Chapter 4 Demand Sites and Catchments – Delta and Valley Floor

This chapter describes the representation of water demands and water use on the Sacramento Valley floor portion of SacWAM using WEAP's catchment objects. Catchments are divided by land use type into agricultural, urban, and refuge. Additionally, 'demand sites' are used to represent urban water demands and deliveries to water users located outside the model domain (e.g., SWP south-of-Delta contractors).

Description of catchment objects properties/parameters is organized using headings of the data tree in the WEAP software. Screenshots of the WEAP interface for each parameter are provided where possible to help the model user understand where parameters are entered in to the model.

4.1 Delineation of Valley Floor

4.1.1 Water Budget Areas

The valley watersheds are aggregated into 25 WBAs (Figure 4-1). SacWAM WBAs are aggregated versions of WBAs defined by DWR for use in their planning models. The one exception to this is WBA 61N, where SacWAM only represents the area to the north of the Stanislaus River.

WBAs describe large regions with similar characteristics (e.g., climatic conditions). In SacWAM, WBAs serve the following purposes:

- To define the boundary of non-district agricultural water users within a region who are aggregated and represented as a single water demand.
- To define the boundary of scattered water users whose water supplies for domestic (or industrial) use are self-produced, who rely on groundwater, and who are represented as a single water demand.
- To define the spatial resolution of hydrologic input data (e.g. precipitation, temperature, wind, and humidity).

In the 1960s, DWR subdivided the Central Valley into three hydrologic regions: Sacramento River, San Joaquin River, and Tulare Lake. These regions were in turn disaggregated into a total of 55 planning regions, termed Detailed Analysis Units (DAUs), which are DWR's standard unit for collecting and reporting land use data, preparing water budgets, and making projections for land use change and urban growth for the California Water Plan. Many of the WBAs follow the boundaries of DAUs, which represent the resolution of DWR's land use and water-use data. This simplifies the generation of model input data and model validation through comparison with annual water budgets prepared by DWR for use in the California Water Plan (DWR, 2009a).

Figure 4-1. Valley Floor Water Budget Area Boundaries

4.1.2 Demand Units

WBAs are subdivided into DUs based on physical, legal, and contract types. DUs are computational units represented by WEAP catchment or demand objects in SacWAM, and represent groups of water users who have similar land uses, climatic conditions, water delivery systems, and water use efficiencies. DUs are differentiated by land use and contract types. Land use types include agricultural, urban, and managed wetland classes. Contract user types include CVP settlement contractors, CVP water service contractors, water right holders in the FRSA who have signed settlement agreements with DWR as part of the SWP, and non-project water users. Grouping users by their water entitlements and water use characteristics facilitates simulation of surface water availability under different hydrologic conditions, and proposed regulatory and operational changes.

4.1.2.1 *Naming Convention*

The naming convention provides a unique identifier for each DU, based on land use type, WBA, and contract type (Table 4-1). These pieces of information are separated by underscores within the naming scheme. The first character in the DU name indicates the land use type ("A" for irrigated agriculture, "U" for urban, and "R" for refuge), followed by the WBA number(s) in which the DU exists, and then by a character indicating the contract type ("S" for settlement or exchange contract holders, "P" for CVP or SWP water service contract holders, and "N" for non-project users). For example, in the naming scheme of DU "A_02_NA," "A" indicates that the DU is an irrigated agricultural area, "02" indicates that it is part of WBA 02, and "NA" specifies that these agricultural water users are provided by non-project sources. The final letter in the name is a repeat of the first letter. The reason for the repetition is due to a naming convention restriction in the WEAP software.

Table 4-1. Demand Unit Naming Convention

Land Use	Settlement/Exchange Contract Holder	CVP/SWP Contract Holder	Non-Project Water Users
Irrigated Agriculture	A_(WBA#)_SA	A_(WBA#)_PA	A_(WBA#)_NA
Urban	U_(WBA#)_SU	U_(WBA#)_PU	U_(WBA#)_NU
Refuge	N/A	R_(WBA#)_PR	R_(WBA#)_NR

Key: CVP = Central Valley Project; SWP=State Water Project; WBA=Water Budget Area.

There are some cases where a further distinction must be made in the naming convention. An example is "A_14_15N_NA," in which there are two groups of users sharing land use, contract type, and climatic characteristics, except that the groups have different water sources and returns. To differentiate between the two groups, a number is placed at the end of the naming scheme, creating DUs "A_14_15_NA1" and "A_14_15_NA2."

The naming convention discussed above provides an explanation of DUs located in WBAs, but there is another naming convention for DUs not contained within a WBA. In the case where municipal areas outside of a WBA are supplied by a river within the Sacramento River Hydrologic Region, a four- to five-character acronym is used. For example, "U_NAPA," represents the cities of Napa, St. Helena, Calistoga, Yountville, and American Canyon, supplied by the North Bay Aqueduct.

4.1.2.2 *Represented Area*

The valley floor portion of the model represents a total of approximately 6,060,000 acres. Agricultural land makes up 5,474,000 acres (680,000 acres of which is agricultural land within the Delta), urban areas make up 538,000 acres, and refuge land accounts for 49,000 acres (Figure 4-2). These areas are represented by a total of 174 DUs, 74 of which are agricultural DUs, 58 of which are urban DUs, and six of which are refuge DUs.

Table 4-2, Table 4-3, and Table 4-4 list each SacWAM DU with water provider information. For agricultural DUs, the water district (WD) or WA supplying water to the DU is listed; for urban DUs the represented municipal area and water agency supplying this area is listed; and for refuge DUs, the associated refuge area and water provider is listed.

Agricultural Lands

SacWAM represents agricultural water use in the Sacramento Valley using DUs built on the standard WEAP catchment object. Each DU receives water from a network of arcs, (known as *Transmission Links* in WEAP), which can include multiple surface water and groundwater sources. All agricultural DUs have at least one groundwater source, and most have a surface source(s) also. The surface water supply arcs link to specified RMs or CMs on a surface water body. Runoff arcs—of which there can be several—from the DU to the stream network convey both rainfall runoff and irrigation return flows. Runoff arcs from the DU to underlying groundwater aquifer(s) represent deep percolation from precipitation and irrigation. At runtime, SacWAM dynamically simulates crop water demands, water deliveries, groundwater pumping, irrigation return flows, and rainfall runoff.

There are 74 agricultural catchment objects in SacWAM, defining the majority of land use on the valley floor (Figure 4-2). Table 4-2 contains a list of all SacWAM agricultural DUs, with the name of the WD or WA represented by the DU. The assignment of land to DUs not only takes into account WD boundaries and access to surface water, but also similarity of cropping patterns and water use efficiency.

Urban Lands

Urban water demands represent a small portion of total water demand when compared to agricultural use but their representation in SacWAM is still significant. In the past, urban demands have been met largely through groundwater pumping rather than through the supply of surface water. However, there is notable predicted urban growth during the next 20 years, which will require a reassessment of urban water demands, and perhaps greater reliance on surface sources (California Water Foundation, 2014).

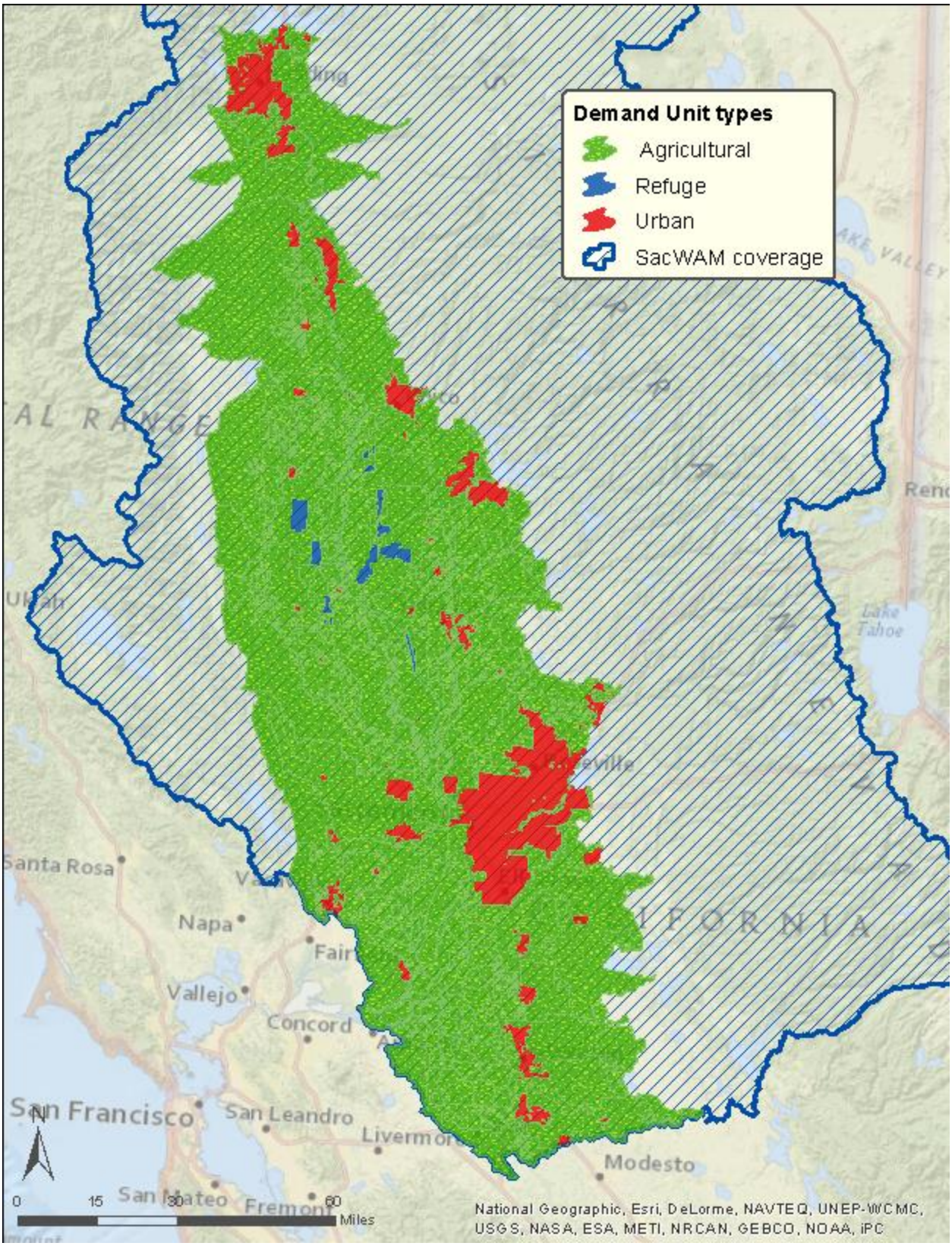


Figure 4-2. Agricultural, Refuge, and Urban Demand Units

There are 58 urban DUs that are identified in SacWAM (Figure 4-2). Forty-nine of these units are located in WBAs within the Sacramento Valley. Each WBA contains a minimum of one urban DU, but in some cases, there are multiple urban DUs within a WBA to account for differing sources of water, contract types, water rights, or water treatment technology. There are also nine urban DUs located in the upper watersheds. Although these DUs are outside of the valley floor, their representation in SacWAM is necessary, as these DUs are supplied by exports from canals and rivers that originate within the Sacramento Valley.

Typically in WEAP models, urban DUs are represented by a single demand site object. However, DUs that are in the Sacramento River Hydrologic Region are represented by both a catchment object and demand site object, placed next to one another. For example, DU "U_03_PU" will have demand site object "U_03_PU" and catchment object "U_03_PU_O." The demand site object represents indoor and outdoor urban demands derived from purveyor data. The catchment object represents the rainfall runoff processes for the entire urban land area. The catchment node is differentiated from the demand site node with a "_O" suffix.

Similar to agricultural catchments, a single urban catchment, such as "U_03_PU_O," will have one or multiple runoff links to the stream network and one or more infiltration links to a groundwater basin(s) representing deep percolation. The demand site, such as "U_03_PU" will have one or multiple transmission links from a surface source(s) and/or groundwater basin(s) (as some urban DUs conjunctively use surface water and groundwater), and a return flow link(s) to a surface water body(s).

Refuge Lands

In SacWAM, refuges are the third major land use classification. The SacWAM refuge classification includes National Wildlife Refuges (NWRs), National Wildlife Management Areas (WMA) and State Wildlife Areas (WA). According to the California Department of Fish and Wildlife (CDFW) (2014), refuges include areas that are "flooded and drained during specific periods of the year utilizing dikes, water control structures, pumps and/or other structures to enhance wildlife habitat values for specific species." There are also private wetlands within agricultural catchments, but these were combined with crop water demands and included as part of the agricultural demand.

Refuge DUs are represented by six demand site objects in SacWAM (Figure 4-2). A single demand site will have one or multiple transmission links from a surface source(s) and a groundwater basin(s), and runoff link(s) to a surface water body in addition to infiltration to a groundwater basin(s).

Table 4-2. Agricultural Demand Units in Sacramento River Hydrologic Region

WBA	Demand Unit	Water District or Agency	Water Provider
02	A_02_NA	Non-district	N/A
	A_02_PA	Clear Creek CSD	CVP
	A_02_SA	Anderson-Cottonwood ID Misc. settlement contractors	CVP
03	A_03_NA	Non-district	N/A
	A_03_PA	Bella Vista WD	CVP
	A_03_SA	Anderson-Cottonwood ID Misc. settlement contractors	CVP
04_06	A_04_06_NA	Non-district (including misc. settlement contractors)	N/A
	A_04_06_PA1	Corning WD Proberta WD Thomes Creek WD	CVP
	A_04_06_PA2	Kirkwood WD	CVP
	A_04_06_PA3	Orland Unit WUA	Reclamation
05	A_05_NA	Los Molinos MWC Non-district (including misc. CVP settlement contractors)	N/A
07	A_07_NA	Non-district	N/A
	A_07_PA	Glide WD Holthouse WD Kanawha WD Orland-Artois WD 4-M WD Colusa County WD Cortina WD Davis WD Dunnigan WD Glenn Valley WD La Grande WD Myers-Marsh MWC Westside WD	CVP
08	A_08_NA	Non-district	N/A
	A_08_PA	Colusa Drain MWC	CVP
	A_08_SA1	Maxwell ID Princeton-Codora-Glenn ID Provident ID Sycamore Family Trust Misc. settlement contractors	CVP
	A_08_SA2	Glenn-Colusa ID	Glenn-Colusa ID (55% of total)
	A_08_SA3	RD 108 River Garden Farms Misc. settlement contractors	CVP
09	A_09_NA	Llano Seco Ranch Dayton MWC Non-district	N/A
	A_09_SA1	Pacific Realty Associates (formerly M&T Chico Ranch)	CVP
	A_09_SA2	RD 1004 Carter MWC Jack Baber Misc. settlement contractors	CVP
10	A_10_NA	Rancho Esquon Durham MWC Non-district	N/A

Table 4-2. Agricultural Demand Units in Sacramento River Hydrologic Region cont.

WBA	Demand Unit	Water District or Agency	Water Provider
11	A_11_NA	Sutter Butte MWC Non-district	N/A
	A_11_SA1	Western Canal WD	SWP
	A_11_SA2	Richvale ID	SWP
	A_11_SA3	Biggs-West Gridley WD Butte WD	SWP
	A_11_SA4	Sutter Extension WD	SWP
12_13	A_12_13_NA	South Feather Water and Power Agency Yuba County WD Non-district	N/A
	A_12_13_SA	Misc. FRSA diverters	N/A
14_15N	A_14_15N_NA1	Non-district	N/A
	A_14_15N_NA2	Cordua ID Hallwood ID Ramirez WD	Yuba County WA
	A_14_15N_NA3	Browns Valley ID	Browns Valley ID, Yuba County WA
	A_14_15N_SA	Misc. FRSA diverters	N/A
15S	A_15S_NA	Non-district Wheatland WD Dry Creek WD South Yuba WD Brophy WD	N/A Yuba County WA
	A_15S_SA	Plumas MWC Misc. FRSA diverters	SWP
16	A_16_NA	Non-district	N/A
	A_16_PA	Feather WD	CVP
	A_16_SA	Garden Highway MWC Tudor ID Oswald ID Misc. FRSA diverters	SWP
17	A_17_NA	Sutter Bypass-Butte Slough WUA Non-district	N/A
	A_17_SA	Misc. FRSA diverters Minor settlement contractors	N/A
18_19	A_18_19_NA	Butte Slough Irrigation Company Sutter Butte MWC Non-district	N/A
	A_18_19_SA	Meridian Farms WC Lomo Cold Storage Sutter MWC Tisdale IDC Bardis et al. Pelger MWC Misc. settlement contractors	CVP
20_25	A_20_25_NA1	Yolo County Flood Control & WCD Non-district	N/A
	A_20_25_NA2	North Delta WA Non-district	N/A
	A_20_25_PA	University of California at Davis Solano ID Maine Prairie WD	Solano County WA Reclamation Reclamation
21	A_21_NA	Non-district	N/A
	A_21_PA	Colusa Drain MWC (22% of total)	CVP
	A_21_SA	Conaway Conservancy Group Misc. settlement contractors	N/A

Table 4-2. Agricultural Demand Units in Sacramento River Hydrologic Region cont.

WBA	Demand Unit	Water District or Agency	Water Provider
22	A_22_NA	Non-district	N/A
	A_22_SA1	Natomas Central MWC Pleasant Grove-Verona MWC Misc. settlement contractors	CVP
	A_22_SA2	Misc. FRSA diverters	N/A
23	A_23_NA	Camp Far West ID South Sutter ID Non-district	South Sutter WD
24	A_24_NA1	Nevada ID	Nevada ID
	A_24_NA2	Placer County WA Zone 5 Non-district	Placer County WA
	A_24_NA3	Placer County WA Zone 1	Placer County WA
26	A_26_NA	Non-district	N/A
50	A_50_NA1	North Delta WA	N/A
	A_50_NA2	North Delta WA	N/A
	A_50_NA3	Central Delta WA North Delta WA	N/A
	A_50_NA4	Central Delta WA North Delta WA	N/A
	A_50_NA5	Central Delta WA North Delta WA South Delta WA	N/A
	A_50_NA6	Byron Bethany ID Central Delta WA North Delta WA	N/A
	A_50_NA7	Byron Bethany ID South Delta WA	N/A
60N	A_60N_NA1	Jackson Valley ID	N/A
	A_60N_NA2	Omochumne-Hartnell WD Clay WD Galt ID	N/A
	A_60N_NA3	North San Joaquin WCD	N/A
	A_60N_NA4	Woodbridge ID Woodbridge Users Association	N/A
	A_60N_NA5	Non-district Riparian diverters	N/A
60S	A_60S_NA	Non-district east Non-district west	N/A
	A_60S_PA	Stockton East WD Central San Joaquin WCD	CVP Reclamation CVP
61N	A_61N_PA	Oakdale ID north South San Joaquin ID	CVP
	A_61N_NA1	Non-district east	N/A
	A_61N_NA2	Non-district Stanislaus River riparian diverters	N/A
	A_61N_NA3	Non-district San Joaquin River riparian diverters downstream from Stanislaus River confluence	N/A

Key: CSD=Community Service District; CVP=Central Valley Project; DWR=Department of Water Resources; FRSA=Feather River Service Area; ID=Irrigation District; IDC=Irrigation and Drainage Company; Misc.=miscellaneous; MWC=Mutual Water Company; N/A=not applicable; Reclamation=U.S. Department of the Interior, Bureau of Reclamation; SWP=State Water Project; WA=Water Agency; WBA=Water Budget Area; WC=Water Company; WCD=Water Conservation District; WD=Water District; WUA=Water Users Association.

Table 4-3. Urban Demand Units in Sacramento River Hydrologic Region

WBA	Demand Unit	Cities, Towns, and Communities	Water Agency Retail (Wholesale)
02	U_02_NU	Anderson	City of Anderson
		Cottonwood	Cottonwood WD
		Lake California	Rio Alto WD
		Small communities	Self-supplied
	U_02_PU	Centerville and Redding	Centerville CSD
		Happy Valley	Clear Creek CSD
		Shasta CSA No. 25	Keswick CSA
		Shasta	Shasta CSD
	U_02_SU	Redding- Foothill, Hill 900 and Cascade zones	City of Redding
03	U_03_NU	Small communities	Self-supplied
	U_03_PU	Shasta CSA No. 6	Jones Valley CSA
		Shasta Lake	City of Shasta Lake
		Mountain Gate	Mountain Gate CSD
		Stillwater Valley	Bella Vista WD
		Bella Vista	
		Palo Cedro	
		Redding	
		Redding- Buckeye and Hilltop zones	City of Redding
	U_03_SU	Redding- Hilltop and Enterprise zones	City of Redding
04_06	U_04_06_NU	Red Bluff	City of Red Bluff
		Corning	City of Corning
		Gerber	Gerber-Las Flores CSD
		Orland	City of Orland
		Small communities	Self-supplied
05	U_05_NU	Red Bluff	City of Red Bluff
		Los Molinos	Los Molinos CSD
		Small communities	Self-supplied
07	U_07_NU	Willows	California Water Service Company
		Arbuckle	Arbuckle Public Utility District
		Small communities	Self-supplied
08	U_08_NU	Hamilton City	California Water Service Company
		Colusa	City of Colusa
		Williams	City of Williams
		Small communities	Self-supplied
09	U_09_NU	Small communities	Self-supplied
10	U_10_NU1	Chico	California Water Service Company
	U_10_NU2	Durham	Durham ID
		Small communities	Self-supplied
11	U_11_NU1	Oroville	Thermalito ID
	U_11_NU2	Biggs	City of Biggs
		Gridley	City of Gridley
		Live Oak	Live Oak WD
		Small communities	Self-supplied
12_13	U_12_13_NU1	Oroville	California Water Service Company; South Feather Water and Power Agency
	U_12_13_NU2	Small communities	Self-supplied ; South Feather Water and Power Agency
14_15N	U_14_15N_NU	Marysville	California Water Service Company
		Small communities	Self-supplied
15S	U_15S_NU	Olivehurst	Olivehurst Public Utility District
		Wheatland	City of Wheatland
		Linda	Linda County WD
		Small communities	Self-supplied
16	U_16_NU	Small communities	Self-supplied
	U_16_PU	Yuba City	City of Yuba City

Table 4-3. Urban Demand Units in Sacramento River Hydrologic Region cont.

WBA	Demand Unit	Cities, Towns, and Communities	Water Agency Retail (Wholesale)
17	U_17_NU	Sutter	Sutter CSD
		Small communities	Self-supplied
18_19	U_18_19_NU	Small communities	Self-supplied
20_25	U_20_25_NU	Davis	City of Davis
		El Macero	
		Willowbank	
		UC Davis	University of California at Davis
		Woodland	City of Woodland
		Winters	City of Winters
		Esparto	Esparto CSD
		Madison	Madison CSD
		Rio Vista	City of Rio Vista
		Dixon	California Water Service Company
		Small communities	Self-supplied
	U_20_25_PU	Vacaville	City of Vacaville
21	U_21_NU	Knights Landing	Knights Landing Service District
		Small communities	Self-supplied
	U_21_PU	West Sacramento (partly in Delta)	City of West Sacramento
22	U_22_NU	Sacramento International Airport	City of Sacramento
		Metro Air Park	Sacramento County WA- Zone 41
		Northgate 880	
		Small communities	Self-supplied
23	U_23_NU	Small communities	Self-supplied
24	U_24_NU1	Auburn	Placer County WA- Upper Zone 1
		Bowman	
		Christian Valley Park	Christian Valley Park CSD
		North Auburn	Nevada ID
		Small communities	Self-supplied
	U_24_NU2	Loomis	Placer County WA- Lower Zone 1
		Newcastle	
		Penryn	
		Rocklin	
		Granite Bay (portion)	
		City of Roseville (portion)	
		City of Lincoln	Placer County WA
		West Placer	Cal-Am WC; Placer County WA
26	U_26_NU1	Northridge	Sacramento Suburban WD-North SA; McClellan; San Juan WD
		Arbors at Antelope McClellan Business Park	Sacramento Suburban WD-North SA; McClellan; San Juan WD
		Arcade- North Highlands	Sacramento Suburban WD-North SA; McClellan; San Juan WD
		Antelope	Cal-Am WC; San Juan WD
		Lincoln Oaks	Cal-Am WC; San Juan WD
		Rio Linda	Rio Linda Elverta CWD; San Juan WD
		Elverta	Rio Linda Elverta CWD; San Juan WD
		Arcade	Sacramento Suburban WD- South SA; City of Sacramento
		Arden	Golden State WD
		Del Paso Service Area	Del Paso Manor WD
		Arden Park Vista Service Area	Sacramento County WA- Zone 41
		Arden	Cal-Am WC
	U_26_NU2	Carmichael	Carmichael WD
	U_26_NU3	City of Sacramento- North	City of Sacramento
		City of Sacramento- South	

Table 4-3. Urban Demand Units in Sacramento River Hydrologic Region cont.

WBA	Demand Unit	Cities, Towns, and Communities	Water Agency Retail (Wholesale)
26	U_26_NU4	Parkway	Cal-Am WC; City of Sacramento
		Suburban	Cal-Am WC; City of Sacramento
		Rosemont	Cal-Am WC; City of Sacramento
		Florin	Florin County WD
		Fruitridge	Fruitridge Vista WD
		Tokay Park	Tokay Park WC- Zone 41
	U_26_NU5	Groundwater remediation	Aerojet
	U_26_NU6	Folsom Lake shoreline	California Parks and Recreation
	U_26_PU1	Roseville	City of Roseville
	U_26_PU2	San Juan Retail Service Area	San Juan WD
		Orange Vale	Orange Vale WC
		City of Citrus Heights	Citrus Heights WD
		Fair Oaks	Fair Oaks WD
		City of Folsom	City of Folsom
		Ashland	San Juan WD
	U_26_PU3	City of Folsom	City of Folsom
		Folsom State Prison	Folsom State Prison
	U_26_PU4	Laguna	Sacramento County WA- South SA, Zone 40
		City of Elk Grove	Elk Grove WD- Tariff Areas No. 1 and 2
		Vineyard	Sacramento County WA- Central SA, Zone 40
		Mather-Sunrise	Sacramento County WA- North SA, Zone 40
		Sunrise/Security Park	Cal-Am WC, Sacramento County WA
	U_26_PU5	Rancho Cordova	Golden State WC
60N	U_60N_NU1	Galt (City of Galt)	City of Galt
		Lodi (City of Lodi)	City of Lodi
		Small communities	Self-supplied
	U_60N_NU2	Rancho Murieta	Rancho Murieta CSD
	U_60N_PU	Rancho Seco Power Plant	Sacramento Municipal Utility District
60S	U_60S_NU1	City of Stockton	City of Stockton; California Water Service Company
	U_60S_NU2	Small communities	Self-supplied
61N	U_61N_NU1	Lathrop	City of Lathrop
			South San Joaquin ID
		Escalon	City of Escalon
			South San Joaquin ID
		Manteca	South San Joaquin ID
	U_61N_NU2	Ripon	City of Ripon
		Oakdale	City of Oakdale
		Riverbank	City of Riverbank
		Small communities	Self-supplied
Supplied by rivers or exports from Valley Floor but not located within a WBA	U_ANTOC	Antioch	City of Antioch
	U_CCWD	Bay Point	Contra Costa Water District
		Clayton	
		Clyde	
		Oakley	
		Pittsburg	
		Port Costa	
	U_CLLPT	Clear Lake	M&I water purveyors
		Lakeport	
		Small communities	
	U_EBMUD	Berkeley	East Bay Municipal Utility District
		Oakland	
		Richmond	
		Walnut Creek	
	U_ELDID	El Dorado Hills	El Dorado Hills ID

Table 4-3. Urban Demand Units in Sacramento River Hydrologic Region cont.

WBA	Demand Unit	Cities, Towns, and Communities	Water Agency Retail (Wholesale)
Supplied by rivers or exports from Valley Floor but not located within a WBA	U_FVTB	Fairfield	City of Fairfield
		Vallejo	City of Vallejo
		Travis Air Force Base	Travis Air Force Base
		Benicia	City of Benicia
		California State Prison- Solano	California State Prison Solano
		Suisun	City of Suisun
	U_JLIND	Jenny Lind/Valley Springs	Calaveras County WD
	U_NAPA	American Canyon	City of American Canyon
		Napa	City of Napa
		City of St. Helena	
		Calistoga	City of Calistoga/Napa
	U_PCWA3	Alta	Dutch Flat Mutual WC
		Dutch Flat	Weimar WC
		Colfax	Midway Heights County WD
		Applegate	Heather Glen CSD
		Meadow Vista	Meadow Vista County WD

Key: CSA=Community Service Area; CSD=Community Service District; CWD=Community Water District; ID=Irrigation District; N/A=not applicable; SA=Service Area; WA=Water Agency; WBA=Water Budget Area; WC=Water Company; WD=Water District; WSD=Water Service District.

Table 4-4. Refuge Demand Units in Sacramento River Hydrologic Region

Water Budget Area	Demand Unit	Refuge/Wildlife Area	Water Provider
08	R_08_PR	Sacramento NWR	Reclamation
		Delevan NWR	
		Colusa NWR	
09	R_09_PR	Llano Seco Unit, Upper Butte Basin SWA	Water rights
		Llano Seco Unit, Sacramento River NWR	
11	R_11_PR	Little Dry Creek, Upper Butte Basin SWA	Western Canal WD
		Howard Slough Unit, Upper Butte Basin SWA	Richvale ID
17	R_17_NR	Butte Sink Duck Clubs	Water rights
			Western Canal WD
	R_17_PR1	Gray Lodge SWA	Reclamation
			DWR (by Exchange)
	R_17_PR2	Sutter NWR	Reclamation
			Sutter Extension WD

Key: DWR=Department of Water Resources; ID=Irrigation District; NWR=National Wildlife Refuge; SWA=State Wildlife Area; WD=Water District.

4.2 Simulation of Crop Water Demands

On the valley floor, evapotranspiration from the land surface is calculated on a daily time step using the dual crop coefficient approach described in Food and Agricultural Organization (FAO) Irrigation and Drainage Paper No. 56 (Allen et al., 1998). Within the WEAP software this approach is referred to as the MABIA method. The method requires inputs of temperature, precipitation, humidity, and windspeed. These data are used to calculate a reference evapotranspiration using the Penman-Monteith Equation. Individual crop types are assigned crop coefficients which are used to scale the reference evapotranspiration to reflect crop specific planting dates, canopy development rates, and harvest dates. In SacWAM, this approach is also used to simulate bare soil evaporation and water use by native and wetland vegetation.

In addition to calculating plant and soil evapotranspiration, the MABIA method calculates surface runoff, infiltration, and deep percolation. For this reason, in addition to the climatic inputs mentioned above, the MABIA algorithm requires specification of soil parameters such as soil water capacity and soil depth. The Soil Conservation Service (SCS) curve number method is used in a modification to the MABIA method to calculate effective rainfall. This modification is described in Section 4.4.3.4. For more details on the MABIA method, the reader is referred to the Help files of the WEAP software (Help>Contents>Calculation Algorithms>Evapotranspiration, Runoff, Infiltration, and Irrigation>MABIA Method).

Crop water use parameters for the MABIA module were based on information obtained from the Sacramento – San Joaquin Basin Study. Planting dates, season length, and single crop coefficient values were obtained from the study (Table 4-5, Table 4-6, and Table 4-7). A discussion of the calibration of the crop coeffiencts is provided in Appendix B.

Table 4-5. Perennial Crop Season Length and Date Parameters Used in CUP Model for Basin Study

Crop	Length of Growing Season (Days)	Start of Growing Season	End of Growing Season
Alfalfa (annual)	365	1-Jan	31-Dec
Almonds	229	1-Mar	15-Oct
Apple	229	1-Apr	15-Nov
Orange	365	1-Jan	31-Dec
Pasture (improved)	365	1-Jan	31-Dec
Wine grapes	215	1-Apr	1-Nov

Table 4-6. Annual Crop Season Length and Date Parameters Used in CUP Model for Basin Study

Crop	Length of Growing Season (Days)	Planting Date	Harvest Date
Beans (dry)	108	15-Jun	30-Sep
Corn (grain)	153	1-May	30-Sep
Corn (silage)	107	1-May	15-Aug
Cotton	154	15-May	15-Oct
Cucumber	93	15-May	31-Aug
Melon	123	15-May	15-Sep
Onion (dry)	215	1-Mar	1-Oct
Potato	123	15-Apr	15-Aug
Rice	139	15-May	30-Sep
Safflower	122	1-Apr	31-Jul
Sugarbeet	200	15-Mar	30-Sep
Tomato	153	1-Apr	31-Aug
Wheat	212	1-Nov	31-May

Table 4-7. Season Length and Crop Coefficient Parameters Used in CUP Model for Basin Study

Crop	Length of Season (Days)	Percent of Growing Season			Crop Coefficients		
		Initial	Development	Mid-Season	K_c ini	K_c mid	K_c end
Alfalfa (annual)	365	25	50	75	1.00	1.00	1.00
Almonds[1]	229	0	50	90	0.55	1.20	0.65
Apple	229	0	50	75	0.55	1.15	0.80
Beans (dry)	108	24	40	91	0.20	1.10	0.10
Corn (grain)	153	20	45	75	0.20	1.05	0.60
Corn (silage)	107	20	45	100	0.20	1.05	1.00
Cotton	154	15	25	85	0.35	1.00	0.50
Cucumber	93	19	47	85	0.80	1.00	0.75
Melon[2]	123	21	50	83	0.75	1.05	0.75
Onion (dry)	215	13	42	72	0.55	1.20	0.55
Orange[1]	365	0	33	67	1.00	1.00	1.00
Pasture (improved)	365	25	50	75	0.95	0.95	0.95
Potato	123	20	45	78	0.70	1.15	0.50
Rice[3]	139	24	37	86	1.16	1.04	1.05
Safflower	122	17	45	80	0.20	1.05	0.25
Sugarbeet	200	15	45	80	0.20	1.15	0.95
Tomato	153	25	50	80	0.20	1.20	0.60
Wheat	212	25	60	90	0.30	1.05	0.15
Wine grapes	215	0	25	75	0.45	0.80	0.35

Notes:
1. Mid-season crop coefficients for almonds and other tree crops may vary between 0.90 – 1.15 depending on whether a cover crop is present.
2. The growing season for melons was revised from 229 days given in CUP to 123 days.
3. Rice parameters were updated for this study using crop coefficients from Linquist et al. (2015).

4.3 Climate

Historical climate data were needed for the entire model domain for the period 1921 to 2009. In consultation with SWRCB staff, the SacWAM development team selected a spatially interpolated, gridded dataset developed by Livneh et al. (2013) as the source for historical climate data. This dataset provides daily precipitation, maximum and minimum temperature, and wind speed (at 10m) for January 1, 1915 to December 31, 2011 on a 1/16 degree grid. The following steps were followed in developing the data:

1. The **Livneh grid** was intersected with the **water budget areas** boundaries.
2. A VBA macro in **valley floor processor** was used to calculate the average of the maximum and minimum daily temperature, precipitation, and wind speed for all **Livneh grid** cells that intersected each WBA.
3. The spreadsheet **Daily CIMIS RH Analysis** was used to calculate an average maximum and minimum daily relative humidity timeseries based on CIMIS data.
4. Data from steps 2 and 3 were combined to create the input files found in **WEAP Input Data**.

The wind data in the Livneh et al. (2013) dataset is provided as wind speed at 10 m above the ground. This data was modified to represent wind speed at 2 m above the ground using the following relationship (Neitsch et al., 2005):

$$wind_2 = wind_{10} * (2/10)^{0.2} \qquad \text{Equation 4-1}$$

where:

$wind_2$ is the wind speed at 2 m above the ground;

$wind_{10}$ is the wind speed at 10 m above the ground.

4.4 Agricultural Catchment Parameters

SacWAM represents agricultural water use in the Sacramento Valley using demand units built on the standard WEAP catchment object. Within each catchment, calculations of crop ET are performed for each crop type using the MABIA method described above. To meet the crop water demand, the demand unit receives water from surface water and groundwater sources via transmission links (solid green line). Return flows are routed using the dashed blue line which represents either runoff (for surface water) or infiltration (for deep percolation). These links convey return flows from both rainfall and irrigation. Agricultural catchments can be recognized by their "A_" prefix.

4.4.1 Conceptual Framework

Agricultural water use in the SacWAM is represented using the conceptual framework illustrated in Figure 4-3. The solid lines shown in the figure are represented in the SacWAM schematic. Additional dashed lines are used to describe water use within the demand unit and are conceptual in nature. Definitions of each flow arc are provided in Table 4-8.

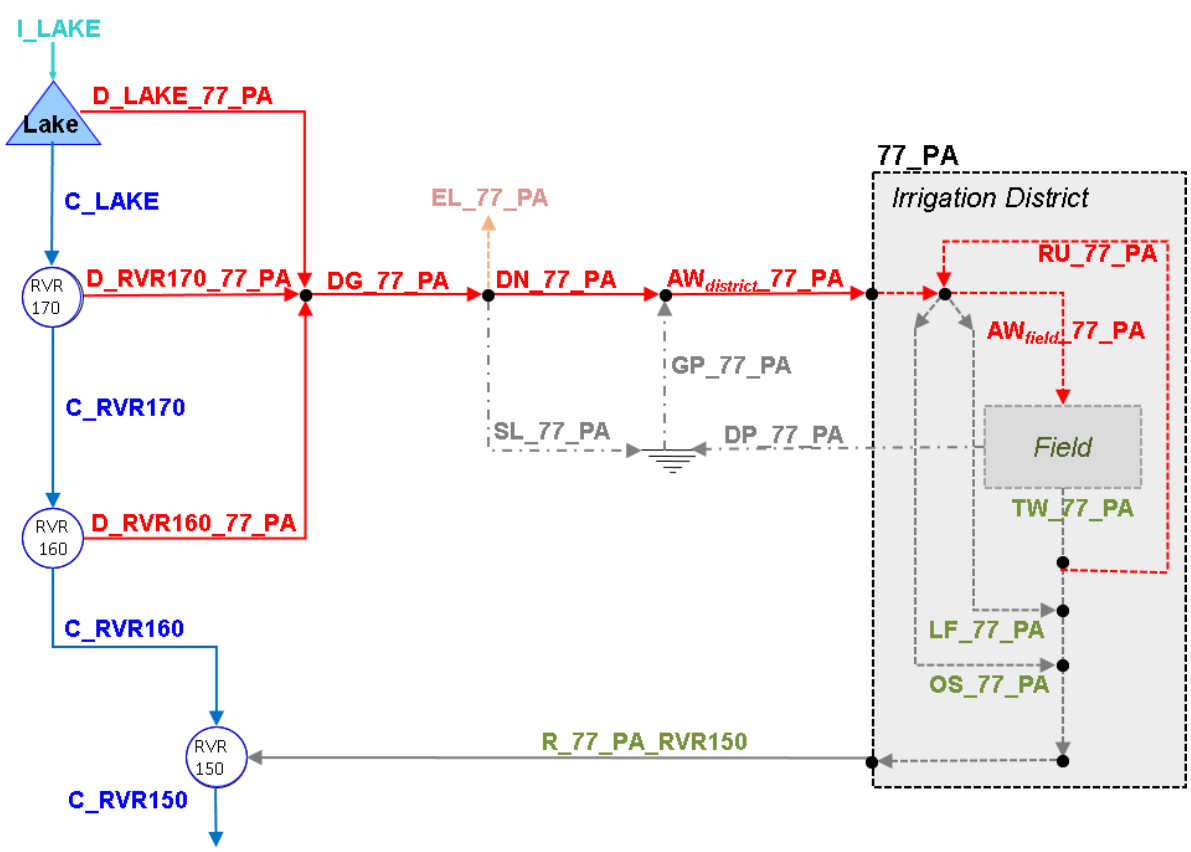


Figure 4-3. Template for Agricultural Water Use

Table 4-8. Flow Arcs for Agricultural Water Use

Arc Prefix	Name	Description
DG	Diversion Gross	The sum of all surface water diversions from the stream or canal system to the demand unit.
DN	Diversion Net	Net surface water reaching the district after accounting for evaporation and seepage conveyance losses.
EL	Evaporation Loss	Evaporative loss from surface water conveyance channels, including that from riparian growth adjacent to these channels.
SL	Seepage Loss	Seepage loss from conveyance structures such as canals.
LF	Lateral Flow Loss	Lateral flow through the banks of the canal distribution system to the adjacent toe drains.
OS	Operational Spill Loss	Flow leaving the canal distribution system, discharging directly to the drain system.
GP	Groundwater Pumping	Groundwater pumping (not subject to conveyance losses).
RU	Reuse	Reuse of tailwater, operating spills, and lateral flows at farm and district scales.
AW_{field}	Applied Water	Applied water at field scale, after accounting for losses from lateral flow and operational spills and supplies from reuse of water.
$AW_{district}$	Applied Water	Applied water at district scale is the sum of surface water deliveries, less conveyance loss, and groundwater pumping.
DP	Deep Percolation Loss	Deep percolation of irrigation water and precipitation at field scale.
TW	Tailwater	Return flow from irrigation at field scale.
R	Return Flow	Return flow at district scale consisting of operational spills, lateral flow, and tailwater, which are not reused.

In the conceptual framework, water supplies available to meet crop water demands are a mix of stream and canal diversions, groundwater pumping, and reuse of tailwater. Stream diversions and deliveries from major canal systems are subject to conveyance losses (evaporation and seepage). In contrast, groundwater pumping is considered to be at field level and not subject to conveyance losses, unless a water district supplements canal deliveries with groundwater pumping into the district canal distribution system. The canal distribution system within an ID is subject to operational spills and lateral flow through the canal banks to adjacent toe drains. Tailwater leaving the field (including flow-through from rice fields and drawdown of ponded water) is available for reuse. Water supplies must meet applied water demands. A fixed fraction of water demands must be met from groundwater pumping, representing farmers who do not have access to surface water.

Groundwater pumping is assumed to be at field scale. Therefore, simulated groundwater pumping is not subject to operational spills and lateral flows. However, in the case of surface water, these flows cannot be represented explicitly in WEAP, and must be represented implicitly by reducing the irrigation efficiency.

4.4.1.1 *Applied Water*

The irrigation water required at the head of the field or farm gate is known as the applied water. The portion of irrigation water that is stored in the root zone and subsequently consumed through ET is known as the consumptive use of applied water. Applied water is related to the consumptive use of applied water by the seasonal application efficiency (SAE).

$$AW_{field}=CUAW/\ SAE \qquad \text{Equation 4-2}$$

where:

AW_{field}=applied water at head of the field
CUAW=consumptive use of applied water
SAE=seasonal application efficiency

Crop-specific SAEs are defined for each WBA. The term SAE is used, rather than irrigation efficiency, to indicate that values are constant over the irrigation season.

4.4.1.2 *Potential Application Efficiency*

Distribution uniformity is a measure of how uniformly water is distributed across the field. It is typically defined as the ratio of some measure of the smallest accumulated depths in the distribution of applied water to the average depth accumulated. Since 1940, NRCS has used the average of the lowest quarter of the distribution to the average of the distribution to define distribution uniformity (Burt et al., 1997). Distribution uniformity differs from irrigation efficiency. For example, water could be applied uniformly across the field, but in excess of crop water requirements and available soil moisture storage, resulting in a low application efficiency and deep percolation of applied water to groundwater. However, distribution uniformity can be used as an upper bound for potential application efficiency (PAE). PAE is based on the concept that the applied water is sufficient to achieve average soil moisture across the least watered quarter of the field equal to field capacity. For this assumption, PAE may be calculated using the following equation:

$$PAE_{field}=DU_{lq} \qquad \text{Equation 4-3}$$

where:

DU_{lq}=distribution uniformity based on the 'lower quarter' concept
PAE=potential application efficiency

SAEs estimated by DWR's Division of Statewide Integrated Water Management (DSIWM) are typically 1 to 1.10 times lower than PAEs based on DUs. The reason for this is that SAEs account for surface water leaving the field as tailwater. To account for this, the SAE is calculated as follows:

$$SAE_{field}=PAE.(1-f_{TW}) \qquad \text{Equation 4-4}$$

and:

$$AW_{field}=\frac{CUAW}{PAE.(1-f_{TW})} \qquad \text{Equation 4-5}$$

where:

f_{TW}=tailwater factor

As described above, at a district scale there are operational spills from the canal distribution system, and lateral flow through the canal banks to the toe drains. Tailwater leaving the field may be captured and

reapplied. It is assumed that there is no reuse of operational spills and lateral flows.[7] The applied water at the boundary of the district and the associated SAE at the district scale may be calculated as follows:

$$AW_{district}=AW_{field}.\frac{(1-f_{RU})}{(1-f_{OS}-f_{LF})} \qquad \text{Equation 4-6}$$

$$AW_{district}=\frac{CUAW}{PAE.(1-f_{TW})}.\frac{(1-f_{RU})}{(1-f_{OS}-f_{LF})} \qquad \text{Equation 4-7}$$

$$SAE_{district}=PAE.\frac{(1-f_{TW}).(1-f_{OS}-f_{LF})}{(1-f_{RU})} \qquad \text{Equation 4-8}$$

where:

$SAE_{district}$=Seasonal application efficiency at district scale
f_{OS}=operational spill factor
f_{LF}=lateral flow factor
f_{TW}=tailwater factor
f_{RU}=reuse factor

Ideally, the operational spills and the lateral flows would be a function of the surface water deliveries rather than the applied water. However, currently there is no mechanism in the WEAP software to explicitly account for these flows. Therefore, operational spills and lateral flows have been included in the irrigation efficiency.

4.4.1.3 *Surface Water Demands*

The demand for surface water at field level is calculated as follows:

$$DN_{max}=(1-f_{GW}).AW_{district} \qquad \text{Equation 4-9}$$

where:

DN_{max}=demand for surface water
f_{GW}=minimum groundwater pumping factor

Surface water deliveries are subject to conveyance losses. When water supplies, water contracts, and/or water rights are not limiting, stream diversions (DG) or deliveries from major canal systems are determined as follows:

[7] Operational spills and lateral flows that are captured and used to meet applied water demands are nor represented in SacWAM as these flows are internal to the demand unit and do not affect the water balance.

$$DG_{max}=DN_{max}/(1 - f_{EV} - f_{SP}) \qquad \text{Equation 4-10}$$

where:

DG=gross surface water diversion (i.e., as measured at point of diversion)
f_{EV}=evaporative loss factor
f_{SP}=seepage loss factor

The net delivery (DN) is only equal to the demand for surface water (DN_{max}) when there are no binding constraints on surface water diversions.

4.4.1.4 *Surface Irrigation Return Flows*

Irrigation water returning to the stream system can be expressed as a function of the applied water demand at the district boundary, as follows:

$$RF=(f_{OS} + f_{LF}).AW_{district} + f_{TW}.AW_{field}.(1 - f_{RU}) \qquad \text{Equation 4-11}$$

$$RF=(f_{OS} + f_{LF}).AW_{district} + f_{TW}.AW_{district}.(1 - f_{OS} - f_{LF}) \qquad \text{Equation 4-12}$$

4.4.1.5 *Deep Percolation from Applied Water*

Irrigation water that infiltrates the soil surface and percolates to the underlying groundwater can be expressed as a function of the applied water demand at the district boundary, as follows:

$$DP=(1 - PAE) \qquad \text{Equation 4-13}$$

$$DP=AW_{field}.(1 - PAE - f_{TW}) \qquad \text{Equation 4-14}$$

$$DP=AW_{district}.\frac{(1-f_{OS}-f_{LF})}{(1-f_{RU})}.(1 - PAE - f_{TW}) \qquad \text{Equation 4-15}$$

4.4.1.6 *Ponded Fields (Rice and Flooded Refuge Lands)*

Fields that are ponded utilize a different conceptual model than the one described above. In SacWAM this applies to rice fields and the portions of refuges that are seasonally or permanently flooded.

Similar to other crops, there are seepage and evaporative losses from the canal system that are represented in the *Loss to Groundwater* and *Loss to System* on the transmission links that connect the DUs catchment object to a stream.

Losses from the flooded lands consist of deep percolation and flow through. Deep percolation is specified in the *Maximum Percolation Rate* parameter. This parameter is set in *Other Assumptions\Valley Floor Hydrology\Calibration Factors\Rice\MaxPercRate*. Flow through, for salinity control, and losses to surface drains are set by the *Release Requirement* parameter. Values for *Release Requirement* are read from the comma-separated values (csv) file SACVAL_Rice_Drainage.csv located in Data\Param\Rice.

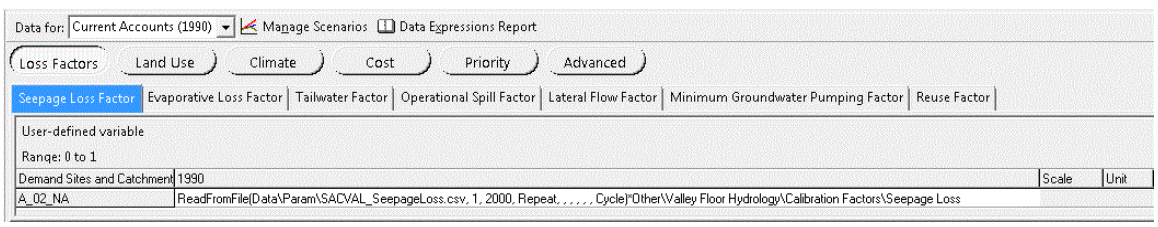
4.4.2 Loss Factors

Loss factors are entered at the DU level in the catchment interface, except for *Potential Application Efficiency*, *Loss to Groundwater*, and *Loss to System*. *Potential Application Efficiency* is listed by WBA and is entered into the *Other Assumptions\Valley Floor Hydrology\Potential Application Efficiency* branch of the model, and Loss to Groundwater and Loss to System are both entered as transmission losses in *Supply and Resources\Transmission Links\Loss to Groundwater* and *Supply and Resources\Transmission Links\Losses* branch of the model.

To maintain flexibility in adjusting model parameters, all loss factors are read into SacWAM using a read-from-file command that references a specific column in the relevant csv file. There are two ways to adjust these parameters, either by altering the factors within the csv file, or globally scaling a factor in the *Other Assumptions\Valley Floor Hydrology\Calibration Factors* branch. To decrease evaporative losses across the model by 20%, for instance, one would change the value of 1 in the *Other Assumptions\Valley Floor Hydrology\Calibration Factors\Evaporative Loss* branch to 0.8. The factors that can be adjusted in this way are: *Seepage Loss*, *Evaporative Loss*, *Tailwater*, *Operational Spill*, *Lateral Flow*, *Reuse*, and *Potential Application Efficiency*.

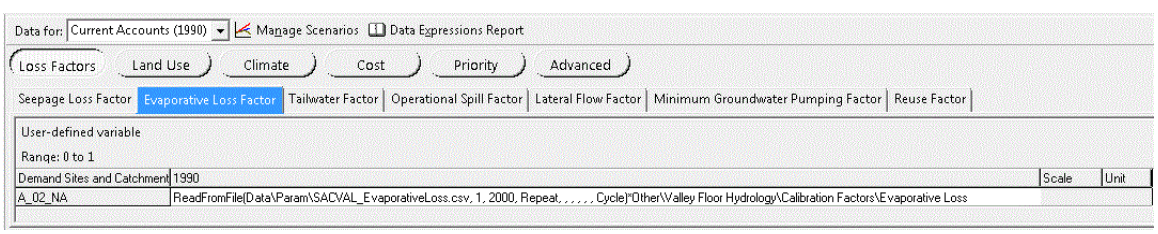
In the current version of SacWAM, loss factors are based on values derived for DWR models. All global factors are currently set to a value of 1.0.

4.4.2.1 *Seepage Loss Factor*



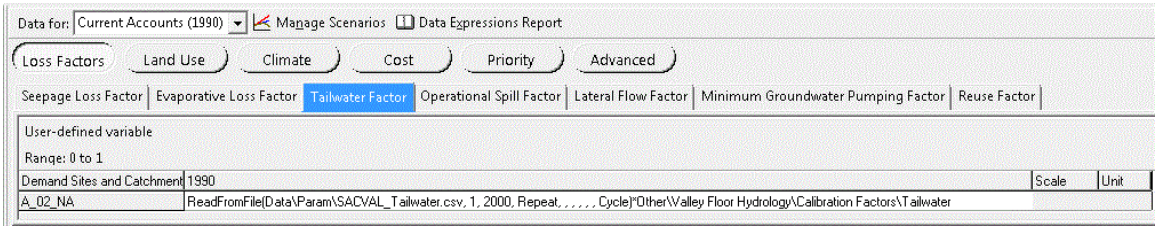
Seepage Loss is loss to the groundwater system from conveyance channels. Initial values were based on default DWR values. These values range from 0.0 to 0.28.

4.4.2.2 *Evaporative Loss Factor*



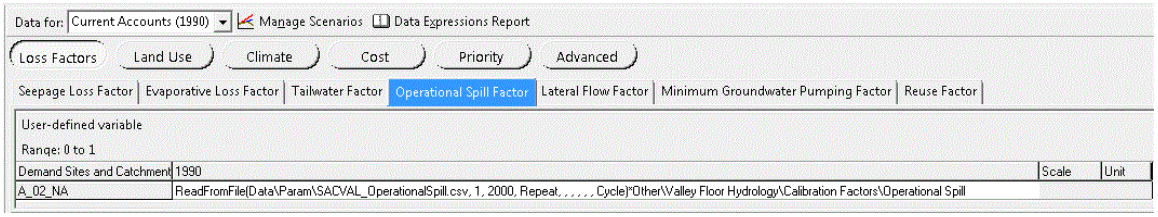
Evaporative Loss is defined as evaporative loss from surface water conveyance channels, including that from riparian growth adjacent to these channels. With the exception of the Delta DUs (DUs A_50_XXX), which have a value of zero, all DUs were assumed to have a value of 0.01.

4.4.2.3 *Tailwater Factor*



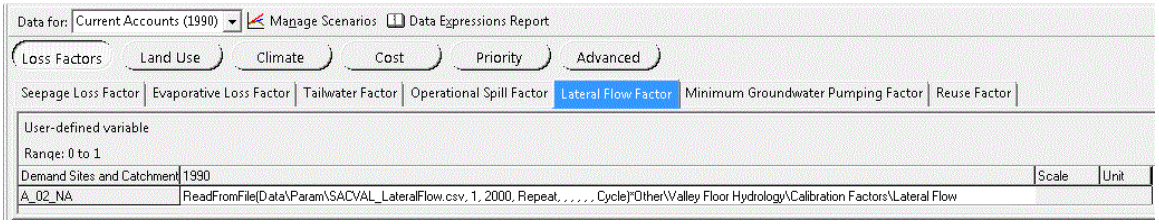
Tailwater factors are assumed to be 0.1, i.e., ten percent of applied water leaves the field as tailwater.

4.4.2.4 *Operational Spill Factor*



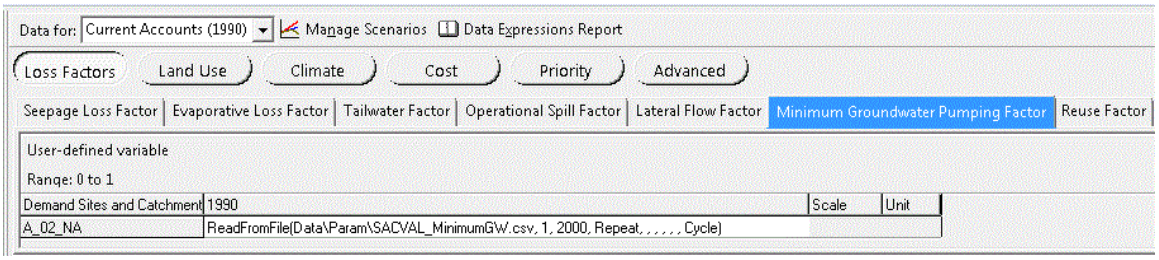
Operational spills associated with canal conveyance in agricultural and refuge DUs and are typically assumed to be three percent of the surface water diversion. However, for a few DUs where operational spills are known to be large (e.g. Anderson-Cottonwood ID), operational losses were increased up to a maximum of 25 percent of the diversion. For buried pipe systems, operational spills are assumed to be zero. These values were based on default DWR values.

4.4.2.5 *Lateral Flow Factor*



Lateral flow is horizontal seepage to the canal toe drains. The portion of lateral flow that is recaptured for irrigation is not represented explicitly in WEAP because this does not affect the water balance or water available at the farm gate. For WEAP, this recaptured water is simulated as remaining within the canal system. These values were based on default DWR values and range from 0.0 to 0.25.

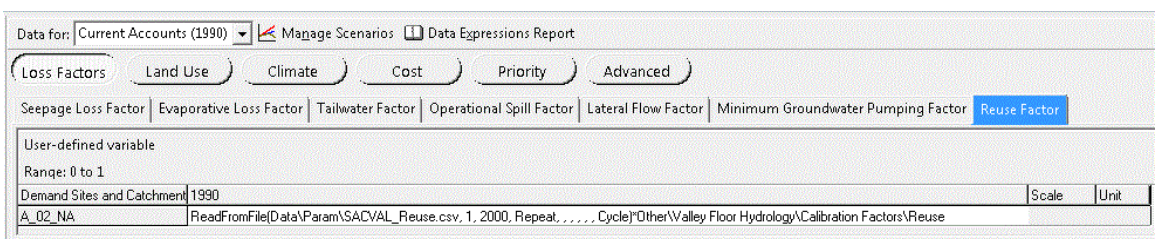
4.4.2.6 *Minimum Groundwater Pumping Factor*



Minimum **groundwater pumping** factors are specified in SacWAM representing the part of the applied water demand that must be met from groundwater pumping. Applied water demands in excess of minimum groundwater pumping are met from surface water and additional groundwater pumping, if necessary.

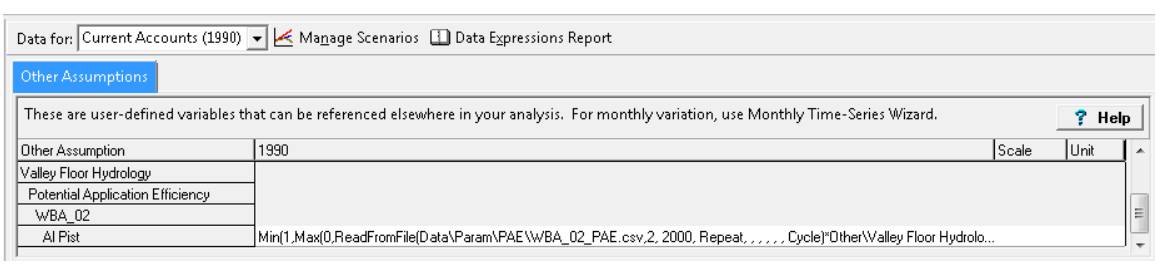
The *Minimum Groundwater Pumping Factor* was determined using information from DWR's county land use surveys (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a). Initial groundwater pumping fractions were calculated as the lands dependent on groundwater only divided by the area of lands that 1) use surface water only 2) use groundwater only or 3) have access to both surface water and groundwater. Each agricultural and urban DU has a *Minimum Groundwater Pumping Factor* in SacWAM. This parameter is used to define the Maximum Flow Percent of Demand parameter on the surface water transmission links (Section 6.6).

4.4.2.7 *Reuse Factor*



Reuse of tailwater from crops other than rice is set equal to zero to ten percent of applied water demand.

4.4.2.8 *Potential Application Efficiency*



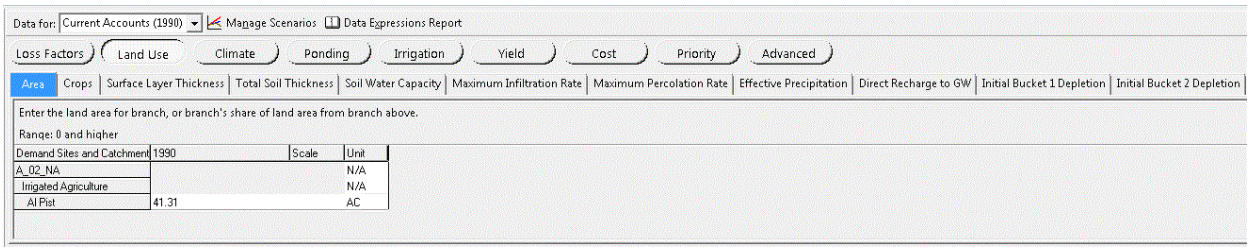
Potential application efficiencies are WBA- and crop-specific. They are discussed in this section as they relate to other Loss Factor parameters, although in SacWAM they are specified in the *Other*

Assumptions\Valley Floor Hydrology\Potential Application Efficiency branch of the model. These values are based on UC Davis (2013) and Sandoval-Solis et al. (2013).

4.4.3 Land Use

Under the *Agricultural Catchments\Land Use* branch, parameter values were set according to the descriptions provided below.

4.4.3.1 *Area*



The following are the data sources used in determining the distribution of area classes in SacWAM DUs:

- WD and WA boundaries and service areas obtained from the California Spatial Information Library (CaSIL), which comprises separate GIS layers for Federal, State, and private water-districts (CaSIL, 2013).
- County land use surveys undertaken by DWR's DSIWM, formerly Division of Planning and Local Assistance (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a).
- County and regional integrated water resources plans and integrated water management plans.
- Reclamation CVP water supply contract renewal (Reclamation, 2013a) and supporting environmental documents (Assessments, Environmental Impact Statements, and Findings of No Significant Impacts) (Reclamation, 2013b).

To define SacWAM agricultural land acreages, DWR land use data were obtained (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a). In the 1950s, DWR began to collect geospatial urban and agricultural land use data by county. Each county is surveyed every seven years. The DWR data include over seventy crop classifications. Due to the large number of classifications, crop types were aggregated where possible to create fewer land use classes for use in SacWAM (Table 4-9). The scheme includes twenty crop classifications in addition to classifications for urban (UR) and native vegetation (NV) areas. Note that the acreages given for wetland areas (DWR classes NR4 and NR5) are lumped with the NV class. The acreages given for wetland areas represent identified wetlands in agricultural areas, and were only identified in the upper half of the Sacramento Valley by the DWR Northern District office.

Table 4-9. SacWAM Agricultural Land Use Classifications

SacWAM Land Use Classification		DWR Land Use Classification	
Crop Type (Code)	**Abbreviation**	**Code**	**Description**
Alfalfa (AL)	Alfalfa	P1	Pasture: Alfalfa
Almonds & Pistachios (AP)	Al Pist	D12	Deciduous Fruits & Nuts: Almonds
		D14	Deciduous Fruits & Nuts: Pistachios
Corn (CR)	Corn	F6	Field Crops: Corn
Cotton (CO)	Cotton	F1	Field Crops: Cotton
Cucurbits (CU)	Cucurb	T9	Truck, Nursery, Berry: Melons, Squash, and Cucumbers
Dry Beans (DB)	DryBean	F10	Field Crops: Beans
Grain (GR)	Grain	G	Grain & Hay: Miscellaneous
		G1	Grain & Hay: Barley
		G2	Grain & Hay: Wheat
		G3	Grain & Hay: Oats
		G6	Grain & Hay: Miscellaneous Mixed
Native Vegetation and Refuges (NV)	Native Vegetation	E	Entry Denied
		I	Idle
		I1	Land not cropped in current or previous season, but cropped in past three years
		I2	New lands being prepared for crop production
		NB	Barren Land
		NB1	Dry Stream Channel
		NB2	Mine Tailing
		NB3	Native Barren
		NC	Native Classes Unsegregated
		NR	Riparian Vegetation
		NR1	Marsh
		NR2	High Water Table Meadow
		NR3	Trees and Shrubs
		NR4	Seasonal Duck Marsh
		N45	Permanent Duck Marsh
		NS	Not Surveyed
		NV	Native Vegetation
		NV1	Grass
		NV2	Light Brush
		NV3	Medium Brush
		NV4	Heavy Brush
		NV5	Brush and Timber
		NV6	Forest
		NW	Water Surface
Onions and Garlic (OG)	On Gar	T10	Truck, Nursery, Berry: Onions and Garlic
Other Deciduous Orchard (OR)	Oth Dec	D	Deciduous Fruits & Nuts: Not Classified
		D1	Deciduous Fruits & Nuts: Apples
		D2	Deciduous Fruits & Nuts: Apricots
		D3	Deciduous Fruits & Nuts: Cherries
		D5	Deciduous Fruits & Nuts: Peaches and Nectarines
		D6	Deciduous Fruits & Nuts: Pears
		D7	Deciduous Fruits & Nuts: Plums
		D8	Deciduous Fruits & Nuts: Prunes
		D9	Deciduous Fruits & Nuts: Figs
		D10	Deciduous Fruits & Nuts: Miscellaneous Deciduous
		D13	Deciduous Fruits & Nuts: Walnuts

Table 4-9. SacWAM Agricultural Land Use Classifications cont.

SacWAM Land Use Classification		DWR Land Use Classification	
Crop Type (Code)	**Abbreviation**	**Code**	**Description**
Other Field (FI)	Oth Fld	F	Field Crops: Not Classified
		F3	Field Crops: Flax
		F4	Field Crops: Hops
		F7	Field Crops: Sorghum
		F8	Field Crops: Sudan
		F11	Field Crops: Miscellaneous Field
		F12	Field Crops: Sunflowers
Pasture (PA)	Pasture	P	Pasture: Not Classified
		P2	Pasture: Clover
		P3	Pasture: Mixed
		P4	Pasture: Native
		P5	Pasture: High Water Native
		P6	Pasture: Miscellaneous Grasses
		P7	Pasture: Turf Farms
Potatoes (PO)	Potato	T12	Truck, Nursery, Berry: Melons, Squash, and Cucumbers
Rice (RI)	Rice and Rice Early	R	Rice: Rice
Safflower (SF)	Safflwr	F2	Field Crops: Safflower
Subtropical (SO)	Subtrop	C	Citrus & Subtropical: Not Classified
		C1	Citrus & Subtropical: Grapefruit
		C2	Citrus & Subtropical: Lemons
		C3	Citrus & Subtropical: Oranges
		C4	Citrus & Subtropical: Dates
		C5	Citrus & Subtropical: Avocados
		C6	Citrus & Subtropical: Olives
		C7	Citrus & Subtropical: Misc. Subtropical
		C8	Citrus & Subtropical: Kiwis
		C9	Citrus & Subtropical: Jojoba
		C10	Citrus & Subtropical: Eucalyptus
Sugar Beets (SB)	SgrBeet	F5	Field Crops: Sugar Beets
Tomatoes (TM: TH)	Pr Tom; Fr Tom	T15	Truck, Nursery, Berry: Tomatoes
Urban (UR)	Urban	S1	Semi-agricultural: Farmsteads
		S2	Semi-agricultural: Livestock Feed Lots
		S3	Semi-agricultural: Dairies
		S4	Semi-agricultural: Poultry Farms
		U	Urban: Not Classified
		UC	Urban Commercial: Not Classified
		UC1	Urban Commercial: Offices, Retailers
		UC2	Urban Commercial: Hotels
		UC3	Urban Commercial: Motels
		UC4	Urban Commercial: Recreation Vehicle Parking, Camping
		UC5	Urban Commercial: Institutions
		UC6	Urban Commercial: Schools
		UC7	Urban Commercial: Municipal Auditoriums, Stadiums, Theaters
		UC8	Urban Commercial: Misc. High Water Use
		UI	Urban Industrial: Not Classified
		UI1	Urban Industrial: Manufacturing, Assembling and Processing
		UI2	Urban Industrial: Extractive Industries
		UI3	Urban Industrial: Storage and Distribution
		UI6	Urban Industrial: Saw Mills
		UI7	Urban Industrial: Oil Refineries
		UI8	Urban Industrial: Paper Mills
		UI9	Urban Industrial: Meat Packing Plants

Table 4-9. SacWAM Agricultural Land Use Classifications cont.

SacWAM Land Use Classification		DWR Land Use Classification	
Crop Type (Code)	**Abbreviation**	**Code**	**Description**
Urban (UR)	Urban	UI10	Urban Industrial: Steel and Aluminum Mills
		UI11	Urban Industrial: Fruit and Vegetable Canneries
		UI12	Urban Industrial: Misc. High Water Use
		UI13	Urban Industrial: Sewage Treatment Plant/Ponds
		UI14	Urban Industrial: Waste Accumulation Sites
		UI15	Urban Industrial: Wind/Solar Farms
		UL	Urban Landscape: Not Classified
		UL1	Urban Landscape: Lawn Area (irrigated)
		UL2	Urban Landscape: Golf Course (irrigated)
		UL3	Urban Landscape: Ornamental Landscape (irrigated)
		UL4	Urban Landscape: Cemeteries (irrigated)
		UL5	Urban Landscape: Cemeteries (not irrigated)
		UR	Urban Residential: Not Classified
		UR1	Urban Residential: Single Family (1-5 acres)
		UR2	Urban Residential: Single Family (1-8 units/acre)
		UR3	Urban Residential: Multi Family
		UR4	Urban Residential: Trailer Courts
		UR11	Urban: Residential, Single Family (1-5 acres), <25% irrigated
		UR13	Urban: Residential, Single Family (1-5 acres), 51%-75% irrigated
		UV	Urban Vacant: Not Classified
		UV1	Urban Vacant: Unpaved Areas
		UV3	Urban Vacant: Railroad Right-Of-Way
		UV4	Urban Vacant: Paved Areas
		UV6	Urban Vacant: Airport Runways
Vineyards (VI)	Vine	V	Vineyard: Not Classified
		V1	Vineyard: Table Grapes
		V2	Vineyard: Wine Grapes
		V3	Vineyard: Raisin Grapes

Once SacWAM land use classes were determined, acreages for each class were found. Irrigated crop acreage (ICA) of DAUs from water years 1998-2007 were obtained from DSIWM. The average annual ICA for this 10-year period was assumed to be representative of "existing conditions." Then, a "snapshot" of land use for the Central Valley was assembled from the county land use surveys to create a continuous mosaic in GIS, although the land use data are derived from different years. The GIS mosaic was intersected with DU polygons and with DAU polygons to obtain the historical irrigated land area for each DU and for each DAU. These historical values were converted to a value representing "existing conditions" by scaling the "snapshot" land use data to match the 10-year DAU value. The following example illustrates this process:

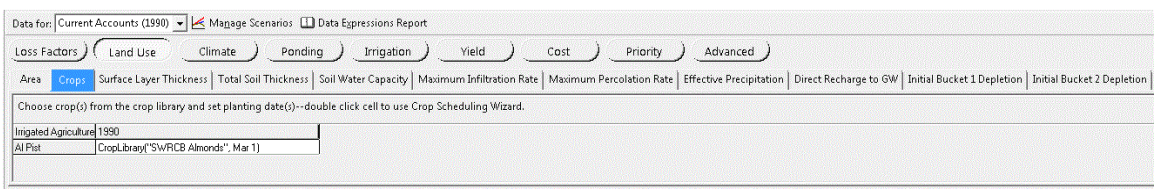
1. Assume the 10-year historical average for wheat in DAU X=10,000 acres
2. Assume the GIS data from the land use mosaic shows 8,000 acres of wheat in DAU X
3. Assume the GIS data from the land use mosaic shows 500 acres of wheat in DU A
4. If DU A is located within DAU X, the existing level acreage for wheat=500*(10,000/8,000) acres

A table was created containing acreage data for each SacWAM DU, displayed in twenty-four columns. Each column indicates the acreage of a specific crop within a DU, listed by its crop code. For instance, "A_02_NA_AL" will contain the acreage of alfalfa in catchment "A_02_NA." There are instances where irrigated land exists inside municipal boundaries which are represented by an urban DU. In this case, the irrigated land was removed from the urban DU and associated with a neighboring agricultural DU. For

example, “A_02_NA” may supply water to neighboring demand site “U_02_SU” for 500 acres of alfalfa. Consequently, the crop acreage of “A_02_NA_AL” will be larger than the irrigated alfalfa physically present in “A_02_NA,” because it includes the alfalfa acreage of “U_02_SU.” It is also the case that agricultural catchments include urban area. These areas include semi-agricultural, industrial and commercial lands that exist outside of municipal boundaries, such as schools, motels, and mills. These areas are simulated using parameters that reflect mostly impermeable surfaces in SacWAM. The final land use dataset for all agricultural lands except for the Delta DUs (A_50_NA1 through A_50_NA7) is contained in the **agricultural land use** file.

The land use dataset for areas within the Sacramento–San Joaquin Delta is documented in the **delta land use** file. A similar approach as described above was used to determine land use acreages in the Delta. In 2006, the Delta Evapotranspiration of Applied Water model (DETAW) was developed by the University of California at Davis to estimate consumptive water demands within the Delta (Kadir, 2006). This development was in cooperation with DSIWM and funded by the Modeling Support Branch of the Bay-Delta office. DETAW estimates consumptive water demands for 168 subareas within the Delta Service Area. To determine land use acreage for the Delta, a shapefile containing these 168 DETAW subregions (DWR, 2014b) was intersected with DWR’s land use survey of Delta lands (DWR, 2007). A look-up table was used to associate each of the DETAW subregions with its SacWAM DU. The result of this process was land use data by crop type for each DU.

4.4.3.2 *Crops*



The Crops parameter is used to specify crop type and planting date. WEAP has a **crop library** (General>Crop Library) where information on crop coefficients, season length, management allowable depletion, and rooting depth is contained. The twenty-two SacWAM crops, plus Native Vegetation and Urban classes were added to the **crop library**. The planting date information entered into the Crop Library were obtained from the DWR Consumptive Use Program (CUP) and Simulation of Evapotranspiration of Applied Water (SIMETAW) models (Orang et al., 2013). The crop coefficients were calibrated to match crop ET values produced by the CUP model. Rooting depth, depletion factors, and maximum height information were obtained from the WEAP database which is based on FAO56 (Allen et al., 1998).

4.4.3.3 *Direct Recharge to GW*

Direct Recharge to GW was assumed to be equal to 0 percent as this feature of the WEAP software was not used.

4.4.3.4 *Effective Precipitation*

A modified SCS Curve Number approach (NRCS, 1986; SCS, 1972) was used to partition the daily rainfall into runoff and infiltration. The modification to the standard approach was the make the maximum soil moisture retention, S, a function of the soil moisture at the end of the previous day (Schroeder et al., 1994).

The effective precipitation is calculated as:

$$P_{eff=} \frac{P-Q}{P} \; x \; 100 \qquad \text{Equation 4-16}$$

where:

P_{eff} = effective precipitation (%)
Q = runoff (in)
P = precipitation (in)

Runoff is calculated using:

$$Q = \frac{(P-0.2S)^2}{(P+0.8S)} \qquad \text{Equation 4-17}$$

where:

S = maximum soil moisture retention (in)

These equations are calculated in the Effective Precipitation parameter of the interface. The expression requires the value of the maximum soil moisture retention, S, which is calculated as a function of the current soil moisture status and is described in the Max Soil Moisture Retention parameter definition.

4.4.3.5 *Initial Bucket 1 Depletion*

Initial Bucket 1 Depletion was assumed to be equal to 0 mm (the WEAP default value).

4.4.3.6 *Initial Bucket 2 Depletion*

Initial Bucket 2 Depletion was assumed to be equal to 0 mm (the WEAP default value).

4.4.3.7 *Max Soil Moisture Retention*

The maximum soil moisture retention, S, is calculated using:

$$S = \begin{bmatrix} S_m \left[1 - \frac{SM - [(FC+WP)/2]}{UL - [(FC+WP)/2]}\right] & for\ SM > (FC+WP)/2 \\ S_m & for\ SM < (FC+WP)/2 \end{bmatrix} \qquad \text{Equation 4-18}$$

where:

S_m = maximum value of S where S = 1000/CN – 10, in inches

SM = soil moisture at the end of the previous day

FC = field capacity of soil

WP = wilting point of soil

UL = soil saturation

Making the maximum soil moisture retention a function of the soil moisture results in increasing runoff as soil moisture increases. The expressions for *Max Soil Moisture Retention* and *Effective Precipitation* are located in the **effective precipitation** spreadsheet.

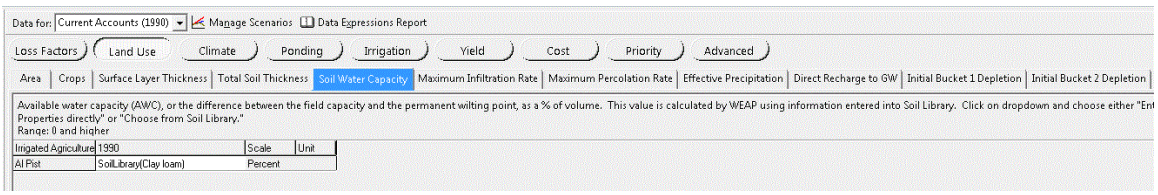
4.4.3.8 *Maximum Infiltration Rate*

The Maximum Infiltration Rate was not specified.

4.4.3.9 *Maximum Percolation Rate*

The Maximum Percolation Rate was specified to 0.025 inches/day for rice based on information from the UC Davis Cooperative Extension. This value is set in *Other Assumptions\Valley Floor Hydrology\Calibration Factors\Rice\MaxPercRate* for Rice and Rice Early. A maximum percolation rate was not set for other crops.

4.4.3.10 *Soil Water Capacity*



Soil water capacity is plant available water calculated as the difference between field capacity and permanent wilting point. This value is specified in the Soil Library (General>Soil Library). All soils were assumed to be clay loam with an available water capacity of 14.5%. This assumption was based on an analysis of **surface soils** in the STATSGO database that found loam and clay loam are the dominant surface soil textures on the Sacramento Valley floor.

4.4.3.11 *Surface Layer Thickness*

Surface Layer Thickness was assumed to be equal to 0.1 m (the WEAP default value). This is the portion of the soil from which bare soil evaporation can extract water.

4.4.3.12 *Total Soil Thickness*

Total Soil Thickness was assumed to be equal to 2 m (the WEAP default value). Transpiration can remove moisture from the depth of soil penetrated by roots (specified in the Crop Library), this parameter specifies the total depth over which the soil moisture balance is calculated.

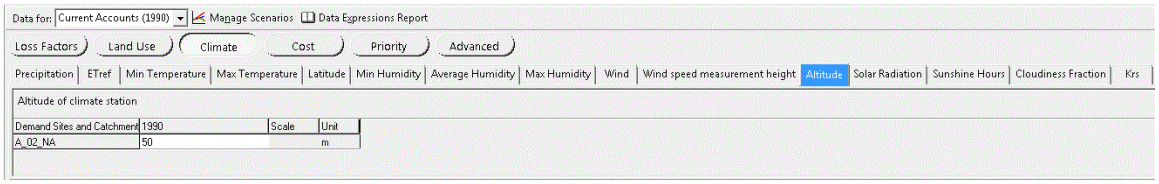
4.4.3.13 *Fraction Covered*

Fraction Covered is used to specify the fraction of the soil that is covered by crop. This value is used to determine the portion of the soil that should be subjected to bare soil evaporation. If this parameter is left blank then MABIA uses an algorithm found in FAO56 that calculates the covered fraction as a function of crop development stage and maximum crop height. In SacWAM this value has been specified for three crops. Alfalfa and pasture were given values of 1.0 since they maintain complete cover year round. Rice was given a value of 1.0 during the rice growing season. This forces the MABIA model to calculate rice ET as the product of the basal crop coefficient and the reference ET. It eliminates all bare soil evaporation. By substituting the literature based single crop coefficient for the basal crop

coefficient, the model was forced to calculate the rice ET at the rate specified in the literature (Linquist et al., 2015).

4.4.4 Climate

4.4.4.1 *Altitude*



This parameter was specified for the valley floor catchments that use the MABIA calculation algorithm. This value was assumed to be 50 m for all catchments.

4.4.4.2 *Average Humidity*

No data were input for *Average Humidity*, because *Minimum Humidity* and *Maximum Humidity* were both specified.

4.4.4.3 *Cloudiness Fraction*

No data were input for the *Cloudiness Fraction*. It was assumed that errors introduced by this assumption are minimal since there is little cloudiness during the period of highest ET (Apr – Oct).

4.4.4.4 *ETref*

No data were input for *ETref*, because SacWAM uses the Penman-Monteith equation to calculate *ETref*.

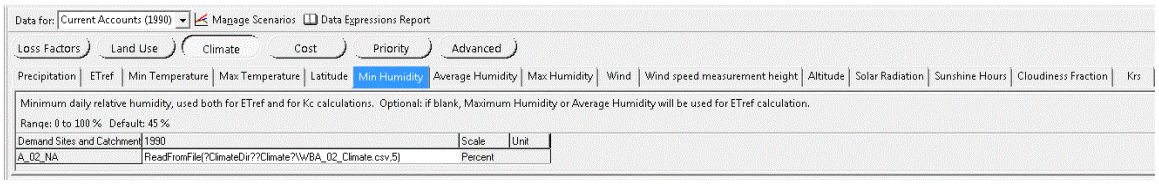
4.4.4.5 *Krs*

Krs is not used in SacWAM as the Penman Monteith equation is used to calculate *ETref.*

4.4.4.6 *Latitude*

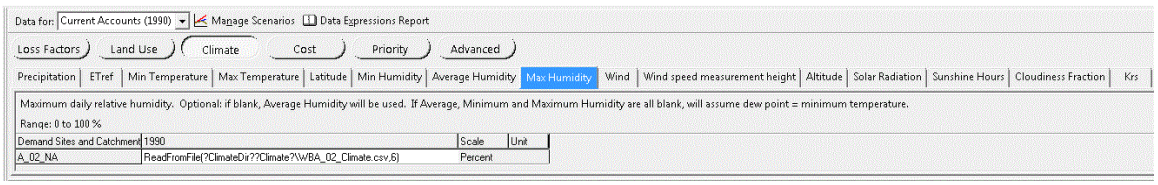
Centroids were calculated in ArcGIS for all DUs and catchments after DUs and catchments had been dissolved into multi-part features. This allowed the calculation of one centroid per DU and catchment rather than one centroid per DU or catchment part. Latitudes were calculated for these points in decimal degrees in WGS1984 UTM Zone 11 N. **Latitudes** were rounded to three decimal places and imported into WEAP.

4.4.4.7 *Min Humidity*



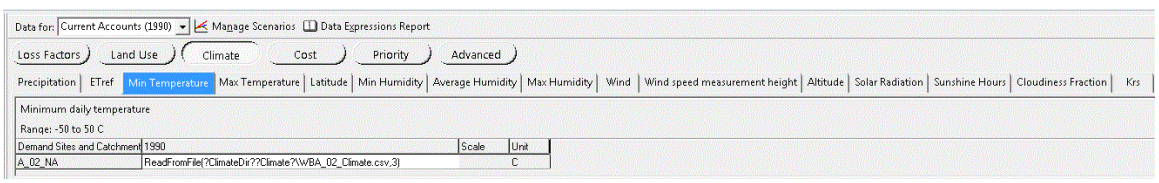
This dataset is read from a csv file located in the model data directory specified in *Key Assumptions\ClimateDir*. The model data directory is located within the Area directory and is called "Data." These data were derived using the approach discussed in Section 4.3.

4.4.4.8 *Max Humidity*



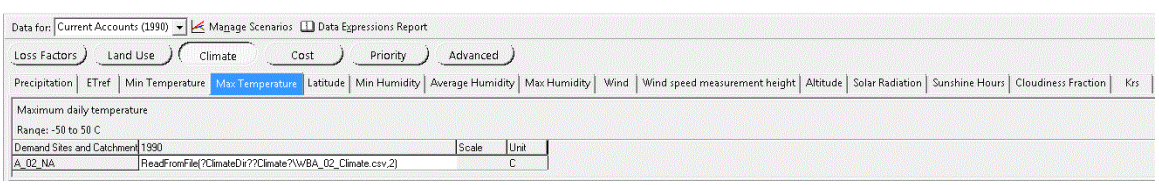
This dataset is read from a csv file located in the model data directory specified in *Key Assumptions\ClimateDir*. The model data directory is located within the Area directory and is called "Data." These data were derived using the approach discussed in Section 4.3.

4.4.4.9 *Min Temperature*



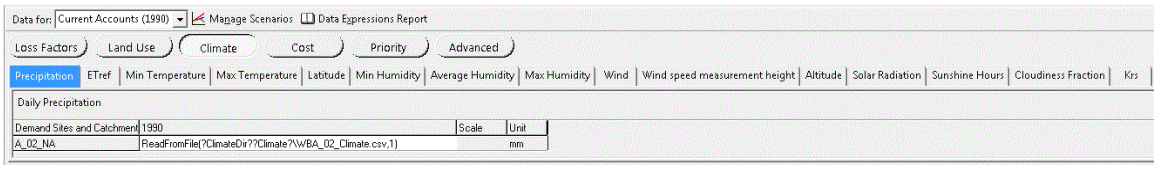
This dataset is read from a csv file located in the model data directory specified in *Key Assumptions\ClimateDir*. The model data directory is located within the Area directory and is called "Data." These data were derived using the approach discussed in Section 4.3.

4.4.4.10 *Max Temperature*



This dataset is read from a csv file located in the model data directory specified in *Key Assumptions\ClimateDir*. The model data directory is located within the Area directory and is called "Data." These data were derived using the approach discussed in Section 4.3.

4.4.4.11 *Precipitation*



This dataset is read from a csv file located in the model data directory specified in *Key Assumptions\ClimateDir*. The model data directory is located within the Area directory and is called "Data." These data were derived using the approach discussed in Section 4.3.

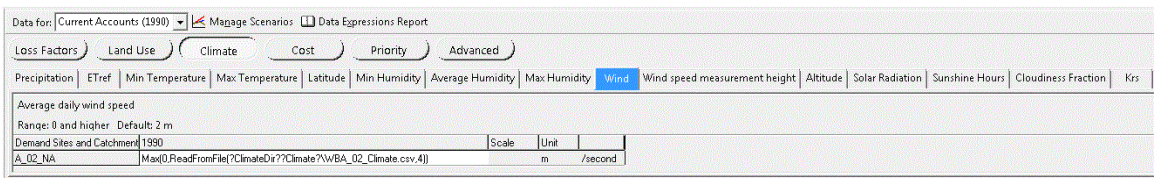
4.4.4.12 *Solar Radiation*

No value for solar radiation was entered; it was calculated in the MABIA module using the minimum and maximum daily temperature and the Hargreaves formula (Hargreaves and Samani, 1985).

4.4.4.13 *Sunshine Hours*

No data were input for *Sunshine Hour*s as it is not required.

4.4.4.14 *Wind*



This dataset is read from a csv file located in the model data directory specified in *Key Assumptions\ClimateDir*. The model data directory is located within the Area directory and is called "Data." These data were derived using the approach discussed in Section 4.3.

4.4.4.15 *Wind Speed Measurement Height*

The *Wind speed measurement height* was set to 2 m which is the standard used in the Penman Monteith Equation.

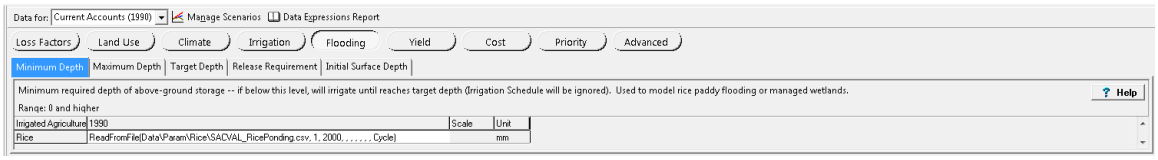
4.4.5 Flooding

Minimum Depth, Maximum Depth, and *Target Depth* were specified in SacWAM only for rice and flooded wetlands in refuge areas.

The timing and magnitude of rice flooding was based on a **rice management description** written by Todd Hillaire of DWR. The flooding pattern begins with a pre-planting irrigation used to saturate the soil and pond water to a depth of 3 inches. This irrigation starts five days prior planting day. Following planting the water is allowed to drain. After plant emergence, water is ponded to a depth of 5 inches (125 mm) on May 26. This depth is maintained until July 1 at which point the depth is increased to a depth of 8 inches (200 mm) by July 31. This depth is maintained until the end of August at which point the field is allowed to drain until September 15. For early rice, this pattern is shifted 3 weeks earlier.

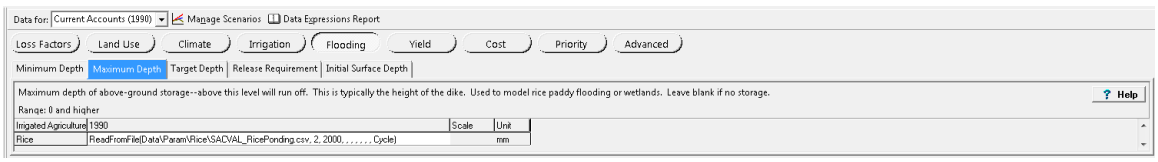
During the winter months the fields are flooded to promote rice-straw decomposition and to attract waterfowl. In SacWAM this flooding is assumed to start on October 15 and reach a *Target Depth* of 3 inches by January 1. Rainfall is allowed to collect in the fields up to a depth of 8 inches. Starting January 15 no more water is added to the fields. During the first two weeks of March the fields are actively drained to a depth of zero inches.

4.4.5.1 *Minimum Depth*



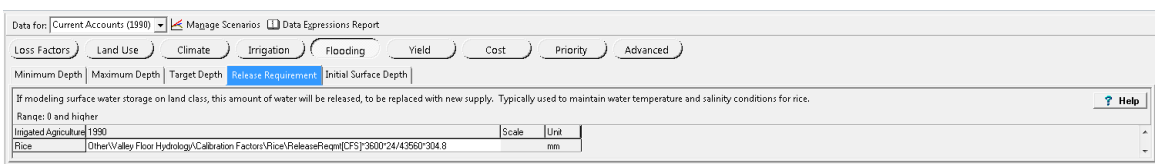
The minimum depth was specified using the timeseries described above.

4.4.5.2 *Maximum Depth*



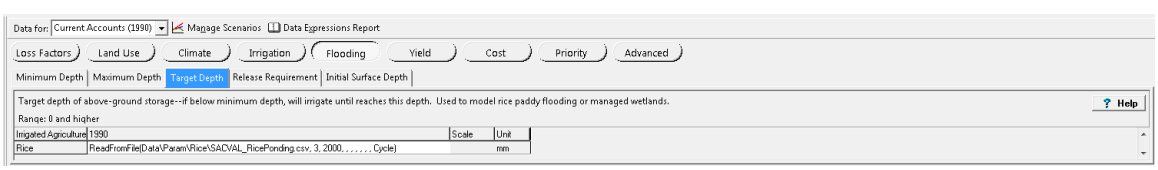
The maximum depth was specified using the timeseries described above with the exception at the end of the rice season this value was kept at 8 inches (200 mm) to allow the ponded water to dissipate due to evaporation and deep percolation.

4.4.5.3 *Release Requirement*



This value was initially set at 2.275 mm/d to represent the continuous flow of water through the rice paddies that is used to control the salt concentration. During calibration this value was adjusted for some regions. These values can be found in SACVAL_Rice_Drainage.csv located in Data\Param\Rice.

4.4.5.4 *Target Depth*



The target depth was set using the timeseries described above.

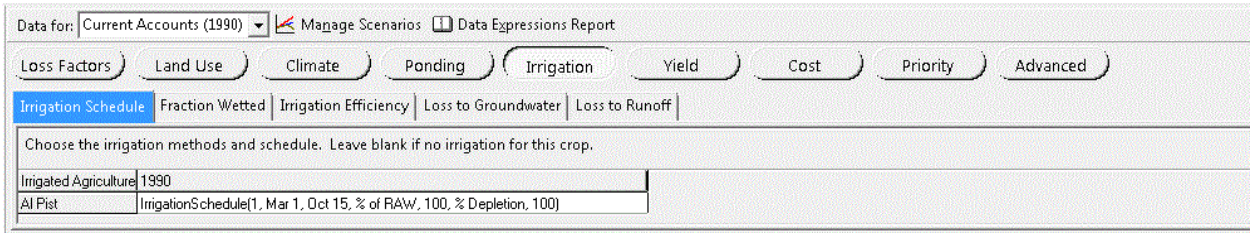
4.4.5.5 *Initial Surface Depth*

The flooding depth at the beginning of the water year is assumed to be 0 mm for all crops and non-irrigated areas in agricultural catchments.

4.4.6 Irrigation

Fraction Wetted, Irrigation Efficiency, Irrigation Schedule, Loss to Groundwater, and *Loss to Runoff* were specified in SacWAM.

4.4.6.1 *Irrigation Schedule*

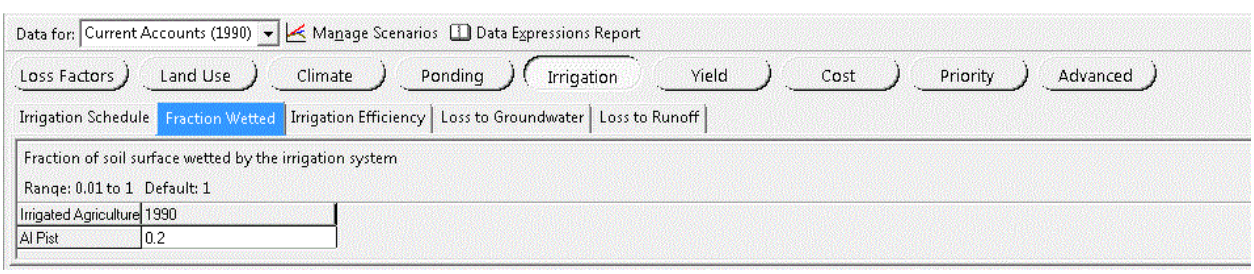


The irrigation schedule is used to enter parameters that control irrigation management. Multiple schedules can be entered if management varies over the growing season. In SacWAM all crops use one irrigation schedule. The information in the schedule includes:

1. The starting day (within the growing season) for which the parameters will apply. In SacWAM this is set to the first day of the growing season.
2. The ending day (within the growing season) for which the parameters will apply. In SacWAM this is set to the last day of the irrigation season.
3. The irrigation trigger. In SacWAM this is set to 100% of the Readily Available Water. The Readily Available Water is the portion of the Available Water Capacity that is usable by the plant without it experiencing water stress.
4. The irrigation amount. In SacWAM this is set to 100% of the depleted water. This means that irrigation will be sufficient to increase soil moisture to field capacity.

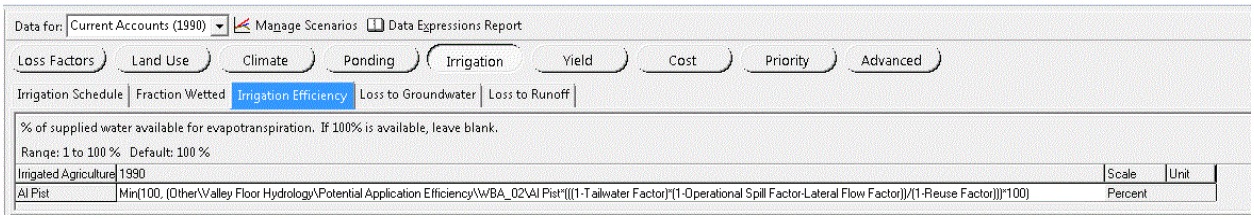
The exception to this is rice. Rice is irrigated if the Target Depth is non-zero and the ponding depth is less than the minimum depth. The irrigation schedule is ignored.

4.4.6.2 *Fraction Wetted*



The **fraction wetted** parameter sets the fraction of the soil that is wetted by an irrigation. This value is a function of the type of irrigation. A range of values from 0.3 to 1.0 is provided in Table 20 of FAO 56 (Allen et al., 1998). In SacWAM the values range from 0.2 for mature orchards to 0.75 for truck crops commonly irrigated with furrow irrigation. These values were set using the dominant irrigation technology found in the county land use reports (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a). For flooded rice, this value is set to 1.0 automatically.

4.4.6.3 *Irrigation Efficiency*



An **irrigation efficiency** is entered at the crop level for each DU, as shown above. *Irrigation Efficiency* is defined in WEAP as the percentage of supplied water available for ET. The following equation is used to calculate this parameter, and its value is constrained between 0 and 100 percent in SacWAM.

$$\textit{Irrigation Efficiency}\ (\%) = \text{PAE}.\ \frac{(1 - f_{TW}).(1 - f_{OS} - f_{LF})}{(1 - f_{RU})} \qquad \text{Equation 4-19}$$

where:

PAE= Potential Application Efficiency

f_{TW}= Tailwater Factor

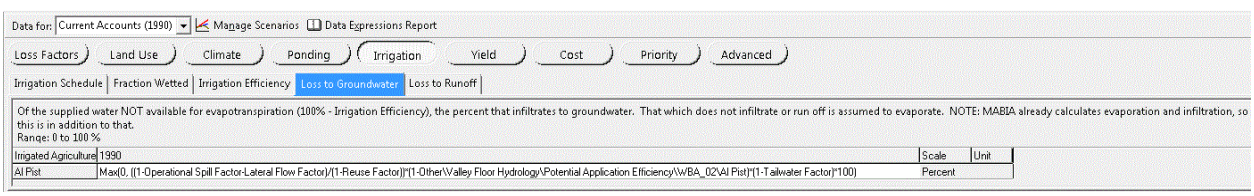
f_{os}= Operational Spill Factor

f_{LF}= Lateral Flow Factor

f_{RU}= Reuse Factor

Note: these factors are defined above in the Conceptual Framework section. For rice, the irrigation efficiency parameter is not used.

4.4.6.4 *Loss to Groundwater*



Loss to groundwater is entered at the crop level for each DU. It is defined as the percent of supplied water not available for ET (100% Irrigation Efficiency) that infiltrates to groundwater. The following equation is used to calculate this parameter, and its value is constrained between 0 and 100 percent in SacWAM.

$$\textit{Loss to Groundwater}\ (\%) = \frac{(1-f_{OS}-f_{LF})}{(1-f_{RU})} \cdot (1 - PAE) \cdot (1 - f_{TW}) \qquad \text{Equation 4-20}$$

where:

f_{os}= Operational Spill Factor

f_{LF}= Lateral Flow Factor

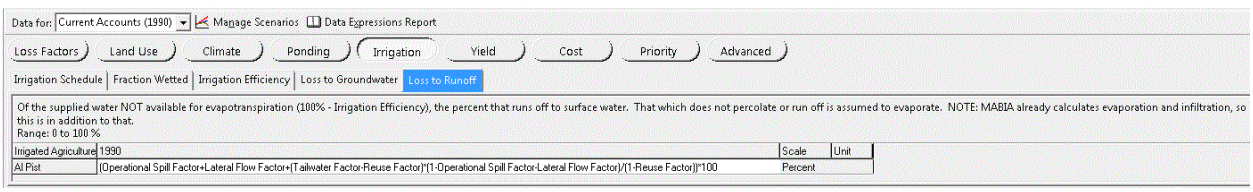
f_{RU}= Reuse Factor

PAE= Potential Application Efficiency

f_{TW}= Tailwater Factor

Note: these factors are defined above in the Conceptual Framework section. For flooded rice, this parameter is not used.

4.4.6.5 *Loss to Runoff*



Loss to runoff is entered at the crop level for each DU. It is defined as the percent of supplied water not available for ET (100%-Irrigation Efficiency) that runs off as surface water. The following equation is used to calculate this parameter, and that value is constrained between 0 and 100 percent in SacWAM.

$$\textit{Loss to Runoff}\ (\%) = f_{OS} + f_{LF} + (f_{TW} - f_{RU}).(1 - f_{OS} - f_{LF})/(1-f_{RU}) \qquad \text{Equation 4-21}$$

where:

f_{os}= Operational Spill Factor (as defined in as defined in 2.3.1.1 Loss Factors)

f_{LF}= Lateral Flow Factor (as defined in as defined in 2.3.1.1 Loss Factors)

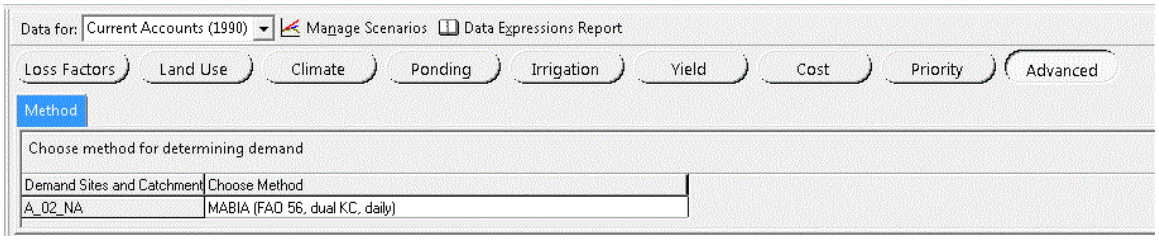
f_{TW}= Tailwater Factor (as defined in as defined in 2.3.1.1 Loss Factors)

f_{RU}= Reuse Factor (as defined in as defined in 2.3.1.1 Loss Factors)

Note: for flooded rice, this parameter is not used.

4.4.7 Advanced

4.4.7.1 *Method*



This is the screen in the WEAP interface where the calculation method for rainfall runoff and irrigation management is selected. In the case of the valley floor catchments, the MABIA crop water demand model was selected.

4.5 Refuge Catchment Parameters

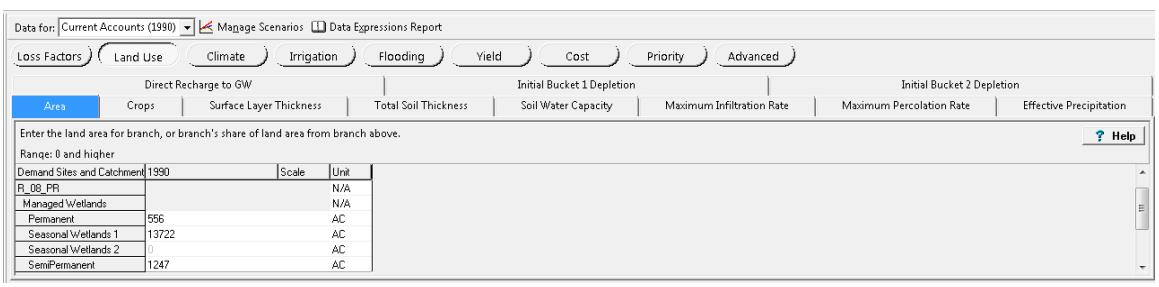
The refuge catchments in SacWAM simulate the management of wildlife refuges including the flooding of permanent, semi-permanent, and seasonal wetlands. Location information for datasets relating to these parameters is contained in Table 4-16.

4.5.1 Loss Factors

Loss associated with water deliveries to refuge catchments is treated in the same way as for agricultural catchments. See Section 4.4 for details.

4.5.2 Land Use

4.5.2.1 *Area*



The following are the data sources used to calculate **refuge land use** areas in SacWAM:

- Water Management Plans (Reclamation, 2011a-b)
- California Water Plan (DWR, 2005) and Update (DWR, 2009b)
- Butte and Sutter Basins Water Data Atlas (DWR, 1994c)
- Sacramento, Delevan, Colusa and Sutter NWRs Draft Comprehensive Conservation Plan (USFWS, 2008a)

Four SacWAM wetland classes are used to represent refuge habitat acreage, in addition to an “Uplands” class. These include: Permanent, SemiPermanent, Seasonal 1, and Seasonal 2. Many refuges and wildlife

areas include multiple class types. The classes have distinct management practices, each making favorable habitat for specific species.

Permanent

Permanent wetlands are kept flooded year-round, but are drawn down every few years to recycle nutrients, increase productivity and discourage carp populations. Water depths in permanent wetlands vary throughout the year due to precipitation patterns, but a permanent wetland will be flooded during every month of the year. Permanent wetlands serve as habitat for egrets, heron, and other fish-eating birds.

SemiPermanent

Semi-permanent wetlands are kept flooded ten months of the year (October through July) and provide wetland habitat during summer months when seasonal wetlands are not flooded. These wetlands are more productive than permanent wetlands because they have a drying cycle. Semi-permanent wetlands are flooded so that the water depth is between four and twelve inches in order to allow ducks and other water birds access to food.

Seasonal 1

Seasonal wetlands are kept flooded from October 1 to January 15 and are managed to grow seed and produce invertebrates for migratory waterfowl and shorebirds. They are typically shallow, and include plants such as swamp timothy and watergrass.

Seasonal 2

The second class of seasonal wetlands are kept flooded from September 1 to January 15 and are also managed to grow seed and produce invertebrates for migratory waterfowl and shorebirds.

Uplands

The “Uplands” SacWAM class contains terrestrial refuge habitat. This class contains non-flooded lands as well as roads and buildings within the refuges.

Refuge acreages were determined for federal and state refuge and wildlife areas. These data were extracted from a variety of sources. Where possible, Water Management Plans (Reclamation, 2011a-b) were used to determine the habitat acreage within NWRs and WAs. These plans exist for most national refuges, and include tables containing habitat types with their associated 2010 acreages. Table 4-10 provides information on the aggregation of Urban Water Management Plan (UWMP) habitat types into SacWAM classes.

Table 4-10. Urban Water Management Plan Habitat Types

SacWAM Class	UWMP Habitat Types
Permanent	Permanent wetland
SemiPermanent	Semi-permanent wetland/brood pond
Seasonal	Seasonal wetland – timothy (not irrigated) Seasonal wetland – timothy (irrigated) Seasonal wetland – smartweed Seasonal wetland – watergrass
Reverse	Reverse cycle wetlands
Uplands	Riparian Irrigated pasture Upland (not irrigated) Upland (managed) Upland (grains) Roads, buildings, etc. Miscellaneous habitat Other

The Sacramento, Delevan, Colusa and Sutter Draft Comprehensive Conservation Plan (USFWS, 2008a) was used to determine habitat acreage in Sutter NWR. The Draft Comprehensive Conservation Plan includes a map of Sutter NWR (Figure 9), with polygons of twelve different habitat types and their associated acreages. These acreages were aggregated into SacWAM refuge classes (Table 4-11).

Table 4-11. Sacramento, Delevan, Colusa, and Sutter Draft Comprehensive Plan Habitat

SacWAM Class	Draft Comprehensive Conservation Plan Habitats
Permanent	Permanent pond
SemiPermanent	Summer water
Seasonal	Seasonal flooded marsh Watergrass
Reverse	--
Uplands	Unclassified Mixed riparian Valley oak riparian Water Annual grassland Unmanaged freshwater wetland Perennial grassland Cottonwood willow

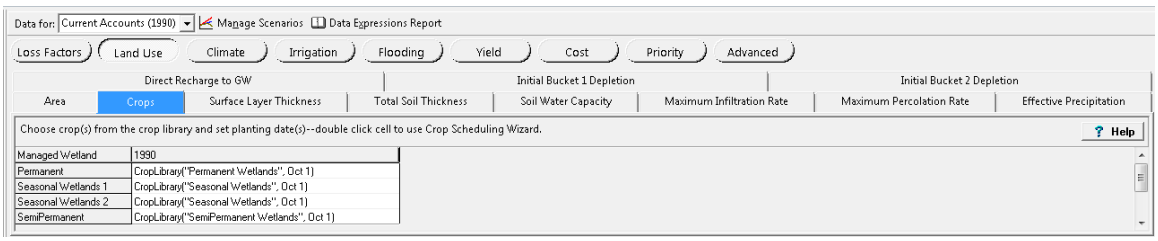
To determine habitat acreages for the Sutter and Butte Sink Duck Clubs, the Butte and Sutter Basins Water Data Atlas (DWR, 1994a) was used. In GIS, the map was overlaid on a parcel map and the various land holdings were analyzed. It was determined that all acreage in the Sutter and Butte Sink Duck Clubs should be considered “Seasonal” wetlands in SacWAM.

Habitat acreages for California wildlife areas are given in the California Water Plan (DWR, 2005) and Update (DWR, 2009b). These data are based on correspondence between DWR’s regional offices and wildlife area managers. Table 4-12 indicates how DWR habitat acreages are represented in SacWAM.

Table 4-12. DWR Habitat Classification

SacWAM Class	DWR Habitat
Permanent	Permanent ponds
SemiPermanent	Summer water
Seasonal	Seasonal marsh
	Watergrass
	Swamp timothy
	Smartweed
Reverse	Winter decomp
Uplands	--

4.5.2.2 *Crops*



Permanent, semi-permanent, seasonal 1 and seasonal 2 wetlands crop types were added to the **crop library**. These "crop" types were given a season length of 365 days and a crop coefficient of 1.0.

4.5.2.3 *Maximum Percolation Rate*

A *Maximum Percolation Rate* for Managed Wetlands was set at 0.025 in/day through *Other Assumptions\Valley Floor Hydrology\Calibration Factors\ Rice\MaxPercRate*. No maximum percolation rate was set for Uplands.

4.5.2.4 *Other Land-Use Parameters*

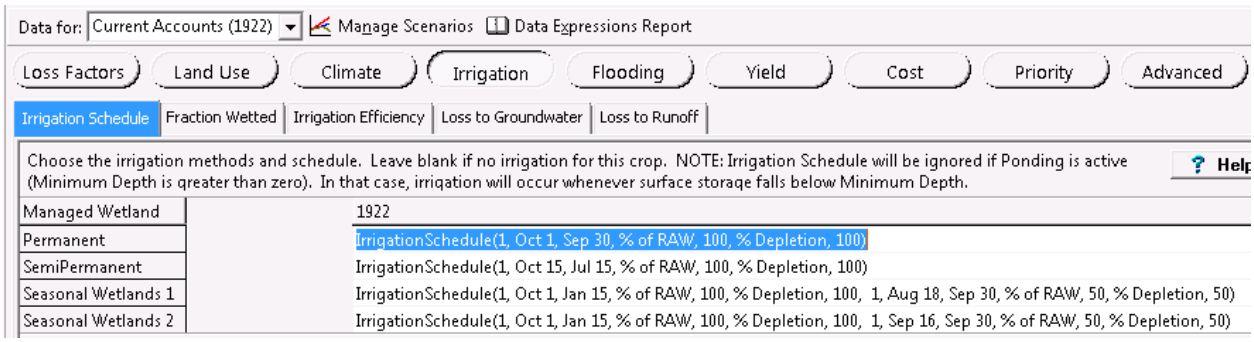
Other land-use parameters (*Surface Layer Thickness, Total Soil Thickness, Soil Water Capacity, Maximum Infiltration Rate, Effective Precipitation, Direct Recharge to GW, Initial Bucket 1 Depletion,* and *Initial Bucket 2 Depletion*) follow the same parameterization rules as indicated for agricultural and urban catchments. Refer to Section 4.4 for details.

4.5.3 Climate

All climate parameters follow the same parameterization rules as indicated for agricultural and urban catchments. Refer to Section 4.4 for details.

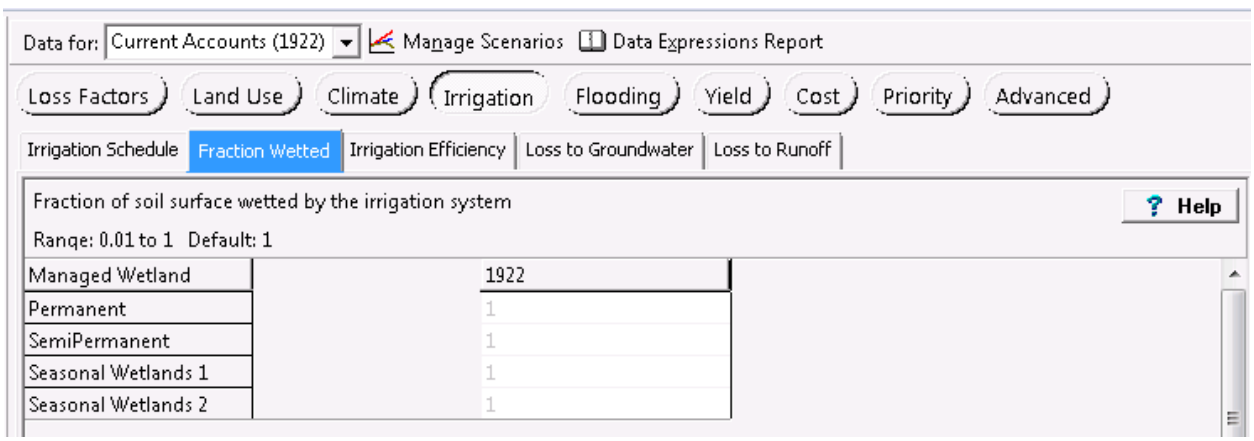
4.5.4 Irrigation

4.5.4.1 *Irrigation Schedule*



For wetlands, the irrigation schedule was set to be in effect during the flooding period. The irrigation trigger and irrigation amount parameters were given values of 30% of RAW and 100% of Depletion, however these values are meaningless as WEAP orders the irrigation necessary to maintain the Target Depth of ponding.

4.5.4.2 *Fraction Wetted*



This value is meaningless since the land is flooded. It was given the default value of 1.0.

4.5.4.3 *Other Irrigation Parameters*

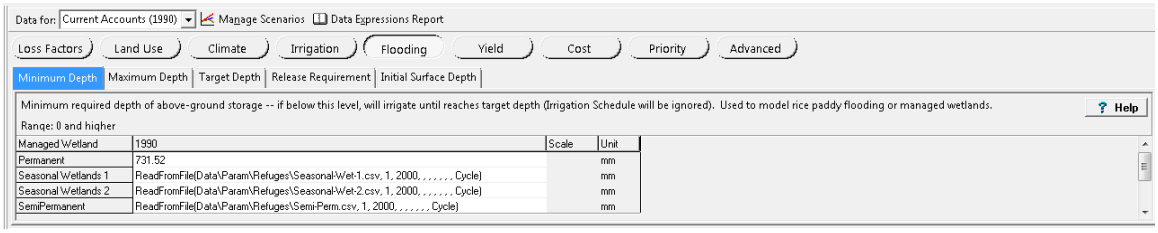
Other Irrigation Parameters include *Irrigation Efficiency*, *Loss to Groundwater*, and *Loss to Runoff*. These three parameters were given values of 100%, 0%, and 0% (WEAP default values) based on the assumption that there are no losses (other than the simulated deep percolation and evaporation) of water in the management of ponded wetlands.

4.5.5 Flooding

Flooded refuge lands were assumed to belong to one of four classes: permanent, semi-permanent, seasonal 1, or seasonal 2. The permanent wetlands have a constant depth of 30 inches (762 mm). The semi-permanent wetlands have a flooding schedule that starts October 15 and increases to 12 inches (300 mm) by October 31. This depth is maintained until July 31. Seasonal wetlands 1 are flooded from

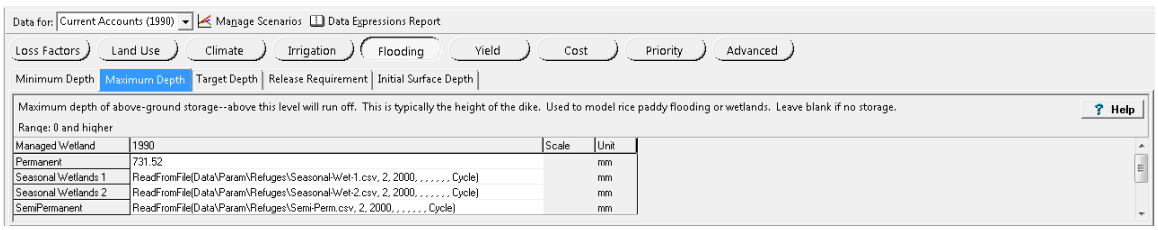
zero on September 1 to 12 inches (300 mm) on November 18. That depth is maintained until January 15. Seasonal wetlands 2 begins flood up on October 1 and reaches a depth of 12 inches (300 mm) by November 25. That depth is maintained until January 15.

4.5.5.1 *Minimum Depth*



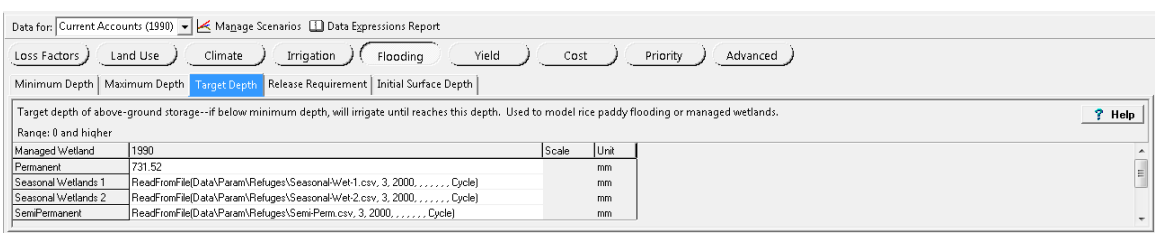
The minimum depth is specified using the timeseries described above.

4.5.5.2 *Maximum Depth*



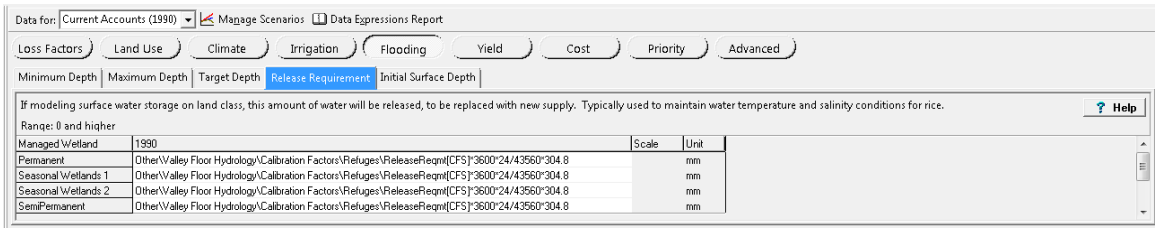
The maximum depth is specified using the timeseries described above with the exception that the maximum depth is held constant for an additional month in the winter to allow the seasonal wetlands to drain through infiltration and evaporation.

4.5.5.3 *Target Depth*



The target depth is specified using the timeseries described above.

4.5.5.4 *Release Requirement*



The release requirement for all flooded wetlands was set to 3 mm/d to simulate the flow through that managers utilize to maintain water quality.

4.5.5.5 *Initial Surface Depth*

This parameter was set to 476 mm for the permanent wetlands and 75 mm for the Seasonal Wetland 1. These are the only two wetland types that need a non-zero flood depth at the beginning of the water year (October 1).

4.5.6 Yield

The WEAP *Yield* feature for refuge catchments is not used.

4.5.7 Cost

The WEAP *Cost* feature for refuge catchments is not used.

4.5.8 Priority

4.5.9 Advanced

Use of the MABIA method is specified here, which follows the same parameterization rules as indicated for agricultural catchments. Refer to Section 4.4.7 for details.

4.6 Urban Catchment Parameters

Each urban area is represented by two nodes: a demand site (red) and a catchment (green). Urban catchments can be distinguished from their demand site counterparts by their "_O" suffix. For more on this distinction, see Urban Lands in Section 4.1.2.2. The urban catchment node in SacWAM contains parameters including Loss Factors, Land Use Climate, and Ponding. Refer to Table 4-16 for the location information of data associated with these parameters.

4.6.1 Loss Factors

The urban catchments simulate the rainfall runoff processes of the urban area. They do not simulate irrigation. Irrigation of urban landscapes is represented by the outdoor water in the urban demand sites. For that reason, the loss factors are generally not applicable to the urban catchments.

4.6.1.1 *Minimum Groundwater Pumping Factor*

For a complete discussion, see the corresponding Minimum Groundwater Pumping Factor sub-section in the Agricultural Catchments Section (4.4.2.6). For urban DUs, the factor is equal to 0.0, except for DUs U_02_SU, U_03_SU, U_26_NU2, and U_26_PU5, with factors of 0.3, 0.3, 0.2, and 0.5, respectively.

4.6.2 Land Use

4.6.2.1 *Area*

The following are the data sources used to determine **urban land use** data for SacWAM DUs:

- Important Farmland maps (Department of Conservation, 2006)
- County land use surveys undertaken by DWR's DSIWM, formerly Division of Planning and Local Assistance (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a)

Since urban catchments are used to simulate runoff for DUs, land use acreages for these areas were needed. Land use in urban areas is divided among two land use classes: UR and NV. These land classes were aggregated from DWR Land Use Classifications for urban (Table 4-13) and native vegetation lands (Table 4-14).

Table 4-13. DWR Land Use Classifications Included in SacWAM Urban Land Use Classes

Category	Code	Description
Semi-agricultural	S1	Farmsteads
	S2	Livestock Feed Lots
	S3	Dairies
	S4	Poultry Farms
Urban	U	Not Classified
Urban Commercial	UC	Not Classified
	UC1	Offices, Retailers
	UC2	Hotels
	UC3	Motels
	UC4	Recreation Vehicle Parking, Camping
	UC5	Institutions
	UC6	Schools
	UC7	Municipal Auditoriums, Stadiums, Theaters
	UC8	Misc. High Water Use
Urban Industrial	UI	Not Classified
	UI1	Manufacturing, Assembling and Processing
	UI2	Extractive Industries
	UI3	Storage and Distribution
	UI6	Saw Mills
	UI7	Oil Refineries
	UI8	Paper Mills
	UI9	Meat Packing Plants
	UI10	Steel and Aluminum Mills
	UI11	Fruit and Vegetable Canneries
	UI12	Misc. High Water Use
	UI13	Sewage Treatment Plant/Ponds
	UI14	Waste Accumulation Sites
	UI15	Wind/Solar Farms
Urban Landscape	UL	Not Classified
	UL1	Lawn Area (irrigated)
	UL2	Golf Course (irrigated)
	UL3	Ornamental Landscape (irrigated)
	UL4	Cemeteries (irrigated)
	UL5	Cemeteries (not irrigated)
Urban Residential	UR	Not Classified
	UR1	Single Family (1-5 acres)
	UR2	Single Family (1-8 units/acre)
	UR3	Multi Family
	UR4	Trailer Courts
	UR11	Single Family (1-5 acres), <25% irrigated
	UR13	Single Family (1-5 acres), 51%-75% irrigated
Urban Vacant	UV	Not Classified
	UV1	Unpaved Areas
	UV3	Railroad Right-Of-Way
	UV4	Paved Areas
	UV6	Airport Runways

Table 4-14. DWR Land Use Classifications Included in SacWAM Native Vegetation Land Use Classes

Code	Description
NR4	Seasonal Duck Marsh
N45	Permanent Duck Marsh
E	Entry Denied
I	Idle
I1	Land not cropped in current or previous season, but cropped in past 3 years
I2	New lands being prepared for crop production
NB	Barren Land
NB1	Dry Stream Channel
NB2	Mine Tailing
NB3	Native Barren
NC	Native Classes Unsegregated
NR	Riparian Vegetation
NR1	Marsh
NR2	High Water Table Meadow
NR3	Trees and Shrubs
NS	Not Surveyed
NV	Native Vegetation
NV1	Grass
NV2	Light Brush
NV3	Medium Brush
NV4	Heavy Brush
NV5	Brush and Timber
NV6	Forest
NW	Water Surface

ICA of DAUs from water years 1998-2007 was obtained from the DSIWM. The average annual ICA for this 10-year period was assumed to be representative of "existing conditions." Then a survey of land use for the Central Valley was assembled from county land use surveys to create a continuous mosaic in GIS, although the land use data are derived from different years. The GIS mosaic was intersected with DU polygons and with DAU polygons to obtain the historical irrigated land area for each DU and for each DAU. These historical values were converted to a value representing existing conditions by scaling the historical land use data to match the 10-year DAU value. The following example illustrates this process:

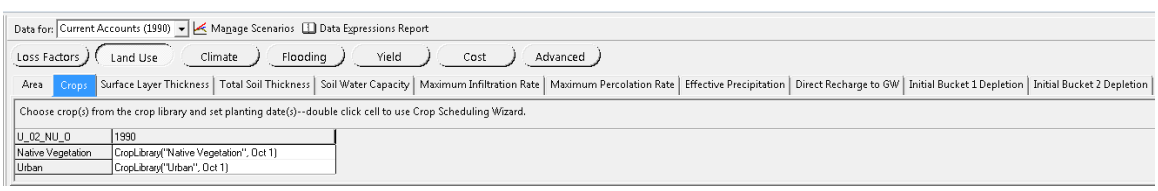
1. Assume the 10-year historical average for wheat in DAU X=10,000 acres
2. Assume the GIS data from the land use mosaic shows 8,000 acres of wheat in DAU X
3. Assume the GIS data from the land use mosaic shows 500 acres of wheat in DU A
4. If DU A is located within DAU X, the existing level acreage for wheat=500*(10,000/8,000) acres

In instances in which irrigated land exists inside municipal boundaries (which are represented by an urban DU), the irrigated land was 'removed' from the urban DU and associated with a neighboring agricultural DU. For example, assume there exist 4,000 acres of irrigated land in U_02_NU and 6,000 acres of irrigated land in neighboring agricultural DU A_02_NA. The 4,000 acres of irrigated land were removed from U_02_NU and associated with A_02_NA. Consequently, there are 10,000 total acres of irrigated land represented by agricultural DU A_02_NA. The total areas of each DU (A_02_NA and U_02_NU) were preserved by adjusting the amount of native vegetation adjusted. In the example

above, 4,000 acres of native vegetation lands would be added to DU U_02_NU and 6,000 acres of native vegetation lands would be subtracted from A_02_NA.

Although there is an "urban" land use classification within the ICA-DSIWM dataset, Important Farmland maps (Department of Conservation, 2006) were used instead as they provide updated information on urban land areas. Important Farmland maps are provided by county from the Farmland Mapping and Monitoring Program. To create these maps, current land use information is combined with NRCS soil survey data (NRCS, 2013b). Land use type for the Important Farmland dataset was determined using current and historical aerial imagery coupled with field verification. Aerial image sources include the US Department of Agriculture National Agricultural Imagery Program, AirPhotoUSA, the High Altitude Missions Branch of the National Aeronautics and Space Administration (NASA), USGS' Earth Resources Observation and Science (EROS) Center, and SPOT Data Corporation (Department of Conservation, 2006). Lands are grouped into the following classes: Prime Farmland, Farmland of Statewide Importance, Unique Farmland, Farmland of Local Importance, Grazing Land, Urban and Built-Up Land, Other Land, and Water. Acreages from Department of Conservation classes "Urban and Built-Up Land" were used to represent the SacWAM urban land class (UR). Since these data were presented on the county level, these acreages were intersected with a county-DAU layer and a DU layer to determine the urban acreages at the DAU and DU level. Because these acreages were used instead of the ICA-DSIWM dataset, an adjustment had to be made to preserve the total area of the DUs. Consequently, an adjustment was made for native vegetation acreage to offset the increase or decrease in urban acreage within a single DU.

4.6.2.2 *Crops*



Native Vegetation and Urban classes were added to the **crop library** (General>Crop Library), just as agricultural crops were. Since these "crop types" have no planting date, these "crops" were given a planting date of October 1 (the start of the water year) and a season length of 365 days.

4.6.2.3 *Maximum Percolation Rate*

A *Maximum Percolation Rate* was not set for the urban class of urban catchments; it was set at 1000 for the native vegetation class under *Other Assumptions\Valley Floor Hydrology\Calibration Factors\MaxPercRate_NV*.

4.6.2.4 *Other Land-Use Parameters*

Other land-use parameters (*Surface Layer Thickness, Total Soil Thickness, Soil Water Capacity, Maximum Infiltration Rate, Effective Precipitation, Direct Recharge to GW, Initial Bucket 1 Depletion,* and *Initial Bucket 2 Depletion*) follow the same parameterization rules as indicated for agricultural catchments. Refer to Section 4.4 for details.

4.6.3 Climate

All climate parameters (*Precipitation, ETref, Min Temperature, Max Temperature, Latitude, Min Humidity, Average Humidity, Max Humidity, Wind, Wind speed measurement height, Altitude, Solar Radiation, Sunshine Hours, Cloudiness Fraction,* and *Krs*) follow the same parameterization rules as indicated for agricultural catchments. Refer to Climate in Section 4.4 for details.

4.6.4 Flooding

Flooding does not apply to urban catchments. Therefore all parameters remain as their WEAP default value (*Initial Surface Depth*, *Minimum Depth, Maximum Depth, Target Depth,* and *Release Requirement* all have values of 0 mm).

4.6.5 Yield

The WEAP 'Yield' feature for urban catchments is not used.

4.6.6 Cost

The WEAP 'Cost' feature for urban catchments is not used.

4.6.7 Advanced

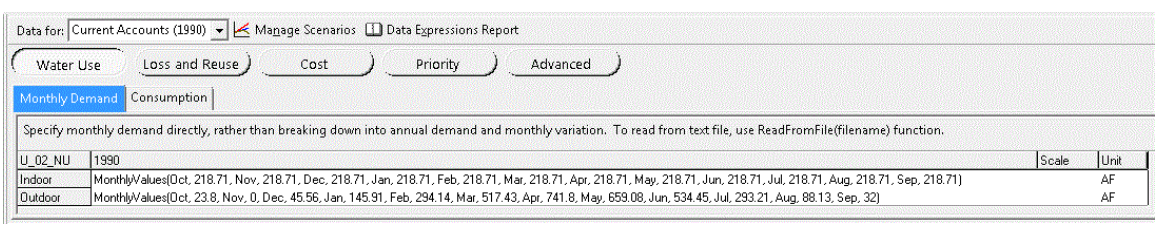
Use of the MABIA method is specified here, which follows the same parameterization rules as indicated for agricultural catchments. Refer to Advanced in Section 4.4 for details.

4.7 Urban Demand Site Parameters

Urban demand sites contain data on monthly indoor and outdoor use of piped water for urban DUs. They can be distinguished from urban catchments by their lack of "_O" at the end of their label. Rainfall runoff processes related to urban land are simulated in the urban catchment objects. Location information for urban demand site data is provided in Table 4-16.

4.7.1 Water Use

4.7.1.1 *Monthly Demand*



Monthly Demand was specified for Indoor (D_I) and Outdoor (D_O) use in SacWAM and are given in acre-feet. The following are the data sources used to determine monthly water demands for urban areas:

DSIWM datasets are summarized in the California Water Plan (Bulletin 160-09 series), and in periodic urban water use (Bulletin 166 series) and industrial water use reports (Bulletin 124 series) (DWR, 1982, 1994d). Water use data from years 1998 to 2003 (DWR, 2011) include:

- population by DAU,
- percentage water use by customer class (residential, manufacturing, commercial, industrial, large landscape),
- indoor-outdoor split for residential and commercial sectors,
- source of water (groundwater or surface water), and
- per capita water use (DWR Northern Regional Office).

Urban Water Management Plans

California municipal suppliers providing service to more than 3,000 customers or supplying more than 3,000 acre-feet of water per year are required to prepare and follow an UWMP. These plans are submitted to DWR every five years, and are summarized by DSIWM as part of the California Water Plan. Suppliers report and evaluate their water deliveries and uses, water supply sources, efficient water uses, and demand management measures. These plans also include information on base daily per capita water use, urban water use targets, interim urban water use targets, and compliance daily per capita water use. UWMPs aim to help municipal suppliers develop long-term conservation plans.

Water Forum Agreement

The Water Forum Agreement helps manage water supply for regions next to the lower American River, and specifically applies to water purveyors within WBAs 26N and 26S (Water Forum, 2006). The goal of this agreement is to balance providing a safe and reliable water supply with maintaining ecological and recreational habitat.

National Census Data

The US Census Bureau collects information via a mailed questionnaire every 10 years. Questions regard income, ethnicity and housing. Geospatial population data are then given on the block-level and larger geographical units. These data are available online at www.census.gov.

Urban demands were determined mostly using Public Water System Statistics (PWSS) questionnaires and 2010 Census data, with some information provided from UWMPs and the integrated groundwater–surface water model developed for Placer, Sacramento, and San Joaquin Counties. Calculation of urban demands relied on the same process as that used in DSIWM. The only exception is that the data provided by DSIWM were originally at the county or DAU scale, and then aggregated at the DU level in SacWAM.

DSIWM collects water use and population data through PWSS questionnaires that are mailed annually to public water purveyors. The data collected from the purveyors in these questionnaires include water production data, population data, metered water deliveries (if applicable), and active service connections by customer class. The six customer classes are: Single-Family Residential, Multi-Family Residential, Residential, Commercial, Industrial, and Landscape, and Other. The “Other” class includes a variety of uses, such as system flushing and wholesale water sold. These data exist through calendar year 2010.

PWSS publicly served water purveyor production data are used to determine urban water demands in SacWAM. The assumption made in using this dataset is that water demands are equal to water

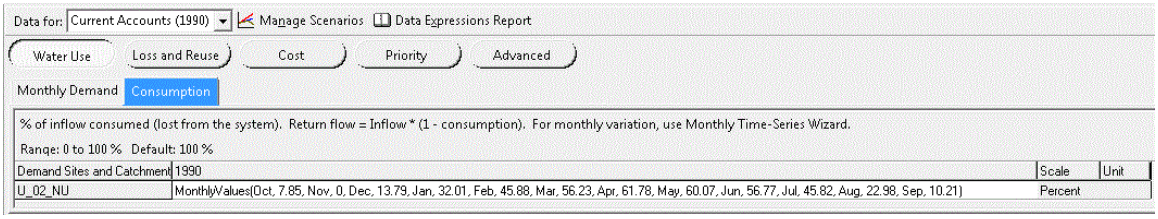
production data. Total urban water demand is the sum of production data for public and self-supplied users, but only publicly supplied production data are given in PWSS questionnaires. Publicly supplied and self-supplied production data were combined to determine urban water demands on the county or DAU scale. These data were then aggregated at the urban DU level for use in SacWAM. For each DU, a list of water purveyors, the population served by that purveyor, and water production data are given. To determine the population that is self-supplied rather than publicly supplied, the population served by public water suppliers was subtracted from the total population within a WBA. The total population within a WBA was determined from 2010 National Census data. This calculation assumes that the population located outside public WA service areas is self-supplied by groundwater. Water use for the self-supplied population was determined by calculating the product of the population and per capita water use. Data on per capita water use was determined in a dataset supplied by DWR's Northern Regional Office. SacWAM population estimates were determined from DSIWM data for 2010, and were defined by DU in the following way:

- GIS data layers of county and DAU boundaries are intersected with 1990 and 2000 census block data to estimate populations for these years.
- California Department of Finance estimates define city (incorporated) and unincorporated populations for counties following year 2000.
- Unincorporated population defined by the California Department of Finance is disaggregated into county-DAUs based on growth rates for unincorporated populations from 1990 to 2000.

SacWAM uses monthly urban demands, so annual DSIWM data had to be disaggregated before being input into SacWAM. Monthly urban demands were based on historical production data for water years 2006 to 2010 from PWSS. In some cases, no delivery data were available for cities within a SacWAM DU, so the monthly delivery pattern is assumed to be the same as that of an adjacent DU. Within the urban demand site node, SacWAM separates urban demand sites into two classes: indoor and outdoor demands. SacWAM defines the monthly indoor demand as equivalent to the demand of the lowest month, and assumes that the indoor demand is constant throughout the year. The outdoor demand class for each month is defined as the difference between that month's total demand and the indoor demand. For example, the minimum demand month for "U_02_NU" is February, with a demand of 218.71 acre feet, so the indoor demand is 218.71 acre feet for each month of the year. In March, the total demand is 264.27 acre feet, so the outdoor demand for March is 45.56 acre feet (264.27-218.71=45.56 acre feet). Urban demand data are input into WEAP as a monthly timeseries. The **urban demand** includes all processing steps relating to the *Monthly Demand* data input into SacWAM.

There are SacWAM regions where no PWSS data exist. In these cases, *Monthly Demand* data were taken from the 2010 UWMPs, and aggregated on the DU level. For regions in SacWAM WBAs 26S and 26N, water purveyor data assembled by Boyle Engineering in the Integrated Groundwater Surface Water Model were used.

4.7.1.2 *Consumption*



Consumption is defined as the percentage of inflow that is consumed (lost from the system). **Urban consumption** monthly demands are explicitly divided into indoor and outdoor water use, so the percentage of consumed water must include a weighted average of these two demands. Indoor consumption is assumed to be zero percent, meaning that there is no loss from the system. SacWAM assumes that 80% of water for outdoor use is consumed (through landscape ET). The following equation is used to calculate monthly consumption for urban demand sites:

$$\textit{Consumption (\%)}=\frac{(0*D_I+0.8*D_O)}{(D_I+D_{O)}}$$

where: D_O= Outdoor Monthly Demand (as defined above in Monthly Demand, Section 4.7.1.1)

For urban demand sites that discharge to surface water bodies, such as to the Sacramento Regional WWTP, the assumption that indoor consumption is zero percent and outdoor consumption is 80 percent is tested during calibration. Historical flows from WWTPs were obtained from the California Data Exchange Center (CDEC), and used to compare to model outputs. Where outflows do not match historical data, the *Loss to Groundwater* parameter was adjusted.

4.7.2 Loss and Reuse

4.7.2.1 *Loss Rate*

The *Loss Rate* is assumed to be equal to 0.

4.7.2.2 *Reuse Rate*

The *Reuse Rate* is assumed to be equal to 0.

4.7.3 Cost

The WEAP *Cost* feature for urban demand sites is not used.

4.7.4 Priority

Demand priorities are discueed in Section 7.2.4.

4.7.5 Advanced

Use method for specifying water use is “monthly demand.”

4.8 Other Demand Site Parameters

4.8.1 South of Delta Demands

Water demands located south of the Delta and served by the DMC and California Aqueduct were included in the model to correctly represent the simulation of Delta exports. Demands for water from the DMC and California Aqueduct were divided into agricultural, exchange, urban, and refuge demands (Table 4-15). Additional "demands" were developed to represent losses. All values were derived from DWR's **Bulletin 113** and **CVP Contractor data**.

Table 4-15. Demand Nodes Used to Represent CVP and SWP South of Delta Demands

State Water Project	Central Valley Project
SWP South Bay Aqueduct Losses	CVP Upper DMC Ag Demands
SWP Upper CA Demands	CVP Upper DMC Urban Demands
SWP CA Demands North	CVP Upper DMC Losses
SWP CA Losses R1 to R2	CVP Upper DMC Water Rights
SWP San Luis Canal Losses R3 to R7	CVP Lower DMC Ag Demands
SWP CA Losses South R8C to R18A	CVP Lower DMC Refuge Demands
SWP South Coast Losses R17 to R30	CVP Lower DMC Exchange Demands
SWP CA Demands South	CVP Lower DMC Losses
SWP Demands South Coast	CVP San Felipe Ag Demands
Cross Valley Canal	CVP San Felipe Urban Demands
	CVP San Luis Canal Ag Demands
	CVP San Luis Canal Urban Demands
	CVP San Luis Canal Refuge Demands
	CVP San Luis Canal Losses R3 to R7
	CVP Mendota Pool Ag Demands
	CVP Mendota Pool Refuge Demands
	CVP Mendota Pool Exchange Demands
	CVP Mendota Pool Water Rights Demands
	CVP CA Refuges

Key: CA=California Aqueduct; CVP=Central Valley Project; DMC=Delta-Mendota Canal; SWP=State Water Project.

4.8.1.1 *Water Use*

Annual Activity Level

The WEAP *Annual Activity Level* feature for other demand sites is not used.

Annual Water Use Rate and Monthly Varaition

Monthly demands for south-of-Delta CVP and SWP contractors are set equal to the product of the annual full contract amount and percent monthly variation. For the CVP, this variation is based on recent historical deliveries.

Monthly Demand

Monthly demands for south-of-Delta SWP contractors are specified by month. These demands are dynamically calculated based on the Table A amount and the monthly pattern of requests, which is a function of the SWP allocation.

Consumption

All deliveries to CVP and SWP south-of-Delta contractotrs is assumed to be 100 percent consumed, as all return flows exit the model domain.

4.8.1.2 *El Dorado ID*

Demands served by the Sly Park project are represented with the El Dorado ID demand site. Demand data were derived from historical flows through the **Camino Conduit**.

4.9 Data Directory

Table 4-16 provides location information in the 2014_WB_WEAP data directory for the datasets referenced in Chapter 4.

Table 4-16. File Location Information for Valley Floor Demand Sites and Catchments

Referenced Name	File Name	File Location*
agricultural land use	SACVAL_Ag_LU_Area.xlsx	Agricultural_Catchments\Land_Use
Bulletin 113	132-12_Table1-6.pdf and 132-12_TableB-4.pdf	South of Delta Demand Sites
Camino Conduit	Camino Conduit Demand Calculation.xlsx	Other Demand Sites
crop library	Crop Library.xlsx	Agricultural_Catchments\Land_Use
CVP Contractor Data	CVP_Water_Contractors_2015.pdf	South of Delta Demand Sites
Daily CIMIS RH Analysis	Daily CIMIS RH Analysis.xlsm	Climate\Valley Floor
delta land use	SACVAL_Ag_Delta_LU_Area.xlsx	Agricultural_Catchments\Land_Use
effective precipitation	Effective Precipitation.xlsx	Agricultural_Catchments\Land_Use
ET calibration	ET Calibration.xlsx	Agricultural_Catchments\Land_Use
evaporative loss	SACVAL_Evaporative_Loss.xlsx	Agricultural_Catchments\Loss_Factors
fraction wetted	SACVAL_FractionWetted.xlsx	Agricultural_Catchments\Irrigation
groundwater pumping	SACVAL_Minimum_Goundwater_Pumping.xlsx	Agricultural_Catchments\Loss_Factors
irrigation efficiency	SACVAL_Irrigation_Efficiency.xlsx	Agricultural_Catchments\Irrigation
lateral flow	SACVAL_Lateral_Flow.xlsx	Agricultural_Catchments\Loss_Factors
latitudes	catchment_and_DU_latitudes.xlsx	...
Livneh grid	Livneh_Grid_Coords_UTM11.shp	GIS\Climate
loss to groundwater	SACVAL_Loss_to_Groundwater.xlsx	Agricultural_Catchments\Irrigation
loss to runoff	SACVAL_Loss_to_Runoff.xlsx	Agricultural_Catchments\Irrigation
operational spills	SACVAL_Operational_Spill.xlsx	Agricultural_Catchments\Loss_Factors
potential application efficiencies	*Individual files by Water Budget Area*	Agricultural_Catchments\Loss_Factors\PAE
rainfall runoff calibration	Rainfall Runoff Calibration.xlsb	Other_Assumptions\Valley Floor Hydrology\SCS Curve Number
refuge land use	SACVAL_Refuge_LU_Area.xlsx	Refuge_Catchments\Land_Use
reuse	SACVAL_Reuse.xlsx	Agricultural_Catchments\Loss_Factors
rice management description	Hillaire_2000.pdf	References
seepage loss	SACVAL_Seepage_Loss.xlsx	Agricultural_Catchments\Loss_Factors
surface soils	Central Valley Soil Analysis.xlsm	Agricultural_Catchments\Land_Use
tailwater	SACVAL_Tailwater.xlsx	Agricultural_Catchments\Loss_Factors
urban consumption	SACVAL_Urban_WU_Consumption.xlsx	Urban_Demand_Sites\Water_Use
urban demand	SACVAL_Urban_WU_MonthlyDemands.xlsx	Urban_Demand_Sites\Water_Use
urban land use	SACVAL_Urban_LU_Area.xlsx	Urban_Catchments
valley floor processor	Valley_Floor_Livneh_Data_Processor.xlsm	Climate\Valley Floor
water budget areas	water_budget_areas.shp	GIS\Boundaries
WEAP Input Data	*Individual files by catchment*	Climate\WEAP Input Data

*Files located at Data\Demand_Sites_and_Catchments\... except for Rainfall Runoff Calibration (Data\...), Rice Management Description (References\...), and GIS files (GIS\...).

3