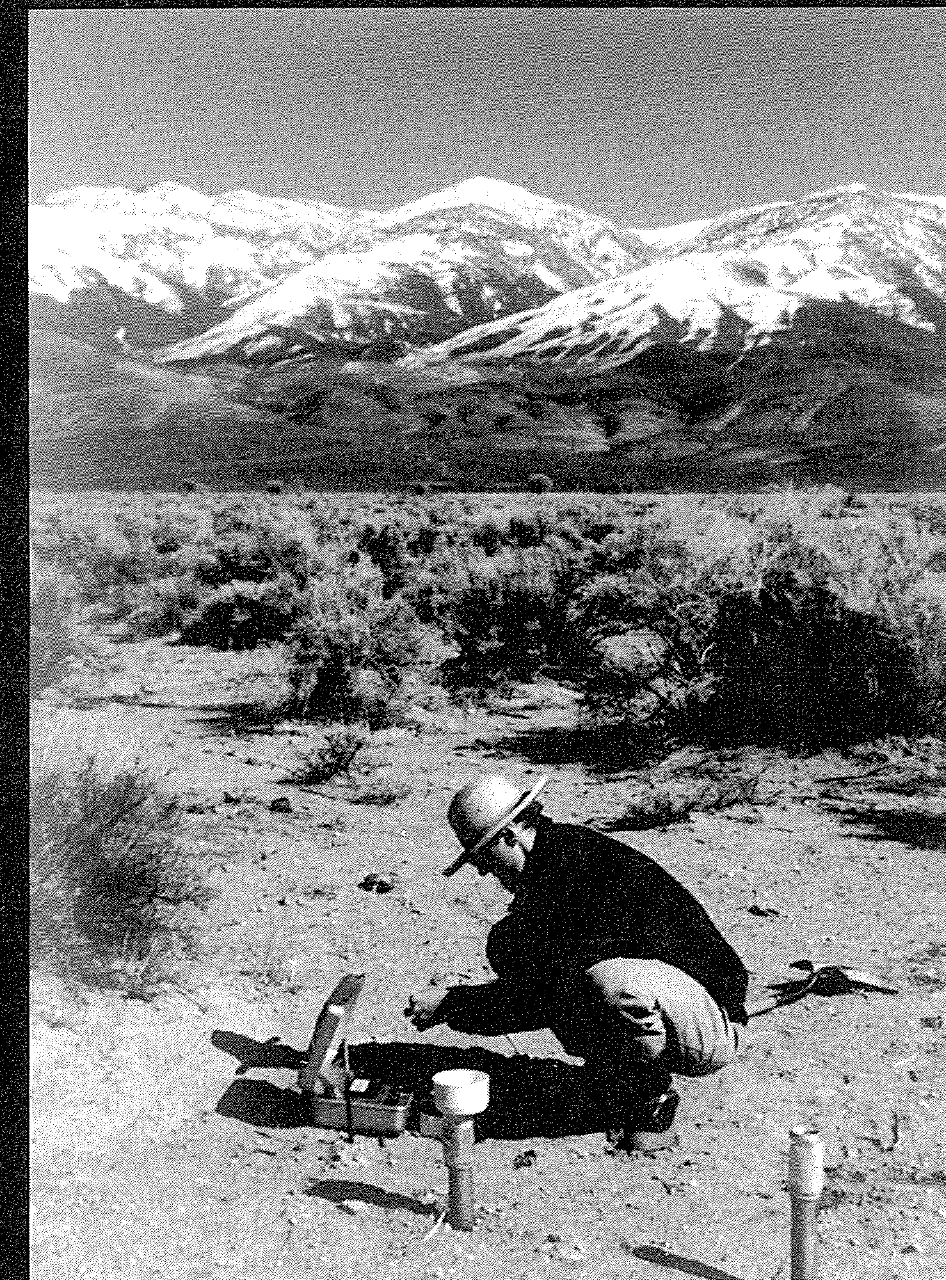
Inyo County Water Department
163 May Street
Bishop, California 93514

The Owens Valley



Monitor

Inyo County Water Department's Fourth Annual Report on Events, Activities and Conditions in the Owens Valley

1995

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This is the Inyo County Water Department's fourth annual report. It covers the year 1995.

It is a compilation of data and results from monitoring and other field and technical work performed by the Inyo County Water Department (ICWD) staff and consultants and the Los Angeles Department of Water and Power (LADWP).

The ICWD was formed in 1980. In accordance with a cooperative Owens Valley water management agreement with LADWP, the ICWD and LADWP monitor water activities in the valley and their impacts on groundwater levels and vegetation, and conduct scientific research on methods of improving water management.

THE OWENS VALLEY

MONITOR

This annual report was produced by the Inyo County Water Department (ICWD) in Bishop, California. Its purpose is to explain the ICWD's yearly monitoring and management activities in the Owens Valley.

Greg James, Water Director
Heidi Walters, Editor

The ICWD also produces a newsletter called the *Owens Valley Water Reporter*. This newsletter covers the activities of the ICWD and water issues in the Owens Valley and the Eastern Sierra. If you would like to receive the newsletter and the annual report, let us know:

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Attn.: Heidi Walters

Front cover: Using a psychrometer, ICWD's Brian Cashore measures soil water at a monitoring site in the Owens Valley.
Back cover: Swallows swoop over flooded area east of Bishop. Photos: Heidi Walters

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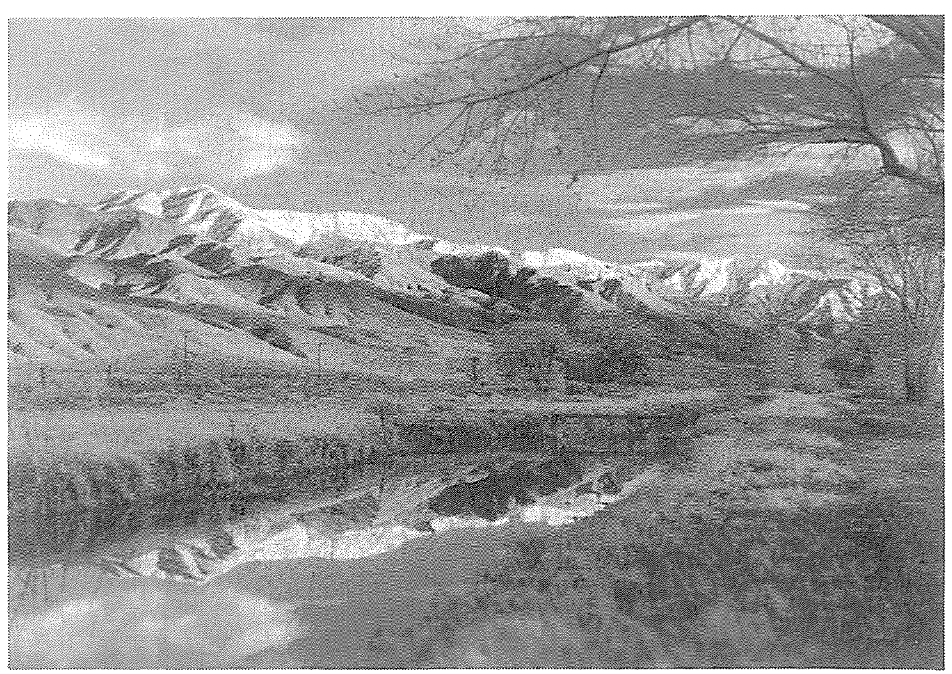


A White Mountains afternoon Photo: Heidi Walters

Inyo County Water Department staff produced the following documents in 1995 and early 1996:

Hydrology

- **A Reconnaissance Survey of Shallow Groundwater pH, Temperature and Electrical Conductivity in the Winter and Spring of 1995 in the Owens Valley of California.** (Report 95-1) Randy Jackson. Under internal review.
- **Shallow Groundwater Levels in the Owens Valley — 1995 Update.** (Report 95-2) Randy Jackson. Under internal review.

Vegetation

- **Germination Tests of Owens Valley Seeds.** (February 1995) Denise Waterbury, Sally Manning, and Irene Yamashita.
- **Report on 1994 Rare Plant Site Visits.** (March 1995) Sally Manning.
- **Results of Four Revegetation Treatments on Barren Farmland in the Owens Valley, California.** (April 1995) Irene S. Yamashita and Sara J. Manning. *pp 142-147 in: B.A. Roundy, E.D. McArthur, J.S. Haley, and D.K. Mann, compilers, Proceedings: Wildland Shrub and Arid Land Restoration Symposium, October 19-21, 1993, Las Vegas, Nev. USDA Forest Service Gen. Tech Rep. INT-GTR-315.* Intermountain Research Station, Ogden, Utah.
- **Shrub Recruitment 1994: A report to the Inyo/Los Angeles Technical Group on results of monitoring for recruitment at permanent monitoring sites.** (July 1995) Sally Manning.
- **Mazourka Canyon Road recruitment site: A report on findings 1992-1994.** (July 1995) Sally Manning.
- **Saltcedar control project, August 1994-August 1995.** (October 1995) Brian Cashore.

Soils

- **An Evaluation of Soil Survey Crop Yield Interpretations for Two Central Iowa Farms.** Aaron L. Steinwand, D.L. Karlan and T.E. Fenton. *Journal of Soil Water Conservation, 1996, 51: 66-77.*
- **Landscape Evolution and Shallow Groundwater Hydrology of the Till Landscape in Central Iowa.** Aaron L. Steinwand and T.E. Fenton. *Soil Science Society of America Journal, 1995, 59: 1370-1377.*

The Inyo County Water Department is in the Web.

Our E-mail address:
inyowaterdept@telis.org

We are constructing a Web page, which we hope eventually will contain our publications: issues of our newsletter, the Owens Valley Water Reporter, our annual report, The Owens Valley Monitor, and scientific reports, publications and other information.

Conferences, classes

- **Nevada Water Resources Conference,** Reno, Nev., March 14-15, 1995 — Randy Jackson.
- **Geomorphology in River and Stream Restoration,** a five-day extension course held at University of California, Berkeley, April 1995 — Brian Cashore.
- **Wildland Shrub Symposium,** Las Cruces, New Mexico, May 1995 — Sally Manning. Talks and poster presentations by researchers from all over the Western United States (and some from the Eastern US) Main topic: the conversion of arid/semi-arid grasslands to desert shrublands — how and why (is it climate- or human-induced or both?) Included a field trip to the Jornada Long-Term Ecological Study Area, which has seen a conversion from black grama grassland to creosote bush shrubland over the last 100 years.
- **California Groundwater Conference,** San Diego, Calif., Sept. 11, 1995 — Randy Jackson
- **California Exotic Pest Plants Council,** Asilomar, Calif., October 1995 — Brian Cashore and Sally Manning. Talks on invasive weeds of California — perspectives, successes, etc. Included a workshop on *Lepidium latifolium*, a weed rapidly spreading throughout the West.
- **California Riparian-River Ecosystem Conference,** Sacramento, Calif., Nov. 14-16, 1995 — Randy Jackson
- **EIR Project Management** class at University of California-Davis, Davis, Calif., — Leah Kirk
- **Desert Lands Rehabilitation Workshop,** Barstow, Calif., Nov. 15-16 — Sally Manning, Denise Waterbury, Irene Yamashita. Organized by Desert Lands Restoration Task Force, a consortium of private, interagency and academic members. Attendees shared information and techniques, gave slide presentations and participated in roundtable discussions and hands-on workshops.

Educational

Sally Manning was involved in a number of educational endeavors in 1995, including:

- serving as a judge at the Home Street School Inventor's Fair. Manning also advised students on their Inyo County Science Fair projects.
- with Denise Waterbury, spending an afternoon teaching Round Valley School 5th and 8th graders how to run a vegetation transect.
- working with science teachers from the Los Angeles area on how to inventory vegetation.
- leading a Southwest State University field trip to demonstrate environmental water management in the Owens Valley.

Committees

- **California Native Plant Society, Plant Communities Committee** (statewide) — Sally Manning — This committee has devised standardized methods for inventorying plant communities, and has published a book called *A Manual of California Vegetation*, by John Sawyer and Todd Keeler-Wolf. This book is a compilation of California's plant communities that have previously been described by researchers.
- **White Mountain Research Station Forum** — Sally Manning, Aaron Steinwand — This group meets to discuss items of mutual interest among local biologists.
- **Interagency Greenhouse Committee** — Irene Yamashita, Denise Waterbury, Sally Manning — This group's goal was to gather information on greenhouse design to build a native plant growth facility at the White Mountain Research Station, with a greenhouse structure, outdoor growing areas, and an interpretive garden.
- **Owens Valley Multi-Species Recovery Task Force** — Sally Manning — This committee advises and reviews the work of consultants who are preparing the Owens Valley Multi-Species Recovery Plan. The plan focuses on listed and candidate plant and animal species living in alkaline areas of the Owens River watershed, and it will designate critical habitat and management recommendations for recovering the species.

EIR negotiations continue

After a hiatus of nearly one year, Inyo County, the City of Los Angeles, two state agencies and two environmental groups resumed negotiations in December 1994 in the hopes of reaching a settlement agreement that would conclude litigation that affects water management in the Owens Valley.

The appellate court has not made a decision on the adequacy of the EIR although the matter has been before the court for nearly four and a half years.

In 1991, the County and Los Angeles approved a historic water management agreement for the Owens Valley which would end two decades of litigation over groundwater pumping. However, before the litigation can be concluded — and the historic agreement fully implemented — an environmental impact report, which addresses the agreement and the impacts of LADWP's water gathering activities since 1970, must be approved by a three-judge appellate court panel in Sacramento.

Los Angeles and the County submitted the required EIR to the appellate court in October 1991. Shortly thereafter, the California Department of Fish and Game, the California State Lands Commission, the Owens Valley Indian Water Commission, the Sierra Club, the Owens Valley Committee, and one individual presented challenges to the EIR's adequacy to the court.

Negotiations aimed at resolving the concerns raised began in late 1991. In 1992, the Owens Valley Indian Water Commission agreed to a settlement and withdrew from the litigation, but the other challenges to the EIR remained. By late 1994, all involved with the litigation had presented their views to the court in formal legal documents.

At about that time, the County and Los Angeles suggested a new settlement approach, and settlement talks which had been dormant for a year resumed. In the absence of a decision by the court on the adequacy of the EIR, settlement discussions continued throughout 1995. In April 1996, Inyo County Water Department Director Greg James reported that good progress was being made and it was hoped that a settlement of the EIR litigation could be reached in the near future. He also noted that the appellate court has not made a decision on the adequacy of the EIR although the matter has been before the court for nearly four and a half years.

Stewards, LADWP agree

On July 14, 1995, an agreement was reached between LADWP and the owners of the Steward Ranch in Big Pine, ending a multi-year dispute. The agreement permanently settles complaints brought against LADWP by Kenneth and Elaine Steward, who said LADWP's nearby groundwater pumping and other water gathering activities had lowered the water table beneath their 160-acre cattle and alfalfa ranch, affecting domestic and irrigation wells and resulting in a loss of alfalfa production and increased electrical costs.

Because some of the LADWP wells involved are used to supply enhancement/mitigation projects, and as a result of the Inyo County/Los Angeles long-term groundwater agreement and EIR, the County was involved in the settlement discussions. The settlement agreement provides that LADWP will supply a new well on the ranch, equip it with a pump, motor, electrical service, and flow meter and connect it to the ranch's reservoir or irrigation system. Also, future electrical bills will be adjusted, if necessary, to compensate for increased pumping costs from deeper levels, the Stewards will receive compensation for lost agricultural production, and the agreement has provisions that insure that future pumping from the LADWP wells will not deprive the ranch of adequate water for its needs.

Inyo Water Commission reviews E/M projects

In late 1994, the Inyo County Water Commission began holding meetings in the Owens Valley towns, aimed at reevaluating enhancement/mitigation (E/M) projects, many of which were initiated in the 1980s. These projects were meant to either enhance an area or mitigate adverse impacts caused by Los Angeles' water gathering. Some of the projects have been completed. Others are in process, and still others have not begun.

The commission has been seeking the public's assessment of these projects and ideas for possible future projects. The meetings continued in 1995 and into 1996. The commission now is in the process of making recommendations to the Inyo/Los Angeles Technical Group about the projects, based on public opinion and input, and feasibility of the projects. Some projects depend on implementation of the Inyo/Los Angeles long-term water management agreement.

Inyo County and Los Angeles agreed to a maximum pumping limit of about 73,000 acre-feet for the 1995-1996 runoff year (April 1, 1995 through March 31, 1996). When the pumping limit was set, it was agreed that if the capacity of the aqueduct and capability of beneficial spreading facilities normally used during wet years were exceeded in runoff year 1995-1996, surface water was to be supplied to those enhancement/mitigation (E/M) projects capable of using the water for as long as such conditions existed. If such an event were to occur, the recommended maximum pumping figure of 73,000 acre-feet would be reduced by the amount of water supplied to the E/M projects during that time period of exceeded capacity.

Capacity of the aqueduct and spreading facilities was exceeded in the runoff year. During this time, about 990 acre-feet of surface water was supplied to E/M projects. As a result, the pumping limit was reduced by 990 acre-feet to 72,010 acre-feet. Actual pumping for the 1995-1996 runoff year was about 70,000 acre-feet.

Total in-valley uses in Owens Valley during the 1995-1996 runoff year were about 112,000 acre-feet. These uses included about 57,000 acre-feet for irrigation, about 20,000 acre-feet for stockwater, about 12,000 acre-feet for recreation and wildlife and about 23,000 acre-feet for E/M projects. Enhancement/mitigation projects were installed by LADWP under the 1984 interim water agreement between Inyo County and Los Angeles. They include Klondike Lake, Lone Pine riparian park, woodlots in Independence and Lone Pine, several pastures and alfalfa fields, and the lower Owens River rewatering project.

Pumping, 4-1-1995 to 3-31-1996

Wellfield	Approx. actual pumping (acre-feet)
Laws	8,000
Bishop	4,000
Big Pine	25,000
Taboose-Aberdeen	7,000
Thibaut-Sawmill	13,000
Independence-Oak	9,000
Symmes-Shepherd	2,700
Bairs-Georges	300
Lone Pine	1,000
TOTAL	70,000

The Inyo/Los Angeles Technical Group develops the pumping program each year based on several factors, including projected runoff derived from snow survey results, and monitoring results of vegetation conditions, water tables, soil water availability to the vegetation and vegetation water requirements. The Inyo/Los Angeles Standing Committee agrees on a pumping limit before adopting the pumping program.

To develop the pumping program, the Technical Group follows guidelines set forth in the long-term agreement on groundwater management, the Green Book (technical manual for carrying out the agreement), the drought recovery policy agreed upon by Inyo County and Los Angeles in 1990, and the 1984 interim agreement between the County and the City.

Under the drought recovery policy, Inyo and LADWP have been managing groundwater pumping in an environmentally conservative manner during the drought, which began in 1987. The policy will be continued for a period of recovery following the drought to allow for recovery of water tables and soil water available to plants in the valley. When the drought began, water tables were at or near the highest levels in about 20 years. But from 1987 to 1989, groundwater pumping was high and water tables in the Owens Valley declined. Since 1990, water tables generally have been rising. (See Hydrology section, page 4.)

Los Angeles' Owens Valley pumping for past 9 years

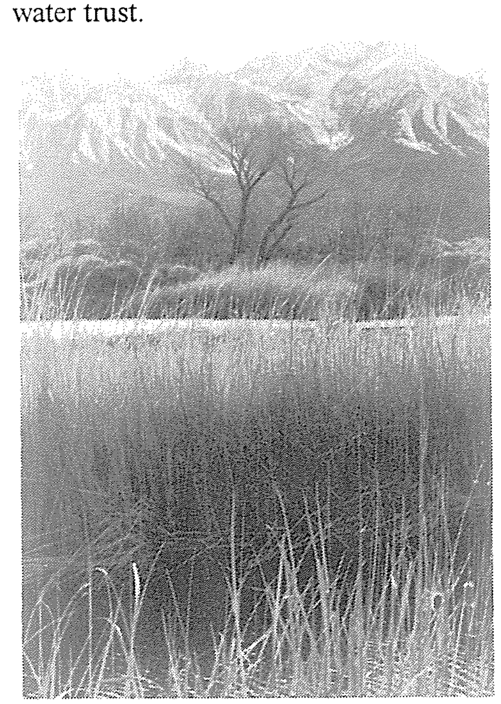
Runoff Year	OV runoff (% normal)	Production wells (acre-feet)	E/M wells (acre-feet)	E/M water use (acre-feet)	Total pumping (acre-feet)
1987/88	65	179,883	29,511	29,360	209,394
1988/89	62	171,012	29,431	30,872	200,443
1989/90	66	133,340	22,563	23,330	155,903
1990/91	52	70,974	18,087	17,949	89,061
1991/92	64	71,736	15,790	20,517	87,526
1992/93	69	71,370	13,765	18,357	85,135
1993/94	117	67,338	8,991	19,310	76,329
1994/95	67	78,143	11,010	20,812	89,153
1995/96	150 (E)	57,000 (E)	13,000 (E)	23,000 (E)	70,000

(E) = preliminary estimate

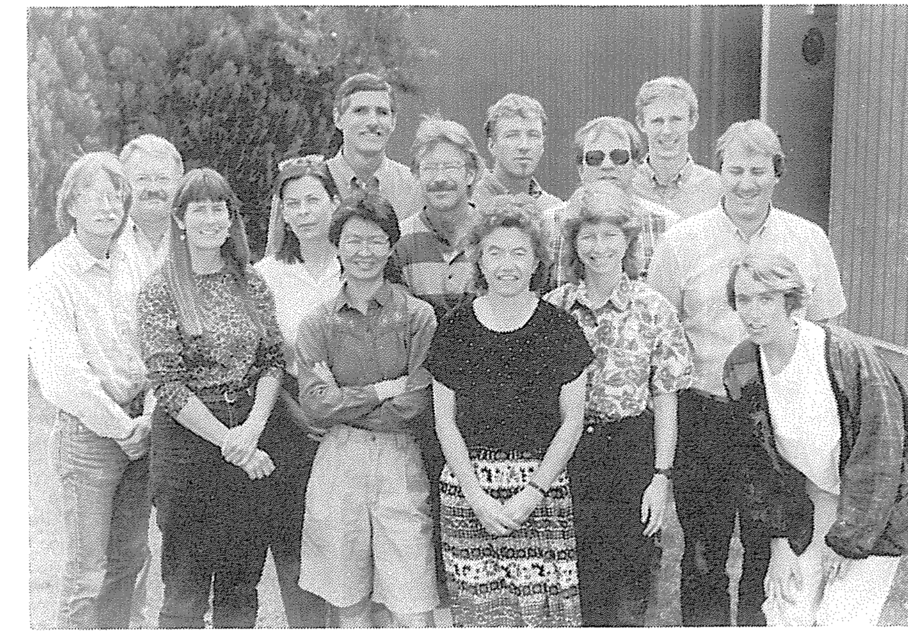
ICWD's budget

Inyo County Water Department's general operations budget for fiscal year 1994-1995 was $993,710. General operations include ongoing monitoring and management in the valley and office administration.

Of the $993,710, $887,033 was provided by the Los Angeles Department of Water and Power, $40,000 came from the county's geothermal trust fund, and $66,677 came from the LADWP/ICWD water trust.



Billy Lake Photo Heidi Walters



The Inyo County Water Department Photo: Heidi Walters

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Supervising Research Assistant
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Denise Waterbury
Research Assistant
Brian Stange
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Jennifer Foote
Summer Research Assistant

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Environmental Specialist
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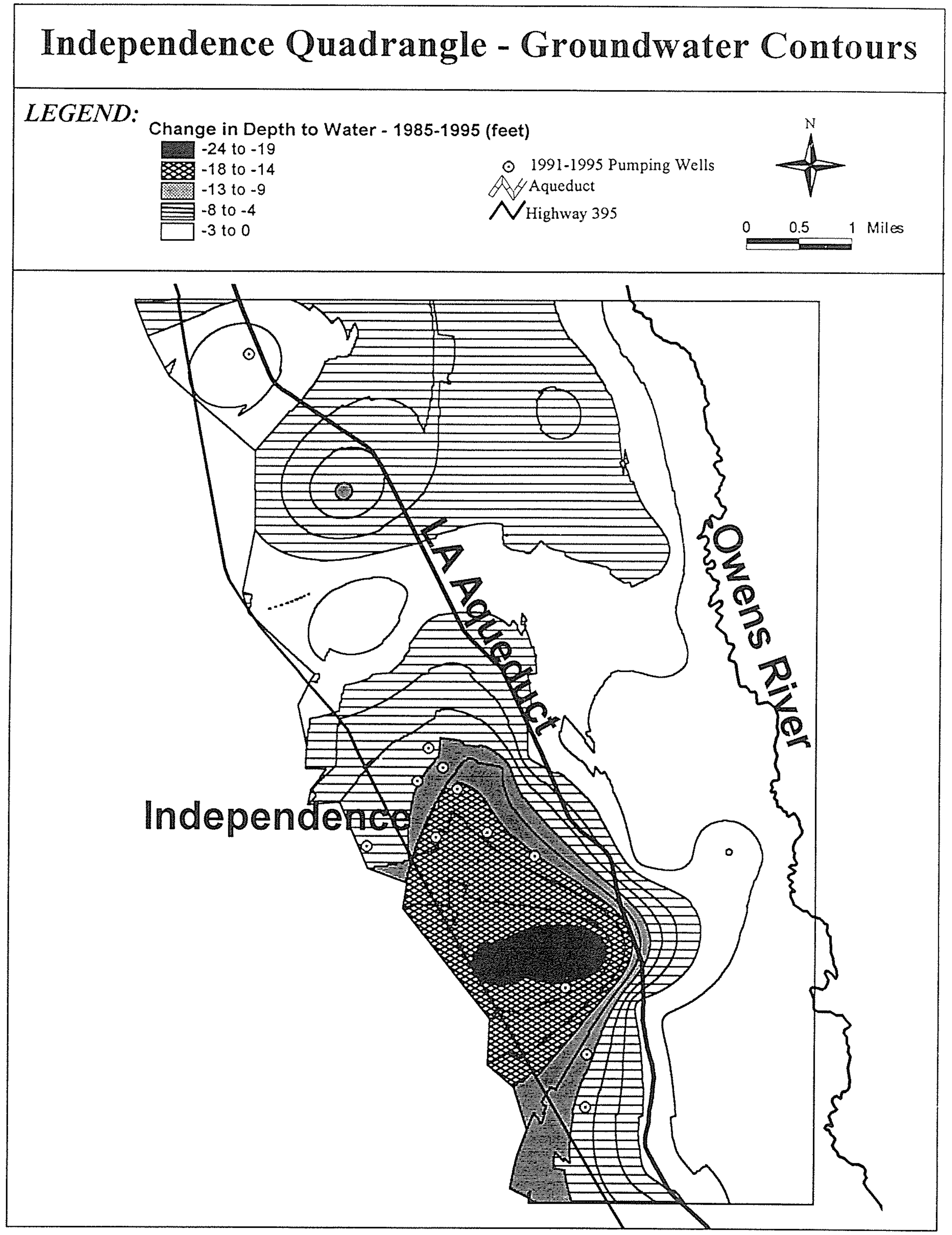


Independence change in depth to groundwater — *The Inyo County Water Department hydrologist develops depth to groundwater contours based on field measurement of test wells throughout the Owens Valley. These groundwater contours can be overlaid with vegetation types, well locations and other datalayers. When this is done, the contours are helpful in assessing the effects of groundwater pumping on vegetation and the overall hydrology of the Owens Valley.*

Monitoring and managing the Owens Valley

Throughout the year, the Inyo County Water Department (ICWD) and the Los Angeles Department of Water and Power (LADWP) monitor the vegetation, groundwater, surface water and soil water in the Owens Valley, as part of the long-term water management agreement between Inyo County and Los Angeles.

The purpose of this monitoring is to document the valley's environmental response to groundwater pumping and other water activities performed by LADWP. Inyo County and Los Angeles use these monitoring results to make management decisions to avoid significant decreases or changes in vegetation and to avoid groundwater mining (the depletion of water in the aquifer that exceeds replenishment from recharge over a 20-year period).

Hydrology

Precipitation

To augment other precipitation measurements made throughout the valley, Inyo County monitors precipitation in the Owens Valley using seven rain gages. The following table shows precipitation totals recorded at each of the rain gage sites for water years 1994 and 1995 (a water year is from October 1 through September 30):

Rain Gage	Precipitation in inches Water Year	
	1993-1994	1994-1995
RG-1, near Five Bridges	3.40	7.60
RG-2, near Laws	3.62	7.80
RG-3, southeast of Bishop	4.34	8.87
RG-4, south of Big Pine	4.24	9.76
RG-5, near Goose Lake	2.15	7.07
RG-6, near Blackrock	2.95	8.67
RG-7, near Independence	1.61	4.88
Average, Owens Valley	3.19	7.81

Snowpack and runoff

Los Angeles Department of Water and Power's April 1, 1995 snow survey found water content in the Mammoth area snowpack to be 180 percent of normal. This was similar to the wet conditions recorded in 1993 and unlike 1994, when the April 1 snowpack water content was 55 percent of normal.

Runoff for April 1995-March 1996 was projected to be 150 percent of normal. In the 1994 runoff year, runoff was estimated to be 67 percent of normal.

Surface water

Surface water flows were much higher in 1995 than in dry 1994 in the Owens River and the more than 20 creeks that flow into the valley from the Sierra Nevada and the White Mountains.

LADWP, which operates three power plants in the Owens River Gorge above Pleasant Valley Reservoir north of Bishop, controls the amount of water flowing through the reservoir. LADWP is required by the California Department of Fish and Game to keep a minimum of 100 cubic feet per second (cfs) flowing into the Owens River below the reservoir to protect fish habitat.

Between April 1, 1994 and March 31, 1995 flows in the Owens River from Pleasant Valley Reservoir ranged from highs near 700 cfs to lows around 100 cfs. But with increased runoff into 1995, flows in the river throughout 1995 were continuously higher than in 1994. Flows in 1995 ranged from lows just below 300 cfs to highs just above 700 cfs, with average flows hovering around 500 cfs.

Groundwater recharge

Recharge, the amount of water percolating into the aquifer, is estimated for each water year, October through September, and is based on projected runoff.

In 1995, total estimated recharge into the Owens Valley was 216,228 acre-feet. In 1994, the total estimated recharge was 117,552 acre-feet.

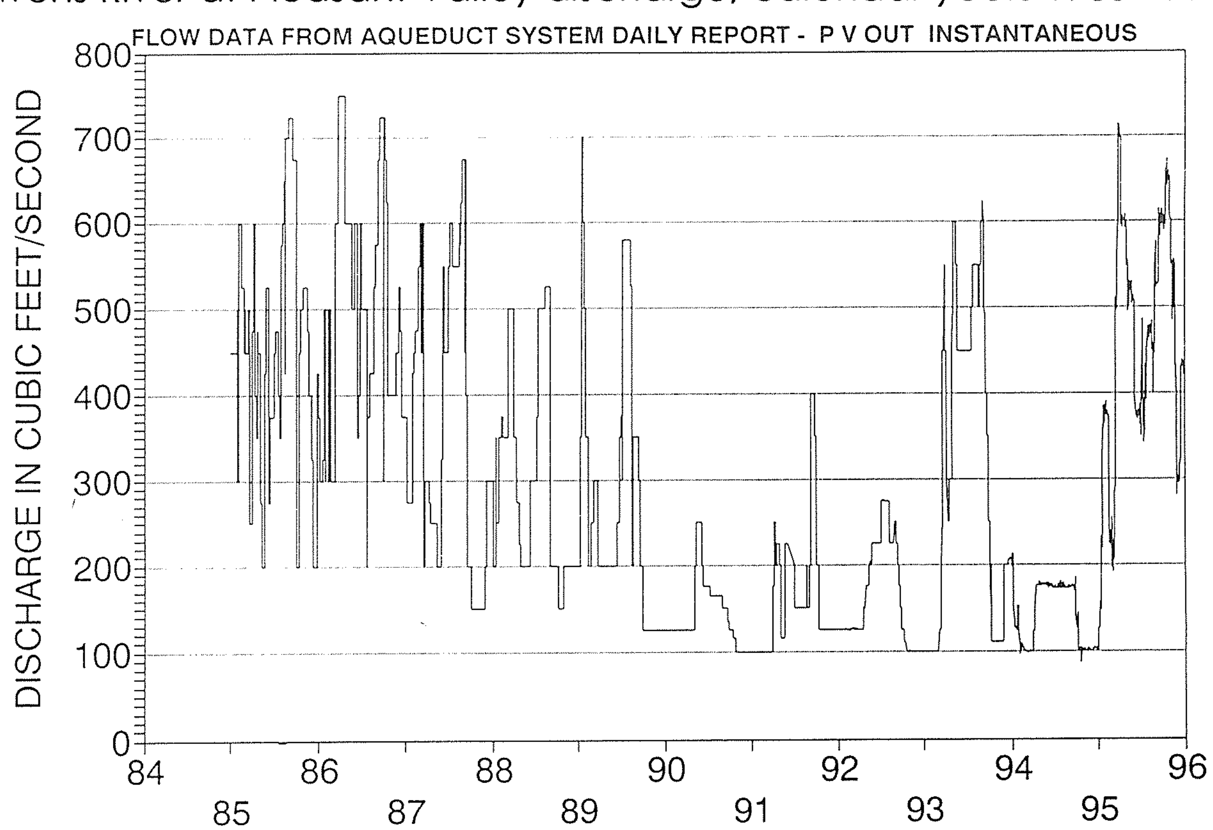
Estimated 1995 recharge by wellfield

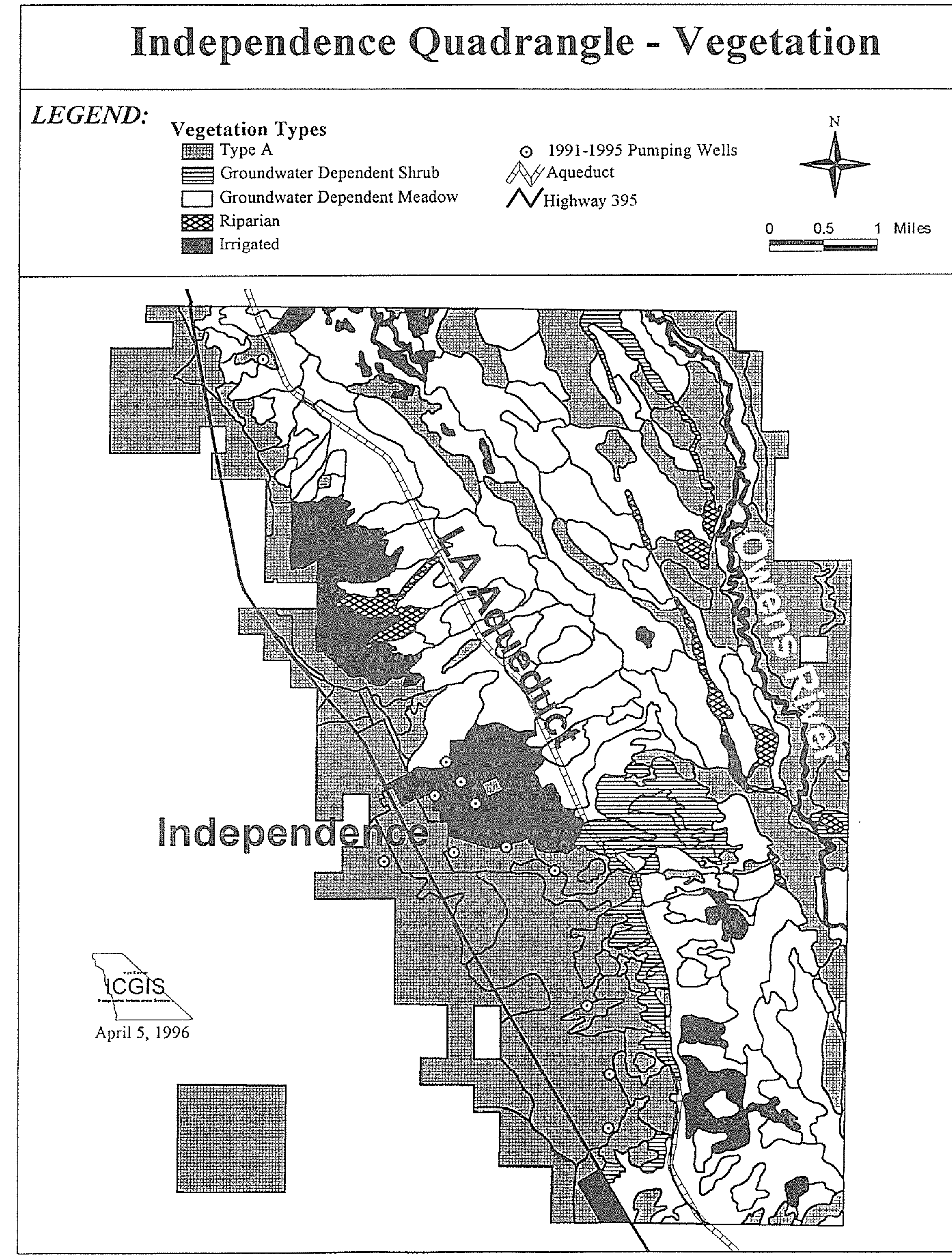
Wellfield	Acre-feet
Laws	19,053
Bishop	51,585
Big Pine	36,383
Taboose-Thibaut	44,601
Ind-Sym-Bairs	47,240
Lone Pine	17,366
Owens Valley Total	216,228

Shallow aquifer water level recovery in 18 indicator wells

	Depth to groundwater (feet) in April						Change April 1994-April 1995 (feet)	Change needed to reach April 1987 water levels (feet)
Wellfield	Well #	1987	1992	1993	1994	1995		
Laws	436T	7.2	Dry at 19	18.5	14.7	15.4	-0.7	+8.2
	492T	32.3	51.3	50.5	41.9	44.5	-2.6	+12.2
Big Pine	425T	14.3	26.6	26.2	24.4	24.1	+0.3	+9.9
	426T	11.4	Dry at 19.7	Dry at 19.7	19.1	19.0	+0.1	+7.6
Taboose-Aberdeen	418T	8.3	17.8	16.8	15.3	14.6	+0.8	+6.3
	419T	6.5	21.8	18.8	15.6	14.5	+1.2	+8.0
	421T	34.3	47.5	45.2	42.6	42.0	+0.5	+7.8
	502T	7.6	Dry at 16	15.7	13.4	13.2	+0.2	+5.6
Thibaut-Sawmill	415T	18.5	33.1	32.4	28.4	29.6	-1.2	+11.1
Independence-Oak	407T	7.2	16.9	15.4	15.6	14.2	+1.4	+7.0
	408T	3.0	9.3	8.3	7.5	6.6	+0.9	+3.6
	409T	17.4	19.4	17.4	12.7	15.4	-2.6	+2.0
Symmes-Shepherd	401T	17.5	25.0	24.4	23.9	23.3	+0.6	+5.8
	403T	6.1	11.4	10.5	10.8	11.0	-0.2	+5.0
	404T	3.8	7.4	6.3	7.3	6.3	+1.0	+2.5
	447T	23.0	47.5	46.4	45.0	46.3	-1.3	+23.3
Bairs-Georges	398T	5.6	7.5	5.4	5.9	5.2	+0.7	-0.4
	400T	6.6	6.8	6.3	6.6	6.1	+0.5	-0.5

Owens River at Pleasant Valley discharge, calendar years 1985-1995





Independence vegetation — *The 1984-1987 vegetation base maps for the Owens Valley have been incorporated into the GIS. Now, vegetation on any quadrangle can be viewed on the computer and overlaid with well locations, roads, and hydrologic datalayers.*

Also, the vegetation parcels can be displayed using the associated attribute tables, which store information on percent live cover, evapotranspiration, and vegetation type. The raw data for these datalayers were provided by the Los Angeles Department of Water and Power.

Since he was hired in fall 1994, Inyo County's GIS Development Specialist Chris Howard has developed a Geographic Information System (GIS) program for the water department and two other departments: roads and the Yucca Mountain division of the planning department.

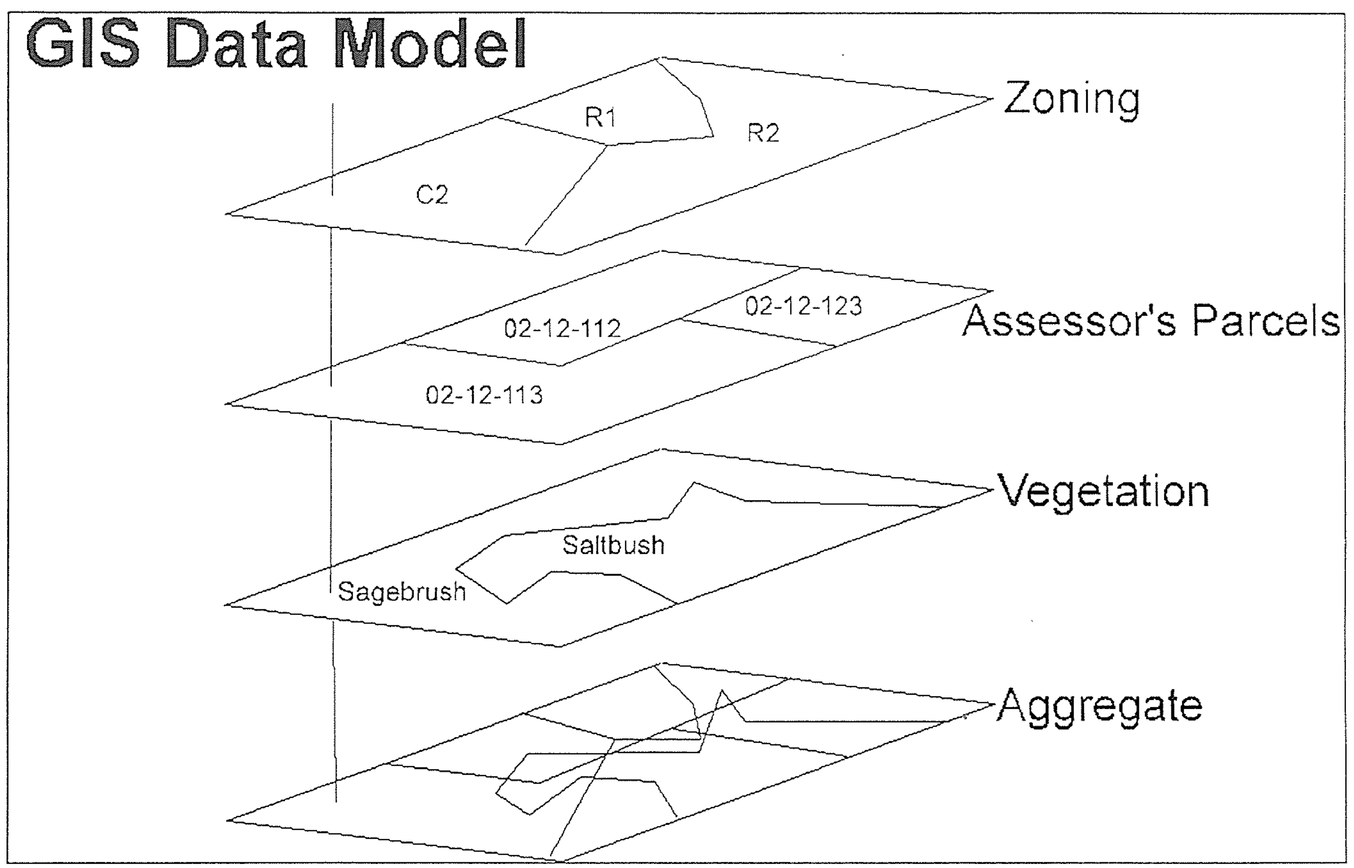
GIS consists of computer software and hardware which together make up a spatially oriented database whereby one can store, manipulate and analyze geographic data.

For the water department, Howard has taken geographic information from state and federal sources, and local data provided by LADWP including production well locations in the valley, vegetation base maps, vegetation monitoring results, and groundwater contours, and entered them into a GIS program. The program enables one to view the data in layers, either separately or overlaid onto each other, and thus analyze conditions in the Owens Valley.

Howard said such a system is more efficient than traditional methods of compilation and analysis, such as paper maps and manual drafting. With the GIS program the water department is able to view more easily different aspects of management in relation to each other. For example, a map can be called up on the computer showing soil types, then monitoring sites can be viewed on top of that, and then production well locations. Or, one could query the GIS database for all of the well locations within 100 meters of the Owens River and the type of vegetation surrounding them. The GIS displays this information graphically.

The GIS program will continue to be updated with information from the ongoing field monitoring program. Soon, when all of the necessary data are entered, GIS will be used by ICWD and LADWP to analyze and explain this information and to help make better water management decisions in the Owens Valley.

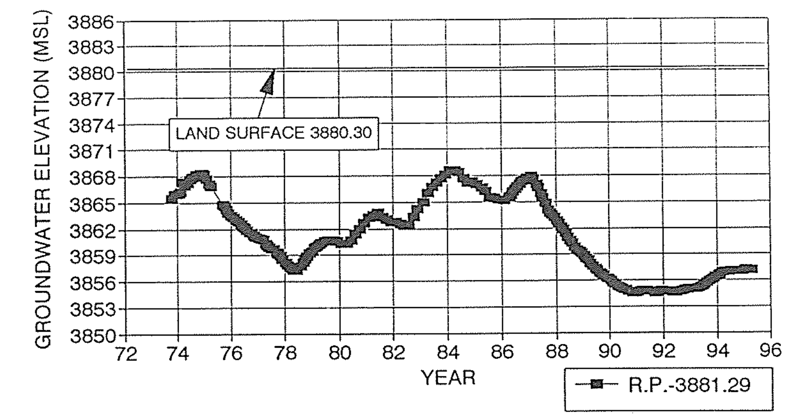
Inyo County is using GIS software called ArcCad and ArcView, made by Environmental Systems Research Institute, and a drawing program called AutoCad.



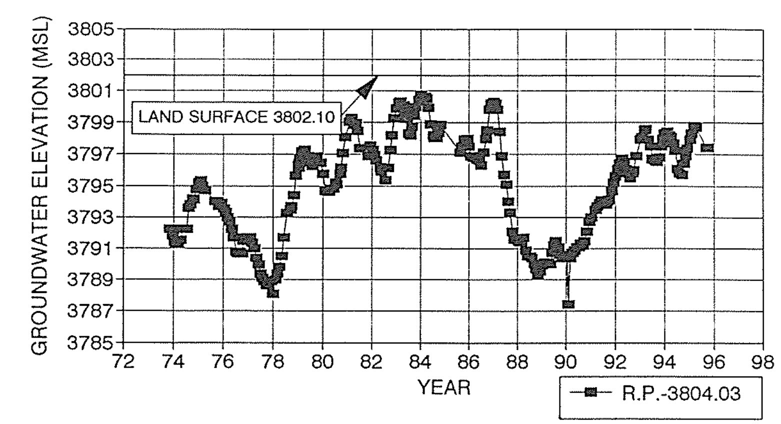
GIS data model *— The GIS consists of a variety of digital map layers, called datalayers. Each datalayer represents a specific thematic feature on the earth. For example, datalayers can represent soils, hydrology, zoning, or assessor parcels. A composite of datalayers can be created that shows the interactions between each datalayer. This process is called overlaying. Through overlaying, one can more easily view and study relationships between the information contained in the various layers.*

Samples of hydrographs showing groundwater elevations 1975-1995

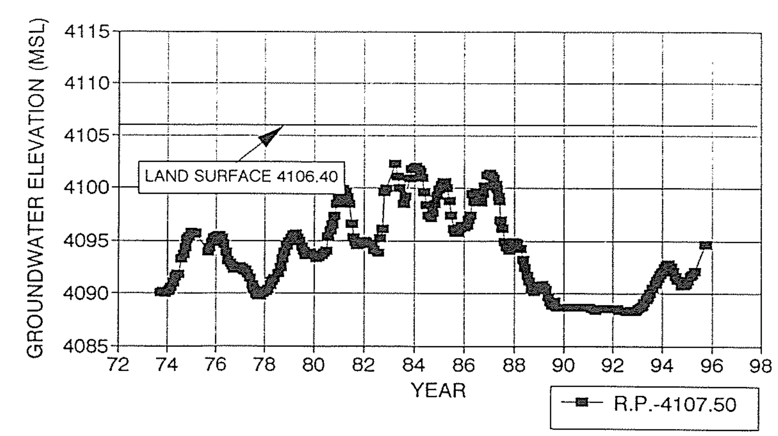
INDICATOR WELL 425T
BIG PINE WELL FIELD



INDICATOR WELL 398T
BAIRS-GEORGES WELL FIELD



INDICATOR WELL 436T
LAWS WELL FIELD



Vegetation

Conditions at permanent vegetation transects

Jennifer Foote, left, and Sally Manning use point frame Photo: Aaron Steinwand

For purposes of monitoring and management, Inyo County and LADWP have established 33 monitoring sites in the Owens Valley, of which 25 are within wellfields in the area of drawdown. The eight monitoring sites not in wellfields are control sites, which are used to monitor conditions in areas not affected by pumping.

Sixty of LADWP's 102 pump-equipped production wells are linked to the monitoring sites. Twenty-one LADWP wells are exempt from the well turn-off provisions of the agreement, either because they are the sole supply for town water systems, fish hatcheries or irrigation, or because they are located away from areas of groundwater-dependent vegetation. Of the remaining 21 unlinked wells, 11 are in Bishop, five are in Laws, one is in Big Pine, three are in Independence, and one is in Bairs-Georges (supplies Diaz Lake).

If, on July 1 or Oct. 1, soil water at any of the permanent monitoring sites is less than the estimated water needs of the vegetation at the site, LADWP wells linked to that site are turned off. According to the Inyo/Los Angeles long-term water management agreement, wells may be turned on once soil water recovers sufficiently to meet the needs of the vegetation at the time the wells were turned off.

However, under the Drought Recovery Policy adopted in 1990 by Inyo County and Los Angeles, wells are not turned on automatically. Rather, well turn on is decided by mutual consent, after taking environmental effects into consideration.

Plant cover

Compared to 1994: According to Inyo County Water Department vegetation scientist Sally Manning, above-average precipitation prior to the 1995 growing season caused an overall increase in plant cover at all monitoring sites, relative to 1994 (a dry year).

At some sites, plant cover not only increased but doubled relative to where it had been in the drought year of 1994. This occurred at both wellfield and control sites. The increase came despite there being, by early summer, no recovery in water tables to rooting zones at most of the permanent monitoring sites where the groundwater levels had been drawn down by heavy groundwater pumping in 1987 and 1988.

Generally, cumulative precipitation was not as high in winter 1995 as it was in 1993 or 1991, but there were two storms in which precipitation exceeded one inch. The heavy precipitation events combined with the cool spring temperatures may have reduced the rate of water loss from the soil caused by evapotranspiration, Manning said, allowing more water to be available longer. This provided conditions favorable for plant growth.

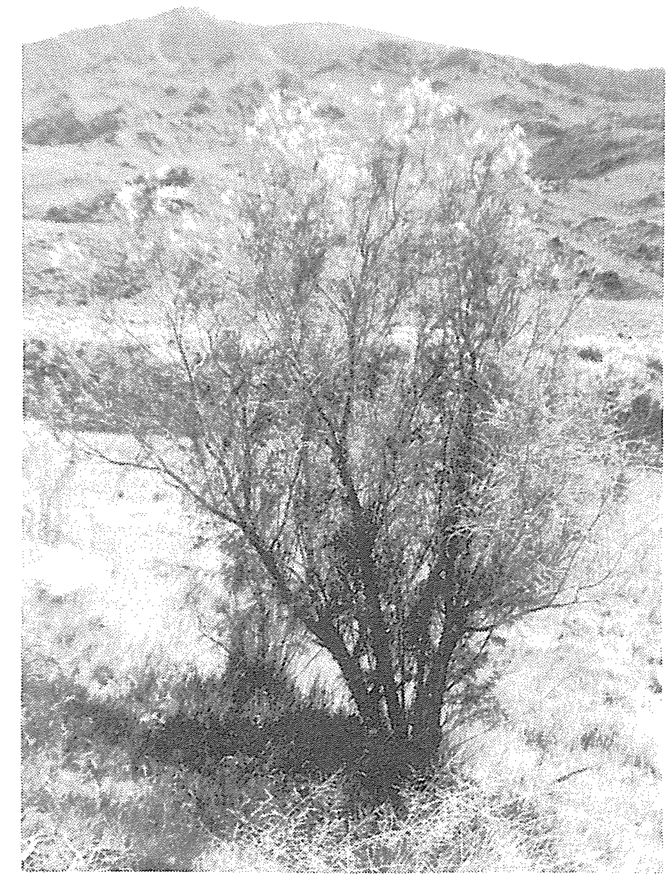
Since 1987: Of the 33 monitoring sites, 14 have been monitored since 1987, when the drought began (the remaining sites were established after that year). Only one of these 14 is a control site. At 11 of the 14 sites, plant cover in 1995 did not reach the level at which it had been measured in 1987. At three of the sites (two in Big Pine, one in Taboose-Aberdeen), it was slightly higher than 1987 levels.

As of July 1, 1995, 14 out of 22 wellfield sites were in soil-water deficit (pumps linked to these sites were not operated). The deficit was caused by the imbalance between high plant water requirement and very little available soil water. In other words, by July 1, most precipitation-derived soil water had been used in plant growth. Also as of July 1, water tables had not come up, so there was no additional water at depth to carry the plants through the rest of the summer.

By Oct. 1, 1995, only one of the 14 sites mentioned

Continued on page 9

Weed control



Saltcedar tree Photo: Heidi Walters

Saltcedar

High runoff in 1995 and consequent water spreading in the valley resulted in new populations of saltcedar (*Tamarix ramosissima*), a non-native, invasive groundwater-using plant that thrives in disturbed areas that were wet at one time. ICWD's Brian Cashore, who initiated a saltcedar control and eradication pilot project in 1994, said similar conditions occurred in 1967-69, which "enabled saltcedar to gain a roothold in the Owens Valley."

New populations such as these continue to be the focus of the pilot project. In 1994, Cashore (with ICWD's Brian Stange and Derik Olson, and Bill Neill, volunteers, and California Department of Forestry crews) began removing outliers of saltcedar (single trees and less established populations), with the goal of slowing the spread of the weed. The primary purpose of the project has been to test different treatments for eradication. Pilot project work continues. A saltcedar control program is a component of the Inyo/Los Angeles Water Agreement, which has yet to be adopted.

Lepidium

A relatively new weed to the valley, perennial pepperweed (*Lepidium latifolium*), exploded into a problem in 1995, forming large thickets in locations around Bishop. ICWD staff, the county agricultural commissioner and LADWP staff have been working together to develop a strategy for confronting this new threat. They conducted a test treatment in the Five Bridges area in 1995, and results will become apparent in spring 1996. Efforts to control *Lepidium* will continue in 1996.

ADDITIONAL STUDIES

In addition to his regular soil water monitoring, ICWD's soil scientist Aaron Steinwand conducted two studies in 1995. One, a cooperative study funded by LADWP, investigated the applicability of a recently developed TDR (time domain reflectometry) instrument to the county's monitoring system. TDR is a device that senses the electrical properties of the soil related to the soil water content. The method is widely used, but past trials with TDR by the ICWD were unsuccessful in Owens Valley soils.

The new TDR device operates on the same principles as previous instruments, but has features designed to overcome the drawbacks encountered in the previous experiments. Five sites were instrumented with the new TDR in two different trials. The sites were also instrumented with neutron probe access tubes for comparison. Steinwand said that, unfortunately, the TDR failed to provide accurate data. The study was terminated, and the instrument was returned to the manufacturer for a refund.

Steinwand conducted the second study in cooperation with the ICWD vegetation staff and Dr. Dani Or, professor of soil physics at Utah State University. The objectives of this study were to monitor the seasonal pattern of plant uptake from the soil profile and to determine the extent vegetation utilizes groundwater under different hydrologic conditions.

Two sites with similar vegetation but different depths to groundwater (shallow and deep) were selected for the study. The soil science staff monitored changes in the soil water caused by water table fluctuations and plant uptake. The vegetation staff monitored plant transpiration and leaf area at regular intervals during the growing season. The vegetation monitoring provided measurements of water uptake to compare with the below-ground observations.

This study will continue and be expanded in 1996.

Revegetation

In the fall of 1991, ICWD's Irene Yamashita and staff transplanted 400 fourwing saltbush plants at a revegetation site in Laws. Since then, Yamashita has monitored the shrubs' growth and survival each year. An overall trend she has noticed is that there has been an annual decrease in mortality.

The plants were transplanted onto barren farmland which was taken out of production in the 1920s and has since produced mostly weeds. There are 1,000 acres of such land throughout the Owens Valley that have been identified by LADWP's environmental impact report as candidates for revegetation.

ICWD initiated the revegetation study at Laws to explore and increase understanding of techniques for rehabilitating such land.

After they were transplanted, the shrubs were subjected to four treatments, applied in different combinations: irrigation, fertilizer, density (how far apart the plants are placed) and weed control. Precipitation, an uncontrollable factor, was monitored. In 1995, Yamashita discontinued the treatments and continued to monitor the plants.

Some results:

- Fewer shrubs die each year. In 1995, no shrubs died, despite the discontinuance of irrigation and weeding. The overall survival rate after four years of study is 61 percent.
- Fertilized shrubs continue to have greater growth indices than unfertilized shrubs.

ICWD staff also continued to monitor the growth and survival of 30 native plants germinated from local seed, grown in containers and then transplanted at the revegetation site. No treatments were applied to these plants.

Also, seeds of several native shrubs had been planted in shallow basins at the site in 1993. None germinated in 1993 or 1994. Early in 1995, more seeds were collected and planted in the basins.

After the wet winter in 1995, some seeds from 1993 and 1995 germinated but few seedlings survived.

Seed germination studies

In 1993, ICWD began conducting germination tests on seeds from native Owens Valley shrubs, in hopes of finding a way to successfully and inexpensively propagate native plants for use in revegetation projects in the valley.

In 1994 and 1995, tests continued, focusing on seeds which in the first tests had shown variable and unpredictable germination.

The first tests, in 1993, used seed collected from eight shrub species: *Atriplex canescens, A. confertifolia, A. parryi, A. polycarpa, A. torreyi, Chrysothamnus nauseosus, C. albidus,* and *Artemisia tridentata.* On some species, a number of pre-treatments were tried to enhance germination or break dormancy. Also, the fruits of some species were cut open to determine how many fruits contained viable seed.

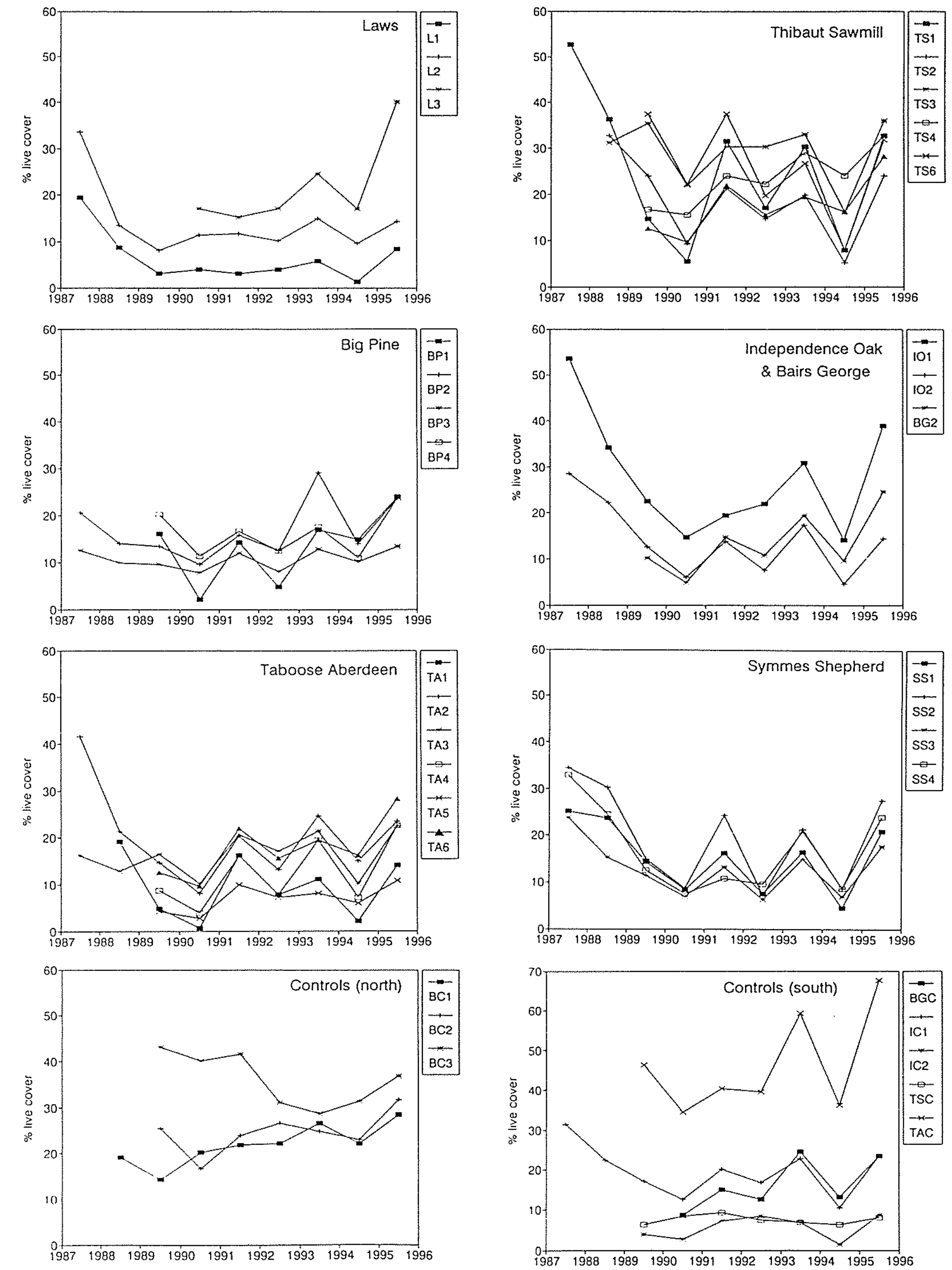
Based on the results of these preliminary efforts, later studies concentrated on other methods to break seed dormancy in the more reluctant species, and on year-to-year variation in fruit fill and germination.

From test results, ICWD concluded that locally collected seeds were viable and that different species have different germination requirements. Not surprisingly, abundant and opportunistic species (*Atriplex torreyi, Artemisia tridentata* and *Chrysothamnus nauseosus*) germinated readily under moist conditions.

The other species appear to have more fickle germination requirements. They not only differ in response to different treatments, they also differ from each other under similar environmental conditions.

Cartons of seedlings grown from local native seed Photo: Heidi Walters

Plant cover at permanent monitoring sites, 1987-1995



In the nine years that vegetation has been monitored in the Owens Valley (1987-1995), seven years were below-average runoff years. Only 1993 and 1995 were above-average runoff years. Precipitation on the valley floor, something to which the Owens Valley vegetation directly responds, in 1991, 1993 and 1995 was above-average. When looking at the changes in plant cover as seen on the graphs, a zigzag pattern can be seen for many sites, where cover was (typically) lowest in 1990, higher in 1991, lower in 1992, higher in 1993, lower in 1994 and higher in 1995. Because of these shifts, it is difficult to draw conclusions about the condition of the vegetation, at least in terms of total cover, at the permanent monitoring sites. Two or more above-average years in a row, coupled with significant water table recovery, would help determine if cover at the sites has reached a new plateau or whether it can further increase from drought year levels.

above had come out of deficit and was showing a soil water surplus. The water table had risen to near the root zone by Oct. 1 at this site near Big Pine, and pumps linked to this site were turned on.

Recruitment

Monitoring plant cover has proven useful for two reasons: forecasting the vegetation water requirements and documenting changes in live cover that might occur as a result of groundwater pumping. However, live cover is not the only characteristic that can show change. Other changes can yield information about what is occurring at a monitoring site. During the 1984-1987 baseline vegetation survey, LADWP collected information on species composition and vegetation cover. Using this information, the vegetation parcels were categorized into plant communities. A natural community consists of much more than the presence and amount of a plant species. By definition, communities display certain attributes that help distinguish them as units. These attributes include demography (e.g. age of the plants), structural characteristics (e.g. height of the vegetation) and function (e.g. pollinators that contribute to gene flow), many of which can be quantified and added to the community description.

In addition, communities typically exhibit some degree of stability. That is, they might withstand many of the natural stresses that are imposed upon them by climate, they might recover from disturbances, and they might persist in their general composition, structure and function over indefinite time periods. One important characteristic of a nat-

Monitoring site recruits, their fates, and a look at Nevada saltbush

RECRUIT TYPE	NUMBER OF RECRUITS SURVIVING 8/91	8/92	8/93	8/94	8/95	% overall
All 1991 recruits	4,437	973	684	520	345	7.9
1991 ATTO only	4,167	891	620	451	295	7.1
wf scrub	1,524	194	59	35	13	0.8
ctl scrub	548	54	28	16	14	2.6
wf meadow	1,911	600	513	379	248	13.0
ctl meadow	184	43	20	21	20	10.8
All 1993 recruits	-	-	735	45	25	3.4
1993 ATTO only	-	-	696	23	12	1.7
wf scrub	-	-	602	3	1	0.2
ctl scrub	-	-	40	3	2	5.0
wf meadow	-	-	31	13	7	22.6
ctl meadow	-	-	23	4	2	8.7
All 1995 recruits	-	-	-	-	21,655	
1995 ATTO only	-	-	-	-	19,685	

Recruitment results since 1991: In the years 1989, 1990, 1992 and 1994, all below-average runoff years, there was very little recruitment (few new plants) at the 33 monitoring sites.

In contrast, in 1991, 1993 and 1995, significant seedling germination occurred at the monitoring sites. To date, 1995 was the banner year. ICWD's Sally Manning counted a total of more than 20,000 new plants. She attributes this impressive amount of recruitment to high pre-growing season precipitation in January and March of 1995.

More than 90 percent of the recruits at the sites are *Atriplex torreyi* (Nevada saltbush = ATTO). The second most common recruits are *Chrysothamnus nauseosus* (rabbitbrush). In this table, Manning has summarized the ATTO data and charted the changes this species' recruits have undergone since 1991.

Manning found that of the 4,167 ATTO seedlings that germinated in 1991, 295 (or 7.1%) were still alive in August 1995. Some of these have become reproductive adults, capable of making seeds of their own. In 1993, fewer ATTO recruits germinated (696). Most of these have since died. Only 1.7% remained in August 1995. Also in this table, Manning has broken the monitoring sites into categories, based on how LADWP originally mapped the site. In these categories, she charts the number of ATTO recruits in August of each year:

wf scrub = shrub-dominated sites in wellfields
ctl scrub = shrub-dominated sites in control areas
wf meadow = grass-dominated sites in wellfields
ctl meadow = grass-dominated sites in control areas

Within these community types, Manning observes that survival is poorest in wellfield scrub areas. In contrast, ATTO recruit survival is highest in grass-dominated sites in wellfields.

Soil water

Soil water conditions

Above normal winter precipitation resulted in increased soil water in 1995, especially at sites in the northern Owens Valley, said ICWD soil scientist, Aaron Steinwand. Seven wellfield monitoring sites went into surplus status from January through April because of the precipitation. Soil water content increased at several other sites but remained below the amount required to change the site status. Steinwand said that even in a wet year in the Owens Valley, precipitation recharges the soil only to shallow depths. This water is readily available to the vegetation — by July 1 most of it had been used up. Six of the seven sites and one other went into deficit on July 1. One site went into surplus in September because of a rising water table. As of October 1, 13 of the 22 wellfield sites were in deficit compared to 14 at the same time in 1994.

Soil water monitoring activities

In January 1995, Steinwand presented a proposal to the Technical Group to revise ICWD's soil water monitoring and data analysis methods. The Technical Group agreed in March to proceed with the new program and with additional development.

The current program is little changed from that outlined in the Green Book (technical appendix to the long-term water management agreement). The well on-off management scheme requires an estimate of plant-available soil water to compare with projected vegetation water needs. Available soil water is the amount of water present that could potentially be used by the vegetation. A small amount of soil water, called the limiting water content, always will be unavailable because: (1) it is strongly adsorbed on particles or within pores; (2) it is too saline for plants to use; or (3) it is held in soil not accessible to plant roots.

The Green Book monitoring program relies on psychrometers to measure soil water. Psychrometers sense the humidity of the soil air. The drier or more saline the soil, the drier the soil air. ICWD uses the Miller method to convert psychrometer readings to values of water content, and to estimate the limiting water content. Shrub-dominated monitoring sites are instrumented with psychrometers at one-meter intervals to a depth of four meters at a single location. Grass-dominated sites have shallower root systems and are monitored to two meters.

The new program will employ the neutron probe instead of psychrometers as the primary monitoring instrument. The neutron probe is a well-established method to measure soil water content. It is based on the interaction of neutron radiation with soil water. To operate, a probe containing a radiation source and detector is lowered through a permanent access tube implanted in the soil and measurements are taken at several depths. The measurements are converted to water content values using a calibration curve constructed specifically for each site.

Steinwand also proposed new procedures to determine limiting water content. Initially, limiting water content will be estimated from the soil texture of samples collected during neutron probe calibration. This is a rough estimate because organic matter and salinity also control the limiting water content. The actual limiting water content will be determined in the ICWD soils laboratory using psychrometers designed for accurate laboratory work. The texture-based estimates will be replaced as new data become available.

Steinwand and ICWD's Derik Olson began installation of access tubes and neutron probe calibration in March and finished in December. Each site was instrumented with three or four tubes, usually to a depth of four meters. Initial estimates of the limiting water content values have been made, and the lab work to derive the final values has begun.

ICWD staff has been monitoring soil water with both instruments — psychrometers and neutron probes — to provide a period of comparison. The length of the comparison varies depending on the neutron access tube installation date. The Technical Group will switch to the new program in early 1996.

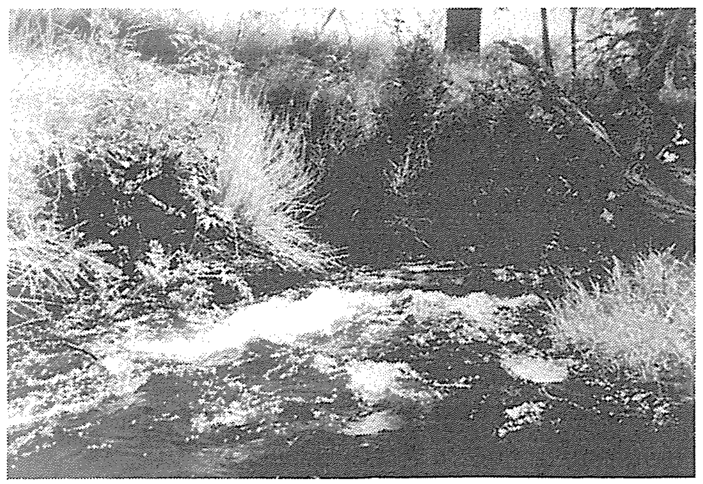
When the switch occurs, Steinwand said the new soil monitoring program using neutron probes will offer several advantages over the current system of using psychrometers:

- Accurate psychrometer measurements require meticulous attention to installation, operation and calibration. The neutron probe is much less sensitive to these sources of error.
- The Miller method conversion was evaluated in previous cooperative studies and shown to be an inaccurate method to determine water content from psychrometer measurements. No such conversion is necessary in the new program.
- The soil profile can be monitored more completely and at more locations at a site with less cost and in less time with the neutron probe.
- Measurement and calibration errors in the neutron probe are more easily quantified, making it easier to target sites needing additional improvements.
- All of the proposed methods are generally accepted. Thus, the data are credible.

Riparian vegetation monitoring

In July 1995, ICWD's Brian Cashore initiated a pilot project to research riparian (streamside vegetation) monitoring techniques. These techniques ultimately could be used in ICWD's and LADWP's proposed riparian monitoring program, the goal of which would be to protect the health of the riparian vegetation.

The riparian monitoring program would entail observing and documenting riparian vegetation over time, and noting



Along a transect at Baker Creek Photo: Brian Cashore

changes, whether naturally caused or otherwise. Riparian monitoring involves measuring the physical and biological parameters of a creek or stream. Physical features include: water volume, flow gradient, channel shape, type of substrate (sediment, gravel, etc.), and setting (a narrow canyon, or a flat valley). Biological features include: plant species present and their cover and composition, and width of the riparian vegetation zone. Monitoring will focus on the biological features — the plants themselves — using the physical features as important background information.

In the pilot project, Cashore selected Baker Creek, near Big Pine, for the first study area. Baker Creek was chosen because of its distinct reaches with a variety of environments and its reliable flow through the summer.

Cashore set up three monitoring sites in three diverse reaches of the creek and began testing the use of the line-point transect, measuring canopy density, recording physical features and performing other tests. Each site also has a permanent photograph point for annual pictures.

Sites will be established on four more creeks in 1996, and ICWD and LADWP will jointly conduct the riparian monitoring. LADWP also will provide flow data for the creeks.

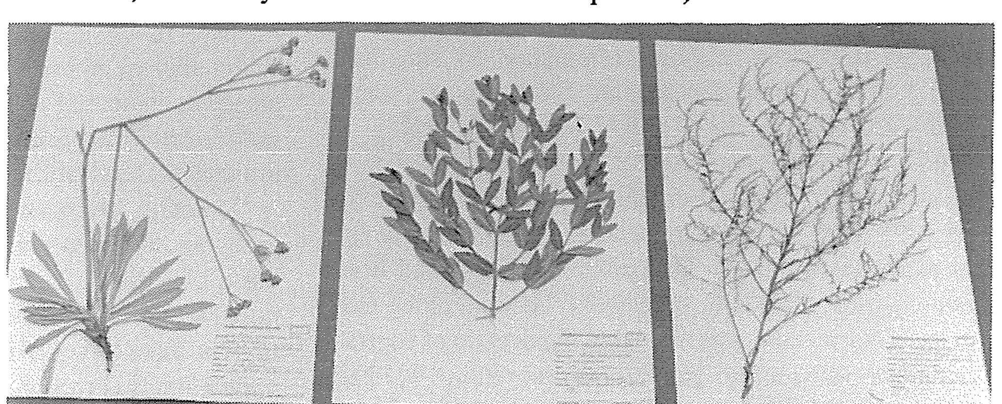
Herbarium

A few years ago, the Inyo County Water Department began developing an herbarium to document and store the various plant species found in the Owens Valley.

ICWD's Denise Waterbury, who is in charge of this project, said the herbarium contains about 90 species representing 23 families, to date. Waterbury said the collection is small, so far, because up until recently, the ICWD had little space for storing the dried, mounted plant specimens. But with a newly acquired herbarium cabinet, Waterbury said she will be able to expand the collection.

There are several reasons for maintaining an herbarium, Waterbury said. These include:

- A collection of voucher plant specimens provides an authentic historical and current record of the area's species;
- An herbarium is helpful for those studying the area's ecology, including scientists, school children and teachers;
- One can more easily identify specimens found in the field by comparing them to the herbarium specimens;
- Collecting, pressing and mounting the plants for the herbarium helps one to more thoroughly learn the plants;
- An herbarium provides a basis for discourse with scientists interested in plant identification (exchange of plant specimens for taxonomic and even DNA-level research is common practice).



Owens Valley plant specimens from ICWD's herbarium Photo: Heidi Walters

ural community, which relates directly to its stability, is the ability of the species within the community to replace themselves. This addition of new individuals, called "recruitment," can occur at any rate. If the community is "mature" it might occur slowly (as older members of the species die). But it might occur more quickly in some communities, especially following a disturbance.

By understanding the natural patterns of species turnover in a community, one recognizes aberrations in the patterns that may be caused by an acute perturbation or a chronic stress. Distinguishing stresses from which a community can recover on its own from those which might permanently alter the system is critical to adequate management of vegetation.

The Inyo County Water Department has been monitoring shrub recruitment at the monitoring sites since 1989. The procedure consists of walking along 100-meter transects at the permanent monitoring sites and taking notes on all of the small plants within one meter of the transect line, identifying the species, noting each plant's distance along the transect, and recording its size. Later, when the data are tallied, ICWD's Manning can calculate mortality and survival, relate the information to pre-growing season precipitation, and characterize changes that have occurred at the sites.

Valley-wide monitoring of vegetation change

The goal of the Inyo County/Los Angeles water agreement is to manage Los Angeles' water gathering activities in the Owens Valley to avoid significant decreases or changes in vegetation. The condition of the vegetation is assessed by annual inventory to see if the goal of the agreement is being achieved. Results of this re-inventory are compared to baseline vegetation conditions as inventoried and mapped by LADWP between 1984 and 1987.

In 1995, ICWD's Sally Manning and staff re-inventoried vegetation cover and composition in 69 areas. These areas, called parcels, are part of a group of about 100 parcels that were first comprehensively re-inventoried in 1992 (and all were part of the first 1984-1987 inventory by LADWP).

Results: perennial live cover:

When change in total perennial cover relative to baseline was averaged for the 39 wellfield parcels re-inventoried in 1995, ICWD staff found no significant change. In contrast, in 1994, average change in these parcels relative to baseline was -37 percent. Manning said that for the first time since this re-inventory has been performed, the control parcels increased measurably in cover compared to baseline condi-

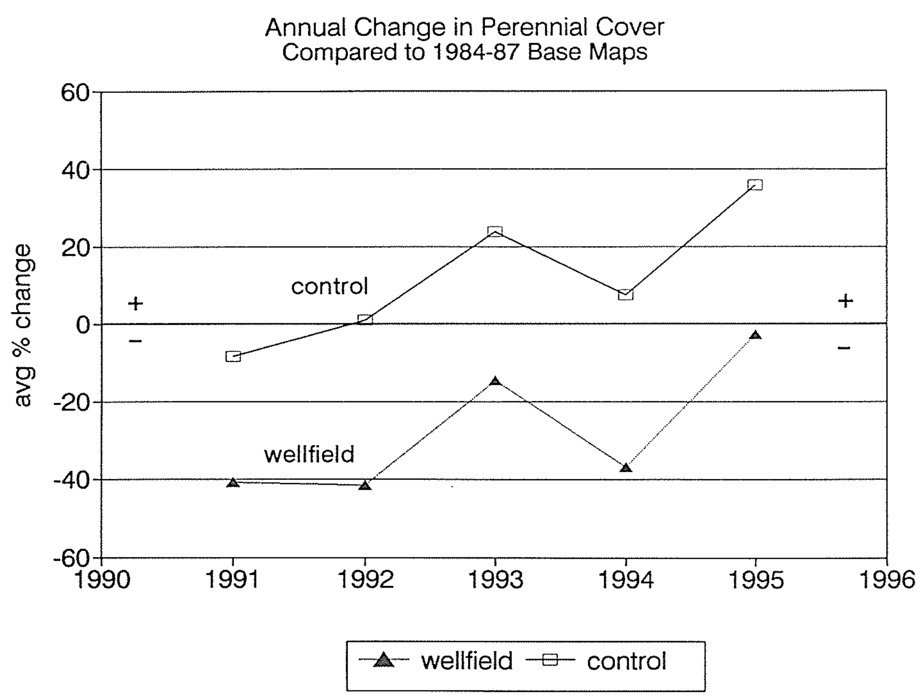
Summary of line-point transect results to measure vegetation change, 1991-1995

from 1984/87 to year	OWENS VALLEY: AVERAGE PERCENT CHANGE wellfield perennials	# parcels	control perennials	# parcels	wellfield annuals	control annuals
1991	**-40.8%**	21	-8.4%	9	**+13.5%**	+1.6%
1992	**-41.8%**	49	+0.9%	50	+10.3%	+5.3%
1993	**-14.8%**	36	+23.8%	24	**+14.2%**	**+3.2%**
1994	**-36.9%**	36	+7.5%	24	-2.2%	-0.7%
1995	-3.5%	39	**+35.6%**	30	**+20.4%**	**+9.9%**

tions. The average increase in perennial cover in the control parcels was +36 percent. These parcels had held steady as a group through the previous years, but when they were provided with the winter precipitation in 1995, they responded by adding significant cover.

The graph, "Annual Change in Perennial Cover," illustrates what has been happening to date. Running horizontally through the center of the graph is the "no change" (zero) line. Points plotted near this zero line would indicate small, if any, changes in perennial cover. Points plotted above the zero line show an increase in cover relative to baseline, and points below the zero line show a decrease.

Note that as a group, the control parcels (open squares) and the wellfield parcels (closed triangles) have been following parallel courses, but they are a fair distance apart. The control parcels have stayed near the zero line or above it, while the wellfield parcels have stayed below the zero line.



The control parcels represent the vegetation's response to drought and precipitation at sites where the water table has not been affected by groundwater pumping (which in most cases means that it has changed very little and has remained in the plant root zone). The control vegetation has responded to drought by not changing measurably from baseline conditions. In wet years, however, it tends to increase. A dry year may bring conditions down closer to baseline, but Manning says the perennial cover would not be expected to fall significantly below baseline, no matter how dry it was.

The wellfield parcels have been subjected not only to drought but also to lowering of the water table, typically to a depth beyond the reach of the plant roots. The data show that cover in these parcels has been consistently below baseline conditions and consistently different from the control parcels.

Manning said the separation between the control and wellfield parcels indicates different current conditions. If these differing conditions persist, the responses of vegetation in the two types of areas might be affected by and/or might respond to environmental changes differently in the future. The response of a wellfield parcel to fire, disease, or insects, for example, might not be the same as the response of a control parcel to the same disturbance.

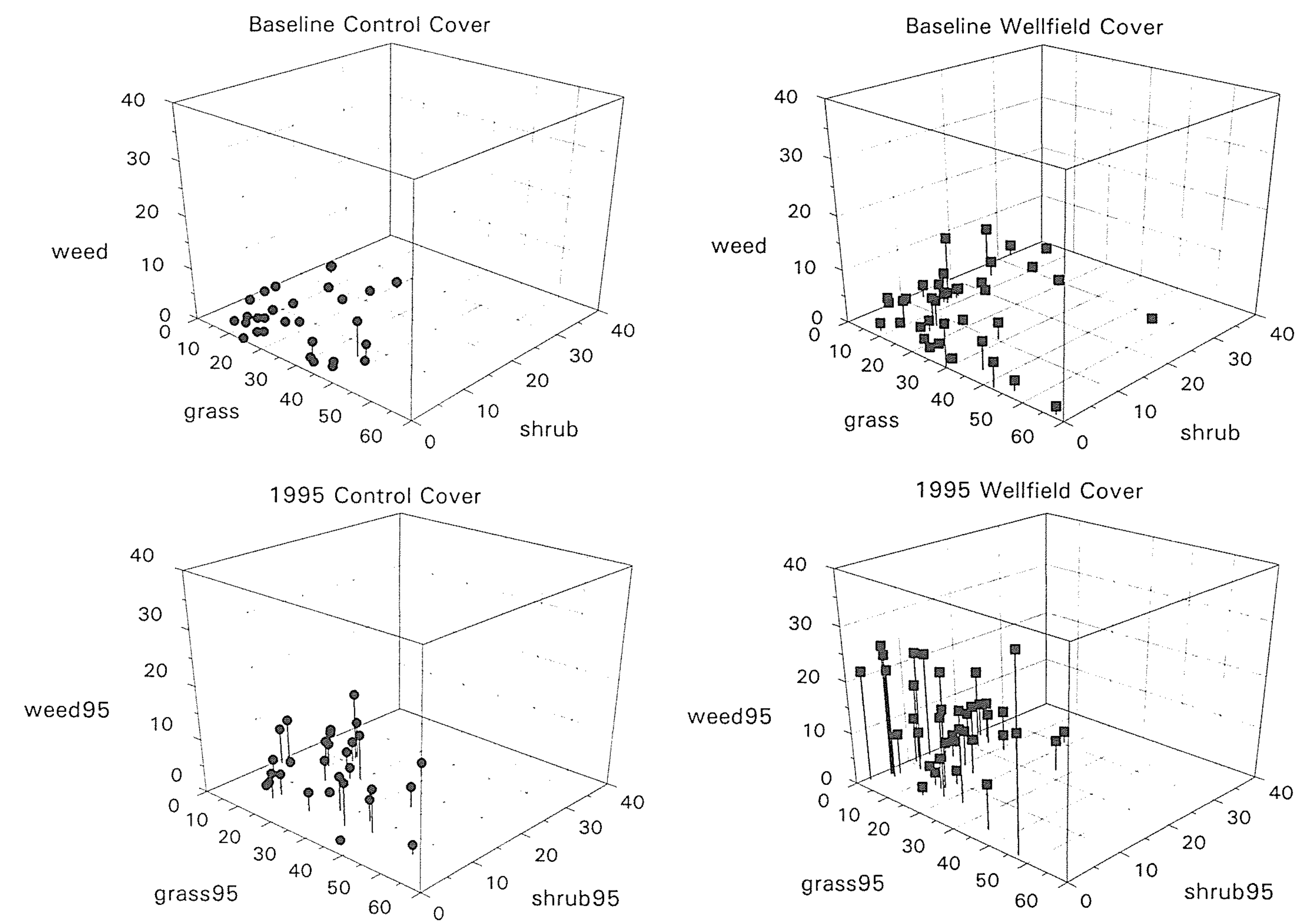
Results: change in plant composition

In order to begin to look for changes in plant composition, Manning has taken all of the 1995 re-inventory data and prepared four three-dimensional charts (page 12). For these charts, Manning divided plant species into three categories.

The grass category included mostly the native perennial grasses and grass-like plants and, when encountered, non-native grasses. Exceptions were the rare occasions when cheatgrass was encountered. Cheatgrass was classified as a weed. Shrubs include all native perennial shrub and shrub-like plants, including willow, rabbitbrush, Nevada saltbush and many others. Weeds are defined as non-native annual plants (such as Russian thistle and bassia), saltcedar, and a few unpalatable native plants.

In these three-dimensional graphs, the cover of grasses is represented along the left axis, the cover of shrubs is along the right axis, and the cover of weeds is on the vertical axis. Two graphs show the grass/shrub/weed proportions that were measured in (1) wellfield parcels and (2) control parcels during the baseline inventory years. Note that the points extend to nearly 60 percent on the grass cover axis, and all are relatively low on the weed cover axis (the points sit on short pins). The other two graphs show grass/shrub/weed proportions as measured in this same group of parcels in 1995. Note that wellfield parcels as a group have moved back along the grass axis and up along the weed axis (taller pins).

Change in plant composition



Rare plant monitoring

Rare plant monitoring is conducted by both ICWD and LADWP.

Calochortus excavatus (alkali mariposa lily)

In 1995 ICWD vegetation staff visited 19 sites and counted 2,771 plants of this species. Staff previously had counted 1,751 plants in 1993, and 672 plants in 1994.

ICWD vegetation scientist Sally Manning said heavy pre-growing season rains probably helped *Calochortus* do well in 1995. Last year, she and staff found 69 *Calochortus* plants near Hines Spring. This population first had been discovered by LADWP in the 1980s. Past pumping had dried up the spring and contributed to the decline of vegetation in its general vicinity. The rare plants seen in 1995 had last been seen during the 1980s; over the intervening years, both Inyo and LADWP had searched the area and found no plants. The showing in 1995 implies that the plant can remain dormant in the soil for many years, Manning said.

Sidalcea covillei (Owens Valley checkerbloom)

In spring 1995, ICWD visited 22 *Sidalcea* sites, including two newly discovered populations. Generally, they found that numbers of plants in these populations held steady or increased in 1995. Increases appear mainly to be manifested in the presence of tiny, new seedlings that germinated at many of the sites.

Manning has been watching closely for the past four years the *Sidalcea* plants at the Five Bridges impact area north of Bishop. In 1995, many of the individuals in this population produced flowers and seeds for the first time in four or more years. Also, new seedling recruitment in the population was recorded, suggesting the presence of a still-viable seed bank left from previous years when the plants were more vigorous.