**Appendix 2.** Watershed characteristics considered as explanatory variables for WARP models.

[WARP, Watershed Regression for Pesticides; CTIC; Conservation Technology Information Center; LULC, Land Use and Land Cover dataset; NCDC, National Climatic Data Center; NLCD, National Land Cover Dataset/Database; NOAA, National Oceanic and Atmospheric Administration; NRI, National Resources Inventory; STATSGO, State Soil Geographic data base; USLE, Universal Soil Loss Equation]

|  |  |
| --- | --- |
| Variable | Description |
| Pesticide use | |
| UI | Annual atrazine agriculturaluse intensity (kg/km2).  For years 1992-1997, sum of use data derived from Thelin and Stone (2010) for applications to NLCDe (Nakagaki and others, 2007) row crops, small grains, fallow, orchards/vineyards/other, LULC orchards/vineyards/other, and pasture/hay crops (30-m resolution, extrapolated to the watershed) divided by watershed area.  For years 1998-2007, sum of use data derived from Thelin and Stone (2010) for applications to NLCD01 (Homer and others, 2007; USGS, 2007; LaMotte, 2008a,b,c,d) cultivated crops and pasture/hay (30-m resolution, extrapolated to the watershed) divided by watershed area. |
| Landuse and population | |
| AG | Percent of basin with agricultural land use.  Sum of NLCD01 (Homer and others, 2007; USGS 2007; LaMotte, 2008a,b,c,d) categories cultivated crops and pasture/hay (30-m cell resolution) divided by watershed area and multiplied by 100. |
| FOREST | Percent of basin with forest land use.  Sum of NLCD01 (Homer and others, 2007; USGS 2007; LaMotte, 2008a,b,c,d) categories deciduous forest, evergreen forest, and mixed forest (30-m cell resolution) divided by watershed area and multiplied by 100. |
| URBAN | Percent of basin with urban land use.  Sum of NLCD01 (Homer and others, 2007; USGS 2007; LaMotte, 2008a,b,c,d) categories developed open space, low intensity, medium intensity, and high intensity (30-m cell resolution) divided by watershed area and multiplied by 100. |
| POPDEN | Mean 2000 population density in watershed (people/km2).  2000 population density by census block groups rasterized at the 100-m resolution (Hitt, 2003). |
| Agriculturalmanagement practices | |
| ARTDRN | Percent of the basin that is artificially drained.  Sum of conservation practice categories 606, 607, and 608 derived from the 1992 NRI (USDA, 1995) areas (practice by county) on NLCDe (Nakagaki and others, 2007) 1992 row crops, small grains, fallow, orchards/vineyards/other, LULC orchards/vineyards/other, and pasture/hay (30-m resolution) divided by watershed area and multiplied by 100. |
| CONTILL | Percent of the watershed with corn crop and conservation tillage.  Sum of CTIC tillage acreage (Baker, 2011) for categories no till, ridge till, and mulch till divided by watershed area and multiplied by 100. |
| REGTILL | Percent of the watershed with corn crop and regular tillage.  Sum of CTIC tillage acreage (Baker, 2011) for categories reduced till and conventional till divided by watershed area and multiplied by 100. |
| IRRI | Percent of the basin that is irrigated.  Sum of irrigation categories 01, 02, and 03 from the 1997 NRI (USDA, 2000) areas (practice by county) on NLCDe (Nakagaki and others, 2007) 1992 row crops, small grains, fallow, orchards/vineyards/other, LULC orchards/vineyards/other, and pasture/hay (30-m resolution ) divided by watershed area and multiplied by 100. |
| TILE | Percent of the basin that is drained by subsurface tiles.  Conservation practice category 606 derived from the 1992 NRI (USDA, 1995) areas (practice by county) on NLCDe (Nakagaki and others, 2007) 1992 row crops, small grains, fallow, orchards/vineyards/other, LULC orchards/vineyards/other, and pasture/hay (30-m resolution) divided by watershed area and multiplied by 100. |
| Soil properties | |
| AWC | Mean available water capacity (fraction) in watershed.  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO available water capacity (Wolock, 1997). |
| CLAY | Mean percent clay in watershed soils.  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO percent clay (Wolock, 1997). |
| HGAB | Mean percent of watershed soils classified as hydrologic soil groups A and B.  Sum of hydrologic soil groups A and B from STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data). Hydrologic soil groups are from an enhanced version of the STATSGO database (Barbara Ruddy and William Battaglin, USGS, 1998, unpublished data) in which missing hydrologic soil group values were populated based on soil characteristics described by Foth and Schafer (1980). |
| HGCD | Mean percent of watershed soils classified as hydrologic soil groups C, D, and C/D.  Sum of hydrologic soil groups C, D, and C/D from STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data).Hydrologic soil groups are from an enhanced version of the STATSGO database (Barbara Ruddy and William Battaglin, USGS, 1998, unpublished data) in which missing hydrologic soil group values were populated on the basis of soil characteristics described by Foth and Schafer (1980). |
| K | Mean soil erodibility of uppermost soil horizon in watershed (K-factor for USLE).  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO K-factor (Wolock, 1997). |
| SRL25 | Mean percent of agricultural area watershed soils with a soil restrictive layer (saturated hydraulic conductivity ≤1) within top 25 cm of soil layer.  SSURGO (USDA, 2010) fields HZDEPTR, KSATR, COKEY, Major Component Flag, MUKEY from tables CHORIZON, COMPONENT, LEGEND, MAPUNIT tables used to determine percent presence of SRL in a MUKEY in tabular format. Tabular percent presence SRL in MUKEY data combined with 30-m raster of SSURGO MUKEYs (converted from a 10-m raster of SSURGO MUKEYs) and overlain on NLCD01 (Homer and others, 2007; USGS 2007; LaMotte, 2008a,b,c,d) agricultural land use and watershed boundaries. |
| SRL50 | Mean percent of agricultural area watershed soils with a soil restrictive layer (saturated hydraulic conductivity ≤1) within top 50 cm of soil layer.  SSURGO (USDA, 2010) fields HZDEPTR, KSATR, COKEY, Major Component Flag, MUKEY from tables CHORIZON, COMPONENT, LEGEND, MAPUNIT tables used to determine percent presence of SRL in a MUKEY in tabular format. Tabular percent presence SRL in MUKEY data combined with 30-m raster of SSURGO MUKEYs (converted from a 10-m raster of SSURGO MUKEYs) and overlain on NLCD01 (Homer and others, 2007; USGS 2007; LaMotte, 2008a,b,c,d) agricultural land use and watershed boundaries. |
| SRL100 | Mean percent of agricultural area watershed soils with a soil restrictive layer (saturated hydraulic conductivity ≤1) within top 100 cm of soil layer.  SSURGO (USDA, 2010) fields HZDEPTR, KSATR, COKEY, Major Component Flag, MUKEY from tables CHORIZON, COMPONENT, LEGEND, MAPUNIT tables used to determine percent presence of SRL in a MUKEY in tabular format. Tabular percent presence SRL in MUKEY data combined with 30-m raster of SSURGO MUKEYs (converted from a 10-m raster of SSURGO MUKEYs) and overlain on NLCD01 (Homer and others, 2007; USGS 2007; LaMotte, 2008a,b,c,d) agricultural land use and watershed boundaries. |
| ORGM | Mean percent organic matter in watershed soils.  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO organic matter (Wolock, 1997). |
| PERM | Mean soil permeability in the watershed (cm/h).  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO permeability (Wolock, 1997). |
| SAND | Mean percent sand in watershed soils.  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO percent sand (Wolock, 1997). |
| SILT | Mean percent silt in watershed soils.  STATSGO (USDA, 1994) polygons converted to 100-m cells (David Wolock, USGS, 2004, unpublished data); weighted averages of STATSGO percent silt (Wolock, 1997). |
| Physical watershed characteristics | |
| WA | Watershed area (km2). |
| ELEV | Mean basin elevation (m).  National Elevation Dataset (USGS, 2003) at 100-m cell resolution. |
| LATC | Latitude of basin centroid (decimal degrees). |
| LONC | Longitude of basin centroid (decimal degrees). |
| SLOPE | Mean percent slope in watershed.  National Elevation Dataset (USGS, 2003) at 100-km cell resolution. |
| Weather/climate characteristics | |
| ADRY | Mean annual number of consecutive dry days, 1961-1990.  NOAA NCDC station data (Williams and others, 2006) used to calculate average annual number of consecutive dry days and spatially interpolate to 1-km cells (David Wolock, USGS, 2005, unpublished data). |
| APPT | Mean annual 1961–1990 precipitation (cm/yr).  NOAA NCDC data (Owensby and Ezell, 1992) interpolated to 1-km cells (David Wolock, USGS, 2005, unpublished data). |
| APPTI | Mean annual precipitation intensity, 1961-1990 (mm/d).  NOAA NCDC station data (Williams and others, 2006) used to calculate average annual precipitation intensity and spatially interpolate to 1-km cells (David Wolock, USGS, 2005, unpublished data). |
| ATEMP | Mean annual 1961–1990 temperature (°C).  NOAA NCDC data (Owensby and Ezell, 1992) interpolated to 1-km cells (David Wolock, USGS, 2001, unpublished data). |
| WET | Mean annual number of consecutive wet days, 1961-1990.  NOAA NCDC station data (Williams and others, 2006) used to calculate average annual number of consecutive wet days and spatially interpolate to 1-km cells (David Wolock, USGS, 2005, unpublished data). |
| R | Mean annual 1971-2000 rainfall erosivity (R-factor for USLE).  Derived from Daly and Taylor (2002). |
| PYEAR | Total precipitation during the year of sampling (mm).  NOAA NCDC data (NCDC, 2007; NCDC, 1994) linked to mapped climate division boundaries (NCDC, 1991)and converted to 1-km cells. |
| PAPRJUN | Total precipitation during April, May, and June of the year of sampling (mm).  NOAA NCDC data (NCDC, 2007; NCDC, 1994) linked to mapped climate division boundaries (NCDC, 1991) and converted to 1-km cells. |
| PAPRSEP | Total precipitation during April through September of the year of sampling (mm).  NOAA NCDC data (NCDC, 2007; NCDC, 1994) linked to mapped climate division boundaries(NCDC, 1991) and converted to 1-km cells. |
| PMAY | Total precipitation during May of the year of sampling (mm).  NOAA NCDC data (NCDC, 2007; NCDC, 1994) linked to mapped climate division boundaries(NCDC, 1991) and converted to 1-km cells. |
| PMJN | Total precipitation during May and June of the year of sampling (mm).  NOAA climate division precipitation data (NCDC, 2007; NCDC, 1994) linked to mapped climate division boundaries (NCDC, 1991) converted to 1-km cells. |
| PMJL | Total precipitation during May, June, and July of the year of sampling (mm).  NOAA NCDC data (NCDC, 2007; NCDC, 1994) linked to mapped climate division boundaries (NCDC, 1991) and converted to 1-km cells. |
| Hydrologicproperties | |
| CONTACT | Mean subsurface contact time (days).  Estimated by TOPMODEL (Beven and Kirkby, 1979). Derivation from watershed model equations that used mapped STATSGO soil characteristics (USDA, 1994) from Wolock (1997) and USGS Digital Elevation Models (USGS, 1993) at the 1:250,000 scale (David M. Wolock, USGS, 2001, written communication). |
| PERDUN | Percent of watershed streamflow contributed by saturation or Dunne overland flow.  Estimated by means of TOPMODEL (Beven and Kirkby, 1979) hydrologic model (Wolock, 2003a). |
| PERHOR | Percent of watershed streamflow contributed by infiltration-excess or Horton overland flow.  Estimated by means of TOPMODEL (Beven and Kirkby, 1979) hydrologic model (Wolock, 2003b). |
| PET | Mean potential evapotranspiration (cm).  Estimated with national temperature data derived from Parameter-Elevation Regressions on Independent Slopes Model (Daly and others, 2002) and the Hamon’s (1961) equation for potential evapotranspiration (David M. Wolock, USGS, 2001, written communication). |
| ROFF | Mean annual 1951-1980 runoff (cm/yr).  USGS data (Gebert and others, 1987) interpolated and converted to 1-km cells (David Wolock, USGS, 2001, unpublished data). |

# ReferencesCited

Baker, N.T., 2011, Tillage practices in the conterminous United States, 1989–2004—Datasets aggregated by watershed: U.S. Geological Survey Data Series 573, 12p.

Beven, K.J., and Kirkby, M.J., 1979. A physically based, variable contributing area model of basin hydrology:Hydrological Sciences Bulletin, v. 24, no. 1, p. 43–69.

Daly, Christopher, Gibson, W.P.,Taylor,G.H.,Johnson, G.L.,and Pasteris, Phillip, 2002, Aknowledge-based approach to the statistical mapping of climate.Climate Research, v. 22, no. 2, p. 99–113.

Daly, Christopher, and Taylor, G.H.,2002, United States mean annual R-factor, 1971–2000: Corvallis Oreg., PRISM Climate Group, Oregon State University, accessed January 2011 at <http://www.prism.oregonstate.edu/pub/prism/maps/Precipitation/rfactor/U.S./us_rfactor_meta.html>.

Foth, H.D., and Schafer, J.W., 1980, Soil geography and land use:New York, John Wiley and Sons, 484 p.

Gebert, W.A., Graczyk, D.J., and Krug, W.R., 1987, Average annual runoff in the United States, 1951–80: U.S. Geological Survey Hydrologic Investigations Atlas HA–710. (Also available at <http://water.usgs.gov/GIS/metadata/usgswrd/XML/runoff.xml>.)

Hamon, W.R., 1961. Estimating potential evapotranspiration:Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, v. 87, no. HY3, p.107–120.

Hitt, K.J., 2003, 2000 population density by block group for the conterminous United States [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?uspopd00x10g>.

Homer, C., Dewitz, J., Fry, J.,Coan, M., Hossain, N., Larson, C.,Herold, N., McKerrow, A., VanDriel, J.N., and Wickman, J.,2007, Completion of the 2001 National Land Cover Database for the conterminous United States:Photogrammetric Engineering & Remote Sensing, v. 73, no. 4, p. 337–341.

LaMotte, A.E., 2008a, National Land Cover Database 2001, Tile 1, northwest United States: U.S. Geological Survey Data Series 383A, [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?nlcd01_1>.

LaMotte, A.E., 2008b, National Land Cover Database 2001 Tile 2, northeast United States: U.S. Geological Survey Data Series 383B, [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?nlcd01_2>.

LaMotte, A.E., 2008c, National Land Cover Database 2001 Tile 3, southwest United States: U.S. Geological Survey Data Series 383C, [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?nlcd01_3>.

LaMotte, A.E., 2008d, National Land Cover Database 2001 Tile 4, southeast United States: U.S. Geological Survey Data Series 383D, [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?nlcd01_4>.

Nakagaki, Naomi,Price, C.P.,Falcone, J.A.,Hitt, K.J.,and Ruddy, B.C., 2007, Enhanced National Land Cover Data 1992 (NLCDe 92): U.S. Geological Survey [digital data], accessed January 2011 at <http://water.usgs.gov/GIS/metadata/usgswrd/XML/nlcde92.xml>.

National Climatic Data Center, 1991. Climate divisions, Edition 1.1 [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?climate_div>.

National Climatic Data Center, 1994, Time bias corrected divisional temperature-precipitation-drought index—Documentation for Data Set TD–9640: Asheville, N.C., National Climatic Data Center, 12 p.

National Climatic Data Center, 2007, Time bias corrected divisional temperature-precipitation-drought index (TD–9640): Accessed January 2011at <http://www1.ncdc.noaa.gov/pub/data/cirs/>*.*

Owensby, J.R., and Ezell, D.S., 1992, Climatography of the United States, No. 81—Monthly station normals of temperature, precipitation, and heating and cooling degree days, 1961–90: Asheville, N.C., National Climatic Data Center, accessed January 2011 at <http://lwf.ncdc.noaa.gov/oa/climate/normals/usnormalshist.html#clim81>.

Thelin, G.P., and Stone, W.W.,2010, Method for estimating annual atrazine use for counties in the conterminous United States, 1992–2007: U.S. Geological Survey Scientific Investigations Report 2010–5034, 129 p. (Also available at <http://pubs.usgs.gov/sir/2010/5034/>.)

U.S. Department of Agriculture, 1994, State Soil Geographic (STATSGO) Database—Data use information: Fort Worth, Tex., Natural Resources Conservation Service, MiscellaneousPublication 1492 (rev. ed.) [variously paged].(Also available at <http://www.nrcs.usda.gov/technical/techtools/statsgo_db.pdf>.)

U.S. Department of Agriculture,1995, 1992 national resources inventory: Washington, D.C., Natural Resources Conservation Service, and Ames, Iowa, Statistical Laboratory, Iowa State University.

U.S. Department of Agriculture,2000, 1997 national resources inventory (reissued 2001): Washington, D.C., Natural Resources Conservation Service, and Ames, Iowa, Statistical Laboratory, Iowa State University, accessed January 2011 at <http://www.nrcs.usda.gov/technical/NRI/>.

U.S. Department of Agriculture, 2010, Soil Survey Geographic (SSURGO) Database: Natural Resources Conservation Service, accessed January 2011 at <http://soildatamart.nrcs.usda.gov>.

U.S. Geological Survey, 1993, Digital elevation models—Data users guide 5: 48 p.

U.S. Geological Survey,2003, National Elevation Data, accessed January 2011 at <http://ned.usgs.gov>.

U.S. Geological Survey, 2007, National Land Cover Database 2001, accessed January 2011 at <http://www.mrlc.gov/mrlc2k_nlcd.asp>.

Williams, C.N., Menne, M.J., Vose, R.S., and Easterling, D.R., 2006, United States historical climatology network daily temperature, precipitation, and snow data: Oak Ridge, Tenn., Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, ORNL/CDIAC-118, NDP-070, accessed January 2011 at <http://cdiac.ornl.gov/epubs/ndp/ushcn/ndp070.html>.

Wolock, D.W., 1997, STATSGO Soil characteristics for the conterminous United States: U.S. Geological Survey Open-File Report 97–656 [digital data], accessed January 2011 at *http://water.usgs.gov/lookup/getspatial?muid*.

Wolock, D.M., 2003a, Saturation overland flow estimated by TOPMODEL for the conterminous United States: U.S. Geological Survey Open-File Report 03–264 [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?satof48>.

Wolock, D.M., 2003b, Infiltration-excess overland flow estimated by TOPMODEL for the conterminous United States: U.S. Geological Survey Open-File Report 03–310 [digital data], accessed January 2011 at <http://water.usgs.gov/lookup/getspatial?ieof48>.