CALIFORNIA TURF

This scenario is intended to represent turf areas (golf courses, parks, sod farms, and recreational fields) in central/northern California. Golf courses and turf farms generally both apply pesticides, however for this scenario parameters were selected to represent golf courses. Consultation with University of California Cooperative Extension (D. Haver, personal communication) indicated that parameterzing the scenario as golf course turf would generally be most conservative due to steeper slopes and proximity of golf courses to surface water resources (a majority of turf farms are located in the desert). Analyses were conducted within a refined area of interest (AOI) where there is a high density of golf courses, precipitation is expected to be high, and irrigation is common (Figure 1).

The most common turfgrass used for athletic fields, parks, and golf courses in California is common bermudagrass (Cynodon dactylon). Other major species used for turfgrass in California include Bentgrass (*Agrostis* spp.*),* Kentucky bluegrass (*Poa pratensis*), ryegrass (*Lolium* spp.), tall fescue (*Festuca arundinacea*), fine fescues (*Festuca* spp.), kikuygrass (*Pennisetum clandestinum*), St. Augustinegrass (*Stenotaphrum secundatum*), zoysiagass (*Zoysia japonica*), and dichondra (*Dichondra micrantha*). Crop parameters for this scenario are based primarily on bermudagrass (*Cynodon* spp.) since it is a primary turf grass for golf courses and athletic fields. Common bermudagrass is drought tolerant and well adapted to sunny conditions. It is a medium, coarse-textured grass with a gray green color, but it becomes dormant and loses its color in cold weather. Common bermudagrass establishes a deep root system and produces long rhizomes and stolons. Common bermudagrass is planted in the spring or summer at a rate of 1 lb seed/1000 sq. ft. Common bermudagrass requires frequent mowing to maintain an attractive quality. It has good wear quality when it is growing, but produces heavy thatch and can produce thatch in light traffic areas (UCIPM, 2003). There are new seeded cultivars of common bermudagrass that have improved turfgrass quality characteristics. Within the vicinity of the AOI, bermudagrass is a common turf grass for golf courses, (Darren Haver, Watershed Management Advisor, UC Cooperative Extension). Bermudagrass grows on a wide variety of soils, from heavy clays to deep sands; tolerating acidic, alkaline and saline conditions. Bermudagrass does best on well-drained sites. Bermuda grass can survive low fertility conditions but requires high nitrogen concentrations for production of good quality turf (Duble 2004).

Metfile W23234 was selected for this scenario since it is the closest metfile to San Francisco. Its data were collected in San Francisco, CA. The station is located approximately 2 meters above mean seal level (AMSL). San Francisco receives approximately 20 inches of rainfall annually with nearly 60% of the annual precipitation occurring in January, February, and March (NOAA, 2006). This station is the closest available weather station that includes data required for PRZM.

Reliable and detailed spatial data regarding the locations and extent of golf courses in the Bay Area are unavailable. In the absence of detailed data, a coarse analysis of golf course locations with respect to STATSGO soils was performed using soils data from NRCS (USDA, 2006a) and the golf locales coverage obtained from Environmental Systems Research Institute, Inc. (ESRI, 2005). Soils were selected based on the overlap between golf courses in the AOI. Based on a geospatial analysis of soils (USDA 2006) and golf course locales (ESRI 2005), Capay soils were chosen to represent turf in the AOI (Table 5).

Based on the soils analysis, approximately 35% of the soils overlapping golf course locales are in hydrologic group D. The Capay series was chosen to represent turf areas in the AOI (Table 5) because it is a one of the most common hydrologic group D soils co-located with golf courses, is among the most erodible, and includes the maximum slope on which golf courses are located (D. Haver, personal communication). Capay soils are in Hydrologic Group D soils and are located on the western edge of the Sacramento Valley and intermountain valleys of the Coast Range of northern California. The soil is extensive in MLRA-17 and has been mapped in MLRA 14 in some places (USDA, 2006b). Clear Lake soils (also widespread) were not used for scenario parameterization since the USLEK (0.174 – 0.24) is significantly lower than Capay. Capay soils co-located with golf course locales in the AOI have a USLE K factor of 0.17 to 0.37 which includes the 90th percentile of these soils in erodibility (Table 5). The Capay series is Fine, smectitic, thermic Typic Haploxererts. Capay soils are on alluvial fans, alluvial flats, interfan basins and basin rims with slopes ranging from 0 to 9 percent. (USDA 2006). Capay soils have an A horizon from 0 to 5 inches (0 to 13 cm) deep and a B horizon from 5 to 62 inches (13 to 157 cm) deep (USDA, 2006).

Table 1. PRZM 3.12 Climate and Time Parameters for San Francisco, CA.		
Parameter	**Value**	**Source/Comments**
Starting Date	Jan. 1, 1961	Meteorological File from San Francisco, CA (W23234)
Ending Date	Dec. 31, 1990	Meteorological File from San Francisco, CA (W23234)
Pan Evaporation Factor (PFAC)	0.77	PRZM Manual Figure 5.1 (EPA 1998). Value represents much of CA coastline.
Snowmelt Factor (SFAC)	0	Snow is not expected to occur in San Francisco.
Minimum Depth of Evaporation (ANETD)	17.5	Mid point of range (15-20), PRZM Manual, Figure 5.2 (EPA 1998).

Table 2. PRZM 3.12 Erosion and Landscape Parameters for California Turf.		
Parameter	**Value**	**Source/Comments**
Method to Calculate Erosion (ERFLAG)	4 (MUSS)	Default value.
USLE K Factor (USLEK)	0.37 tons EI^{-1}*	NRCS Soil Data Mart Database for Capay Silty Clay Loam, Solano County, CA. (http://soildatamart.nrcs.usda.gov/).
USLE LS Factor (USLELS)	1.8	Calculated according to Haan and Barfield (1978) equation: $LS = ((\lambda/72.6)^m)((430x^2 + 30x + 0.43)/6.613)$, where λ = slope length, x = SLP/100 and m = constant. In this case, λ = 400 m (default value) and m = 0.5 (EPA 2004).
USLE P Factor (USLEP)	0.5	Set to 0.5 for 3-8% slopes (EPA 2004).
Field Area (AFIELD)	172 ha	Area of Shipman Reservoir watershed (EPA, 1999)
NRCS Hyetograph (IREG)	1	PRZM Manual, Figure 5.12 (EPA, 1998). Value represents most central CA and parts of northern CA where most golf course are located.
Slope (SLP)	7.5 %	Slopes range from 5-10%. (Darren Haver, Watershed Management Advisor, UC Cooperative Extension). Midpoint of the range (EPA, 2004).
Hydraulic Length (HL)	600 m	Shipman Reservoir (EPA, 1999)
Irrigation Flag (IRFLAG)	1	Darren Haver, Watershed Management Advisor, UC Cooperative Extension. 1 = year round
Irrigation Type (IRTYP)	3 (sprinkler)	Golf courses irrigate year round. (Darren Haver, Watershed Management Advisor, UC Cooperative Extension); and Irrigation Guidance for developing PRZM Scenarios, Table 3; (EPA 2005).
Leaching Factor (FLEACH)	0.1	Irrigation Guidance for developing PRZM Scenario, Table 3; (June 15, 2005).

Fraction of Water Capacity when Irrigation is Applied (PCDEPL)	0.5	Turf irrigation is highly variable in California. Courses typically have irrigation specialists. (D. Haver, Watershed Management Advisor, UC Cooperative Extension). Set to default as per Irrigation Guidance for developing PRZM Scenario, Table 3; (EPA 2005).
Maximum Rate at which Irrigation is Applied (RATEAP)	0.1 cm hr^{-1}	Turf irrigation is highly variable in California. Courses typically have irrigation specialists. (D. Haver, Watershed Management Advisor, UC Cooperative Extension). Set to default as per Irrigation Guidance for developing PRZM Scenario, Table 3; (EPA 2005).
* EI = 100 ft-tons * in/ acre*hr		

Table 3. PRZM 3.12 Crop Parameters for California - Turf.		
Parameter	**Value**	**Source/Comments**
Initial Crop (INICRP)	1	Default value
Initial Surface Condition (ISCOND)	2	2 = cover crop. Cover crops are typically planted on golf courses to keep them green when bermudagrass goes dormant (Darren Haver, Watershed Management Advisor, UC Cooperative Extension).
Number of Different Crops (NDC)	1	Set to number of crops in simulation. Default value.
Number of Cropping Periods (NCPDS)	30	Set to weather data in meteorological file: San Francisco, CA (W23234)
Maximum rainfall interception storage of crop (CINTCP)	0.1	Taken from PAturf and FLturf scenarios.
Maximum Active Root Depth (AMXDR)	15 cm	The majority of berbuda grass roots are found in the top 6 inches of soil. (Duble 2004).
Maximum Canopy Coverage (COVMAX)	100	Taken from PAturf and FLturf scenarios.
Soil Surface Condition After Harvest (ICNAH)	2	2 = cover crop. Cover crops are typically planted on golf courses to keep them green when bermudagrass goes dormant (Darren Haver, Watershed Management Advisor, UC Cooperative Extension).
Date of Crop Emergence (EMD, EMM, IYREM)	1/1/1961	Grasses generally emerge in late fall, beginning in September. Grass generally stops growing in late July. (Darren Haver, Watershed Management Advisor, UC Cooperative Extension) This scenario was modeled as year round coverage.
Date of Crop Maturity (MAD, MAM, IYRMAT)	1/2/1961	
Date of Crop Harvest (HAD, HAM, IYRHAR)	31/12/1961	
Maximum Dry Weight (WFMAX)	0.0	Not used in scenario.
Maximum Canopy Height (HTMAX)	1.3	Most turf is maintained at 0.5 inches or less. (Darren Haver, Watershed Management Advisor, UC Cooperative Extension)
SCS Curve Number (CN)	80, 80, 80	Table 2-2a, USDA 1986. Curve numbers are selected based on ↑good condition↑open space areas for hydrologic soil group D. Same number year round, since no cropping season.
Manning's N Value (MNGN)	0.110	RUSLE Project; C21PCPCN for Sacramento Pasture, cool season with no till (USDA, 2000a). Data are from Sacramento, which is the closest RUSLE file with similar crop practices.
USLE C Factor (USLEC)	0.001	RUSLE Project; C21PCPCN for Sacramento Pasture, cool season with no till (USDA, 2000a). Data are from Sacramento, which is the closest RUSLE file with similar crop practices.

Table 4. PRZM 3.12 "Capay Silty Clay Loam" Soil Parameters for California - Turf.		
Parameter	**Value**	**Source/Comments**
Total Soil Depth (CORED)	205 cm	Capay Silty Clay Loam, Solano County, CA. NRCS Soil Data Mart Database (http://soildatamart.nrcs.usda.gov/).
Number of Horizons (NHORIZ)	5	
Horizon Thickness (THKNS)	2 cm (HORIZN =1) 10 cm (HORIZN =2) 43 cm (HORIZN =3) 74 cm (HORIZN =4) 76 cm (HORIZN =5)	Top horizon split in two and thatch layer added as HORIZN 1. Soil parameters of HORIZN 1 according to EPA guidance on development of turf scenario.
Bulk Density (BD)	0.37 g/cm3 (HORIZN = 1) 1.48 g/cm3 (HORIZN =2) 1.48 g/cm3 (HORIZN =3) 1.53 g/cm3 (HORIZN =4) 1.53 g/cm3 (HORIZN =5)	
Initial Water Content (THETO)	0.47 cm3/cm3 (HORIZN =1) 0.352 cm3/cm3 (HORIZN =2) 0.352 cm3/cm3 (HORIZN =3) 0.348 cm3/cm3 (HORIZN =4) 0.349 cm3/cm3 (HORIZN =5)	PRZM Scenario Guidance (2004).
Compartment Thickness (DPN)	0.1 cm (HORIZN = 1) 5 cm (HORIZN = 2) 1 cm (HORIZN = 3) 2 cm (HORIZN = 4) 4 cm (HORIZN = 5)	
Field Capacity (THEFC)	0.47 cm3/cm3 (HORIZN =1) 0.352 cm3/cm3 (HORIZN =2) 0.352 cm3/cm3 (HORIZN =3) 0.348 cm3/cm3 (HORIZN =4) 0.349 cm3/cm3 (HORIZN =5)	
Wilting Point (THEWP)	0.27 cm3/cm3 (HORIZN =1) 0.241 cm3/cm3 (HORIZN =2) 0.241 cm3/cm3 (HORIZN =3) 0.300 cm3/cm3 (HORIZN =4) 0.236 cm3/cm3 (HORIZN =5)	
Organic Carbon Content (OC)	35.6 % (HORIZN = 1) 0.87 % (HORIZN =2) 0.87 % (HORIZN =3) 0.44 % (HORIZN =4) 0.15 % (HORIZN =5)	Adjusted using the relationship % OC = % Organic Matter/1.724 (Doucette 2000).

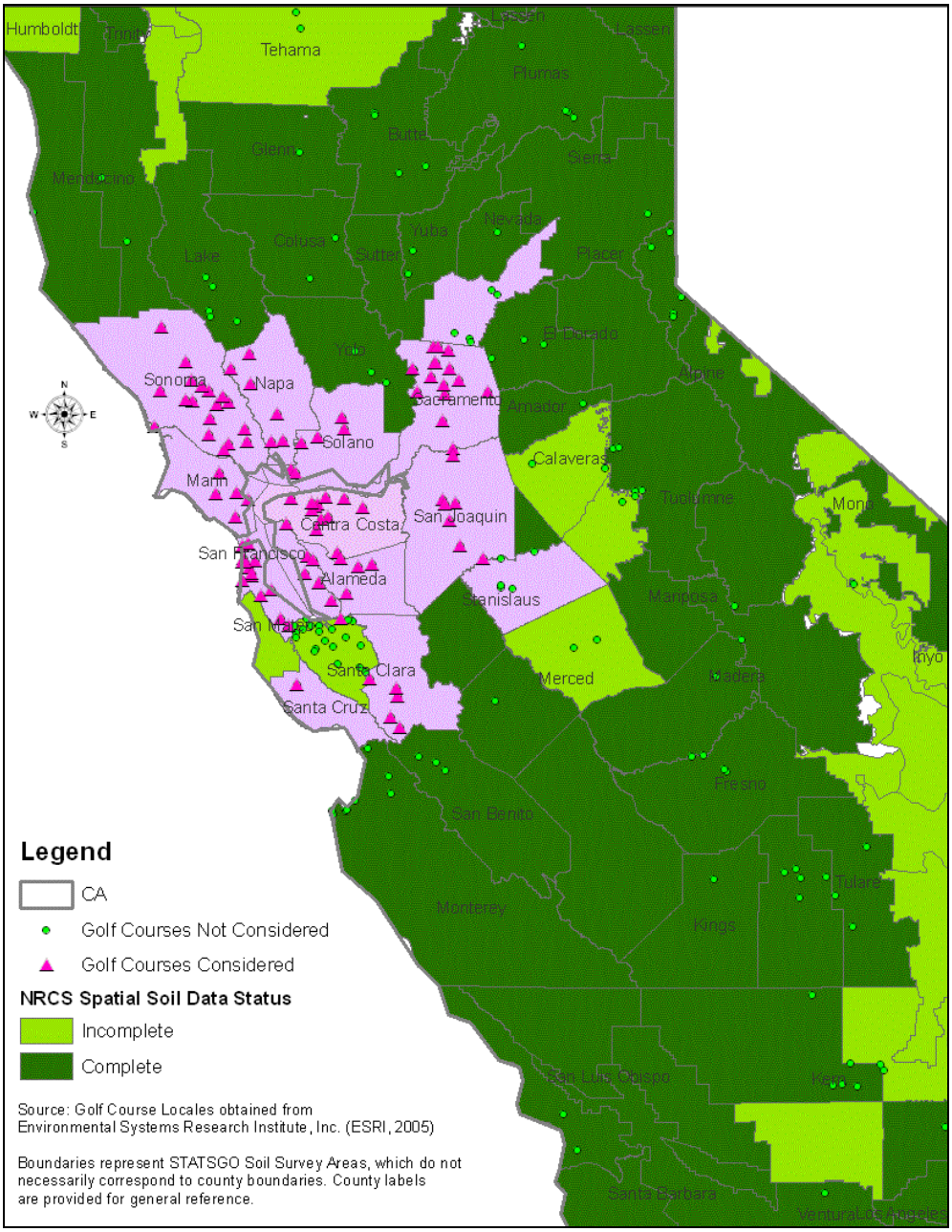

Figure 1. Turf Area of Interest (AOI), including golf course locales and spatial soil data availability.

Table 5. Soils co-located with golf courses areas in the AOI based on USDA 2006 soils data and ESRI 2005 golf course locales.										
Soil	**Total Acreage***	**% Area**	**Drainage**	**Erodibility**	**Slopes (%)**	**pH**	**OM (%)**	**% Sand**	**% Silt**	**% Clay**
CLEAR LAKE	83,988	12.7%	D	0.17-0.24	0-5	6.5-7.5	2.5	22.1	27.9	50
CAPAY	69,978	10.5%	D	0.17-0.37	0-9	7.3-7.5	1.5	18.5-22.1	27.9-44	37.5-50
ORTHENTS	60,205	9.1%	B	-	0-75	-	0.25	-	-	-
SAN JOAQUIN	37,485	5.6%	D	0.32-0.37	0-3	6.1	0.75	26.5-68.8	16.2-53.5	15-20
JACKTONE	35,850	5.4%	D	0.24	0-2	7.5	3.5	22.1	27.9	50
DIABLO	32,610	4.9%	D	0.2	15-30	7.5	2.5	22.1	27.9	50
LAUGHLIN	26,195	3.9%	C	0.37	50-75	5.8	3.5	41.4	37.1	21.5
LOS OSOS	24,540	3.7%	C	0.28-0.37	15-50	6.1-6.5	1.5-3	35.4-39.2	33.6-37.3	23.5-31
LOS GATOS	23,371	3.5%	C	0.37	30-75	6.7	2.5	39.8	37.7	22.5
URBAN LAND	17,860	2.7%	D	-	0-2	-	-	-	-	-
HAIRE	17,180	2.6%	C	0.37	2-9	5.6	2	39.2	37.3	23.5
BLUCHER	13,511	2.0%	C	0.32-0.37	0-5	6.1-6.7	3	26.5-68.8	16.2-53.5	15-20
LODO	11,580	1.7%	D	0.24	9-30	6.5	3.5	35.4	33.6	31
FIDDYMENT	11,240	1.7%	D	0.37	1-8	6.5	1.5	69.6	16.4	14
SAILBOAT	10,840	1.6%	B/C	0.43	0-2	6.7	1-1.25	26.3	52.7	21
DANVILLE	10,660	1.6%	C	0.28	0-2	6.7	2.5	20	49	31
GOULDING	10,551	1.6%	D	0.37	15-30	6.1	1.5	34.2	37.3	28.5
XERORTHENTS-URBAN LAND COMPLEX	10,115	1.5%	-	-	-	-	-	-	-	-
CROPLEY	9,985	1.5%	D	0.2	2-9	7-7.5	2	22.1	27.9	50
ZAMORA	9,409	1.4%	B	0.37	0-2	6.7	3	7	64.5	28.5
POSITAS	8,984	1.4%	D	0.37	2-20	5.8	1.35	42.1	37.9	20
XERARENTS	8,900	1.3%	-	-	0-5	-	0	-	-	-
SAURIN	8,640	1.3%	C	0.37	15-50	6.1	2	33.5	36.5	30
ARGONAUT	8,300	1.3%	D	0.37	3-8	6.1	1.5	43.8	40.2	16
REYES	6,800	1.0%	D	0.28	0-2	4.6	6	17.3	47.7	35
GALT	6,430	1.0%	D	0.24	0-2	6.7	1.5	22.1	27.9	50
RIVERWASH	6,225	0.9%	D	0.05	0-2	-	0.05	97.9	1.6	0.5
WRIGHT	5,985	0.9%	D/C	0.37	0-5	5.8	2.5	43	39.5	17.5
CONEJO	5,398	0.8%	B/C	0.2-0.24	0-2	6.7-7	2.5	35.4-39.2	33.6-37.3	23.5-31
DELHI	5,360	0.8%	A	0.2-0.24	0-5	7	0.5	80.5-96.8	0.7-17	2.5
TIERRA	4,980	0.8%	D	0.32	9-15	5.6	3	41.6	37.4	21
DIBBLE	4,183	0.6%	C	0.28-0.37	2-15	5.8-6.1	0.75-1.25	34.2	37.3	28.5

Table 5. Soils co-located with golf courses areas in the AOI based on USDA 2006 soils data and ESRI 2005 golf course locales.										
Soil	**Total Acreage***	**% Area**	**Drainage**	**Erodibility**	**Slopes (%)**	**pH**	**OM (%)**	**% Sand**	**% Silt**	**% Clay**
BALE	4,055	0.6%	C	0.32-0.37	0-5	6.1	2	35.4-41.4	33.6-37.1	21.5-31
HEDGE	4,040	0.6%	C/D	0.37	0-2	6.5	1	43.8	40.2	16
XEROFLUVENTS	3,936	0.6%	B	-	0-2	-	-	-	-	-
PESCADERO	3,769	0.6%	D	0.28	0-2	6.3-7.3	1.5-2.5	28.1-35.4	29.4-33.6	31-42.5
RED BLUFF	3,690	0.6%	C	0.37	0-2	5.8	1	41.6	37.4	21
MAXWELL	3,330	0.5%	D	0.28	2-9	7.5	2	23.3	29.2	47.5
LOS ROBLES	2,940	0.4%	B	0.37	0-5	7	2	35.4	33.6	31
RINCON	2,665	0.4%	C	0.28	0-2	6.7	1.5	33.5	36.5	30
ROHNERVILLE	2,656	0.4%	B	0.37	9-15	5.6	2	39.2	37.3	23.5
STOCKTON	2,465	0.4%	D	0.37	0-2	7.9	1.5	18.1	50.9	31
DURIXERALFS	2,410	0.4%	D	0.24	0-1	6.7	0.25	28.1	29.4	42.5
YOLO	2,377	0.4%	B/A	0.28-0.37	0-10	6.7-7.6	2-3	41.6-65.9	19.1-37.4	15-21
SIRDRAK	2,340	0.4%	A	0.15	5-50	5.8	3	96	1.5	2.5
GARRETSON	2,310	0.3%	B	0.32-0.37	0-5	6.7-7.5	1.25	41.6-42.1	37.4-37.9	20-21
PLEASANTON	1,689	0.3%	B	0.37	0-15	5	1.5	34.2-43	37.3-38.5	18.5-28.5
LIVEOAK	1,600	0.2%	B	0.2	0-2	6.7	2	59.6	17.9	22.5
MILLSHOLM	1,565	0.2%	D	0.55	30-50	6.1	2	24.5	52	23.5
ACCELERATOR	1,495	0.2%	B	0.32	5-15	5.6	1.5	42.1	37.9	20
RIOBLANCHO	1,275	0.2%	C	0.28	0-2	7.9	3.5	34.2	37.3	28.5
SAN ANDREAS	1,250	0.2%	C	0.15	30-75	5.8	2.5	66.9	20.1	13
SEBASTOPOL	1,235	0.2%	B	0.24	9-15	5	2	65.9	19.1	15
ALLUVIAL LAND	1,136	0.2%	C	0.24	0-2	6.5	1.5	33.3	31.7	35
OMNI	945	0.1%	D	0.24	0-2	8.2	3.5	34.2	32.3	33.5
LAUGENOUR	760	0.1%	B	0.28	0-2	8.2	0.75	44.3	40.7	15
SYCAMORE	242	0.0%	D	0.49	0-2	8.2	0.75	11.2	67.3	21.5

* Acreage represents the total map unit acreage for a map unit that contains at least one golf course locale in the area of interest and does not represent total golf course acreage on the corresponding soil.
- Erodibility, pH, OM, Sand, Silt, Clay are those listed in STATSGO as representative for the soil mapping unit.

References

Duble, R.L. 2004. Bermudagrass, The Sports Turf of the South. Texas cooperative extension. Posted 3/10/2004. Available at: http://extension-horticulture.tamu.edu/plantanswers/turf/publications/bermuda.html

Environmental Systems Research Institute, Inc. (ESRI). 2005. United States Golf Course Locales Coverage. ArcGIS v.9.2 Data Package.

EPA. 1998. Carsel, R.F., J.C. Imhoff, P.R. Hummel, J.M. Cheplick, and A.S. Donigian, Jr. PRZM-3, A Model for Predicting Pesticide and Nitrogen Fate in the Crop Root and Unsaturated Soil Zones: Users Manual for Release 3.0. National Exposure Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, Athens, GA.

EPA. 1999. Jones, R.D., J. Breithaupt, J. Carleton, L. Libelo, J. Lin, R. Matzner, and R. Parker. Guidance for Use of the Index Reservoir in Drinking Water Exposure Assessments. Environmental Fate and Effects Division, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, DC.

EPA. 2004. Pesticide Root Zone Model (PRZM) Field and Orchard Crop Scenarios: Guidance for Selecting Field Crop and Orchard Scenario Input Parameters. November 15, 2001; Revisions July 2004.

EPA. 2005. Irrigation Guidance for developing PRZM Scenario. June 15, 2005.

Haan, C.T. and B.J. Barfield. 1978. Hydrology and Sedimentology of Surface Mined Lands. Office of Continuing Education and Extension, College of Engineering, University of Kentucky, Lexington, Kentucky 40506. pp. 286.
UCIPM. 2003. Turfgrasses. University of California Integrated Pest Management, Statewide Pest Management Program. June 2003. Online at: http://www.ipm.ucdavis.edu/PMG
/r785900111.html

USDA. 1986. Urban Hydrology for Small Watersheds. United States Department of Agriculture, Natural Resources Communication Service. Technical Release 55.

USDA. 2006a. Soil Survey Areas of the San Francisco Bay Area. U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS), Soil Data Mart. March 1, 2006. Online at: http://soildatamart.nrcs.usda.gov.

USDA. 2006b. Official Series Description. CAPAY Series. Information from the website:
http://ortho.ftw.nrcs.usda.gov/osd/dat/C/CAPAY.html.