



# *Alternative Cover Assessment Program 2002 Annual Report*

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## 1.0 Introduction

### 1.1 Purpose

The U.S. Environmental Protection Agency (USEPA) initiated the Alternative Cover Assessment Program (ACAP) in 1998 to address a growing interest in innovative alternatives to conventional designs for final landfill closure. Interest in alternative cover designs has stemmed from the requirement for adequate long-term protection of human health and the environment, recognized limitations of current prescriptive designs, and cost.

Conventional designs for landfill covers are based on criteria developed by USEPA for closure of RCRA Subtitle C (hazardous waste) or RCRA Subtitle D (municipal solid waste) landfills. Subtitle D guidance provides minimum criteria for four categories of covers based on the design of the liner underlying the waste (see Table 1). These designs rely on combinations of soil layers of specified thickness and hydraulic properties and geosynthetics to impede the movement of water through the cover and into the waste. Although effective, composite designs of soil and geosynthetic materials can be costly, especially if the required low-permeability soil materials are not locally available.

Table 1. Landfill liner and corresponding prescriptive cover designs.

Existing liner design	Prescriptive cover design
No liner	<ul style="list-style-type: none"><li>• 15 cm erosion protection layer</li><li>• 45 cm barrier layer with <math>K_{sat} \leq 10^{-5}</math> cm/sec or <math>\leq K_{sat}</math> of underlying soils, whichever is less</li></ul>
Soil liner with $K_{sat} \leq 10^{-6}$ cm/sec	<ul style="list-style-type: none"><li>• 15 cm erosion protection layer</li><li>• 45 cm barrier layer with <math>K_{sat} \leq 10^{-6}</math> cm/sec</li></ul>
Soil liner with $K_{sat} \leq 10^{-7}$ cm/sec	<ul style="list-style-type: none"><li>• 15 cm erosion protection layer</li><li>• 45 cm barrier layer with <math>K_{sat} \leq 10^{-7}</math> cm/sec</li></ul>
Composite Liner: Soil layer with $K_{sat} \leq 10^{-7}$ cm/sec overlain by geomembrane	<ul style="list-style-type: none"><li>• 15 cm erosion protection layer</li><li>• Geomembrane</li><li>• 45 cm barrier layer with <math>K_{sat} \leq 10^{-5}</math> cm/sec</li></ul>

USEPA RCRA guidelines stipulate that alternative designs may be approved by regulatory agencies if performance equivalent to the prescriptive can be demonstrated. The development of alternative designs has been hampered by:

- Lack of credible field data
- Absence of rigorously tested models for predicting hydrologic performance of landfill facilities
- Lack of regional or national design guidance that integrates cover design options with the relevant environmental variables. Successful deployment of alternative covers will depend on a shift away from prescriptive designs and toward descriptive design processes that account for the site-specific variables of soil, climate and plants.

The driving forces behind the support for the current research into alternative cover designs come from both the landfills themselves who seek alternatives to costly prescriptive designs, and from regulators with interest in environmentally responsible designs for their regions of influence.

## 1.2 Program History

ACAP was initiated in 1998 by the USEPA under the Superfund Innovative Technology Evaluation Program (SITE), which was established to promote development of promising innovative solutions for hazardous waste issues.

The program has four phases:

- Phase I: Review current data collection efforts and numerical modeling capabilities relative to landfill cover design,
- Phase II: Design, construct, and operate (for 5 years) a network of alternative cover testing facilities,
- Phase III: Analyze field results with improved numerical models to predict long-term performance of alternative cover systems at the selected testing sites,
- Phase IV: Develop a comprehensive guidance document for alternative cover systems.

The ACAP team from the Desert Research Institute (DRI) and Battelle Memorial Institute (Pacific Northwest Division) completed Phase I in September 1999. The Phase I report is currently (Oct. 2002) in the final stages of editing, release is expected during calendar year 2002.

Science Applications International Corporation completed design and installation of the ACAP field facilities in November 2000 with assistance from DRI, Battelle, and the University of Wisconsin-Madison. Test facilities were constructed at twelve sites throughout the United States (Figure 1). Data collection and maintenance operations continue with USEPA plans to operate the network until 2005. This report summarizes activities through fiscal year 2002.

## 1.3 ACAP Sites and Cover Designs

Ownership of the 12 ACAP sites represents private firms, local (both city and county) government, and the federal government (U.S. Department of Energy and the U.S. Marine Corps). Details of the ACAP sites and program are given in Tables 2 and 3.

Within the research network there is a broad sampling of the environmental factors that influence the performance of final landfill covers. These environmental factors become design parameters when emphasis is shifted from use of a conventional design in favor of a site-specific descriptive design process. Within the climatic regime of a site, the primary factors that influence success of a cover design are soil hydrologic parameters, and plant community characteristics.



Figure 1. Location map of ACAP sites.

Soil hydrologic parameters most influential in the performance of alternative earthen final covers (AEFCs) are water holding capacity and hydraulic conductivity. Soils with higher water holding capacity are generally favored for their ability to store precipitation within reach of the surface processes of evaporation and transpiration. An exception to this is the use of coarse-grained soils in a fine-over-coarse arrangement to create a capillary break. Cost favors the use of locally available soils (often from the landfill site itself) in the design of AEFCs while conventional designs may require importation of fine-grained soils to meet the minimum hydraulic conductivity requirement inherent in RCRA conventional designs. Soils used in the ACAP program for construction of AEFCs range from the clay-rich soil used in an evapotranspiration-type design to sand for a capillary break. Fine-grained soils used for construction of conventional covers were available on site at some locations; at others sites the soil was imported. Figure 2 indicates the profiles of the cover designs.

The ideal plant community for an AEFC is one that takes up water for transpiration throughout the soil profile and throughout the year. Site characteristics limit this function primarily by temperature and seasonality of precipitation. Plant community characteristics vary widely across the study sites. While most of the sites have (or have proposed) revegetation efforts consisting primarily of annual and perennial grass mixtures, other sites have employed trees and shrubs to provide transpiration. Two sites (Albany and Cedar Rapids) have planted hybrid poplar trees with an understory of grasses. One test plot at Sacramento has been planted with oleander shrubs in addition to a grass and annual seed mixture. General plant community characteristics are shown in Figure 2 and summarized in Table 4.

Table 2. ACAP site details.

Facility / Location	Owner / Contact	Landfill Type	Active / Inactive	Activity / Total Capacity	Est. Closure Date
Kiefer Landfill 12701 Kiefer Blvd. Sloughhouse CA 95683	Sacramento County Public Works Agency Chris Richgels 9850 Goethe Road Sacramento, CA 95827-3561 916.875.7011 <a href="mailto:richgelse@saccounty.net">richgelse@saccounty.net</a>	RCRA D (MSW, industrial, commercial, C&D debris)	Active	500,000 tons/yr	2035
Altamont Landfill and Resource Recovery Facility 10840 Altamont Pass Road Livermore, CA 94550-9745	Waste Management, Inc. Ken Lewis 10840 Altamont Pass Road Livermore, CA 94550-9745 925.455.7350 <a href="mailto:kewis@wm.com">kewis@wm.com</a>	RCRA D (MSW, industrial, commercial, C&D debris)	Active	2,000,000 tons/yr	2010
Monterey Peninsula Landfill 14201 Del Monte Blvd. Marina CA 93933	Monterey Regional Waste Management District Rick Shedden P.O. Box 1670 Marina, CA 93933-1670 831.384.5313 <a href="mailto:rshedden@mrwmd.org">rshedden@mrwmd.org</a>	RCRA D (MSW, industrial, commercial, C&D debris)	Active	220,000 tons/yr	2090
Monticello Uranium Mill Tailings Repository 731 Highway 191 Monticello UT 84535	U.S. Department of Energy Jody Waugh 2597 B ¾ Road Grand Junction, Co 81503 970.248.6431 <a href="mailto:Jody.Waugh@gjo.doe.gov">Jody.Waugh@gjo.doe.gov</a>	Hazardous waste, mill tailings, asbestos	Inactive	2,600,000 cubic yards	1975
Finley Buttes Regional Landfill 73221 Bombing Range Road Boardman, OR 97818	Waste Connections, Inc. Dan Swanson 611 SE Kaiser, P.O. Box 61726 Vancouver, WA 98666 360.695.4858 <a href="mailto:dansw@wcnx.org">dansw@wcnx.org</a>	MSW	Active	500,000 tons/yr	2004
Lake County Landfill 3500 Kerr Dam Rd. Polson MT 59860	Lake County Solid Waste Management District Mark Nelson 12 5 <sup>th</sup> Ave East Polson, MT 59860 406.883.7325 <a href="mailto:trashman@compuplus.net">trashman@compuplus.net</a>	MSW	Active	28,000 tons/yr	2001

Table 2. ACAP site details (continued).

Facility / Location	Owner / Contact	Landfill Type	Active / Inactive	Activity / Total Capacity	Est. Closure Date
Lewis and Clark County Landfill 4075 Deal Rd. Helena MT 59602	Lewis and Clark County Public Works Dept. Will Selser 3402 Cooney Dr. Helena, MT 59602 406.447.1635 <a href="mailto:selser@co.lewis-clark.mt.us">selser@co.lewis-clark.mt.us</a>	RCRA D (MSW, industrial, commercial, C&D debris)	Active	353,700 cubic yards	2045
Bluestem Solid Waste Agency 1954 County Home Rd. Marion IA 52302	Bluestem Solid Waste Agency Dave Hogan 6301 Kirkwood Blvd. SW P.O. Box 2068 Cedar Rapids, IA 52406 319.398.1278 1.888.398.1278 (toll free) <a href="mailto:dhogan@bluestem.org">dhogan@bluestem.org</a>	RCRA D (MSW, industrial, commercial, C&D debris)	Active	825,000 tons to date (40-45K tons/yr)	2002
Douglas County Recycling and Disposal Facility 14320 N. 216 <sup>th</sup> St. Bennington NE 68007	Waste Management of Nebraska Ken Mertl 14320 N. 216 <sup>th</sup> Street Bennington, NE 68007 402.478.5196 <a href="mailto:kmertl@wm.com">kmertl@wm.com</a>	MSW	Active	600,000 tons/yr	2003
Center Hill Landfill Center Hill Rd. and Este Ave. Cincinnati OH 45224	City of Cincinnati Steve Rock (USEPA) 5995 Center Hill Avenue Cincinnati, OH 45224 513.569.7149 <a href="mailto:Rock.Steven@epamail.epa.gov">Rock.Steven@epamail.epa.gov</a>	MSW, commercial, industrial, residential	Inactive	NA	1977
Green II Landfill 34581 Clay Hill Rd. Logan OH 43138	Goodyear Tire and Rubber Co., Inc. and PPG Industries Shannon Lloyd Sharp and Associates 982 Crupper Avenue Columbus, OH 43229 614.841.4650 <a href="mailto:sdlloyd@sharptech.net">sdlloyd@sharptech.net</a>	MSW and hazardous waste	Inactive	NA	1978
U.S. Marine Corps Logistics Base Radford Blvd. Albany GA 31704	U.S. Marine Corps Brian Ventura / Mike Pearson 814 Radford Blvd., STE 20315 Albany, GA 31704-0315 229.639.6261 <a href="mailto:venturabj@matcom.usmc.mil">venturabj@matcom.usmc.mil</a> <a href="mailto:pearsonms@matcom.usmc.mil">pearsonms@matcom.usmc.mil</a>	No official classification	Inactive	175,000 tons	1988

Table 3. ACAP program details.

Facility Location	# Test Sections	Prescriptive Design	Alternative Design	Date Construction Completed	Date Vegetation Applied	Precipitation (inches/year)
Sacramento	2	NA	ET-type	July 25, 1999	Grasses: November 1999 Shrubs: March 2000	17.2
Altamont	2	Composite	ET-type	Nov. 9, 2000	December 2000	13.5
Marina	2	Composite	ET-type imported soil	May 25, 2000	October 2000	16.2
Monticello	1 - 7.5 Acre Lysimeter and 2 Caisson Lysimeters			June 23, 2000	Spring 2000	15
Boardman	3	Composite	ET-type	Nov. 17, 2000	Early February 2001	8.7
Polson	2	Composite	ET-type with capillary barrier	Oct. 19, 1999	March 31, 2000 reseeded April 10, 2000	13.6
Helena	1	NA	ET-type	Oct. 18, 1999	Final week of November 1999	12
Cedar Rapids	3	Composite	ET-type	Oct. 2, 2000	Grasses: Sept. 29-Oct. 11, 2000 Trees: Late March 2001	36.4
Omaha	3	Composite	ET-type	Aug. 11, 2000	October 2000	28
Cincinnati	Leachate Collection System	NA	ET-type	Feb. 15, 2000	May-June 1999, replanted portions in Fall 1999 and Spring 2000	36-38
Logan	Leachate Collection System	NA	ET-type	March 2, 2000	May-June 1999 (20% replanting in Spring 2001)	36-39
Albany	2	Compacted clay	ET-type	March 18, 2000	March 15-17, 2000	50.4



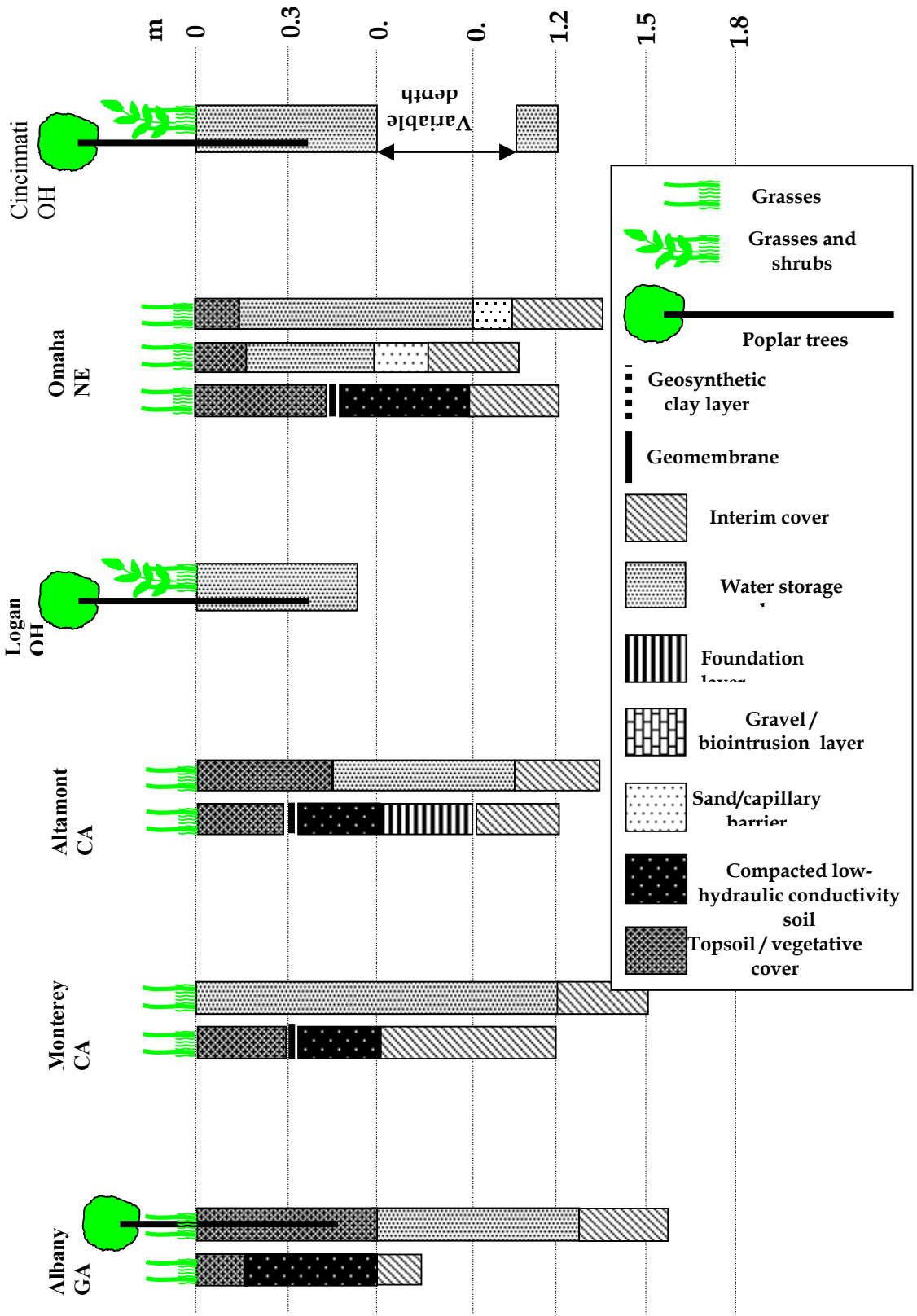


Figure 2. ACAP cover design profiles.

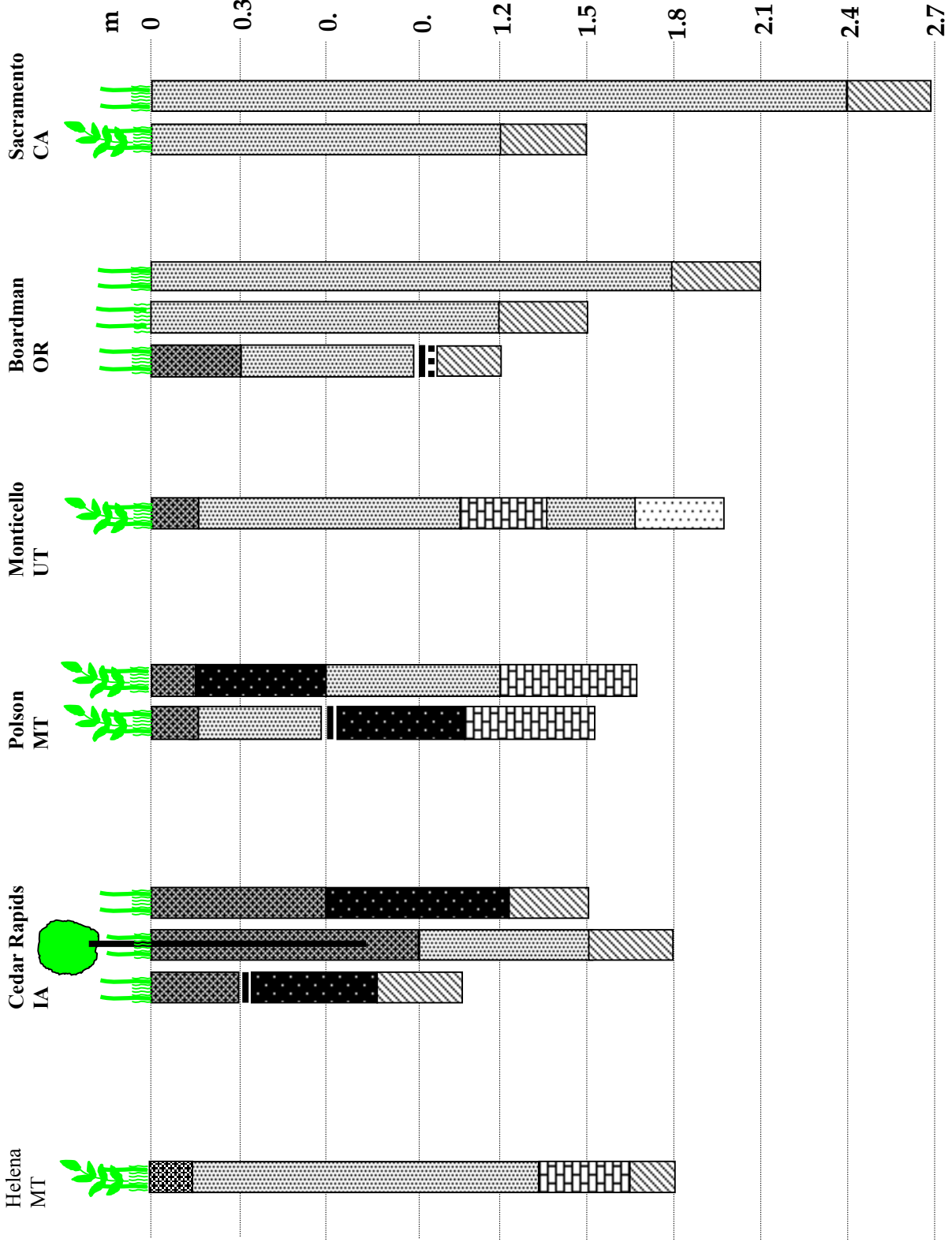


Figure 2 (continued). ACAP cover design profiles.

Table 4. Vegetation mixtures planted at ACAP sites.

Site	Site Seed Mixture
Omaha	Cool Season Grasses: Brome and Switchgrasses
Albany	Bermuda Grass, Perennial Rye, and Eastern Cottonwood and Black Poplar, Imperial Carolina DN-34 (Ecap only)
Altamont	Soft chess, slender oats, foxtail chess, Italian ryegrass, red-stemmed filaree, black mustard, yellow star-thistle, prickly lettuce, bull thistle, prickly sow-thistle, blue dicks, California poppy, purple owl's-clover, and miniature lupine
Cedar Rapids	Indian Grass, Little Bluestem, Big Bluestem, Side Oats, and Switch Grass, Tall Fescue Lawn Mix, and Crown Vetch
Boardman	Siberian, Bluebunch, and Thickspike Wheatgrasses, Alfalfa, and Yellow Blossom Sweetclover
Helena	Bluebunch, Slender, and West Wheatgrasses, Sandburg Bluegrass, Sheep Fescue, Blue Gamma, Green Needlegrass, and Needle-and-Thread
Sacramento	California Brome, Purple Needlegrass, Zorro Fescue, Arroyo Lupin, and Oleander bushes.
Marina	Blue Wild Rye, California Brome, Creeping Wild Rye, and Pacific Hairgrass
Polson	Thickspike, Bluebunch, Slender, and Crested Wheatgrasses, Mountain Brome, Idaho Fescue, Prarie Junegrass, Needle-and-Thread, Meadow Brome, Canada and Kentucky Bluegrasses, Yarrow, Fringed Sagewort, Alfalfa, Rubber Rabbitbrush, Prickly Rose, Arrowleaf Balsamroot, and Dolted Gayfeather, Lewis Flax, and Silky Lupine, and Cicer Milkvetch
Monticello	Western and Crested Wheatgrasses, Gray Rabittbrush, Sagebrush, Pinyon, and Juniper

#### 1.4 ACAP Research Facilities and Measurement Systems

The primary features of the ACAP program are the large pan-type lysimeters (Benson et al. 1999) located at 10 of the sites (Figure 3). These 10 m x 20 m geomembrane basins allow direct measurement of most variables in the near-surface water budget. The geomembrane is low-density linear polyethylene (LLDPE) and forms the bottom and sides of the lysimeter. Full-scale (in depth) models of the tested cover designs were constructed in the lysimeters. A geocomposite drainage layer was placed between the geomembrane and the cover soils to protect the membrane and allow rapid lateral transmission of intercepted water through the drainage collection system. Surface berms surround the lysimeter to prevent run-on and collect run-off. Collection systems made of PVC pipe carry drainage and surface run-off water to measurement systems. Soils within the lysimeters are instrumented at multiple depths for measurement of soil moisture content and matric potential.

The ACAP sites at Center Hill (Cincinnati OH) and Green II (Logan OH) do not include drainage lysimeters as the basis for performance monitoring. Both sites are closed with final covers in place and offered alternative methods for estimating the performance of the covers. The landfill at Green II was located in an abandoned clay mine and, as such, rests atop a natural base of low-permeability soil. Leachate from the site is collected in two collection trenches and

pumped to a storage tank. Measurement of leachate is accomplished by monitoring the fluid level in the storage tank. The landfill at Center Hill is also closed with a final cover and does not include a liner. Leachate collected by two collection trenches is monitored with a flow meter.

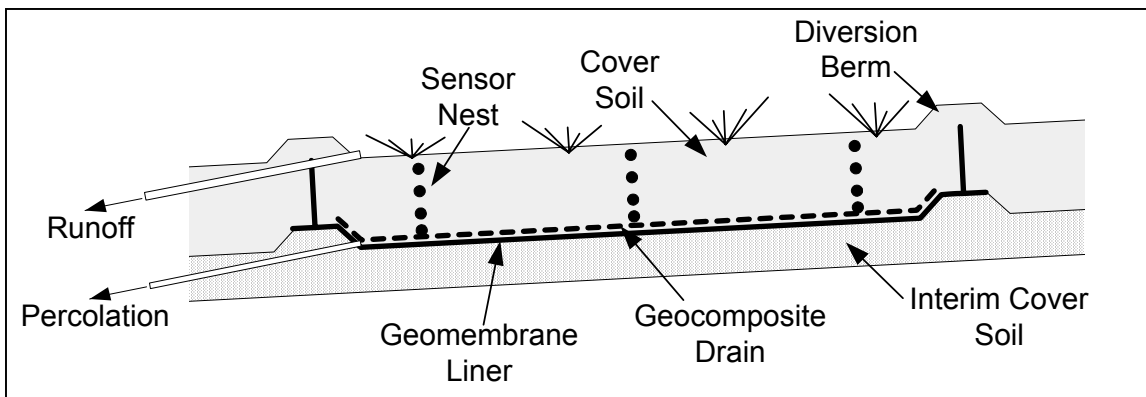


Figure 3. Schematic of ACAP drainage lysimeter.

The emphasis on measurement in the ACAP program is continuous determination of the components of the water budget in the near-surface soils. Those components are 1) precipitation, 2) surface flow, 3) soil moisture storage, and 4) deep percolation. ET is estimated by the difference between precipitation and the other components. A measurement of each variable is taken every 60 minutes. Data are normally stored on one-hour intervals. At times of intense activity (an intense rain event with high surface runoff, for example), data are stored at time intervals as short as every 15 seconds. Table 5 specifies the measured variables at the ACAP sites.

The primary method of measuring deep percolation and surface runoff is by a dosing siphon. The siphons used in the ACAP program are activated by the addition of 85-100 liters of water to the siphon basins (95 liters corresponds to 0.475 mm of flux distributed aurally across the lysimeter). Siphon activation triggers a float switch to send a signal to the data logger. Each basin is individually calibrated. A pressure transducer, located in the bottom of each siphon basin, makes additional verification of siphon events by use of an algorithm in the data logger program that determines the rate and direction of change in the transducer measurements. In each deep percolation basin, where expected flow rates are low, a tipping bucket gauge provides an additional measurement of flux.

Soil moisture storage is determined by integration of point measurements of soil moisture content. Moisture content probes are located at several depths in the cover. Instrument nests are located at three locations on the surface of each lysimeter.

Measured meteorological parameters include precipitation, air temperature, relative humidity, solar radiation, wind speed, and wind direction. Potential evapotranspiration is calculated. A central instrument station includes the meteorological instruments, data logger, multiplexers, solar panel (at most sites), along with a cellular phone that allows daily remote access to the data (Figure 4).

Table 5. Measured variables at ACAP sites.

Measurement	Instrument	Frequency of measurement (or time resolution)	Frequency of calibration
Lysimeter drainage	Dosing siphon	By event	Initial and annual
	Pressure transducer	Hourly to 15 sec.	Initial and annual
	Tipping bucket gauge	By event	Initial and annual
Surface runoff	Dosing siphon	By event	Initial and annual
	Pressure transducer	Hourly to 15 sec.	Initial and annual
	Tipping bucket gauge	By event	Initial and annual
Interflow	Dosing siphon	By event	Initial and annual
	Pressure transducer	Hourly to 15 sec.	Initial and annual
	Tipping bucket gauge	By event	Initial and annual
Soil moisture content	Water content reflectometer	Hourly	Initial
Soil matric potential	Heat dissipation unit	Daily to hourly	Initial
Soil temperature	Thermocouple	Hourly	Initial
Precipitation	Tipping bucket gauge (with snow adapter)	By event	Initial and annual
Solar radiation	Pyranometer	Hourly	Initial and bi-annual
Wind speed	Cup anemometer	Hourly	Initial and annual
Wind direction	Potentiometer	Hourly	Initial and annual
Air Temperature	Thermistor	Hourly	Initial and annual
Relative humidity	Capacitance-film	Hourly	Initial and annual

An extensive program of soil sampling was conducted during construction of the lysimeters. Samples were taken following placement of each soil lift (between 15 cm and 45 cm of soil). The sampling schedule consisted of four disturbed samples (5-gal buckets), two Shelby tubes, and two large (15 cm x 15 cm) undisturbed block samples. Disturbed samples were analyzed for grain size distribution, Atterberg limits and compaction characteristics, the Shelby tube samples for saturated hydraulic conductivity, and the large undisturbed samples for water retention parameters.



Figure 4. Typical instrument installation.ACAP

## 2.0 Data Collection and Assessment

### 2.1 Data Collection and Storage

ACAP data collection activities were initiated at each site as the final stage of construction. Data are collected daily from each site via an automated system operated through the Western Regional Climate Center (WRCC) located at DRI. At each site, field data are collected and stored in a data logger (CSI Model 23X). The field data loggers are automatically interrogated daily via phone (cell or land line). The data are imported into the Weabase system and parsed into a format accessible to both users and the automated web-based data display. Weabase automatically checks the data for out-of-range values and notifies the project manager and database manager of irregularities via e-mail. The data are made available to an interactive web-based system that allows users to evaluate conditions at each site in near-real time (observations are typically available the following day). Raw and parsed data are stored on disc at DRI and are backed up to both tape (weekly) and cd (monthly). Parsed data are transferred to the University of Wisconsin-Madison for processing, QA checks, and plotting.

### 2.2 Data Processing

Processing of the ACAP field data begins with sorting the hourly data and adding it to the existing data files. Precipitation and irrigation (if present) are combined into “water applied” to a test section. Volumetric water contents are then computed using soil-specific calibration equations. Matric suction for each soil layer is computed from the temperature differentials and probe-specific calibration equations. Data from the basins are used to compute hourly runoff,

lateral flow, and percolation. Rapid stage data from the basin are used to calculate flows when large drops in stage are recorded.

### 2.3 Water Balance Quantities

Water balance calculations are made after the initial data processing. Soil water storage is computed by integrating the water content data over the volume of the test section. The hourly data for soil water storage as well as runoff, lateral flow, and percolation are then summed for each day to define daily water balance quantities. Daily ET is computed as a residual of the mass balance by subtracting lateral flow, surface runoff, percolation and change in soil water storage from applied water.

### 2.4 Data Quality Checks

Quality of the processed data is verified in terms of completeness and reliability. Checks are first made to ensure that data are not missing and are assigned to the proper columns in the data files. Data from the collection basins are then evaluated by comparing dose counts, tips, and stage measurements to determine if the basins are functioning properly. Potential problems that can be identified through this process include clogging, leakage, and sensor failure. Probe errors are indicated by out-of-range readings and physical quantities (e.g., water contents, suction, precipitation volume) that are not physically possible. Recommendations for maintenance are made based on the outcome of this assessment.

## 3.0 Soil Testing

During construction of the research facilities the ACAP team conducted a very extensive schedule of soil sampling. Following placement of each lift of soil in the test sections samples were taken for analysis of standard geotechnical parameters as well as hydraulic characteristics. Most of the analyses were completed within a few months of test section construction. Analysis for unsaturated hydraulic parameters is quite time consuming, however, and that aspect of the testing program has continued. Table 6 indicates the current status of the soils testing program and lists analyses completed and analyses to be completed this coming year. Data summaries for work completed are assembled as University of Wisconsin Reports and are posted to the ACAP ftp site on the DRI server.

Table 6. Summary of soil analysis activities.

	Compaction	K-sat	Index parameters	SWCC
Albany	Completed	Completed	Completed	Completed
Altamont	Completed	Completed	Completed	Partial
Boardman	Completed	Completed	Completed	Partial
Cedar Rapids	Completed	Completed	Completed	Partial
Helena	Completed	Completed	Completed	Completed
Monterey	Completed	Completed	Completed	Partial
Monticello	Completed	Completed	Completed	Completed
Omaha	Completed	Completed	Completed	Partial
Polson	Completed	Completed	Completed	Completed
Sacramento	Completed	Completed	Completed	Completed

## 4.0 Site Maintenance

Each site in the ACAP network was visited at least once this during 2002 for calibration and repair activities as well as general maintenance. In addition to the activities required by ACAP protocol, additional sampling was conducted at most sites. Additional activities included:

- block soil samples for determination of changes in hydraulic properties due to environmental conditions and plant activities at the site,
- root depth and density samples to determine the location of transpiration effects in the soil profile,
- leaf area index measurements by both instrumented measurement and clipping vegetation samples from 1 m<sup>2</sup> sections of the test sections.

Site maintenance, calibration and sampling activities are summarized in the site visit logs in Appendix A. These logs represent the most recent visits to the sites and are not a comprehensive list of corrective actions taken. There have been numerous maintenance activities, such as minor changes to data logger programs that are not included in the logs. Most of the minor site activities are accomplished via telephone communications with the field data loggers and do not involve human presence at the site. All ACAP activities are logged.

## 5.0 Results

The purpose of the results section of this report is to summarize the overall performance of the covers primarily with respect to percolation as a response to precipitation. A more complete description of all of the water balance components including surface runoff, soil water storage, and evapotranspiration is to be found in Roesler et al. (2002). As of the writing of this report (Oct. 2002), all of the ACAP sites have been operational for at least two years.

The data are beginning to indicate the performance of both the prescriptive and alternative cover systems. In some instances performance levels verify expectations both intuitive and numerically simulated, in others there have been surprises. Following are general summaries of the overall performance of the test sections for each site. Data reported in this report are through July 17, 2002. Project data are summarized in Table 7 and test section performance plots (Figures 5 through 37) are located in Appendix B.

### 5.1 Albany, GA Site

Data collection at the Albany, GA site began April 19, 2000. Irrigation was applied to the alternative (E-Cap) cover to maintain the poplar trees. A small quantity of irrigation water was applied to the RCRA cover as well. The water balance summaries for the two test sections at the Albany are shown in Figures 5, 6 and 7. Total applied water (precipitation plus irrigation) during the 28-month data collection period for the alternative cover was 2160 mm resulting in 185 mm of total percolation. Total applied water for the RCRA cover was 1835 mm resulting in 683 mm of percolation. Mean annual precipitation at the site is 1280 mm.



Most of the percolation through the alternative cover occurred in response to summer rain during 2000 prior to establishment of a functional vegetation community on the test section. The rate of percolation slowed during the fall of 2000 and did not rise significantly during the summers of 2001 and 2002.

In contrast to the alternative test section, the RCRA cover has exhibited percolation throughout the test period. Steady percolation for the first several months of operation was replaced during the relatively dry fall of 2000 with pulses of percolation following rain events. Since the water storage capacity of the RCRA has never been exceeded (according to data from the soil moisture probes in the cover) preferential flow through desiccation cracks is likely the cause of both the quantity and timing of flow through the cover.

## 5.2 Altamont, CA Site

Data collection at the Altamont CA site began November 10, 2000. Water balance summaries for the test sections at the Altamont site are shown in Figures 8, 9 and 10. Total precipitation during the 18-month data collection period was 509 mm. Mean annual precipitation for the site is about 340 mm.

No percolation was recorded in the RCRA test section during the monitoring period. Percolation through the alternative cover totaled 1.4 mm and was in response to a single large rain event. Preferential flow is likely the cause of flow through the alternative cover since the water content probes in the lower layers of the cover did not register an increase in moisture content as a result of that event.

## 5.3 Boardman, OR Site

Data collection at the Boardman site began December 9, 2000. Water balance summaries for the test sections at the Boardman site are shown in Figures 11, 12, 13 and 14. Total recorded precipitation during the 19-month data collection period was 211 mm. Mean annual precipitation for the site is about 220 mm. Trace amounts of percolation (< 1mm) were recorded for all three test sections.

## 5.4 Cedar Rapids, IA Site

Data collection at the Cedar Rapids site began October 3, 2000. Data were lost for a six-month period from mid-October 2001 to early May 2002 due to a variety of instrument and communication problems. Water balance summaries for the test sections at the Cedar Rapids site are shown in Figures 15, 16, 17 and 18. Total recorded precipitation during the 21-month data collection period was 1277 mm. Mean annual precipitation for the site is about 925 mm.

Percolation was recorded in all three test sections. Flow through the RCRA (composite) cover totaled 6.1 mm. The compacted clay cover (IDNR design) allowed 18.1 mm, and the alternative cover (E-Cap) 190.5 mm. Percolation through all three tested covers occurred when field saturation of the cover soils was reached.

## 5.5 Helena MT Site

Data collection at the Helena site began October 10, 1999. Water balance summaries for the test section at the Helena site are shown in Figures 19 and 20. Total recorded precipitation during the 33-month data collection period was 540 mm. Mean annual precipitation for the site is about 305 mm. No percolation has been recorded from the alternative cover at the Helena site.

## 5.6 Monticello UT Site

Data collection at the Monticello site began August 2, 2000. Water balance summaries for the test section at the Monticello site are shown in Figures 21 and 22. Total recorded precipitation during the 23-month data collection period was 525 mm. Mean annual precipitation for the site is about 384 mm. Cumulative percolation through the Monticello cover is less than 0.1 mm.

## 5.7 Monterey CA Site

Data collection at the Monterey site began May 27, 2000. Water balance summaries for the test sections at the Monterey site are shown in Figures 23, 24 and 25. Total recorded precipitation during the 25-month data collection period was 624 mm. Mean annual precipitation for the site is about 412 mm.

Total percolation through the RCRA (composite) cover totaled 34.5 mm during the monitoring period. Percolation through the RCRA cover may be underestimated due to an equipment failure. The dosing basin developed a leak and flow was recorded solely with the tipping bucket gauge, which tends to under-record. Percolation through the composite cover is probably due to punctures in the geomembrane. The vegetative cover soil, which contained a variety of construction debris including concrete fragments and scrap rebar, was placed directly on the membrane during construction. This was done following extensive communication with the site consulting engineer.

Percolation through the alternative cover totaled 117.5 mm and appears to have been in response to heavy precipitation events during the winter months.

## 5.8 Omaha NE Site

Data collection at the Omaha site began October 5, 2000. Water balance summaries for the test sections at the Omaha site are shown in Figures 26, 27, 28 and 29. Total recorded precipitation during the 21-month data collection period was 784 mm. Mean annual precipitation for the site is 711 mm.

Total percolation through the RCRA (composite) cover totaled 5.5 mm. the thin (760 mm) capillary barrier transmitted 95.1 mm of percolation, and the thick (1060 mm) capillary barrier transmitted 55.7 mm of percolation. Most of the percolation from all three covers occurred during the spring of 2001 when a large amount of rainfall was recorded.

## 5.9 Polson, MT Site

Data collection at the Polson site began November 19, 1999. Water balance summaries for the test sections at the Polson site are shown in Figures 30, 31 and 32. Total recorded precipitation during the 32-month data collection period was 837 mm. Mean annual precipitation for the site is about 382 mm.

Percolation occurred through both tested covers and was nearly identical with the RCRA (composite) cover transmitting 0.48 mm and the alternative cover transmitting 0.43 mm. Flow through both covers occurred in response to snow melt events during winter months and other rain events. The water storage capacity of neither cover was exceeded during the monitoring period indicating that preferential flow was likely the cause of percolation.

## 5.10 Sacramento, CA Site

Data collection at the Sacramento site began July 29, 1999. Water balance summaries for the test sections at the Sacramento site are shown in Figures 33, 34 and 35. Total recorded precipitation during the 36-month data collection period was 1152 mm. Mean annual precipitation for the site is about 438 mm.

Percolation has occurred through both alternative covers at Sacramento. The thick alternative cover recorded 8.5 mm of percolation; the thin alternative cover 132 mm. Percolation through both covers appears to be in response to large winter rain events.

## 5.11 Cincinnati, OH Site

Data collection at the Cincinnati site began December 7, 1999. The research site at Center Hill is an atypical ACAP installation and does not use a drainage lysimeter to evaluate the flux of moisture through the cover. Instead, performance is evaluated by recording flow through a leachate collection system equipped with a flow measurement device. A summary of flow measurements is shown in Figure 36. Visual examination of the data indicates the presence of two trends. One is seasonal with leachate production lower in summer than in winter, presumably from the increase in evapotranspiration during the warm season. The second is a general reduction in leachate production through the evaluation period.

## 5.12 Logan, OH Site

Data collection at the Logan site began March 2, 2000. The research site at Green II is an atypical ACAP installation and does not use a drainage lysimeter to evaluate the flux of moisture through the cover. Instead, performance is evaluated by recording fluid collected in a series of leachate collection trenches. A summary of flow measurements is shown in Figure 37. The graph shows a total of about 6 million liters of leachate collected. A definite seasonal variation is present with most of the flow occurring during the months between late winter and early summer.

## References

- Benson, C., Abichou, T., Wang, X., Gee, G., and Albright, W. 1999. Test section installation instructions – alternative cover assessment program, Environmental Geotechnics Report 99-3, Dept. of Civil and Environmental Engineering, University of Wisconsin-Madison.
- Roesler, A. C., C. H. Benson. W. H. Albright, 2002. Field Hydrology and Model Predictions for Final Covers in the Alternative Assessment Program – 2002. Geo Engineering Report No. 02-08, Dept. of Civil and Environmental Engineering, University of Wisconsin-Madison.

Table 7. General performance data for ACAP lysimeter sites.

Site <i>Test Pad</i>	Cover Design	Start Date	Current Data	Avg. Annual Precip (mm)	Cum. Precip (mm)	Cum. Percolation (mm)	Cum. Surface Runoff (mm)	Cum. Lateral Flow (mm)	Cum. ET (mm)
<b>Albany GA</b> <i>Prescriptive Alternative</i>	Comp. clay ET-type	04/19/00 04/19/00	07/17/02 07/17/02	1280	1835.2* 2160.0*	682.8 185.4	203.5 15.3	-- --	1005 2064
<b>Altamont CA</b> <i>Prescriptive Alternative</i>	Composite / comp. clay ET-type	11/10/00 11/10/00	07/17/02 07/17/02	368	509.0 509.0	0.1 1.3	14.8 26.4	3.8 --	487 528
<b>Cedar Rapids IA</b> <i>Prescriptive IDNR Alternative</i>	Composite / comp. clay Comp. Clay ET-type	10/03/00 10/03/00 10/03/00	07/17/02 07/17/02 07/17/02	925	1277.4 1277.4 1277.4	6.1 18.1 190.5	43.0 44.8 59.5	26.9 23.1 --	1153 1077 970
<b>Boardman OR</b> <i>Prescriptive Thin Alternative Thick Alternative</i>	Composite / GCL ET-type ET-type	12/09/00 12/09/00 12/09/00	07/17/02 07/17/02 07/17/02	219	211.3 211.3 211.3	Trace Trace Trace	0 0 0	0 -- --	247 241 281
<b>Helena MT</b> <i>Alternative</i>	ET / cap. barrier	10/19/99	07/17/02	305	539.5	0	30.8	--	448
<b>Sacramento CA</b> <i>Thin Alternative Thick Alternative</i>	ET-type ET-type	07/29/99 07/29/99	07/17/02 07/17/02	440	1151.6 1151.6	131.9 8.5	122.5 69.8	-- --	916 1080
<b>Monterey CA</b> <i>Prescriptive Alternative</i>	Composite / comp. clay ET-type	05/27/00 05/27/00	07/17/02 07/17/02	412	624.1 624.1	34.6 117.4	85.7 0	14.5 --	523 594
<b>Monticello UT</b> <i>Alternative</i>	Multi-layer cap. barrier	08/12/00	07/17/02	384	524.7	Trace	10.2	--	592
<b>Omaha NE</b> <i>Prescriptive Thick Alternative Thin Alternative</i>	Composite / comp. clay ET / cap. barrier ET / cap. barrier	10/05/00 10/05/00 10/05/00	07/17/02 07/16/02 07/16/02	711	784.1 784.1 784.1	5.5 55.7 98.2	70.8 54.9 73.2	27.4 -- --	621 705 628
<b>Polson MT</b> <i>Prescriptive Alternative</i>	Composite / comp. clay ET / cap. barrier	11/19/99 11/19/99	07/17/02 07/17/02	382	837.2 837.2	0.4 0.5	23.3 19.2	-- 30.8	796 758

\*Precipitation quantities differ at Albany due to differences in irrigation of the two test pads.

## Appendix A - Site Visit Notes - 2002

### Bluestem – Cedar Rapids

9/9-11/02 B. Lyles and B. Albright - annual site visit

9/9 Drove from Omaha, arrived about 5pm. Hot (95), humid (80%), clear, calm winds.

9/10 Warm (80), heavy dew (95-30% RH), windy, overcast, trace rain.

9/11 Warm (85), heavy dew (95-35% RH), calm winds, clear.

Flow measurement systems:

- All of the water levels in the dose basins were at or above the bell.
- The L2 basin was damaged, presumably by a mower, and was repaired with Orenco epoxy.
- The D2 and D3 tipper funnels were plugged which accounts for the lack of tips. The funnels were cleaned and drilled out with a 3/8" drill.
- The tipper in D2 was not functioning and was replaced.
- All dose floats were functioning fine.
- Installed vents in all the basins.
- Left a ladder in the L2 basin for future maintenance.
- Druck pressure transducers all were working.
- All sediment tanks were full.
- All of the sediment tanks were removed from the system by plumbing 2" PVC through the tanks. The site operator is going to fill the tanks with soil.
- Fiala Plumbing installed a vertical section of pipe in the sump and hard plumbed the sump pump discharge line. This should solve the problem of the creek flooding into the manhole and preventing proper dose basin function.

Weather station:

- Installed a transfer standard for the AT/RH; the temperature checked out okay, but the relative humidity was approximately 15% lower than the transfer standard – the sensor was replaced.
- The windset was replaced with the sensor removed from Omaha after new bearing were installed.
- A wiring error was found while testing the windset – the ground wire was inadvertently wired into an input channel and data since the March visit should be checked.
- All the WCR sensors in the E-CAP were reading 9999 indicating failure. Voltages to the AM416 checked fine. The failure appears to be intermittent and the mux should be replaced. Will order new mux and will send to Eric A. for installation.
- 110-volt power was brought up to the data logger from the sump.
- Landline phone service was supplied to the site.
- The solar panel and cell phone equipment were removed.
- All other sensors appeared to be working fine.
- New desiccant

Test sections:

- Photos
- Berms all OK
- Minor cleaning of SRO inlets
- One block soil sample was collected from outside each section.
- Shelby tubes were placed in the IDNR and ECAP sections – to be removed by the site operator.

- Root sample trenches were cut by backhoe on the north side of the ECAP and on south side of the RCRA section. Root samples were collected in 4" increments over a depth of 4 feet.
- LAI measurements were made as follows: 5 samples with 3 reps were made on each grass-covered test section; measurements were random over the cover. On the E-CAP, one set of measurements was made at ground level to capture both trees and grass and another set was made above the grass level to capture just trees. On the E-CAP section transect #1 was in line with the tree row trunks, trans. #2 was along the tree canopy line, trans #3 was in the center of two rows (the canopy has not closed), trans #4 was along the tree canopy line and trans #5 was along the tree trunk line.

## **MCLB – Albany**

9/6-7/02 B. Lyles and B. Albright – annual site visit

Overcast, hot and humid. Site overall appeared to be in good shape.

Flow measurement systems:

- All basins were at or above the bells
- Calibration check on all basins and tipper
- Slight (CaCO<sub>3</sub>?) precipitate on the funnel and tipper in the RCRA drain, very heavy precipitate in the alt drain plugging the funnel and coating the funnel screen,
- All float switches were high – adjusted all downward approx. 3". After adjustment all switches recorded flushes.
- Drilled out the funnel on the RCRA tipper – tips were recorded fine – an attempt was made to chip off as much precipitant as possible, but the calibration was much less than expected for 504 ml.
- Alt tipper not recording tips - replaced
- All basins were outfitted with 1" PVC vents.
- Both sediment tanks were plumbed through with 2" PVC.
- The alt SRO inlet screen had a hole from a rodent(?) and was repaired. Both dosing basin outlet screen were replaced with a ¼" hardware cloth basket (approximately 4" diameter and 12" long) to reduce the possibility of clogging by increasing the surface area, as both screens had partial blockage from grass clippings (both test sections are mowed every two weeks).
- Calibrated all four basins using irrigation system for water source with site garden hose.
- Removed extra dose counters and wired all connection inside basins and inside short PVC tubes.
- Replaced float switch in alt drain – although there was no evidence of sensor failure, the cable insulation was wet on the inside.

Weather station:

- Replaced wind set with laboratory rebuilt unit,
- Replaced HMP45C with lab calibrated unit,
- Cleaned and leveled pyrometer,
- Cleaned and calibrated precip gauge,
- Installed new desiccant.

Test Section:

- Photos
- Soil block samples were collected: two samples were collected outside the RCRA section and two samples collected inside the alt section (upper portion of test section). The reason for

inside-the-section sampling was that the original soil inside the section was different from that outside the section.

- No Shelby tube samples or root samples taken. Soil too hard to dig without help.
- No veg samples taken. Both sections are mowed regularly and were just prior to visit.
- LAI measurements were made: 3 reps at five locations on the RCRA section – one in each corner and one in the center of the section. 5 transects were measured on the alt section – 3 reps with 5 transects. – All RCRA readings were made in the very short grass. On the ALT section transect one was inline with the tree row trunks, trans. 2 was along the tree canopy line, trans 3 was in the center of two rows (the canopy has not closed), trans 4 was along the tree canopy line and trans 5 was along the tree trunk line.
- Berms OK

## **Omaha**

9/8-9/02 B. Lyles and B. Albright – annual site visit

Annual site maintenance visit. Mostly sunny, 10-20 mph winds, 70-90 degrees, 30-85% RH.

Flow measurement system:

- Water level was at or above the bell in all basins.
- Calibrated all basins
- All three drainage basin inlet pipes were tilted upward, due to settlement. The inlet into drain 3 (alt 1) was tilted so that water could no longer drip into the tipping bucket. All three inlet pipes were heated and bent downward so that they aligned with the center of the tipping buckets.
- All three tippers calibrated and OK
- All but two dose float switches were operating fine; drain 2 (alt 2) and drain 3 (alt 1) were replaced with “super single” float switches.
- Two outlet screens were missing and all three SRO outlets were partially blocked; all of the screens were replaced with ¼” hardware cloth.
- All three sediment tanks were removed from the system by plumbing 2” PVC through the tanks; the site operator will fill the tanks with soil.
- Vents were installed in each basin.
- Caps were installed on the bottom of each transducer tube and the transducers were secured with new zip ties.

Weather station:

- One leg of weather station tower was damaged, but the tower appears to be stable.
- The wind set was replaced with the sensor recently removed from Albany after new bearings were installed.
- An air temperature / relative humidity transfer standard was used to verify that the existing sensor was within calibration specifications.
- The precipitation gauge was inspected; the tipping buckets had a slight oil / antifreeze residue and the funnel was plugged with dirt and was cleaned prior to calibration.
- New desiccant

Test sections:

- Photos
- All inlet screens were in good shape.



- All of the lower berms were much lower than was originally constructed, possibly due to mower scalping.
- Overall the site appeared to be in good shape – freshly mowed.
- Block soil samples were collected from outside of each test section.
- Shelby tube soil samples were collected near the upper instrument nest in the two alternative test sections. These two samples were left in the ground for the site operator to remove with a tractor.
- One soil root pit was dug down-slope of the RCRA cover; samples were collected in 4” increments, down to 36”.
- Plant clipping samples were collected from each test section; approximately 15-20% bare soil in the two alternatives, and RCRA was < 10% bare soil.
- LAI measurements were performed on each test section, generally working from the top of the test section down-slope.
- The drainage test pipes were capped off approximately 12” below grade; two of the test pipes showed mower damage and therefore were viewed as potential leak paths.

Data logger program changes were made:

- Code was added to bulk load the transducer high / low stage dose trigger calibration data
- added subroutine 7 to initialize old stage readings to current on start up
- changed flag 2 counter from 360 to 2160
- changed WD from P71 to P69
- changed HDU measurement time from noon to 530 am; updated high / low stage triggers
- optimized the program label data.

Need:

- Check with site operator regarding antifreeze supplies
- Email site operator to backfill sediment tanks with soil
- Email site operator regarding Shelby tubes

## **Boardman – Finley Buttes**

8/16-17/02 B. Lyles and B. Albright – first annual site visit

Flow measurement system:

- Checked dose basins – adjusted the float switch in the RCRA SRO
- Installed zip-ties at the top of all transducer support tubes
- Did not install 1” PVC caps at the bottom of the support tubes, the cables were too short to raise the tubes
- Calibrated all basins
- Calibrated tippers, all OK
- All float switches and tippers worked fine
- Installed vents in all basins
- Removed clay sealant around connector pipes in the sediment tanks and sealed them silicone
- Filled all sediment tanks to their overflow point
- Returned water level in all basins to the bottom of the bell (used the fire hose from a hydrant approximately 100 feet from the basins).

Wx station:

- changed the orientation of the cross arm approximately 30 degrees clockwise so the cross-arm is on a north-south bearing

- Replaced windset W5031 with W5016 (after the bearings were replaced)
- Replaced AT / RH sensor T3310095 with T3310068
- Moved windset to the south end of the crossarm and moved the pyranometer to the other end
- Cleaned and re-leveled pyranometer
- Cleaned up the AC power cord and sealed enclosures.
- Removed old solar panel – AC power was installed some time ago.
- One HDU was found to read temperature, but not dt – checked all wires, concluded that sensor failure is not at the mux.
- New desiccant

#### Test sections:

- Three block soil samples were taken; one from below the thick alt and RCRA sections and one from above the thin section. Block samples were shipped to XWang.
- Shelby tube samples were taken from the thick and thin alt covers.
- LAI measurements were taken with the Licor wand.
- Above ground veg samples were taken for each section and bagged for shipment to XWang.
- Photos were taken of all 3 sections.
- SRO inlets were checked. The inlet for the thin section was totally obscured. Inlet was cleaned.
- Root samples were taken from lower corner of the RCRA section to 52 inches. Pit was dug and refilled with a loader. Samples were shipped to XWang.
- Berms OK

## Helena

8/12-13/02 B. Lyles, B. Albright – annual site visit

Arrived on site ~4pm MDT; partly cloudy, mid-80's, slight breeze.

Saved the existing program = h020812.dld; downloaded all data = helena.dat.

#### Flow measurement systems:

- Calibrated both basins
- Water level in the SRO was about 6" above bell, water level in drain was ~ 1" below the bell.
- Installed 1" PVC caps on transducer supports and installed vents in each basin.
- Checked both dose counters and the drain tipper – all were okay.
- Sed tank was muddy, water was up to the 2" connecting pipe.
- SRO inlet screen was partial blocked with sediment – cleared sediment away with a shovel.
- Updated high / low trigger values based on the current stage calibration data.

#### Wx station:

- WS was not functioning – removed SN W5014 – installed W5008 . WD okay
- Replaced AT/RH sensor T3630029 with sensor T3310046 (the old sensor was reading 24 degree C and 24 %, the new sensor was reading 29 degrees and 17 %).
- Precip gauge was in good shape – calibration took 93ml / 10 tips. Repeated calibration took 94ml / 10 tips. Adjusted screws in one turn each – calibration took 86 ml / 10 tips; adjusted screws in ¼ turn each – calibration took 83 ml / 10 tips. There was some residual oil on the tipping bucket, but over the gauge was very clean.

Test sections:

- Collected Shelby tube sample from the test section approximately 7 feet from the berm at the upper end of the test section.
- Performed LAI measurements on the test section. Collected above ground veg sample from test section.
- Collected 2 block soil samples and shipped to XWang.
- Took photos
- Berms OK

## **Polson – Lake County**

8/14-15/02 B. Lyles, B. Albright – annual site visit

Performed annual site visit. Clear to moderate clouds, mid 80's, slight breeze. Both test sections were well vegetated, with vegetation up to 4 feet tall. Tail of windset was bend down touching the cross arm.

Flow measurement systems:

- Inspected all 5 dose basins, found all basins to be above the bottom of the bell (BOB), except for the lateral basin was approximately 6" inches low. Probably due to lead at pipe outlet. No good solution. Not a drainage basin so not a critical measurement. Lateral flows in the RCRA cover are probably fairly high so small leak won't be a big problem.
- Installed new zip-ties to secure transducers prior to calibration
- installed 1" PVC end caps, then calibrated the basins with the dose basin calibrator.
- Updated the high / low trigger values in the program.
- Calibrated the drain tippers.
- All tipper and dose counters worked fine.
- Performed a mini-calibration of the lateral basin from the initial low point (bottom of the 2" outlet pipe) to the BOB.
- Vents were installed in each dose basin.
- The sediment tanks were deactivated by plumbing pipe straight through the old sediment tanks.

Wx station:

- Replaced the wind set.
- Set up the transfer standard AT/RH and performed a one-point calibration (approximately 18C and 69%).
- Calibrated precipitation gage – found that the gage was over collecting by about 10%, adjusted screw in ¼ turn and got the gage within ~ 3%.
- Upon final check it was found that the power, control and output from the AM25T were loose – all wires were tightened as needed.
- Approximately 4 gallons of glycol are on site and we left new rubber bands for the snow adaptor.

Test sections:

- Berms OK
- Photos

- LAI measurements were taken, RCRA LAI approx., alt LAI was approx. 1.4
- Root samples were collected from a soil pit on the south side of the alt section to about 40" depth
- Shelby tube sample was collected from the alt cover.
- Vegetation samples were collected from each test section.
- Two soil block samples were taken: one from east (above) the alt section and one from west (below) the RCRA section.
- All samples shipped to XWang
- George, a site laborer, was instructed to backfill the sediment tanks, the root sample pit and the Shelby tube sample holes with sand.

## **Altamont**

3/13/02 B. Lyles and B. Albright – annual site visit

Flow measurement system:

- Water level at or above bell in all basins
- Performed dose basin calibration.
- Lateral and SRO1 (both RCRA) difficult to dose, water would just flow out the outlet pipe as fast as we put it in. We presume this was due to the biological consumption of oxygen in the bell. Water was tea colored and slimy.
- Wire-ties were added to transducers after the calibration were performed . The transducer data may have shifted slightly following calibration.
- Both sed tanks down about 1" – filled. Resealed RCRA outlet pipe

Instrument station:

- Removed old cell phone
- Checked T/RH with transfer standard – OK
- Leveled solar radiation sensor
- Calibrated rain gauge – OK
- Replaced W/S – SN W5004

Test sections:

- Berms OK
- SRO inlets clear
- No LAI or soil block samples this trip
- Photos

## **Monterey**

Annual site visit: B. Lyles and B. Albright – March 11-12, 2002

Flow measurement systems:

- Water level in both sed tanks at outlet
- Water level in all basins at or above bell
- Calibrated all dose basins
- Calibrated tippers
- Druck pressure transducers calibrated and OK
- Outlets clear

Instrument station:

- Changed wind set – WS bearing rough
- Checked T/RH with transfer standard. RH off calibration – installed new.
- Solar Radiation OK
- Rain gauge OK – calibrated
- Changed desiccant

Test sections:

- Berms OK
- No vegetation, LAI or soil block samples
- Photos taken

## **Sacramento – Kiefer**

Annual site visit – B. Lyles, D. Decker – May 30, 2002

Flow measurement systems:

- Repaired leak in thick drainage basin. Water was above the bell due to recent spring drainage. Water was siphoned from the basin. A disk grinder was used on the epoxy seam between the basin floor and sidewall, was cleaned with acetone, and a fillet of epoxy was applied to the base seam and around the outlet pipe and sidewall.
- Calibrated dose basins - OK
- Calibrated tippers
- Replaced float switch in thin drainage basin
- Installed vents on all basins
- This basin outlet covered with soil from recent road grading activities

Instrument station:

- Replaced air temperature / relative humidity sensor
- Performed a CPDP signal check. Signal coverage was very good, but Airlink had to be called for technical assistance and they had to open a new “service window”. The phone was not installed, because we did not have a null modem with us, but the data logger is pre wired for it.
- Calibrated precipitation gauge.
- New bearings for W/S
- W/D OK
- Calibrated rain gauge

Test sections:

- SRO inlets holes in screens. Rodents in SRO sed tanks
- Berms OK
- Veg doing fine
- No veg, LAI or soil block samples
- ACAP sign gone

Suggestions:

- ASAP the site operator should backhoe a trench to provide adequate drainage from the thin drainage basin.

### **Center Hill - Cincinnati**

Annual site visit – B. Lyles – June 20, 2002

Drove to site from Green II, via Louisville, KY.

Instrument station:

- Replaced WS sn:W5024 with WS sn:B2827,
- replaced AT/RH sn:T3310068 with sn:T3730021,
- calibrated rain gauge.
- Opened datalogger enclosure and all looked good.

### **Green II – Logan**

Annual site visit – B. Lyles – June 20, 2002

Drove to site from Louisville, KY.

Instrument station:

- Replaced WS sn:W5009 with WS sn:W5011,
- replaced AT/RH sn:T3310046 with sn:T3310060,
- Calibrated tipping bucket gauge. The precip gage tipping mechanism was not screwed to the base. Should check with Sharp and Associates to see why.
- Was not able to access datalogger.

**Appendix B. Water balance summaries for the ACAP sites.**

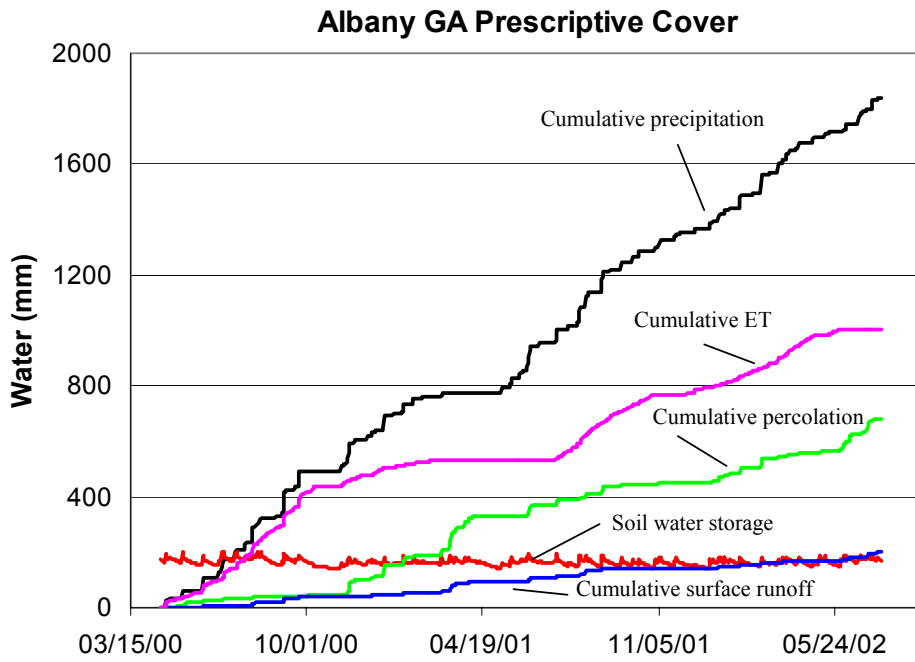


Figure 5. Water balance summary for the prescriptive cover at the Albany GA ACAP site.

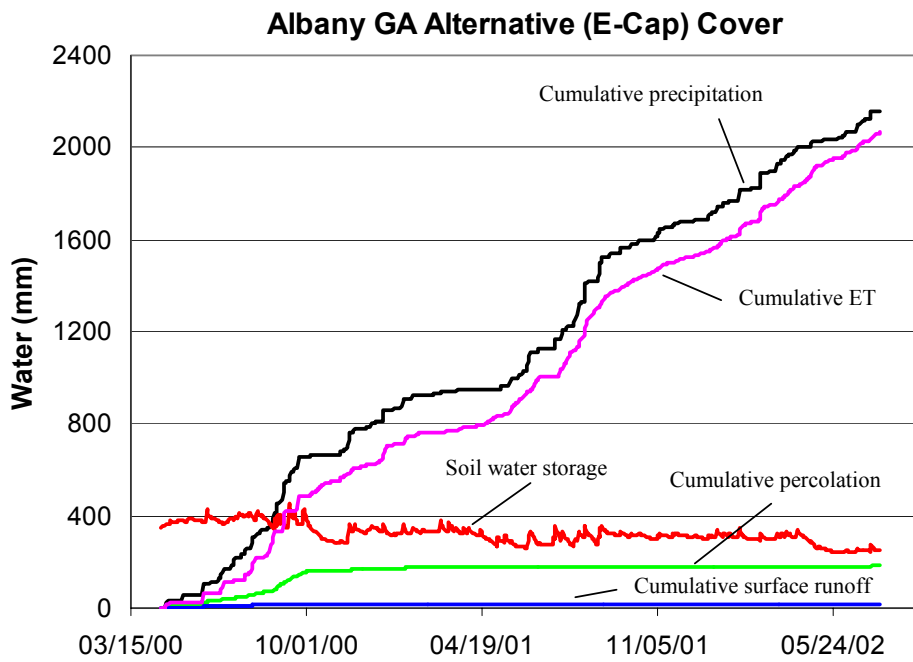


Figure 6. Water balance summary for the alternative cover at the Albany GA ACAP site.



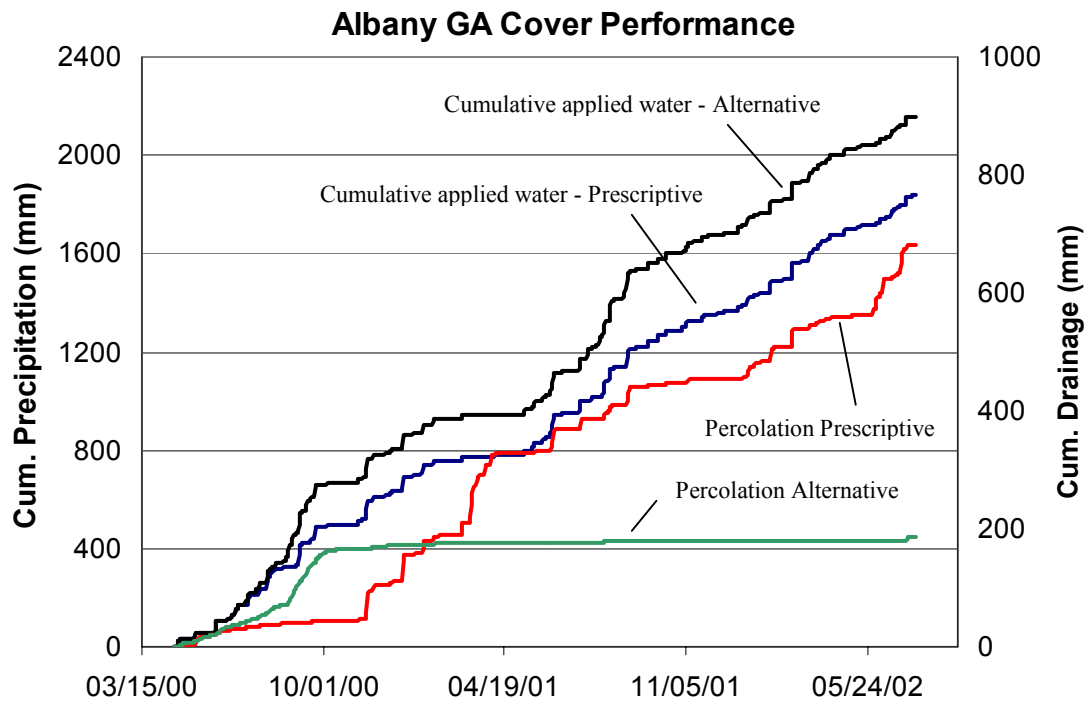


Figure 7. Cover performance at Albany GA.

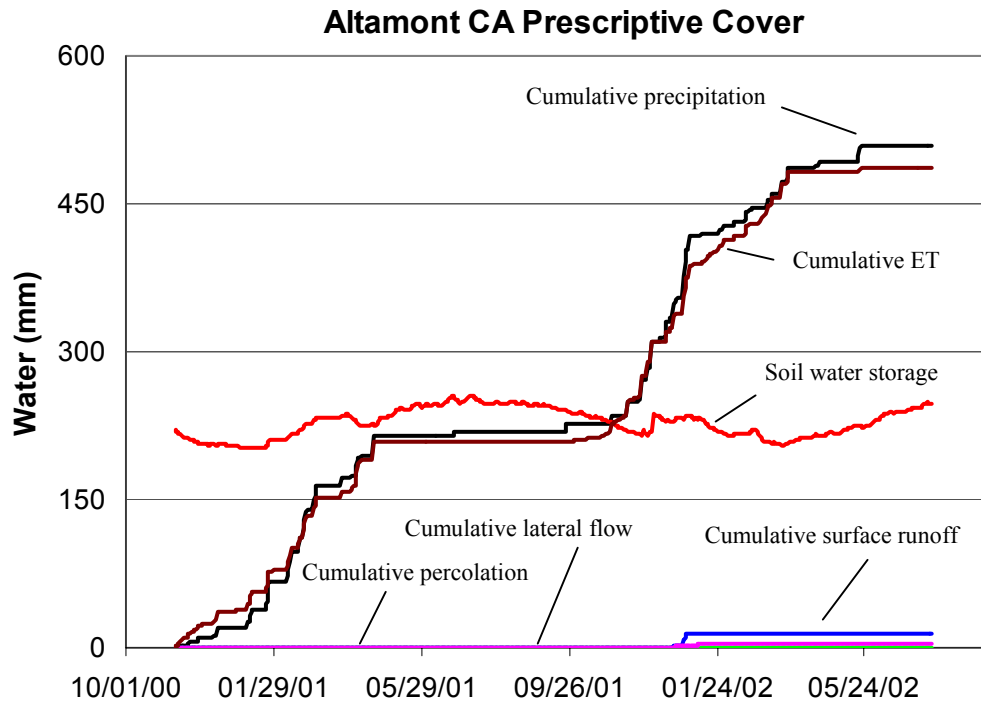


Figure 8. Water balance summary for the prescriptive cover at the Altamont CA ACAP site.

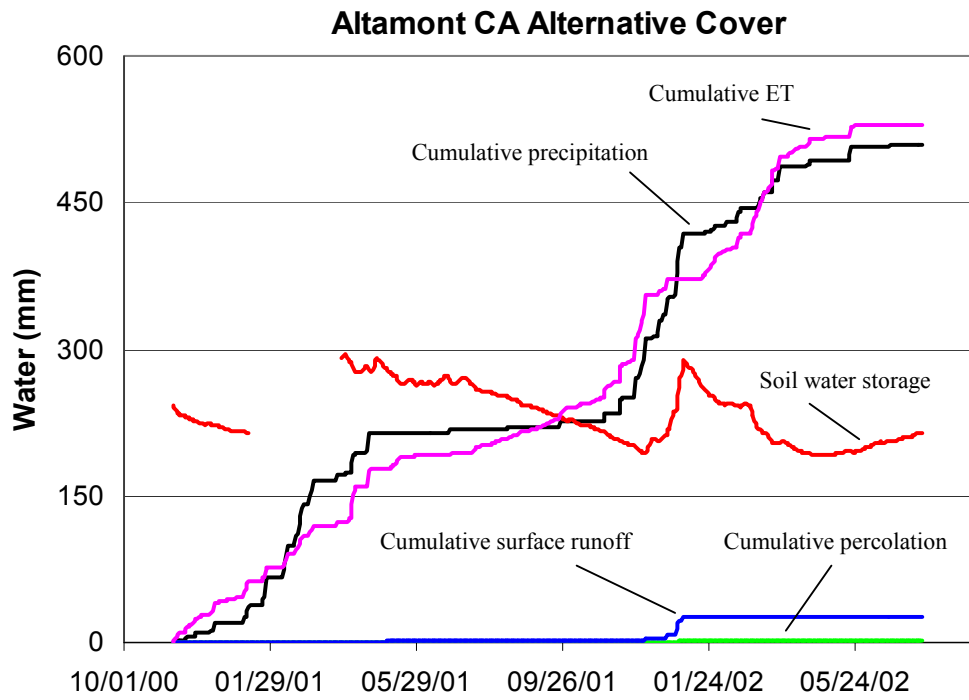


Figure 9. Water balance summary for the alternative cover at the Altamont CA ACAP site.

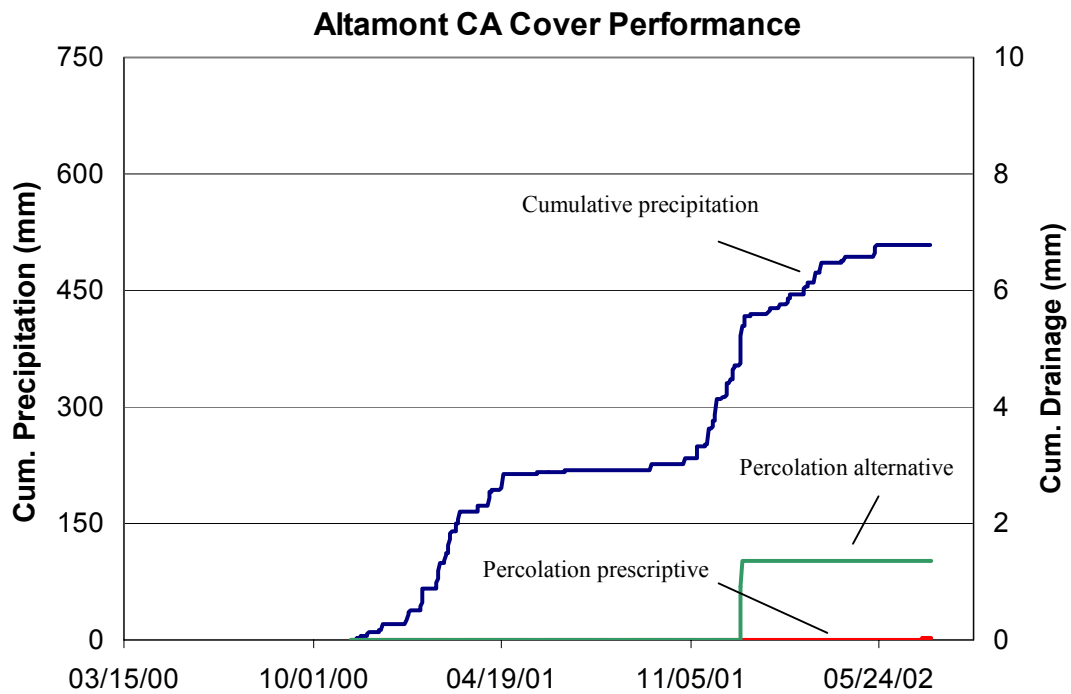


Figure 10. Cover performance at Altamont CA.

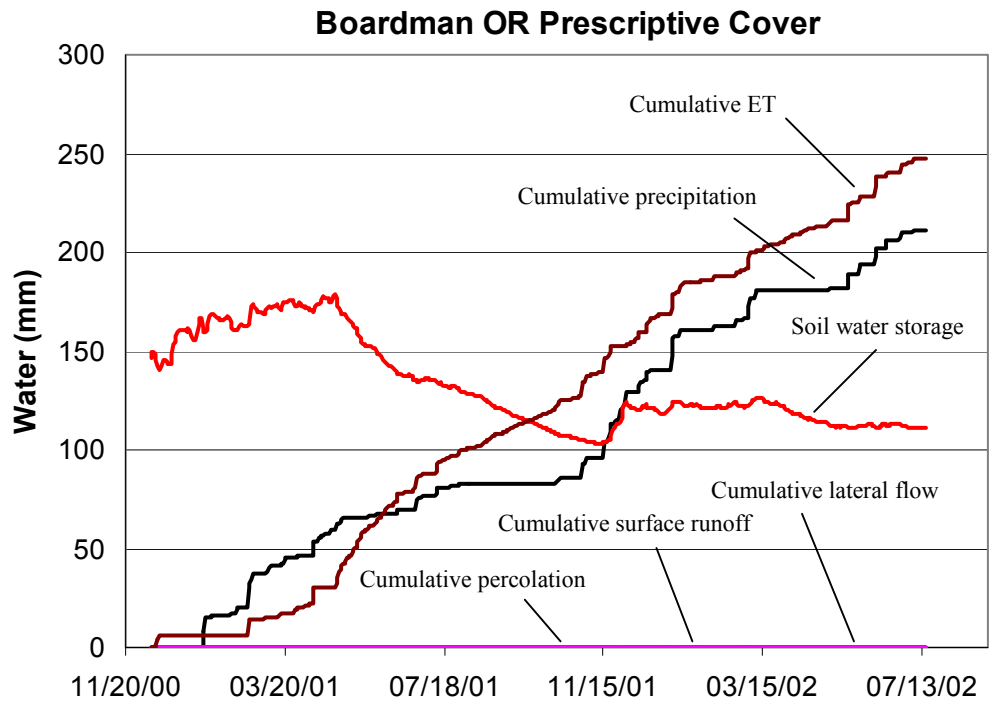


Figure 11. Water balance summary for the prescriptive cover design at the Boardman OR ACAP site.

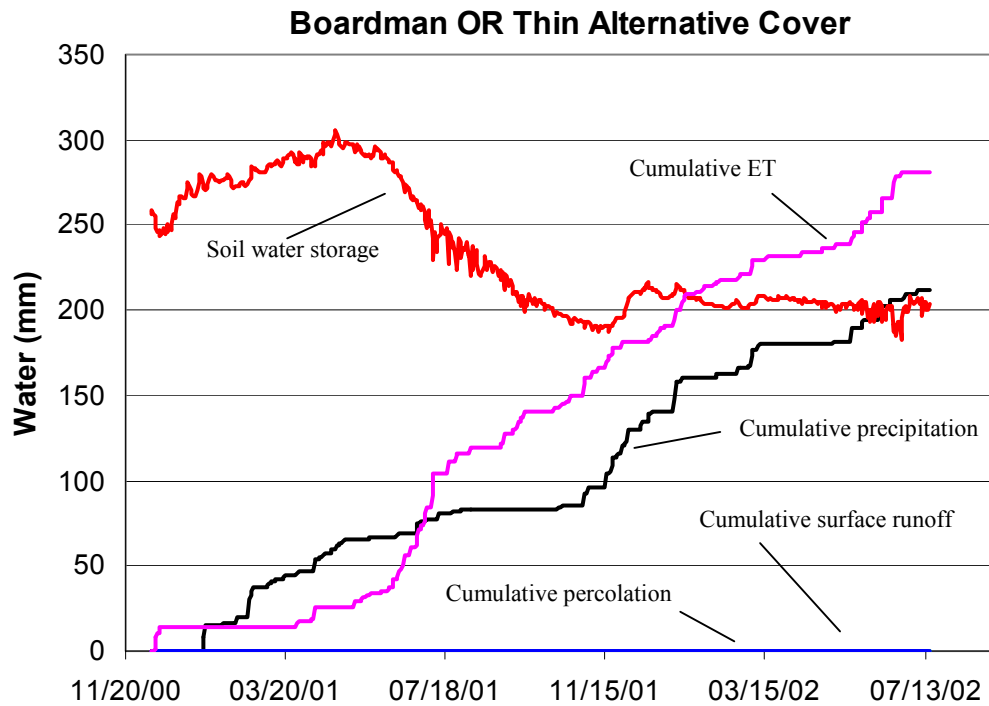


Figure 12. Water balance summary for the thin alternative cover design at the Boardman OR ACAP site.

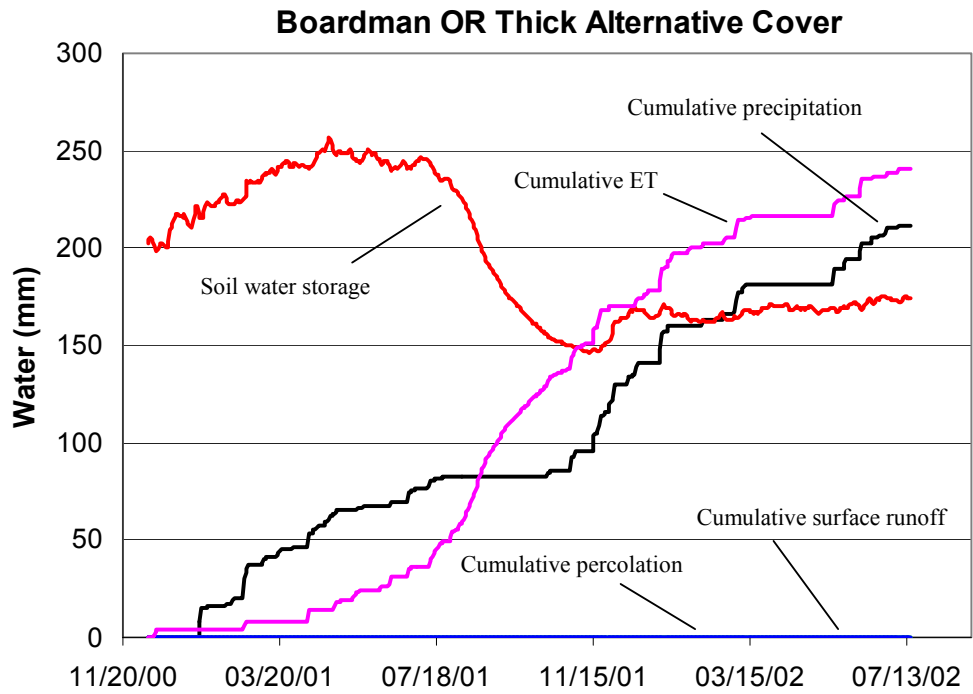


Figure 13. Water balance summary for the thick alternative cover design at the Boardman OR ACAP site.

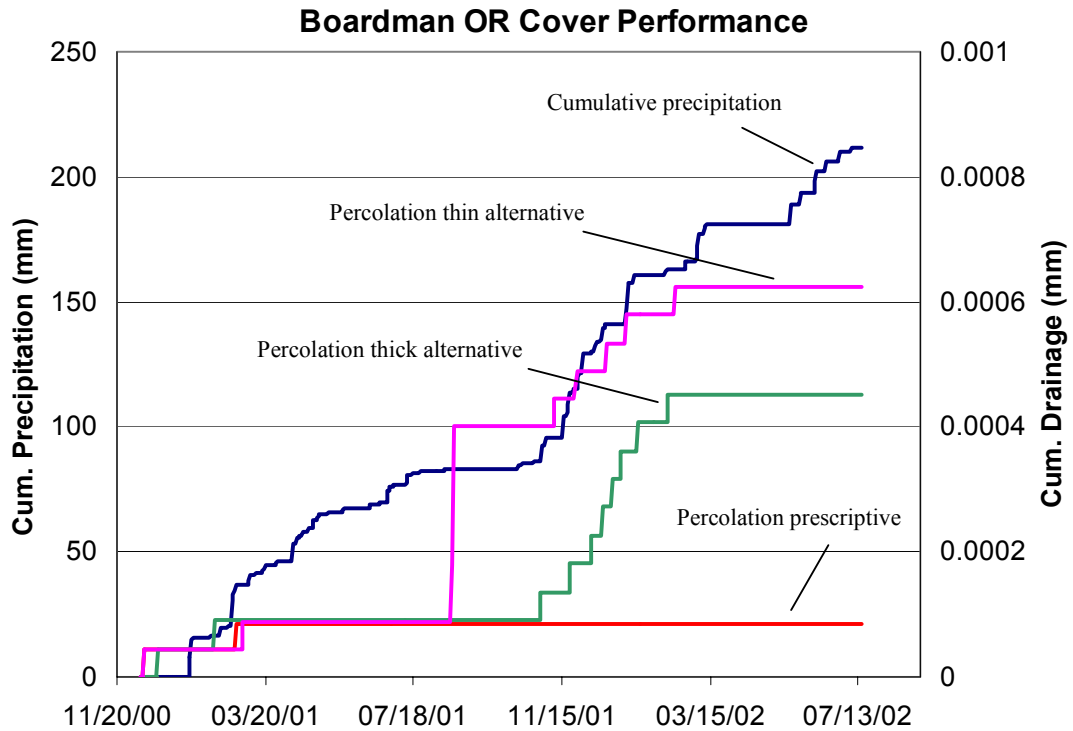


Figure 14 Cover performance at Boardman OR.

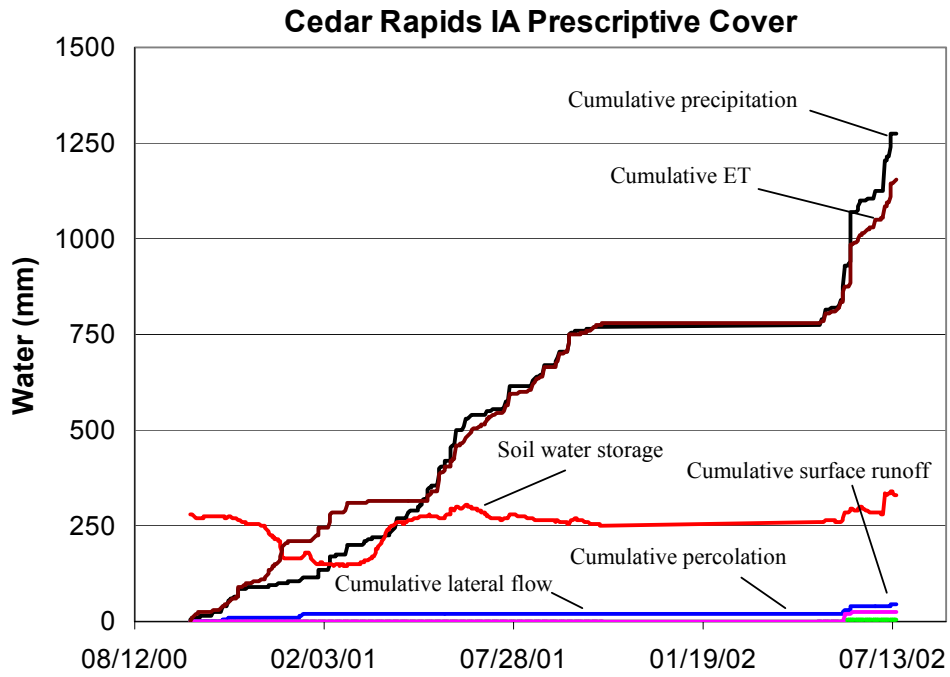


Figure 15. Water balance summary for the prescriptive cover design at the Cedar Rapids IA ACAP site.

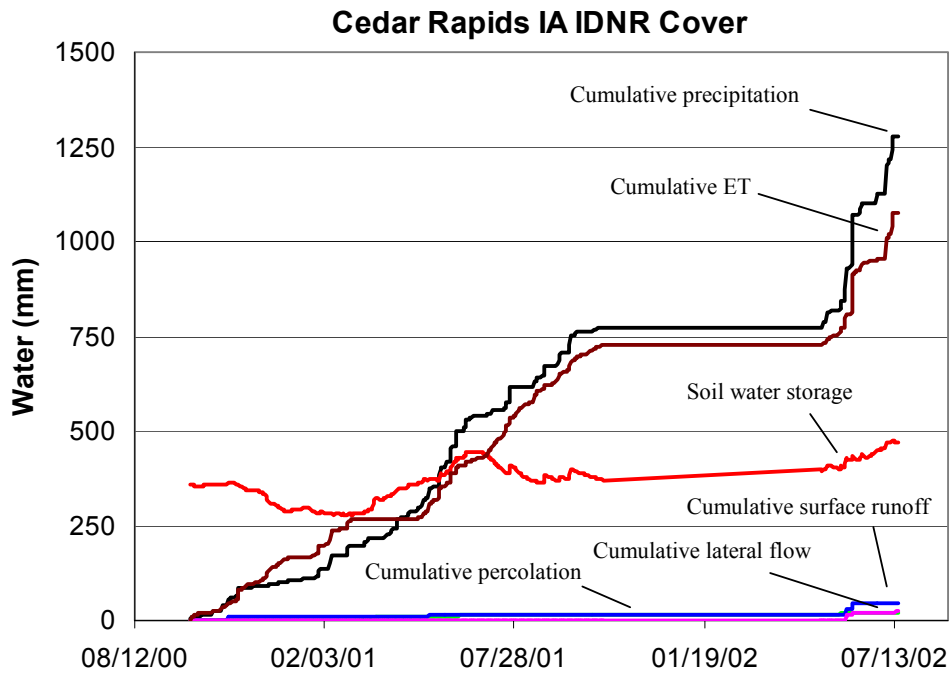


Figure 16. Water balance summary for the IDNR cover design at the Cedar Rapids IA ACAP site.

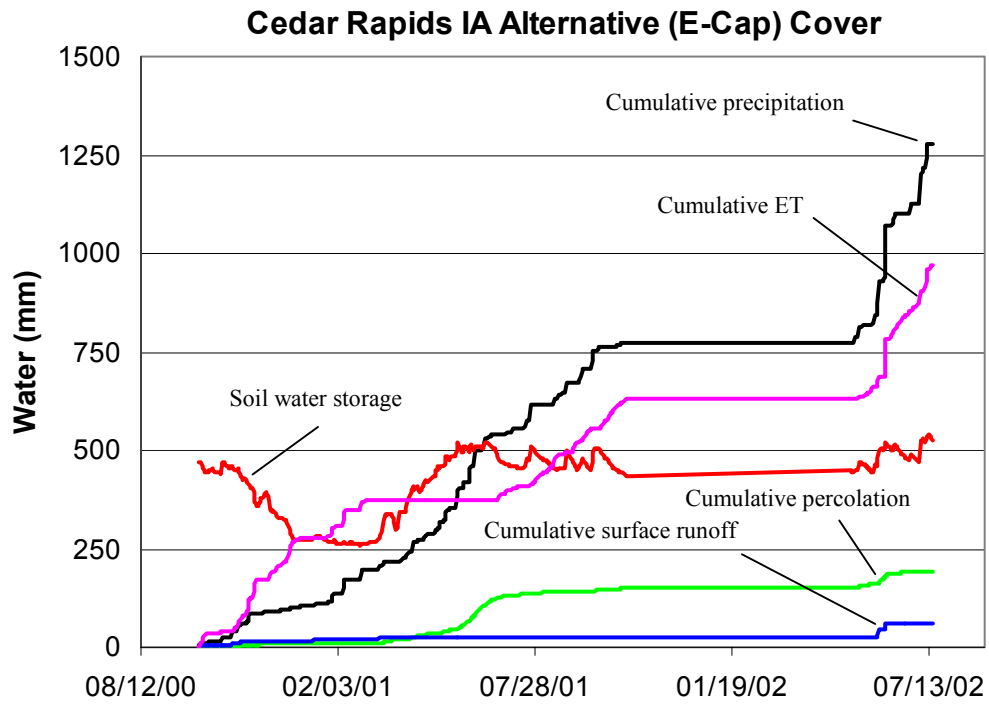


Figure 17. Water balance summary for the alternative (E-Cap) cover design at the Cedar Rapids IA ACAP site.

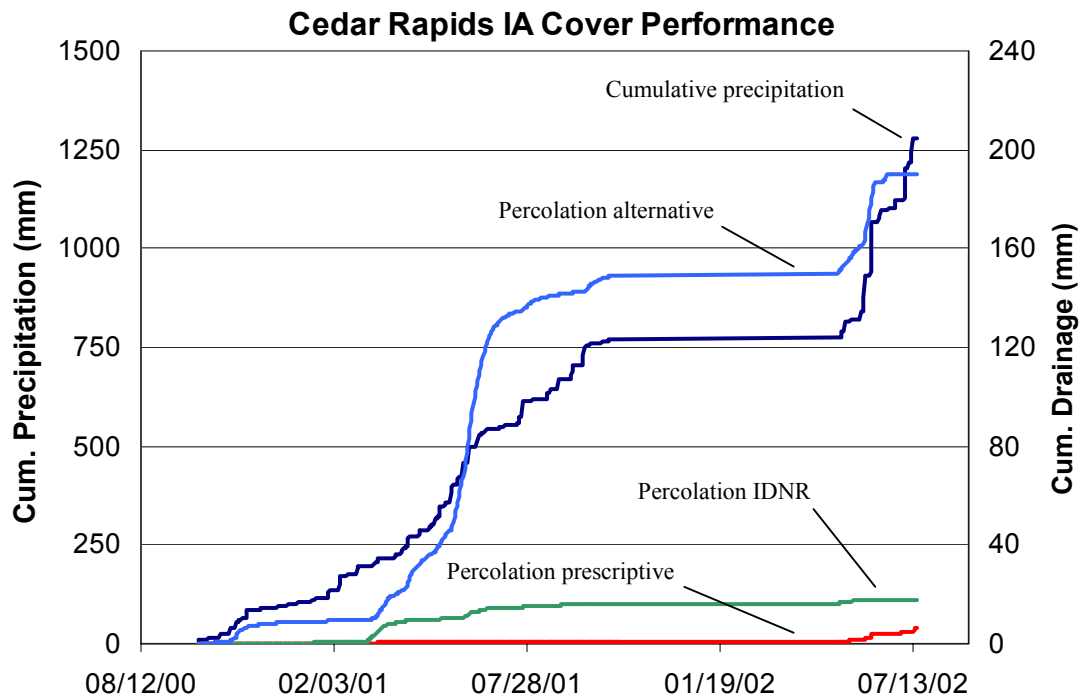


Figure 18. Cover performance at Cedar Rapids IA.

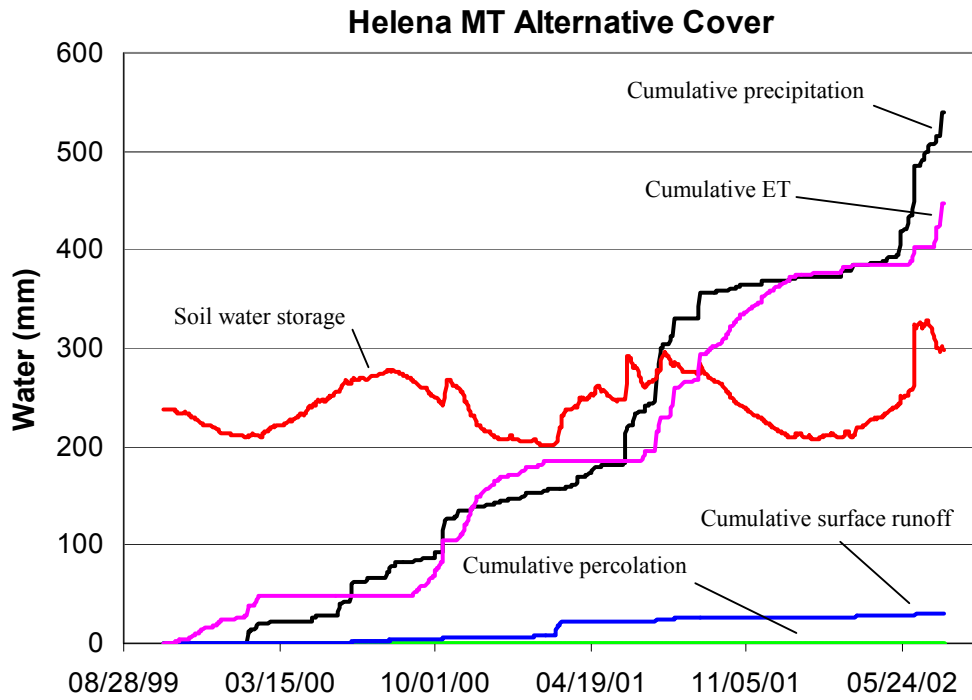


Figure 19. Water balance summary for the alternative cover design at the Helena MT ACAP site.

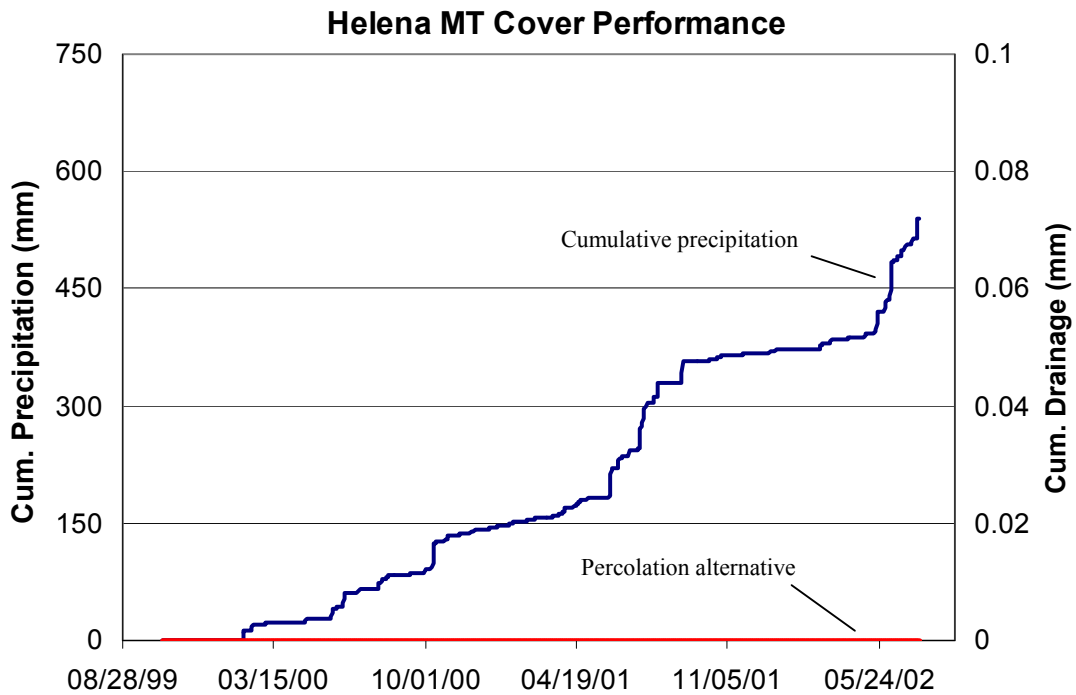


Figure 20. Cover performance at Helena MT.

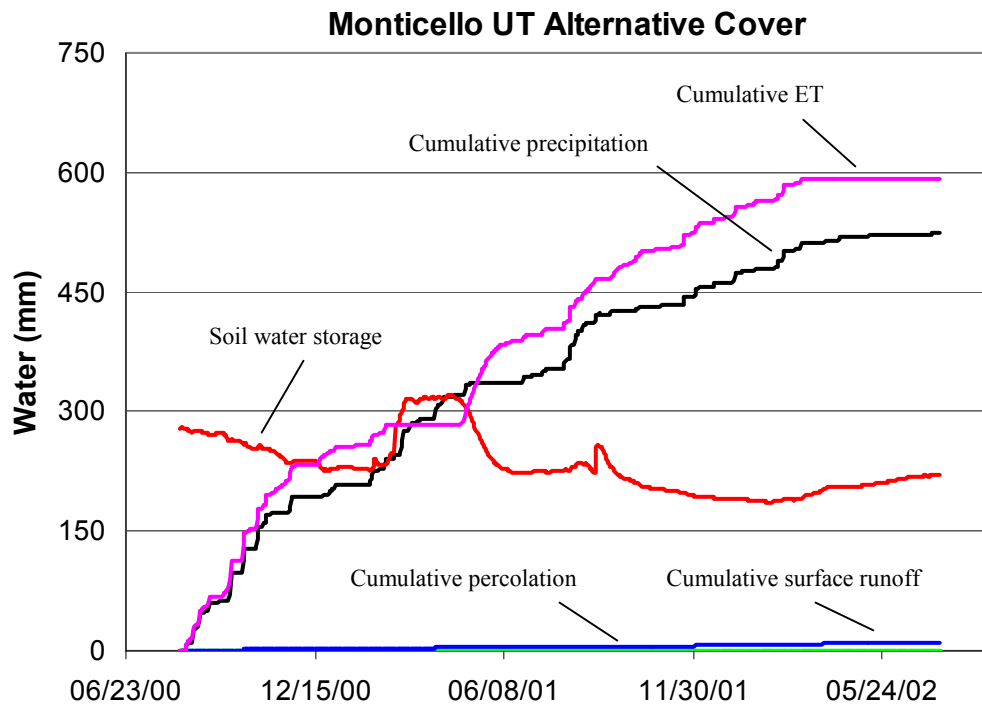


Figure 21. Water balance summary for the alternative cover design at the Monticello UT ACAP site.

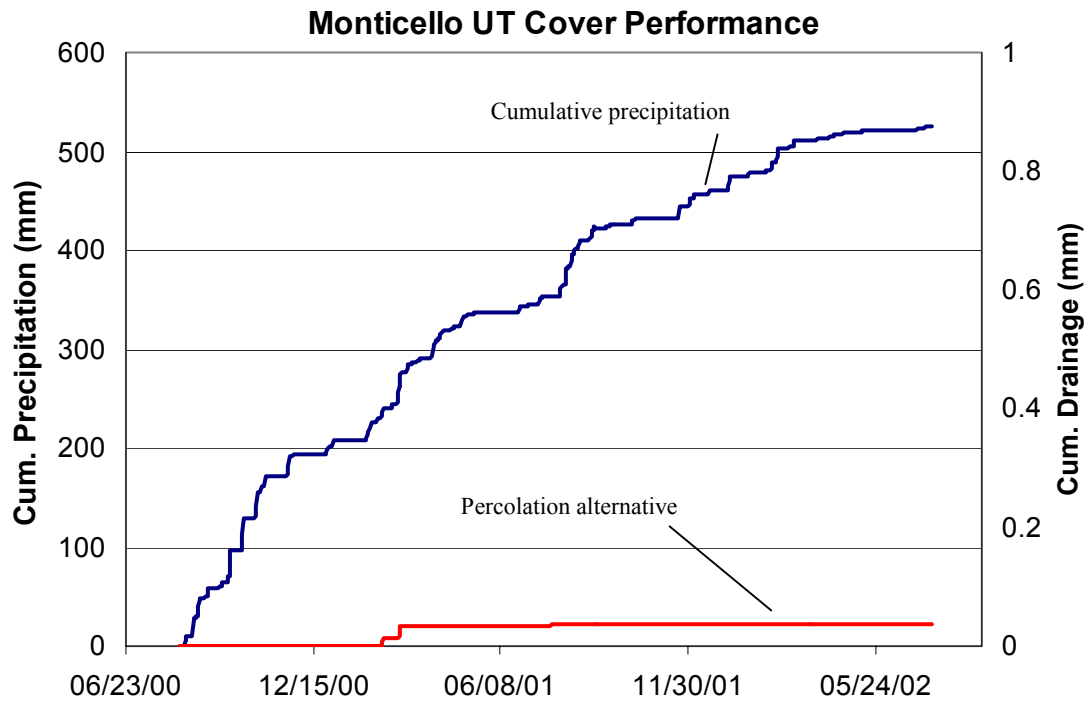


Figure 22. Cover performance at Monticello UT.



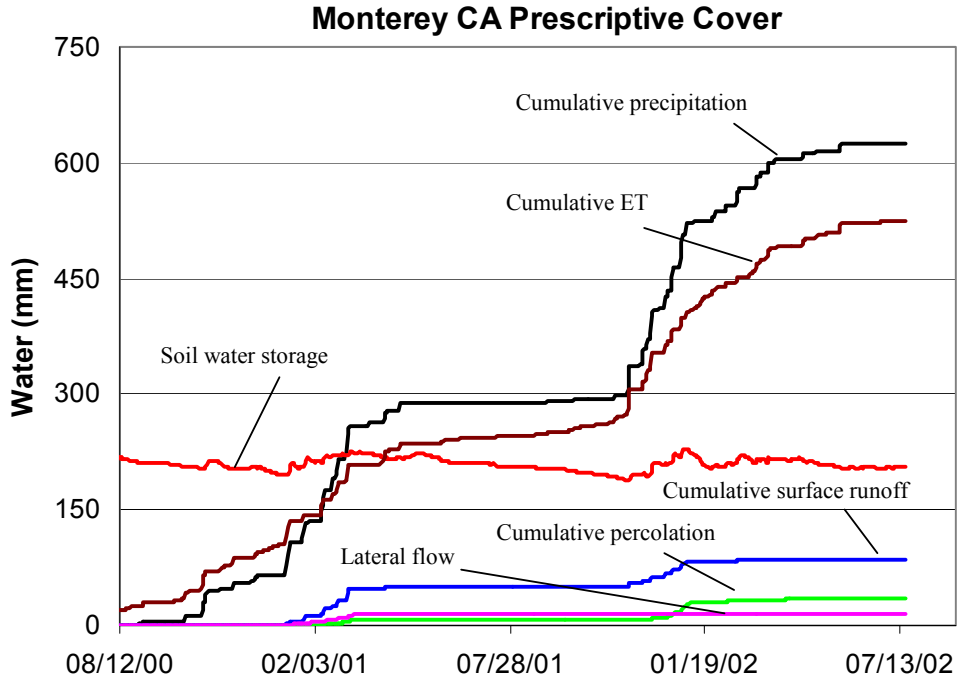


Figure 23. Water balance summary for the prescriptive cover design at the Monterey CA ACAP site.

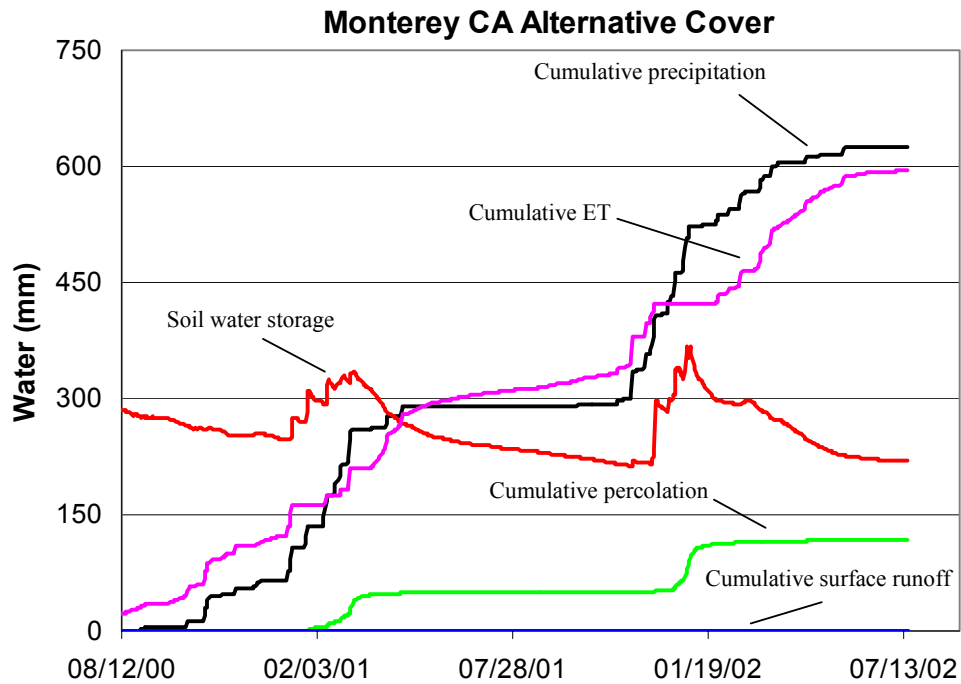


Figure 24. Water balance summary for the alternative cover design at the Monterey CA ACAP site.

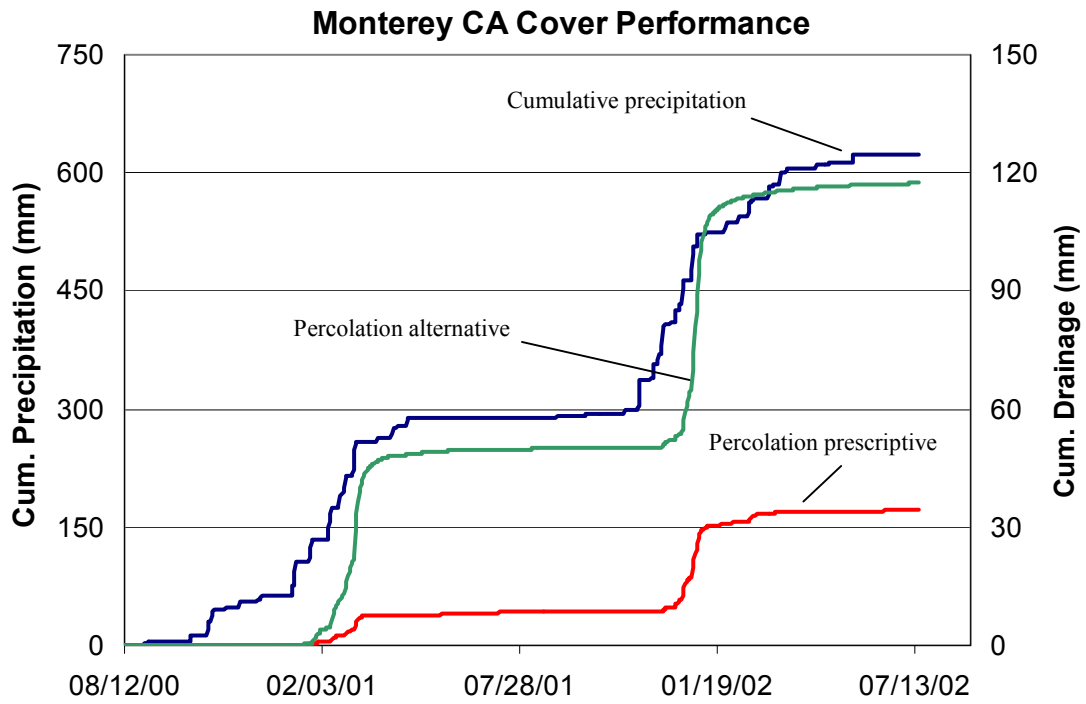


Figure 25. Cover performance at Monterey CA.

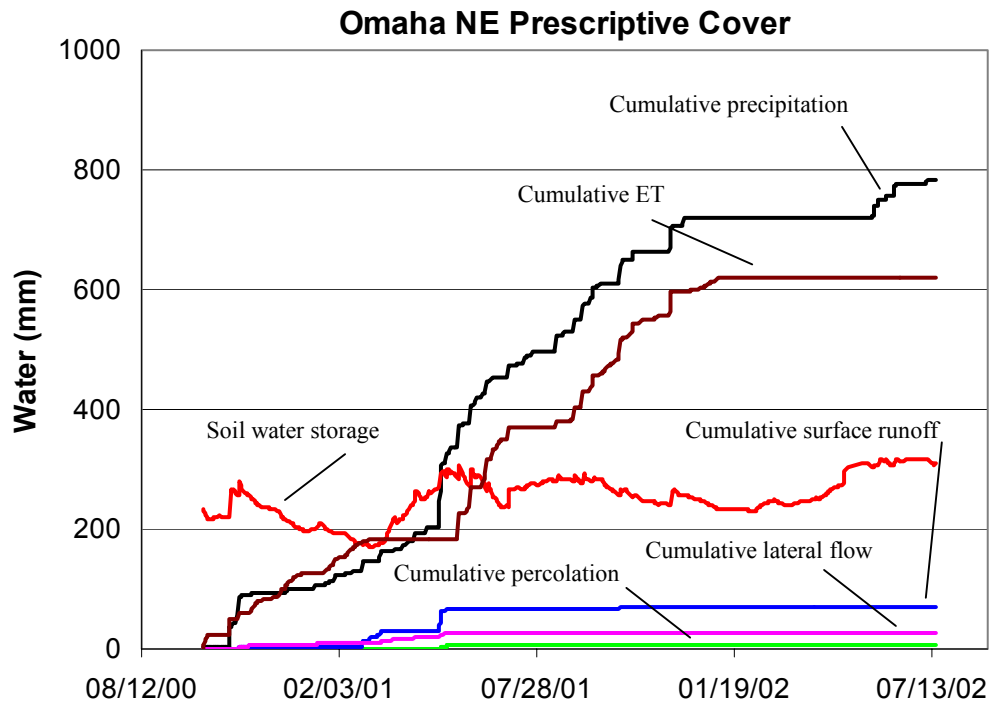


Figure 26. Water balance summary for the prescriptive cover design at the Omaha NE ACAP site.

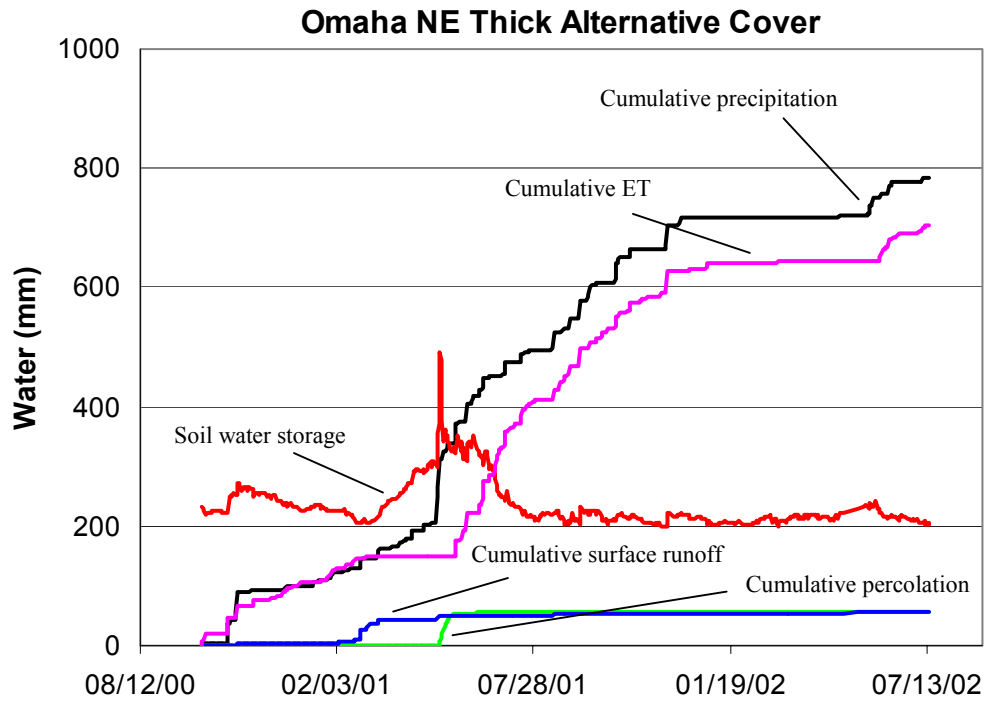


Figure 27. Water balance summary for the thick alternative cover design at the Omaha NE ACAP site.

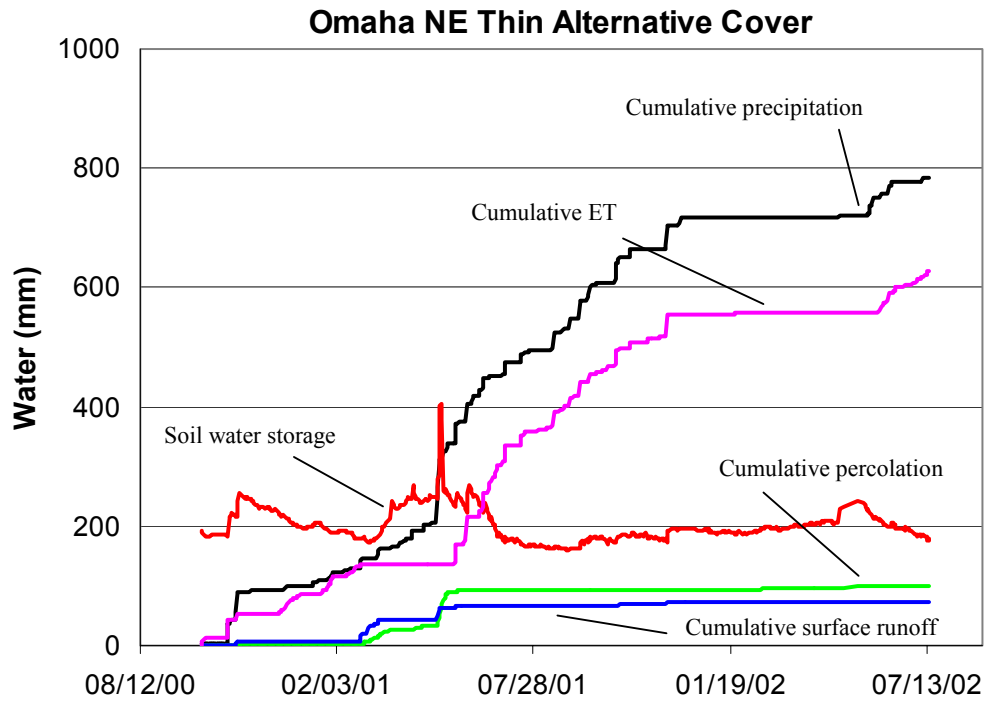


Figure 28. Water balance summary for the thin alternative cover design at the Omaha NE ACAP site.

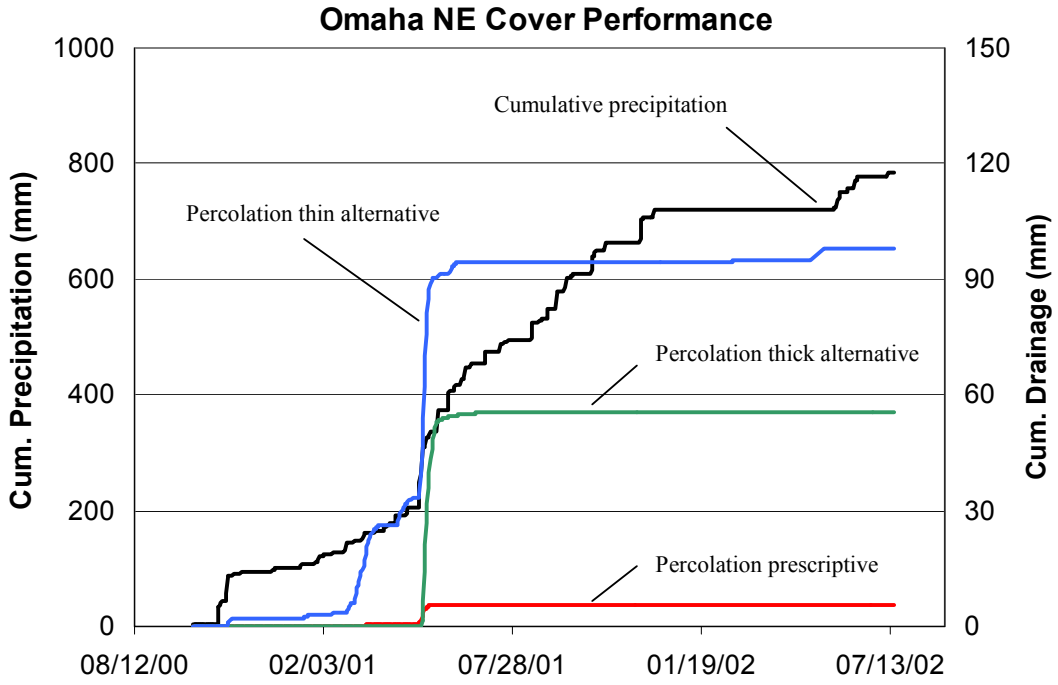


Figure 29. Cover performance at Omaha NE.

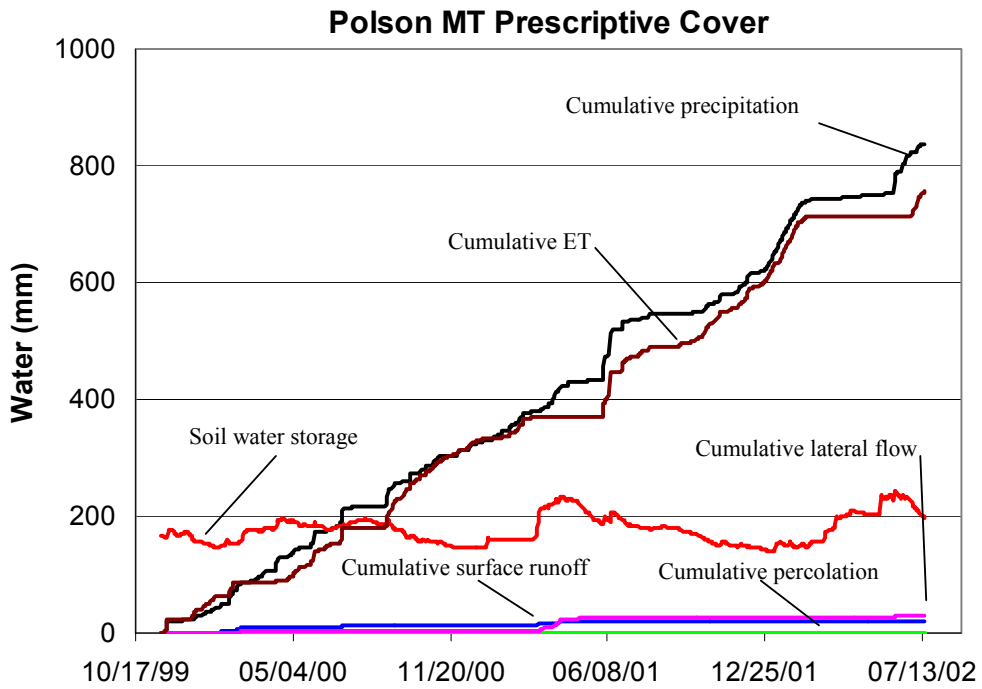


Figure 30. Water balance summary for the prescriptive cover design at the Polson MT ACAP site.

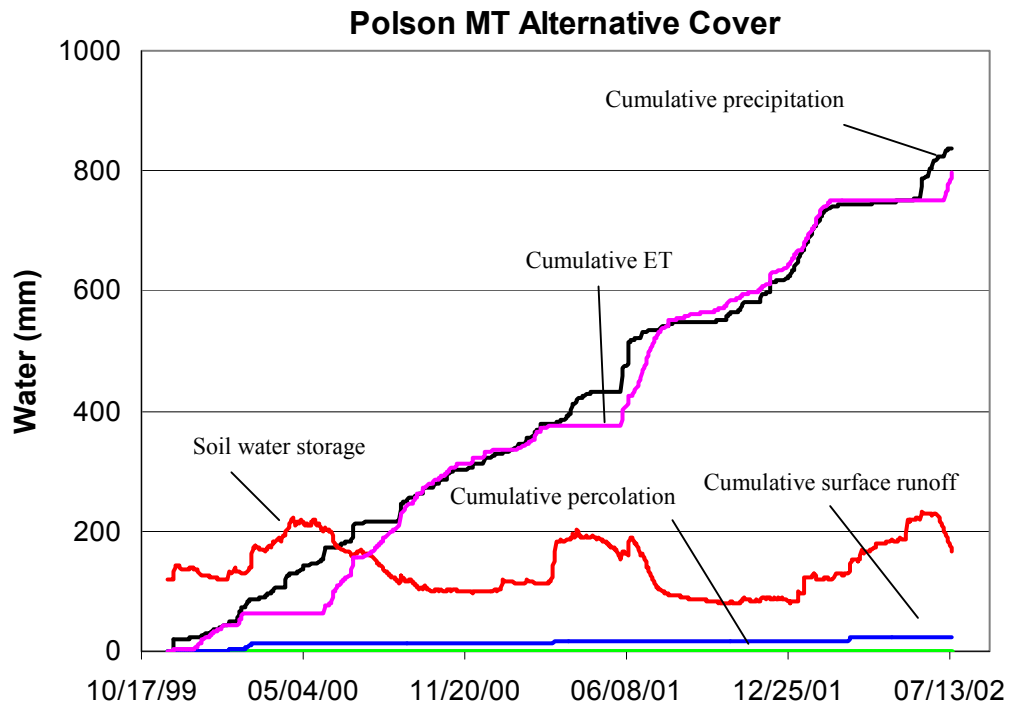


Figure 31. Water balance summary for the alternative cover design at the Polson MT ACAP site.

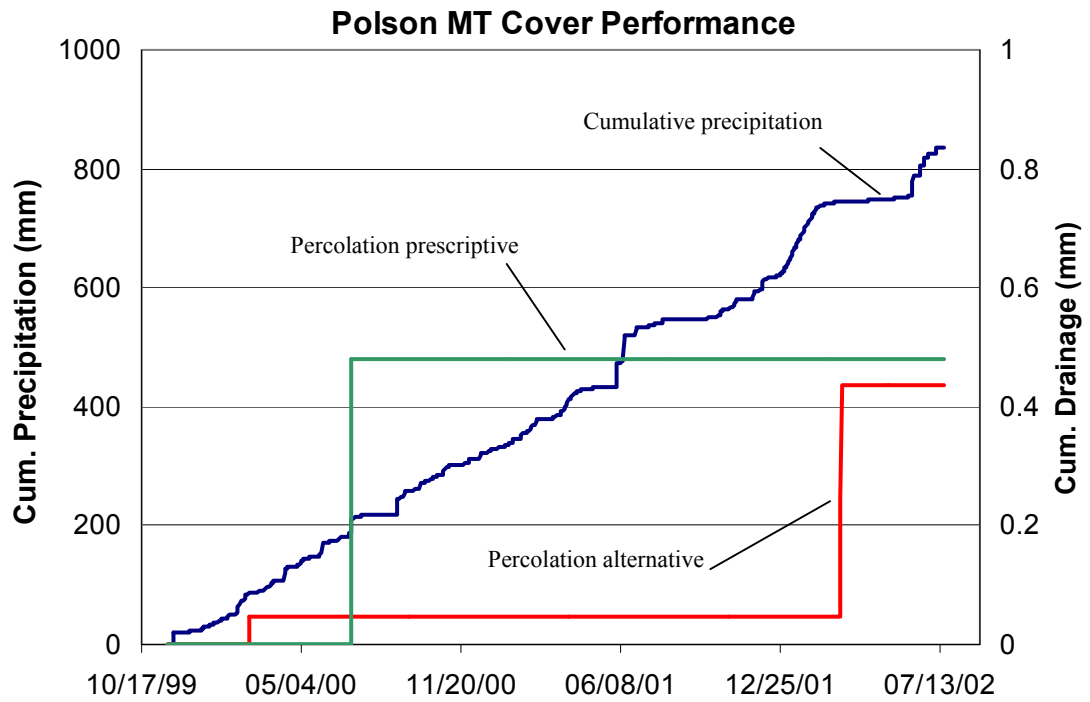


Figure 32. Cover performance at Polson MT.

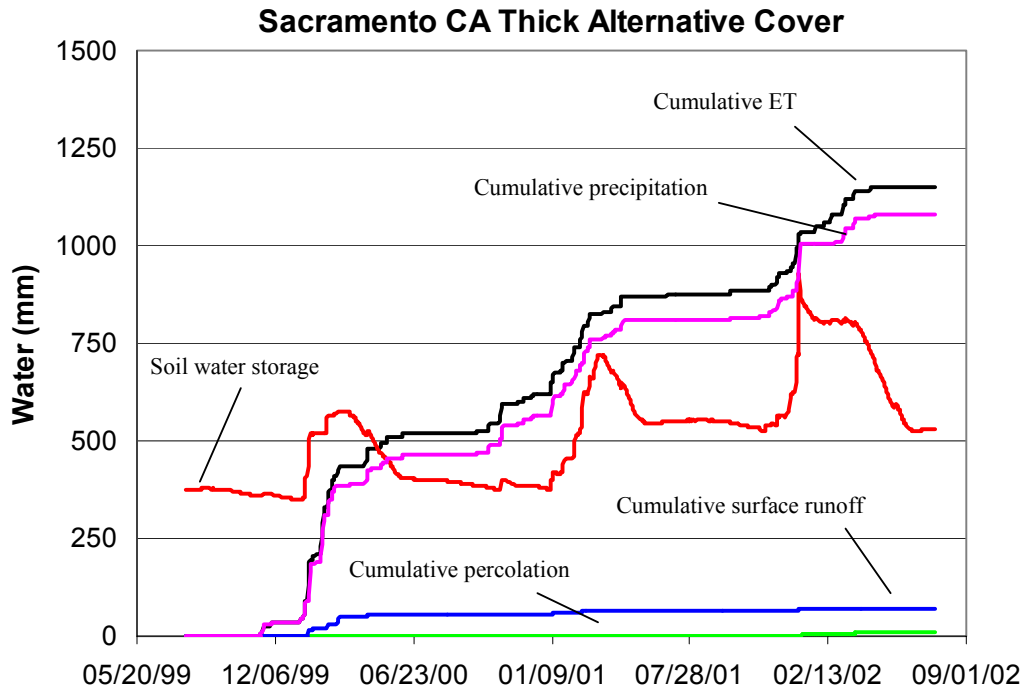


Figure 33. Water balance summary for the thick alternative cover design at the Sacramento CA ACAP site.

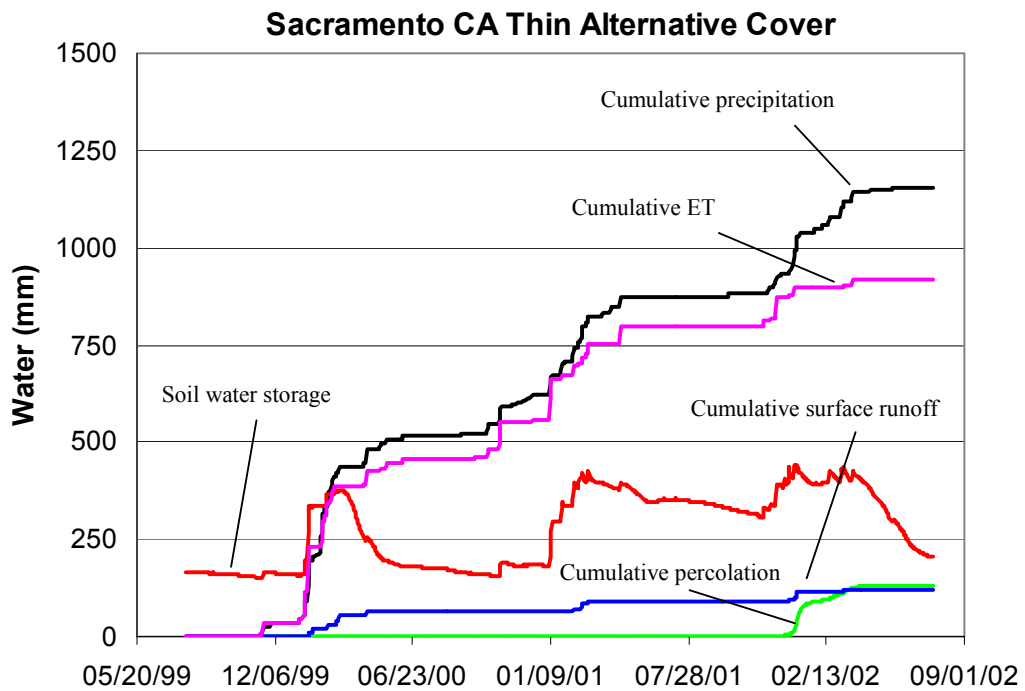


Figure 34. Water balance summary for the thin alternative cover design at the Sacramento CA ACAP site.

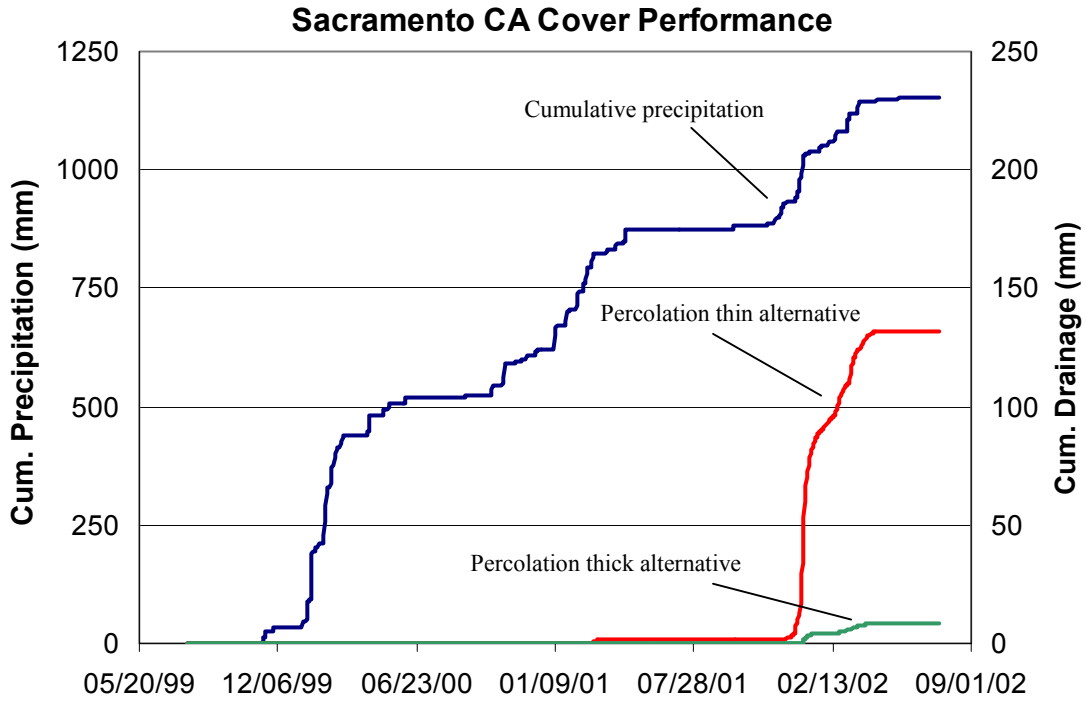


Figure 35. Cover performance at Sacramento CA.

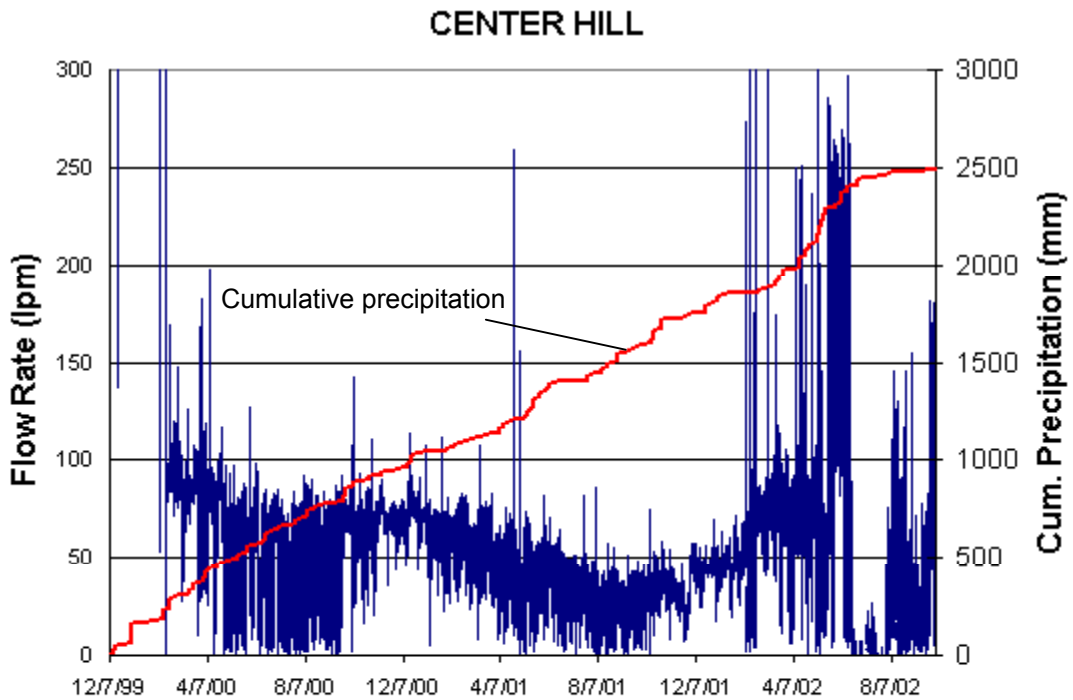


Figure 36. Summary of leachate flow measurements at the Center Hill Landfill ACAP site.

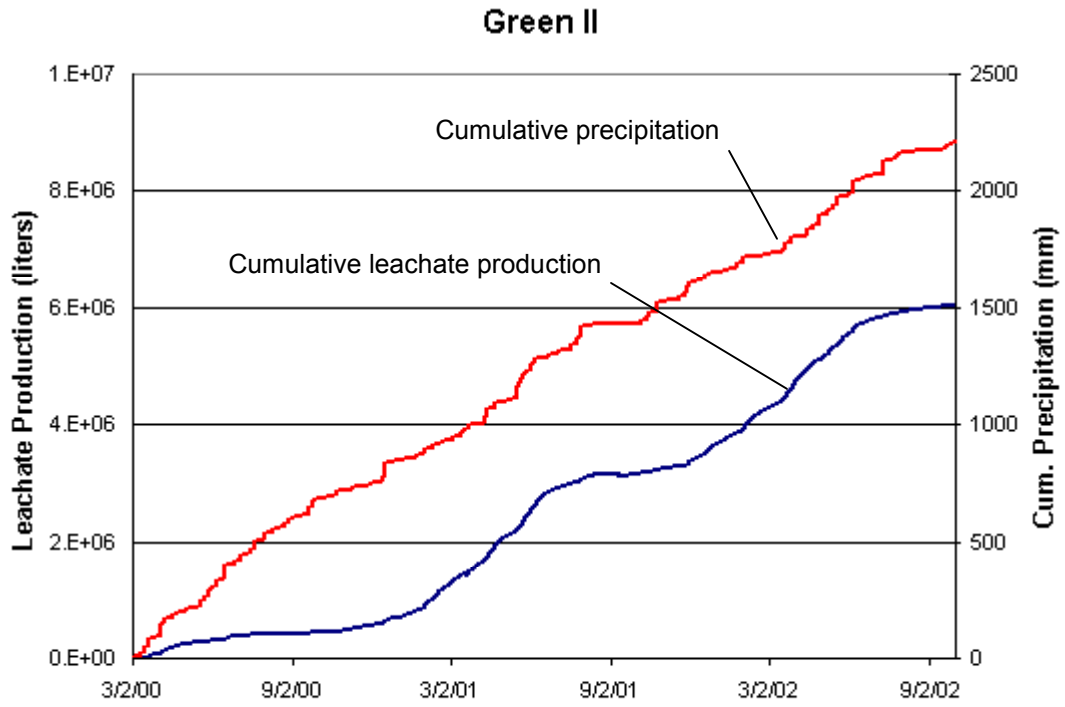


Figure 37. Summary of leachate flow measurements at the Green II Landfill ACAP site.