Navajo County Department of Public Works

ADOT Hydrology Manual Guidelines: Estimating Percent Impervious Cover

The Navajo County Department of Public Works has developed the following two tables to help estimate the average percent of impervious cover. Estimates of average percent of impervious cover are required by the ADOT Hydrology Manual HEC-1 methodology. The following three methods for estimating percent impervious cover are recommended for use in Navajo County:

Method One: Navajo County Zoning Codes

Method One requires that Navajo County Zoning Maps are overlaid on the watershed boundary maps for the project. The area within each zoning designation in each watershed, or sub-basin, is then measured[1] and matched to the average percent impervious value for each zoning code listed in Table 1. The measured land area and percent impervious value may then be entered in the Green-Ampt parameter worksheet, or may be weighted manually to obtain a representative average percent impervious value for the watershed, or sub-basin.

Information Required for Method One:

1. Watershed or sub-basin boundary map.
2. Navajo County Zoning map for the project area.

Application Procedure:

1. Delineate the watershed and sub-basin boundaries.
2. Overlay the Navajo County Zoning Map on the watershed boundary map.
3. Measure land area in each zoning designation within each sub-basin.
4. Read recommended average percent impervious value for each zoning designation from Table 1.
5. Enter land area and corresponding percent impervious value for each zoning designation in the Green-Ampt parameter spreadsheet, or manually compute weighted average percent impervious value for each sub-basin. The weighted percent impervious value for the watershed, or sub-basin, is also required if the urban area time of concentration equation is used.

[1] Areas on maps may be measured using a planimeter, a digitizing tablet, or other manual methods.

Method Two: Land Use Type Classification

Method Two requires that a map of land uses observed in the watershed, or sub-basins, are overlaid on the watershed boundary maps for the project. The area within each land use classification in each watershed, or sub-basin, is then measured and matched to the average percent impervious value for each land use type listed in Table 2. The measured land area and percent impervious value may then be entered in the Green-Ampt parameter worksheet, or may be weighted manually to obtain a representative average percent impervious value for the watershed, or sub-basin.

Information Required:

1. Watershed or sub-basin boundary map.
2. Aerial photograph or map showing land use types in watershed.

Application Procedure:

1. Delineate the watershed and sub-basin boundaries.
2. Overlay the land use map on the watershed boundary map.
3. Measure land area of each land use type within each sub-basin.
4. Read recommended average percent impervious value for each land use type from Table 2.
5. Enter land area and corresponding percent impervious value for each land use type in the Green-Ampt parameter spreadsheet, or manually compute weighted average percent impervious value for each sub-basin. The weighted percent impervious value for the watershed, or sub-basin, is also required if the urban area time of concentration equation is used.

Method Three: Measure Percent Impervious Directly

For Method Three, the actual land area in the watershed, or sub-basin, covered by impervious surfaces is measured directly from recent aerial photographs, other approved maps, or maps showing proposed site/development plans. Method Three typically yields the most accurate estimates of percent impervious cover within a specific watershed, although it is labor intensive, and requires detailed mapping of existing land uses.

Information Required:

1. Watershed or sub-basin boundary map.
2. Aerial photograph or maps showing land use types in watershed. Maps must be of sufficient detail to show all impervious surfaces in the entire watershed.

Application Procedure:

1. Delineate watershed and sub-basin boundaries.
2. Measure the area of the impervious surfaces within each sub-basin.
3. Compute the percent of impervious surfaces within each sub-basin.
4. Enter computed percent impervious value in the Green-Ampt parameter spreadsheet, or on the Time of Concentration worksheet.

Application Notes:

1. Existing vs. Future Conditions. Use of Table 1 implicitly assumes total future build out at the existing zoning. Therefore, hydrologic modeling based on the values in Table 1 may reflect future conditions runoff rates (depending on other modeling assumptions used), but does not reflect potential changes in runoff rates following build out if the existing zoning is modified.

2. Measured Impervious Surfaces. Care should be exercised when measuring the percent of impervious surfaces directly from aerial photography or other maps. Special consideration should be given to account for landscaping underlain with impermeable layers (e.g., plastic or geotextiles), landscaped areas which could be saturated by irrigation prior to the design storm, and impervious surfaces that are not visible in aerial photographs due to tree canopy cover.

3. Directly Connected Impervious Surfaces. The directly connected impervious area, of effective impervious area, is the portion of land area in a watershed that drains directly to the outlet of the drainage area without flowing over any pervious surfaces or in constructed (non-natural) channels. When estimating the weighted average percent impervious cover by direct measurement, the modeler should be careful to distinguish unconnected impervious surfaces from directly connected impervious surfaces. Flow in roadside ditches and constructed earthen channels is considered flow over an impervious surface.

Table 1. Navajo County Dept. of Public Works Recommended Percent Impervious Values

Zoning Code	Land Use Classification	Land Use Description	Percent Impervious Value
A-General	SINGLE FAMILY	Churches, farms, public schools, golf courses, hospitals, commercial feed lots, nurseries, corrals, quarters for servants & caretakers, private swimming pools.	25-50 (Use of Table 2 Recommended)
Rural-20	SINGLE FAMILY	Schools, parks, churches, public utility buildings, farms, home occupations, accessory buildings, public riding stables, plant nurseries and green houses, roadside stands.	15
Rural-10	Same as Rural-20	Same as Rural-20	20
Rural-5	Same as Rural-20	Same as Rural-20	25
Rural-1	Same as Rural-20	Same as Rural-20	30
R1-43	SINGLE FAMILY	Single family dwellings, churches, schools, public utility buildings, private clubs, parks, home occupations, accessory buildings.	40
R1-10	Same as R1-43		60
R-2	MULTIPLE FAMILY	R1-43 uses, multi-family dwellings, boarding houses, fraternal institutions & rest homes.	70
R-3	MULTIPLE FAMILY	R-2 uses and mobile home parks and subdivisions.	70
C-1	NEIGHBORHOOD COMMERCIAL	R-3 uses, food markets, drug stores, personal service shops, travel trailer parks, wholesale & distribution activities, retail & wholesale commerce, commercial entertainment.	70
IND-1	LIGHT INDUSTRIAL	C-1 uses (except dwellings), offices, radio & television facilities, limited manufacturing.	70
IND-2	HEAVY INDUSTRIAL	Any industrial use (with exceptions).	90

Notes:
1. If the recommended values given in Table 1 or Table 2 are not used, documentation justifying the use of alternative values must be provided with the hydrologic modeling. Documentation must include technical references that support use of the alternative values, as well as copies of computation sheets for all calculations.
2. Percent impervious values for zoning classifications not shown in this table should be approved in writing by the Navajo County Dept. of Public Works prior to submittal of the drainage report.

Table 2. Navajo County Dept. of Public Works Recommended Percent Impervious Values by Land Use Classification	
Land Use Classification	**Percent Impervious Value**
Agricultural Fields[1]	0
Undeveloped Areas	
Natural Vegetation	0
Unimproved, Vacant Land	5
Open Space	
Lawns	5
Golf Courses	5
Parks & Cemeteries	10
Playgrounds	25
Schools	40
Suburban Residential - Single Family Dwellings	
5 Acre Lots or Larger	5
2 Acre Lots or Larger	10
Residential - Single Family Dwellings	
4 Residence per Acre	35
3 Residences per Acre	25
2 Residences per Acre	20
1 Residences per Acre	15
Multi-Family Residential	
5-7 Residences per Acre	55
8+ Residences per Acre	55
Apartments & Condominiums	70
Mobile Home Park	60
Commercial & Business	
Neighborhood Business	70
Downtown Business District	90
Industrial	
Light Industry	60
Heavy Industry	90

1. Crop areas only - does not include areas with farm buildings or other structures.

Technical References for Average Percent Impervious Cover Estimates

ADOT, 1969, *Hydrologic Design for Highway Drainage in Arizona.* Report by E. I. Jencsok/ Arizona Highway Department - Bridge Division. March 1969.

CCRFCD, 1990, *Hydrologic Criteria and Drainage Design Manual.* Report for Clark County Regional Flood Control District by WRC Engineering, Inc.

COS, 1993, *Design Standards and Policies Manual.* Report by City of Scottsdale, Arizona. Revised 1996.

FCDMC, 1995, *Hydrologic Design Manual.* Report by Flood Control District of Maricopa County.

OCHM, 1986, *Orange County Hydrology Manual.* Report by Orange County (California) Environmental Management Agency. October 1986.

PCFCD&DOT, 1979, *Hydrology Manual for Engineering Design and Flood Plain Management with Pima County, Arizona for the Prediction of Peak Discharges from Surface Runoff on Small Semiarid Watersheds for the 2-Year Through 100-Year Recurrence Intervals.* Report by the Pima County Dept. of Transportation and Flood Control District. September 1979.

Ponce, V.M., 1989, *Engineering Hydrology - Principles and Practices*, Prentice Hall Co., Englewood Cliffs, New Jersey.

USDA, 1985, *Technical Release 55 - Urban Hydrology for Small Watersheds.* Report by United States Dept. of Agriculture. May 1985.

USDCM, 1969, *Urban Storm Drainage Criteria Manual*, Denver Regional Council of Governments, Denver, Colorado. March 1969.

USDT, 1979, *Design of Urban Highway Drainage - The State of the Art*, Report by the United States Department of Transportation, Federal Highway Administration. August 1979.