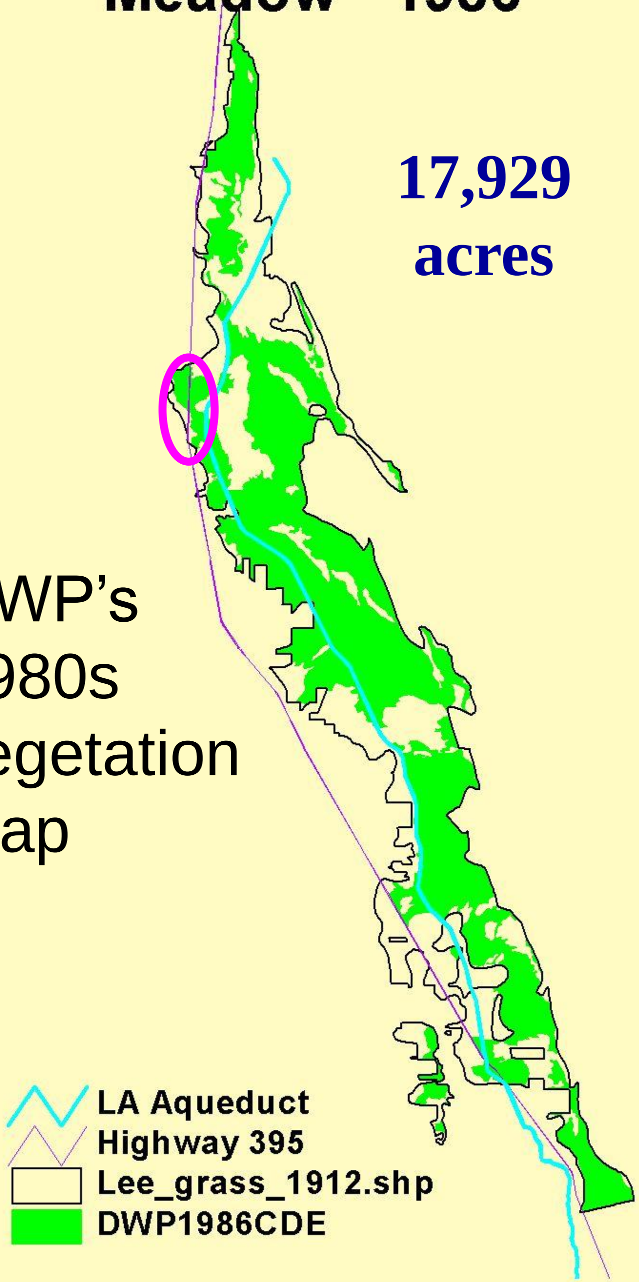


Lee’s
1912
meadow
vegetation



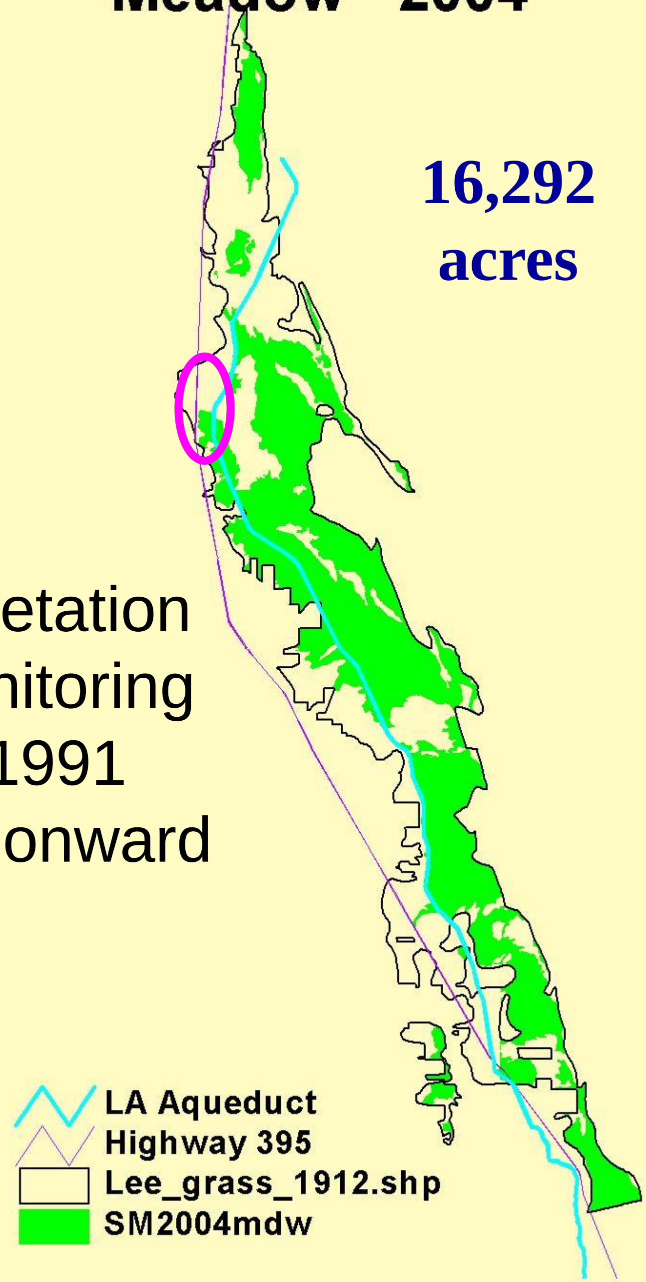
DWP’s
1980s
vegetation
map

Meadow ~1986

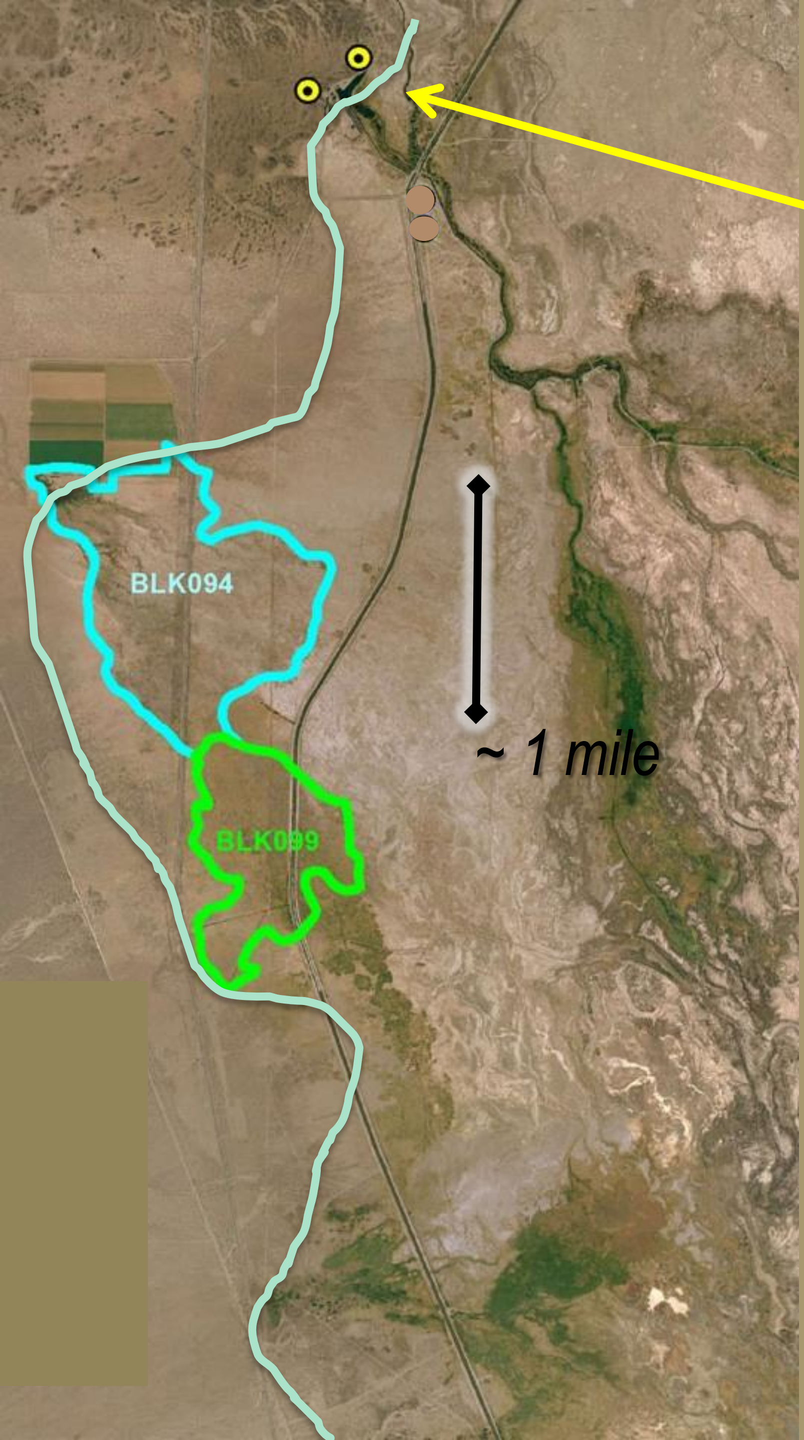


DWP's 1980s vegetation map

Meadow ~2004

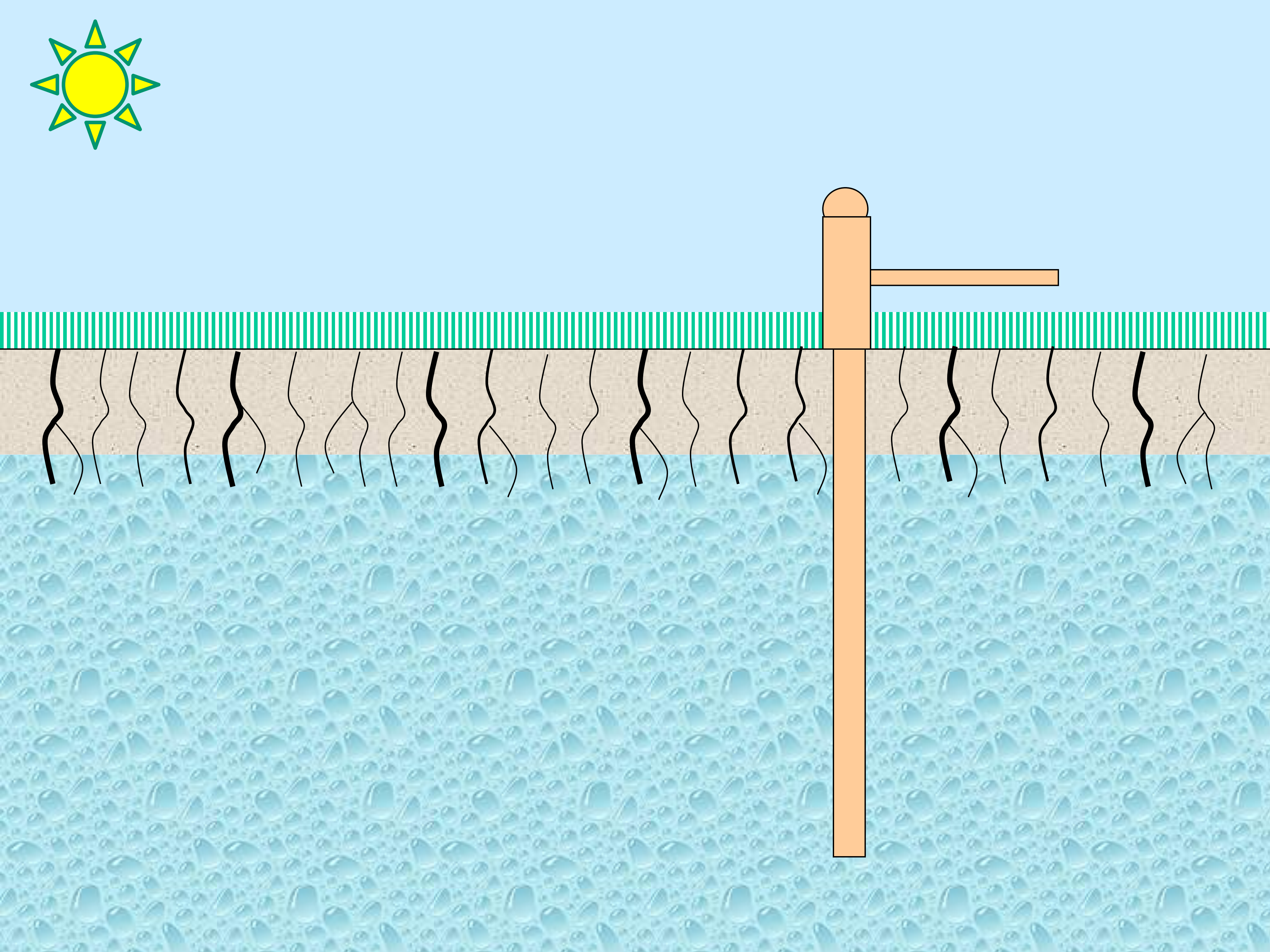


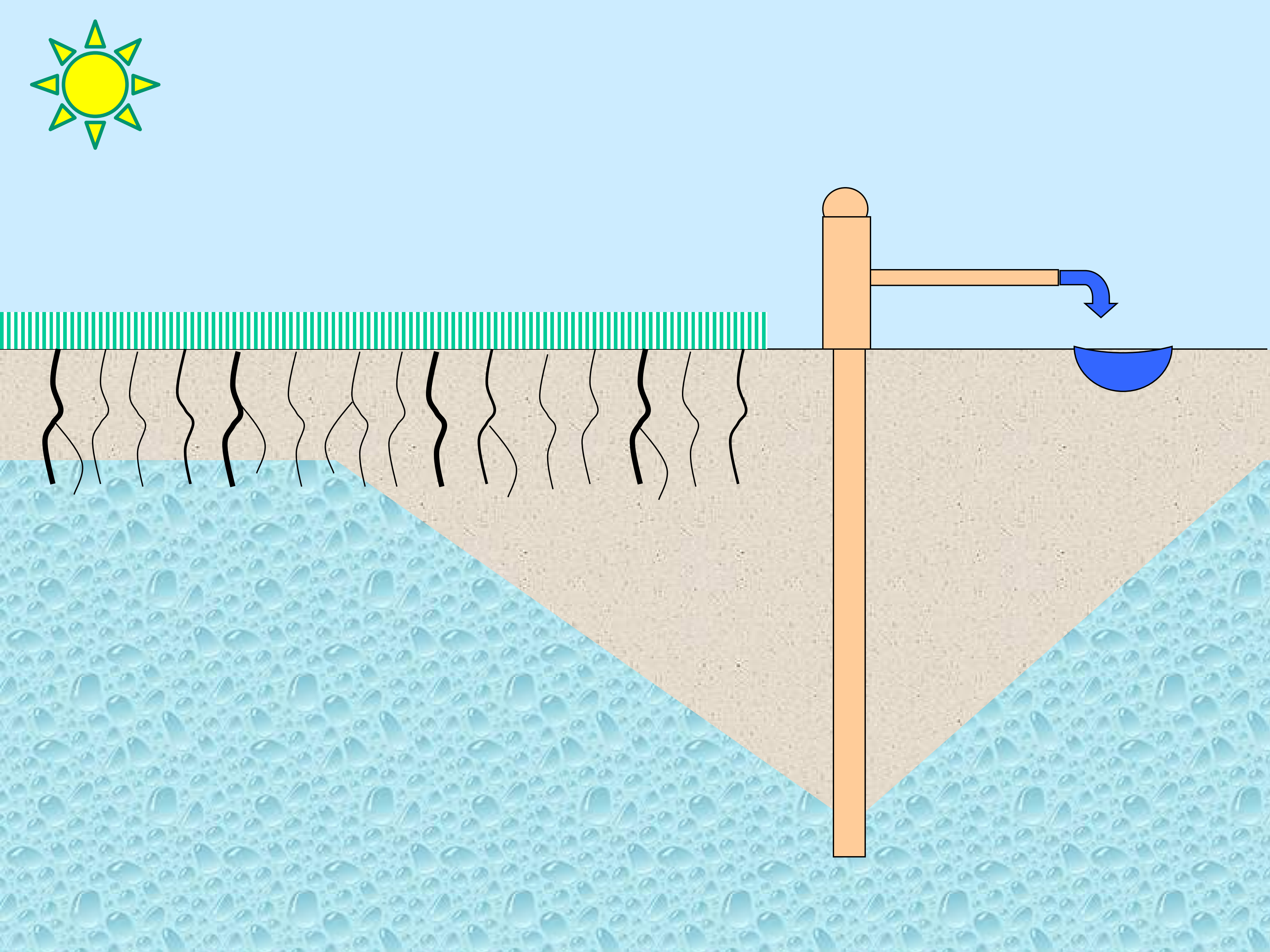
vegetation monitoring 1991 onward

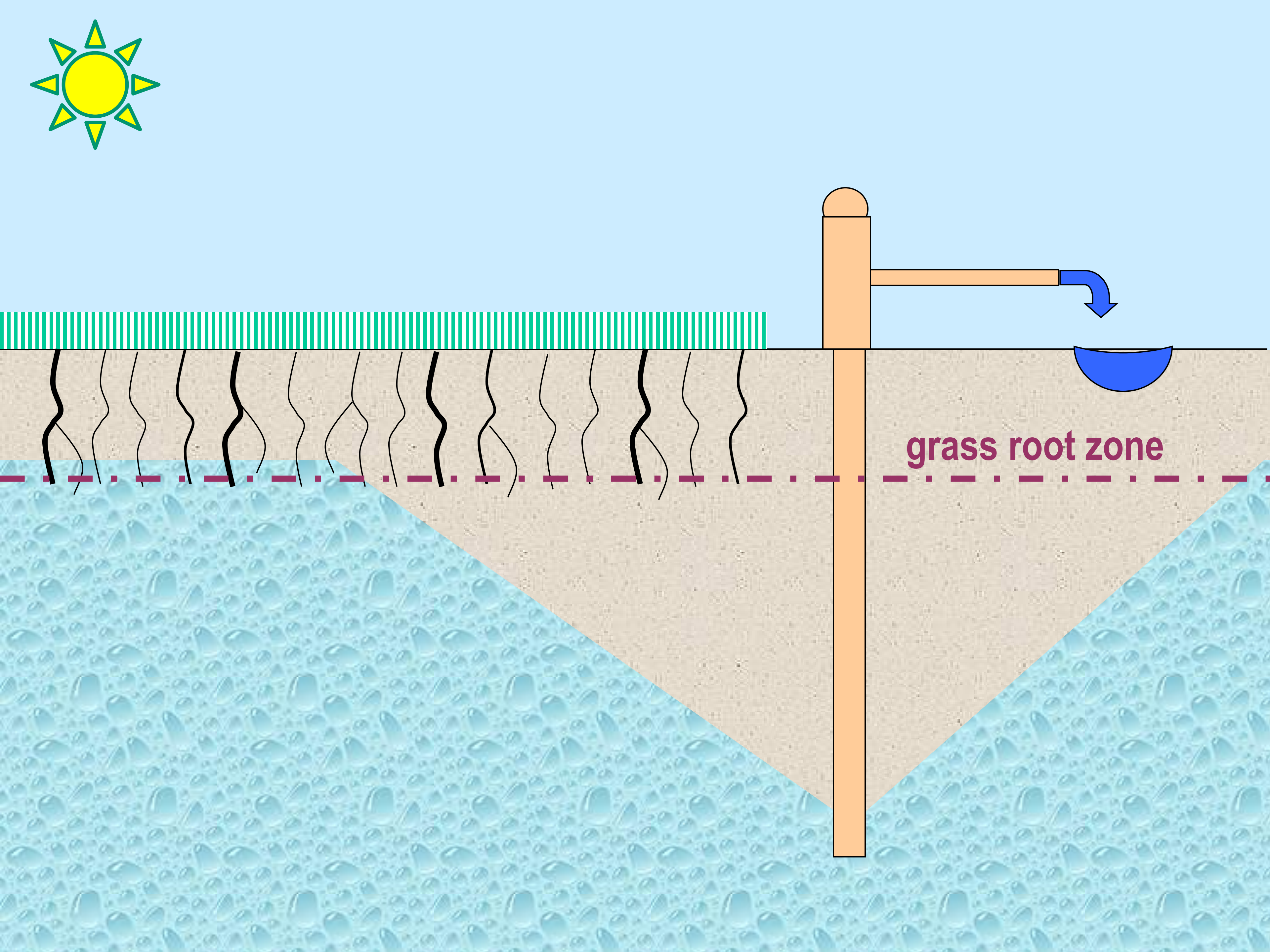


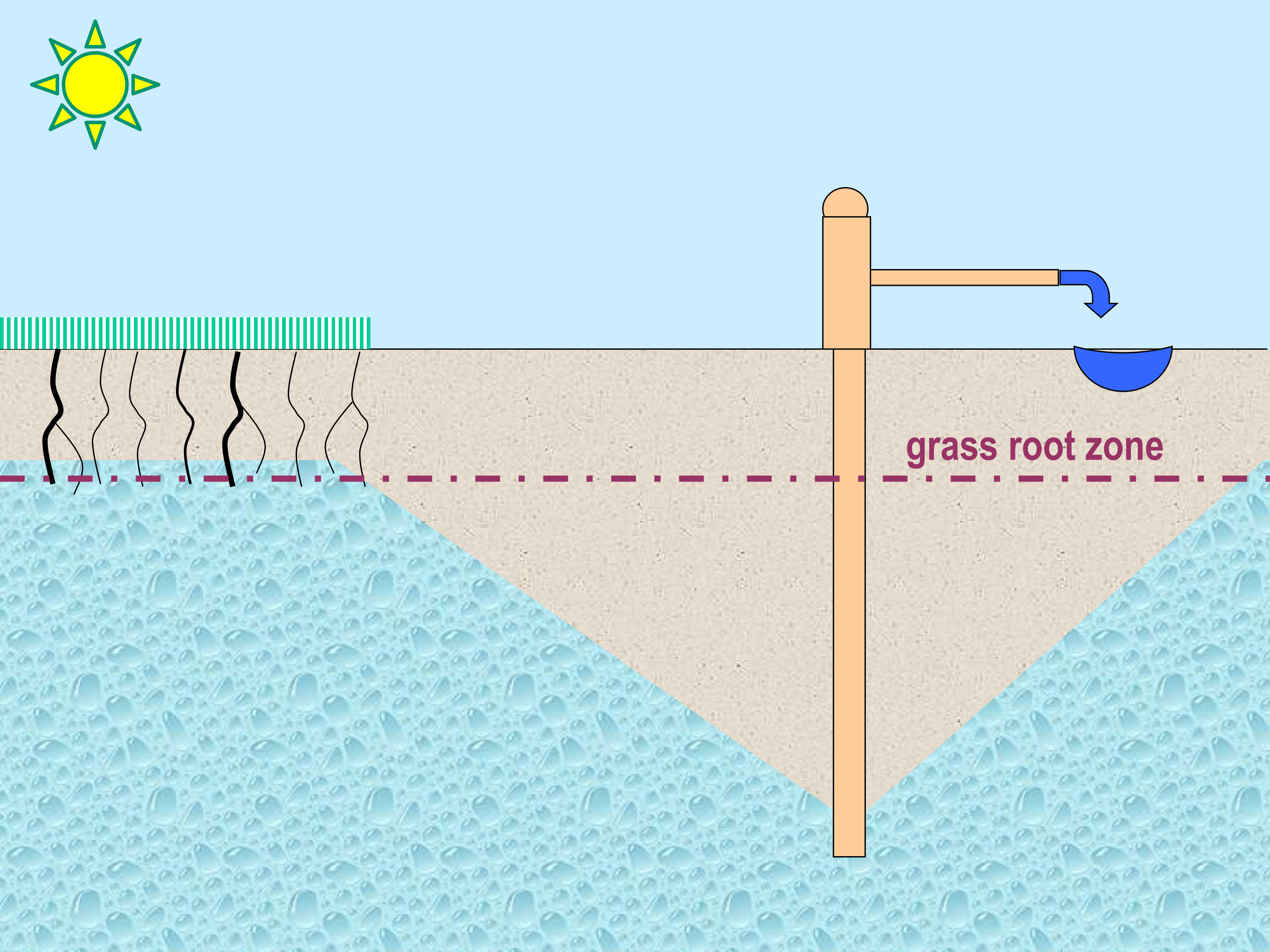
Excessive pumping from these (fish hatchery) wells has degraded A meadow mapped by Lee in 1912 – and by DWP in 1986.

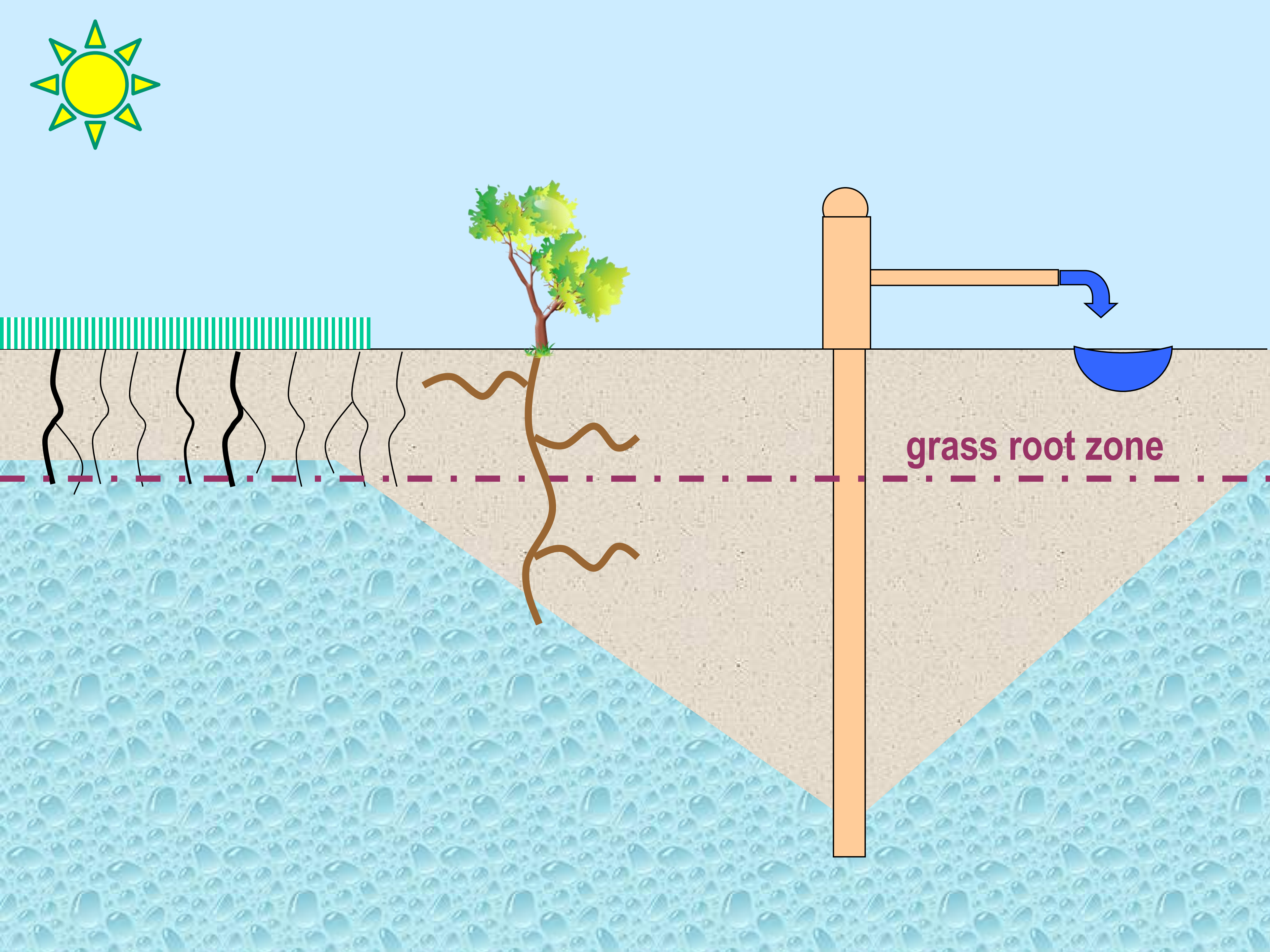
Affected area is known as Blackrock 94.

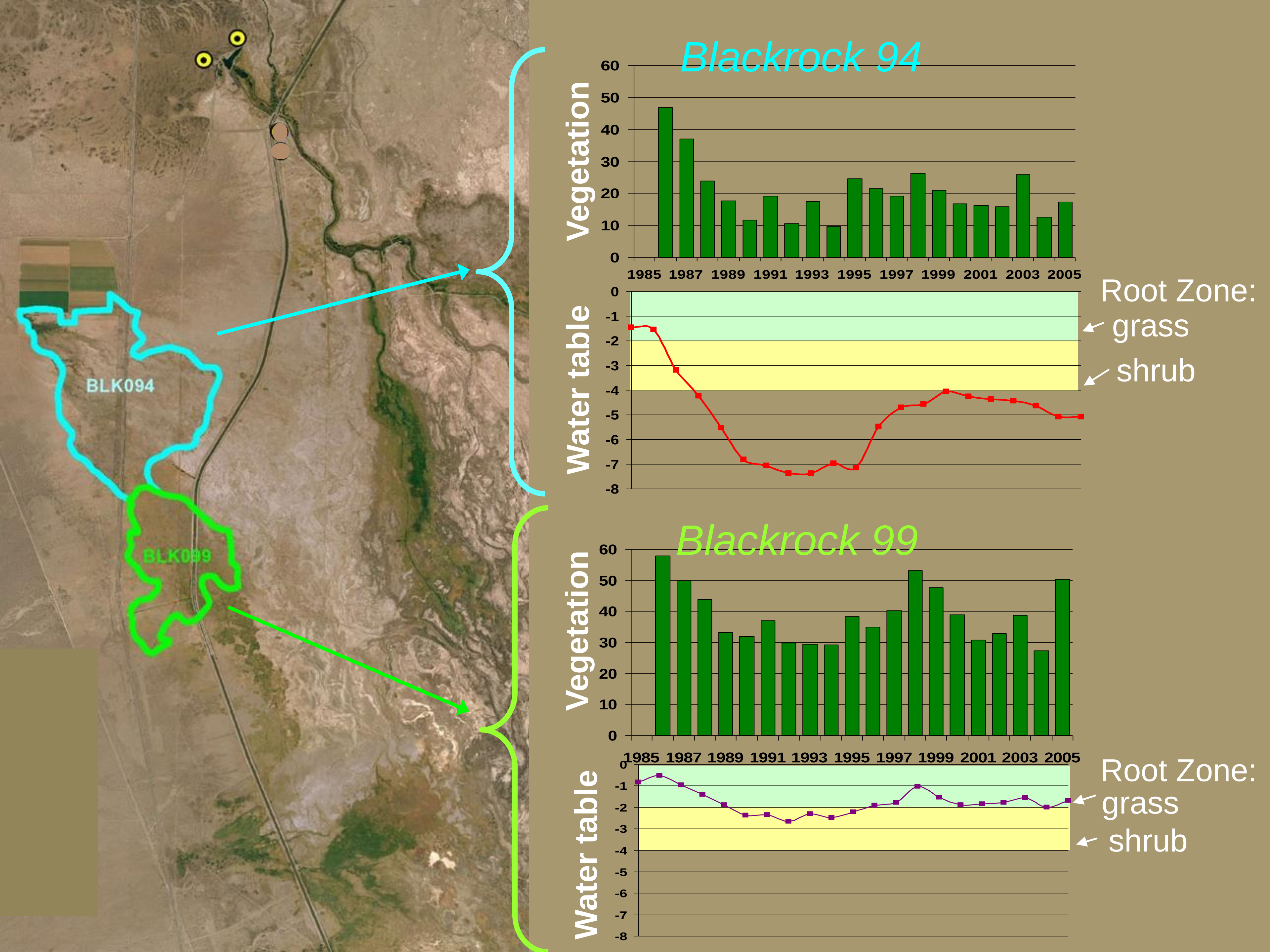





grass root zone


grass root zone


grass root zone



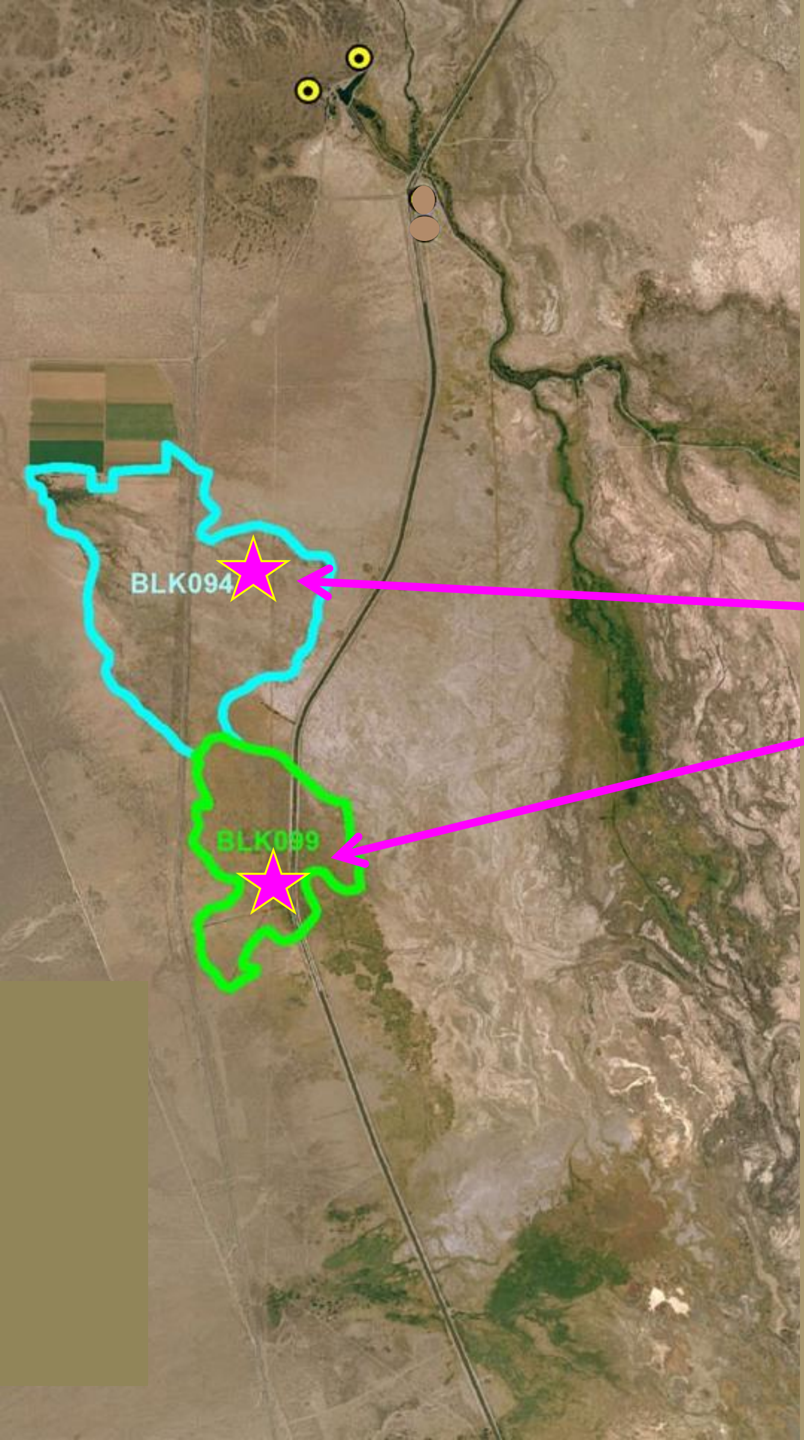
BLK094
BLK099
Blackrock 94
Vegetation
60
50
40
30
20
10
0
1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005
Water table
0
-1
-2
-3
-4
-5
-6
-7
-8
Root Zone:
grass
shrub
Blackrock 99
Vegetation
60
50
40
30
20
10
0
1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005
Water table
0
-1
-2
-3
-4
-5
-6
-7
-8
Root Zone:
grass
shrub

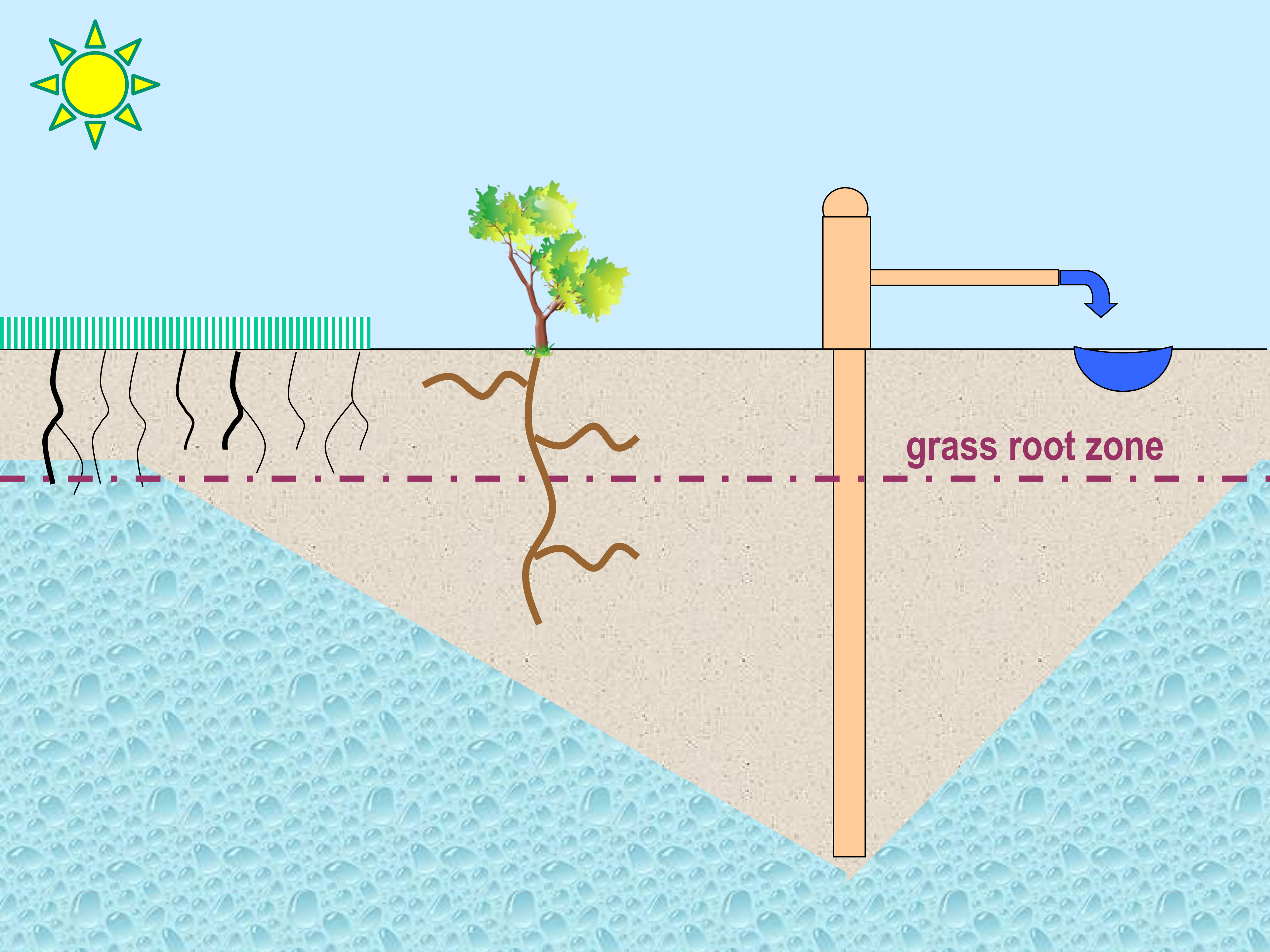
Permanent Transect Blackrock 94

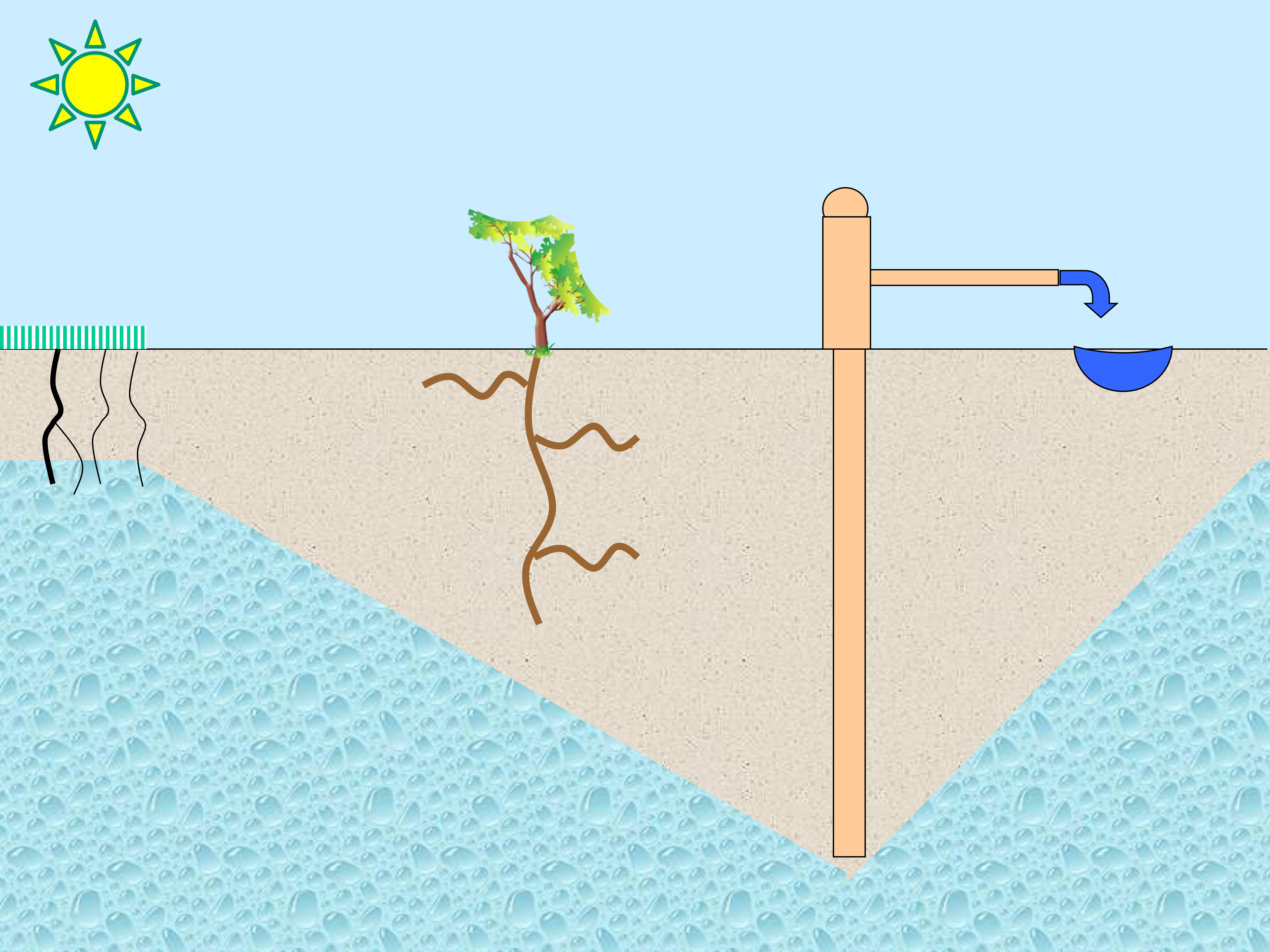
1988 33%cov
Green grass 29%
Some shrubs 4%

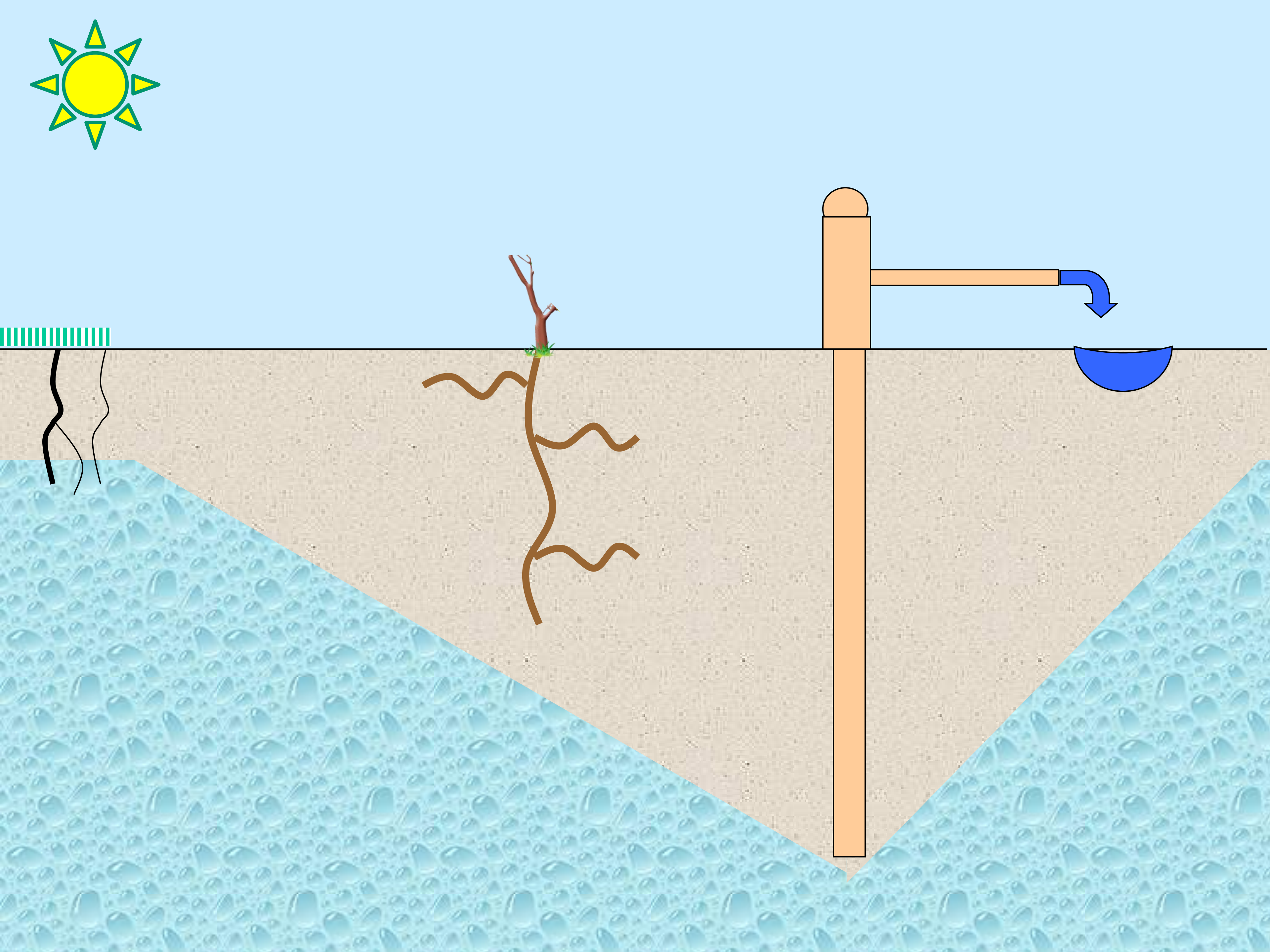
2007 15%cov
~Dead grass 4%
Shrubs dominate 11%

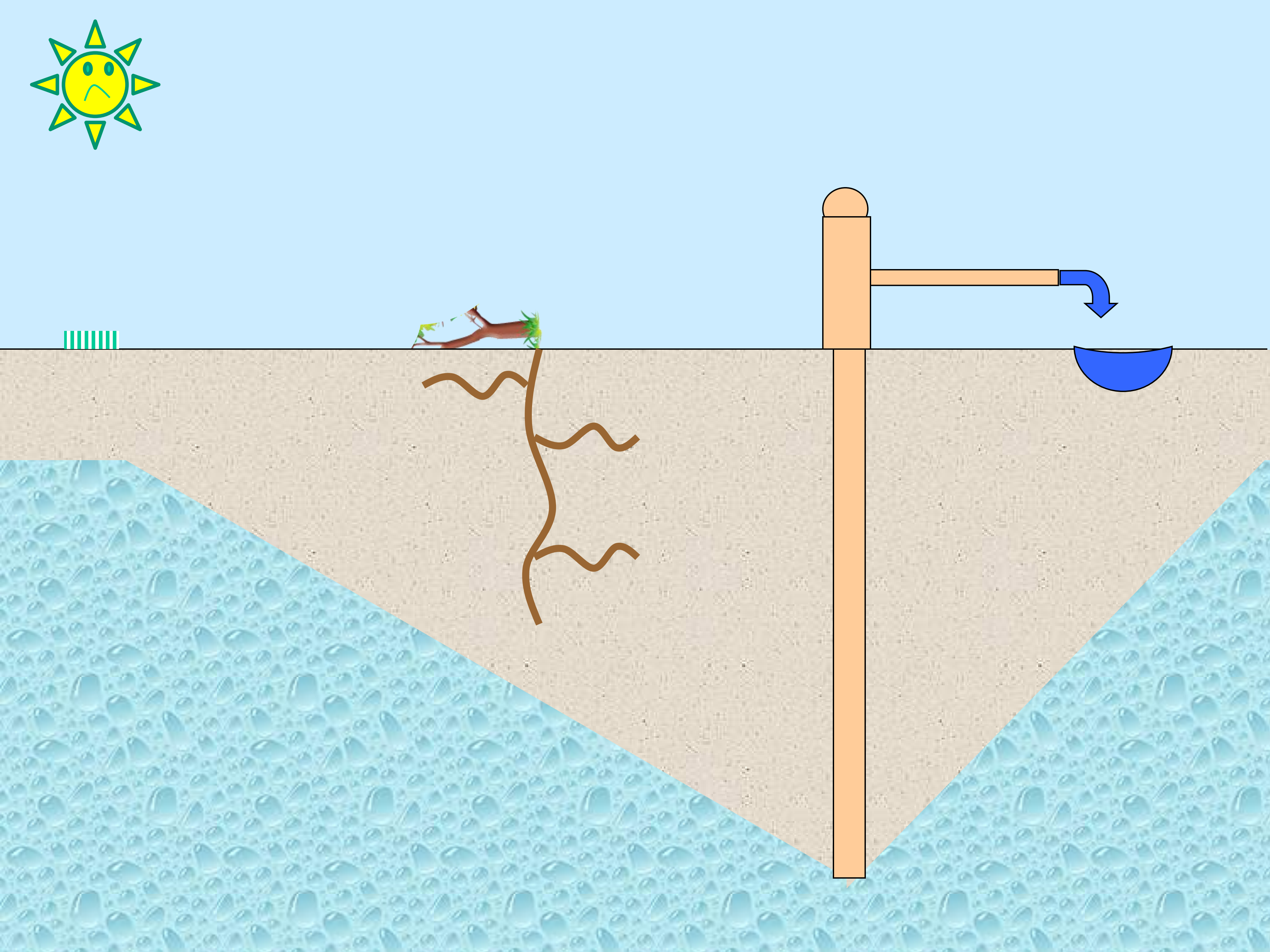
Loss of viable population of rare plant




grass root zone







Permanent Transect Blackrock 94

1987 53%cov
Green grass 42%
Some shrubs 11%

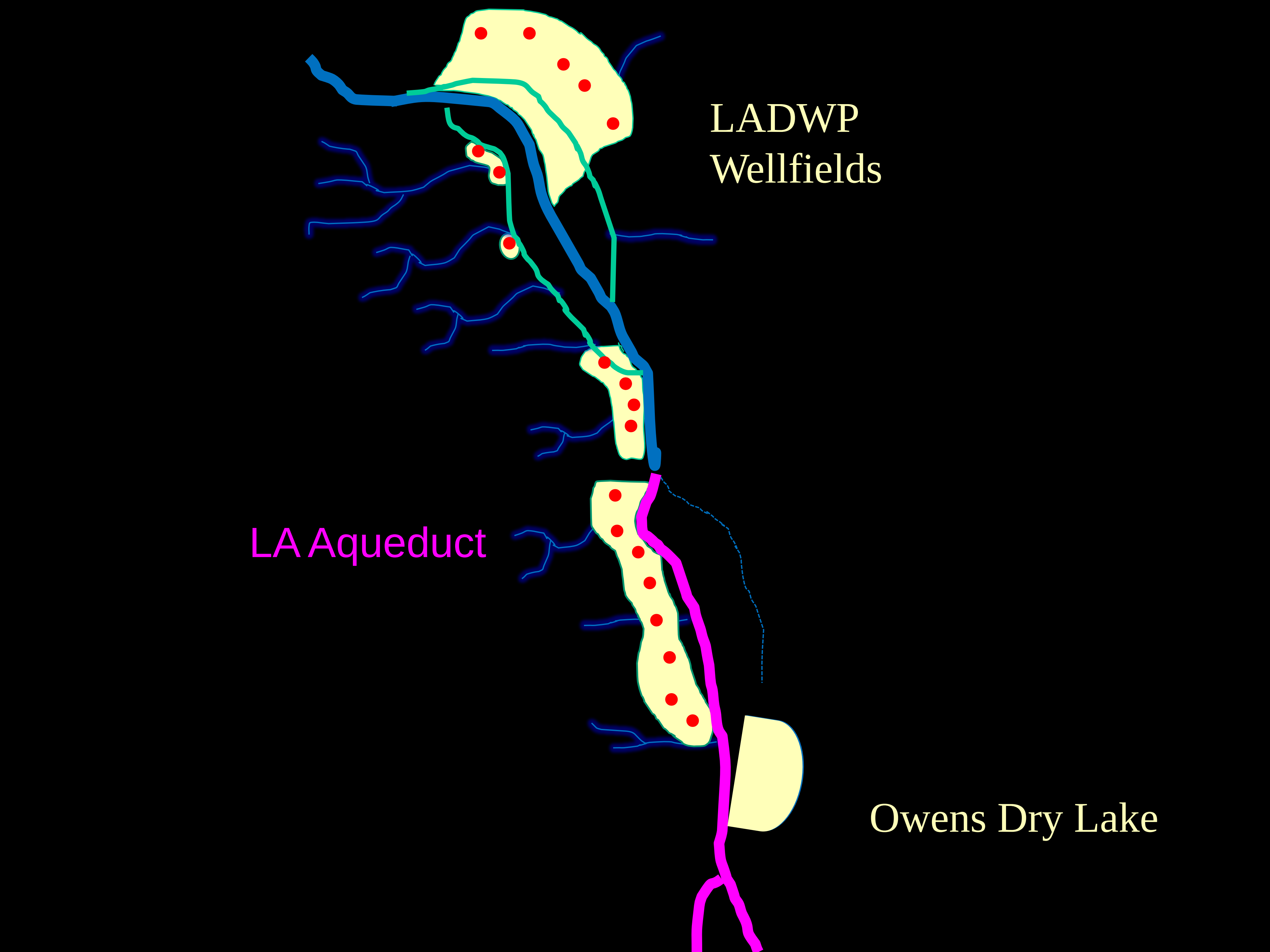
2007 14%cov
~Dead grass 1%
Shrubs dominate 13%

Permanent Transect Blackrock 94

1987 53%cov
Green grass 42%
Some shrubs 11%

Burned 2007
No groundwater = poor recovery

2012 4%?cov
grass ~ 1%
Shrubs ~ 4%


LADWP
Wellfields
LA Aqueduct
Owens Dry Lake

wind

March 30, 2010. View ESE from BP showing the dust rising high in sky and probably into the Inyo Mountains

DWP Pumping results in:

- Depressed water tables, “permanently”
- Loss of springs & wetlands
- Loss of meadow - Ecosystem conversion from groundwater to precipitation dependence
- Loss of animal habitat, native perennial grass cover, rare species
- Dominance by shrubs (or non native species)
- Increased potential for non native weedy species to thrive
- Erosion, dust storms
- Reduced forage for livestock
- And, it just looks bad!

DWP'S 1976 EIR

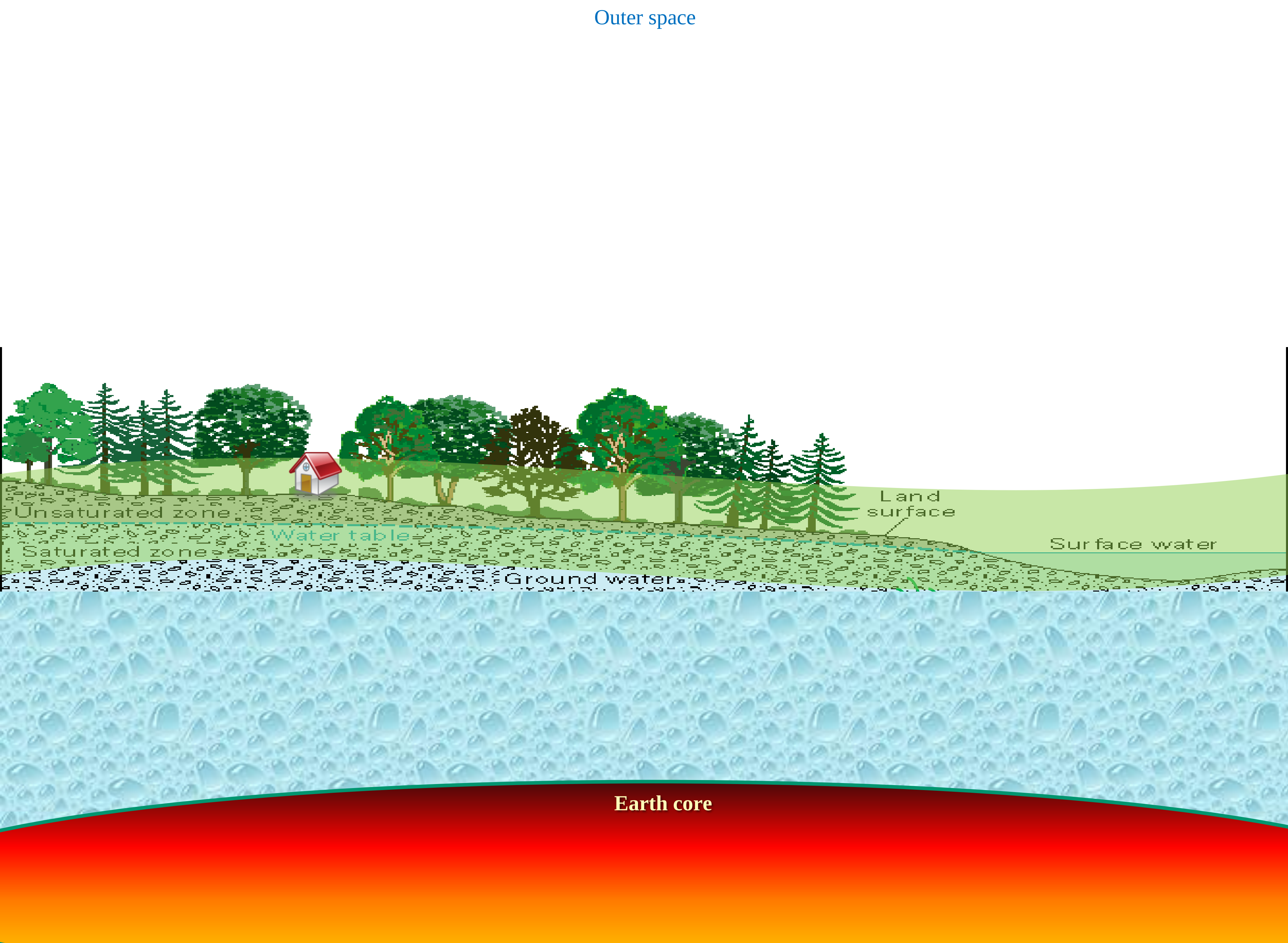
"The alkali grasslands will probably be the most noticeably impacted vegetation type"

N = none
L = low
M = moderate
H = high
VH = very high
E = extreme

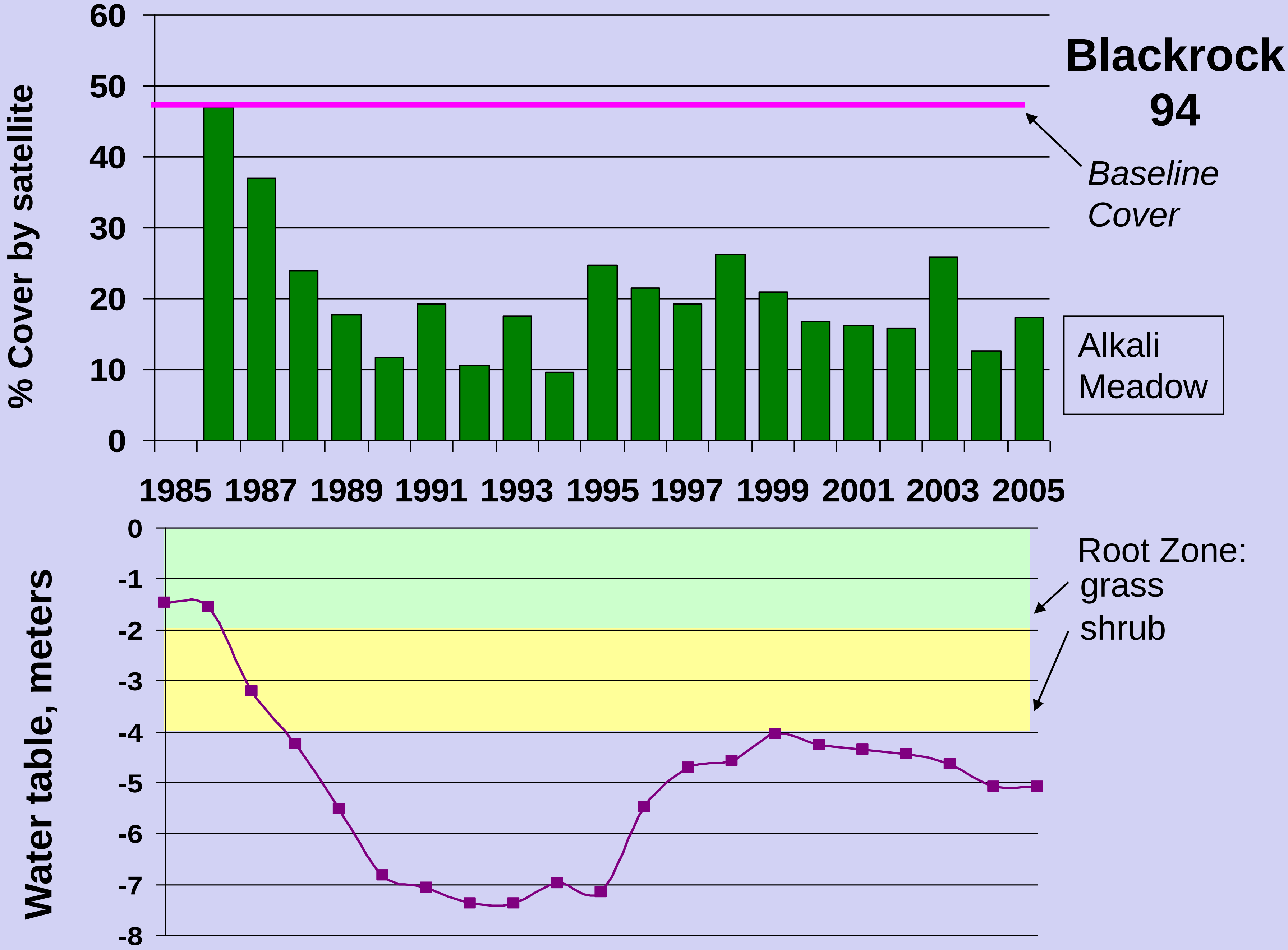
Vegetation Impact Matrix for Owens Valley

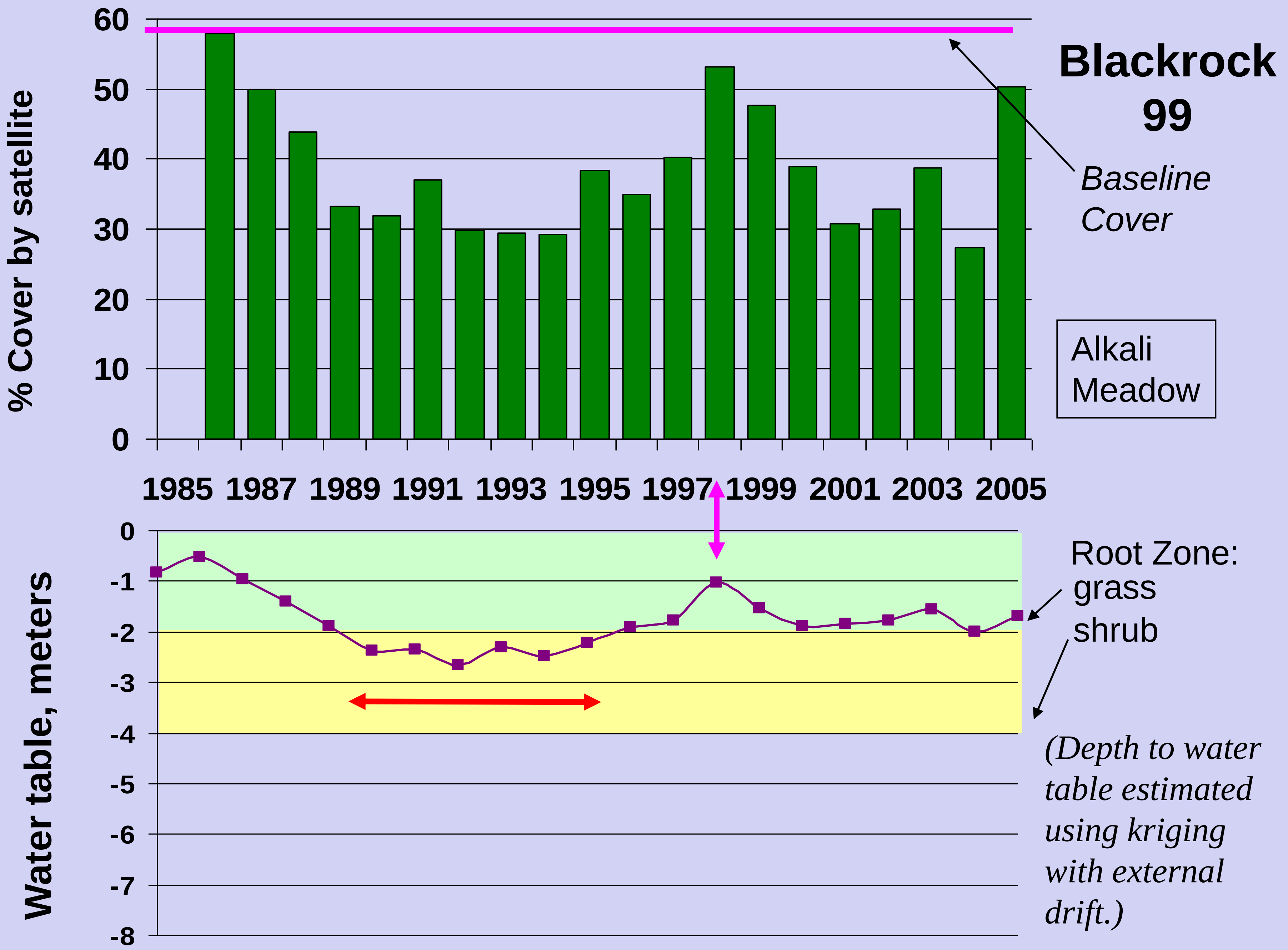
Water Table Depression (Feet)	Vegetation Types: Tule Marsh	Riparian/ Woodland	Alkali Grassland	Alkali Scrubland
	6/8*	5/8	6-8/8-10	7-8/15
0-10	N-M-VH**	N-L-M	N-M-H	N-L
10-15	E	H	VH-E	M-H
15+	E	VH	E	H-VH-E

* 6/8 = Chronic response threshold/acute response threshold (DTW in Feet).

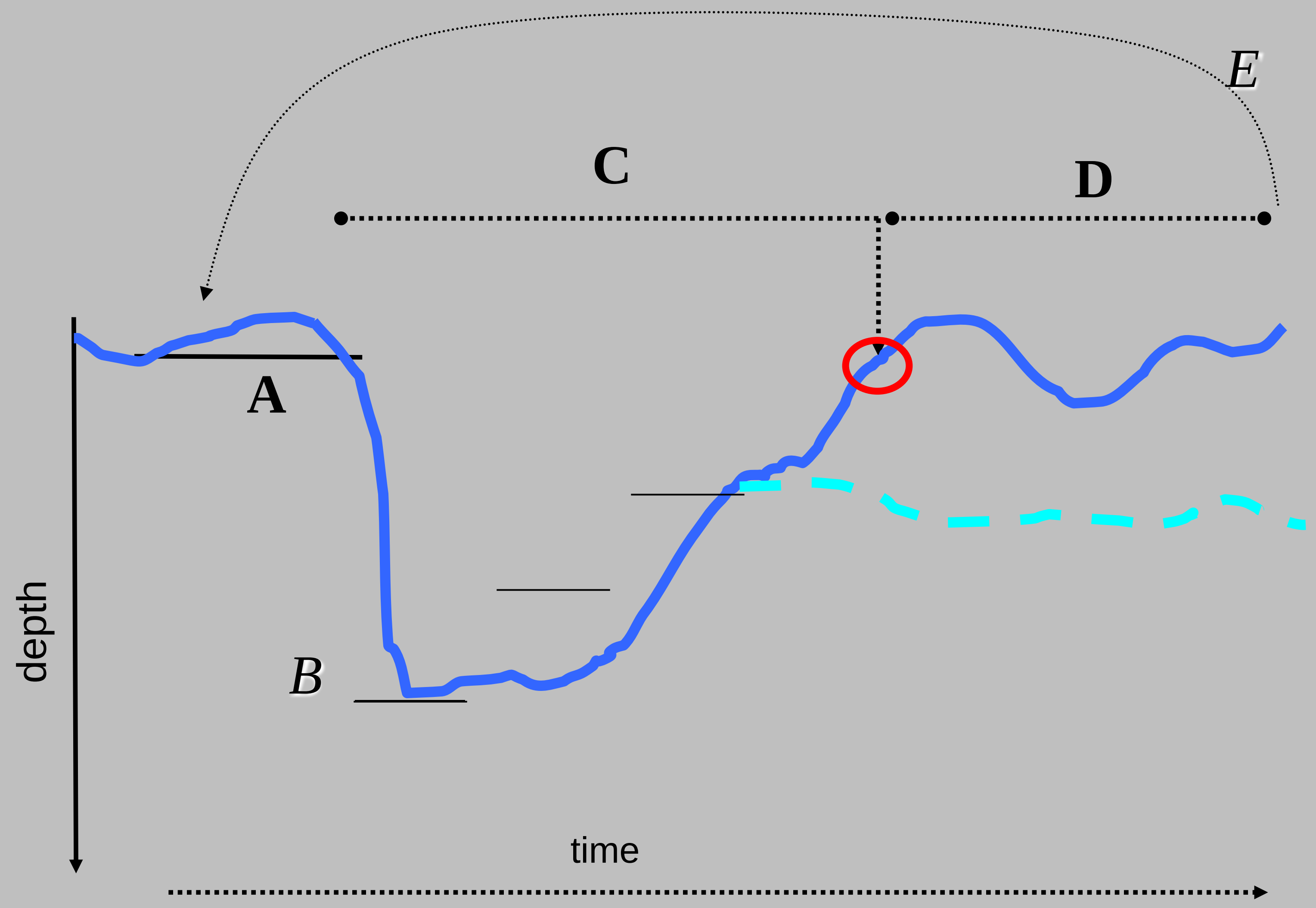

Outer space
Land
surface
Unsaturated zone
Water table
Saturated zone
Surface water
Ground water
Earth core




Blackrock 94
Baseline Cover
Alkali Meadow
% Cover by satellite
60
50
40
30
20
10
0
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Water table, meters
0
-1
-2
-3
-4
-5
-6
-7
-8
Root Zone:
grass
shrub



Blackrock 99
Baseline Cover
Alkali Meadow
% Cover by satellite
60
50
40
30
20
10
0
1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005
Water table, meters
0
-1
-2
-3
-4
-5
-6
-7
-8
Root Zone:
grass
shrub
(Depth to water table estimated using kriging with external drift.)



Water Table Based Management: Set baseline (A), allow pumping, but only to the point from which water table can recover (B) in the specified amount of time. (C). After recovery period (D), monitor (E) to see how it worked.

What’s been learned:

- Understand the ecosystem and hydrology
- Identify values
- Manage the hydrology
- Monitor response
- Modify management as needed

Conclusion:

➡ Gather the stakeholders

- Understand the ecosystem and hydrology
- Identify values
- **MANAGE the HYDROLOGY**
- Monitor response
- Modify management as needed

➡ Officially include stakeholders in decisions