United States Department of Agriculture

August 2016

Hydrology Technical Note No. 4

Hydrologic Analyses of Post-Wildfire Conditions

Natural Resources Conservation Service

References

Aldridge, B. N., and J. M. Garrett, 1973. Roughness coefficients for stream channels in Arizona. U.S. Geological Survey Open-File Report, Tucson, AZ.

Bathurst, J.C. 1985. Flow resistance estimation in mountain rivers. Journal of Hydraulic Engineering 111(4), 625–643.

Bedient, P.B., W.C. Huber, and B.E. Vieux. 2012. Hydrology and Floodplain Analysis, Prentice Hall, NJ, 5th Edition, 801 pages.

Benavides-Solario, J.D., and L.H. MacDonald. 2001. Post-fire runoff and erosion from simulated rainfall on small plots, Colorado Front Range. Hydrological Processes, 15, 2931–2952.

Beven, K.J. 1989. Changing ideas in hydrology -- the case of physically-based models. Journal of Hydrology 105, 157–172.

Beven, K.J. 2001. How far can we go in distributed hydological modelling? Hydrology and Earth System Sciences 5, 1–12.

Canfield, H.E., Goodrich, D.C. 2005. Suggested changes to AGWA to account for fire (V. 2.1). Southwest Watershed Research Center, USDA-ARS, Tucson, AZ.

Canfield, H.E., D.C. Goodrich, and I.S. Burns. 2005. Selection of parameters values to model post-fire runoff and sediment transport at the watershed scale in Southwestern forests.

Cannon, S.H., J.E. Gartner, C. Parrett, and M. Parise. 2003. Wildfire-related debris-flow generation through episodic progressive sediment-bulking processes, western USA. In Proceedings: Debris-Flow Hazards Mitigation: Mechanics, Prediction, and Assessment.

Cerrelli, G.A. 2005. FIRE HYDRO, a simplified method for predicting peak discharges to assist in the design of flood protection measures western wildfires. In Proceedings of the ASCE 2005 Watershed Management Conference, July 2005, Williamsburg, VA. pp. 935–941.

CFR (Code of Federal Regulations), 2005. Emergency watershed protection program. 7 CFR Part 624.4.

Chen, L., M. Berli, C. Karletta. 2013. Examining modeling approaches for the rainfall-runoff process in wildfire-affected watersheds: using San Dimas Experimental Forest. Journal of the American Water Resources Association 1–16.

Conedera, M., L. Peter, P. Marxer, F. Forster, D. Rickenmann, L. Re. 2003. Consequences of forest fires on the hydrogeological response of mountain catchments: a case study of the Riale Buffaga, Ticino, Switzerland. Earth Surface Processes and Landforms 28, 117–129.

Debano, L.F., J.F. Osborn, J.S. Krammes, J. Letey. 1967. Soil wettability and wetting agents: our current knowledge of the problem. USDA Forest Service Research Paper PSW-43: 13.

DeBano, L.F. 2000a. Water repellency in soils: a historical overview. Journal of Hydrology, 231–232, 4-32.

DeBano, L.F. 2000b. The role of fire and soil heating on water repellency in wildland environments: a review. Journal of Hydrology, 231-232, 195–206.

DeBano, L.F. 1981. Water repellent soils: a state-of-the art. USDA Forest Service, General Technical Report PSW-46.

Dendy, G.S. 1987. A 24-hour rainfall distribution and peak rate factors for use in Southwest Florida. Masters Thesis, University of Central Florida, Orlando, FL, 172 pages.

Doerr, S.H. 1998. On standardizing the 'Water Drop Penetration Time' and the 'Molarity of an Ethanol Droplet' techniques to classify soil hydrophobicity: A case study using medium textured soils. Earth Surface Processes and Landforms 23, 663–668.

Doerr. S.H., R.A. Shakesby, R.P.D. Walsh. 2000. Soil water repellency: its causes, characteristics and hydro-geomorphological significance. Earth Science Reviews, 51, 33–65.

Dyrness, C.T. 1976. Effect of wildfire on soil wettability in the high cascades of Oregon. USDA Forest Service, Pacific Northwest Research Station, Research Paper PNW-202, 19 p.

Elliott, J.G., M.E. Smith, M.J. Friedel, M.R. Stevens, C.R. Bossong, D.W. Litke, R.S. Parker, C. Costello, J. Wagner, S.J. Char, M.A. Bauer, and S.R. Wilds. 2005. Analysis and mapping of post-fire hydrologic hazards for the 2002 Hayman, Coal Seam, and Missionary Ridge wildfires, Colorado. USGS Scientific Investigations Report 2004-5300, 80 pages.

Engman, E.T. 1986. Roughness coefficients for routing surface runoff. Journal of Irrigation and Drainage Engineering 112 (1). Amer. Soc. of Civil Eng., New York, NY. pp. 39–53.

ESRI (Environmental Systems Resource Institute). 2010. ArcMap 10.0 ESRI, Redlands, CA.

Fang, X., et al. 2005. Revisit of NRCS unit hydrograph procedures. In Proceedings of the ASCE Texas Section Spring Meeting, Austin, TX, April 2005, 21 pages.

Flanagan, D.C., et al. 2001. Chapter 7: The Water Erosion Prediction Project (WEPP) model. In Landscape Erosion and Evolution Modeling. Kluwer Academic Publishers, Norwell, MA. 51 pages.

Folmar, N.D., and A.C. Miller. 2008. Development of an empirical lag time equation. ASCE Journal of Irrigation and Drainage Engineering 112(1), pp. 39–53.

Foltz, R.B., P.R. Robichaud, and H. Rhee. 2009. A synthesis of post-fire road treatments for BAER teams: methods, treatment effectiveness, and decisionmaking tools for rehabilitation. USDA Forest Service General Technical Report RMRS-GTR-228.

Garen, D.C., D.S. Moore. 2005 Curve number hydrology in water quality modeling: uses, abuses and future directions. Journal of the American Water Resources Association 42(2), 377–388.

Giraud, R.E., and G.N. McDonald. 2007. The 2000-2004 fire-related debris flows in northern Utah. In: Proceedings 1st North American Landslide Conference, AEG Special Publication 23, 1522–1531.

Goodrich, D.C. 1992. Discussion of "The kinematic wave controversy" by Victor M. Ponce (April, 1991, Vol. 117, No. 4). ASCE Journal of Hydraulic Engineering 118(9): 1334–1335.

Goodrich, D.C., et al. 2005. Rapid post-fire hydrologic watershed assessment using the AGUA GIS-based hydrologic modeling tool. In Proceedings of the ASCE 2005 Watershed Management Conference, July 2005, Williamsburg, VA, pp. 1–12.

Hawkins, R.H., D.E. Woodward, A.T. Hjelmfelt, J.A. Van Mullem, and Q.D. Quan. 2002. Runoff curve number method: examination of the initial abstraction ratio. Proceedings Federal Interagency Hydrologic Modeling Conference, Las Vegas, NV, 12pp.

Hawkins, R.H. 1993 Asymptotic determination of runoff curve numbers from data. Journal of Irrigation and Drainage Engineering 119, 334–345.

Hawkins, R.H., R.J. Greenberg. 1990. WILDCAT4 flow model. School of Renewable Natural Resources, University of Arizona, Tucson, AZ, BLM contact: Dan Muller, Denver, CO.

Henkle, J.E., E. Wohl, N. Beckman. 2011. Locations of channel heads in the semiarid Colorado Front Range, USA Geomorphology 129, 309–319.

Hey, R.D. 1979. Flow resistance in gravel bed rivers, ASCE Journal of the Hydraulics Division, 105(4), 365–379.

Hicks, D.M., P.D. Mason. 1998. Roughness characteristics of New Zealand rivers, 2nd Edition, Water Resource Publications.

Hudak, A.T., P.R. Robichaud, J.S. Evans, J. Clark, K. Lannom, P. Morgan, C. Stone. 2004. Field validation of burned area reflectance classification (BARC) products for post fire assessment. Remote Sensing for Field Users: Proceedings of the Tenth Forest Service Remote Sensing Applications Conference, Salt Lake City, UT, April 5–9 2004.

Huffman, E.L., L.H. MacDonald, and J.D. Stednick. 2001. Strength and persistence of fire-induced soil hydrophobicity under ponderosa and lodgepole pine, Colorado Front Range. Hydrologic Processes, 15, 2877–2892.

Jakob, M. 2005. A size classification for debris flows. Engineering Geology, 79, 151–161.

Jarrett, R.D. 1984. Hydraulics of high-gradient streams. Journal of Hydraulic Engineering 110 (11), 1519–1539.

Keeley, J.E. 2009. Fire intensity, fire severity and burn severity: a brief review and suggested usage. International Journal of Wildland Fire, 18, 116–126.

LACDPW (Los Angeles County Department of Public Works), 2006. Sedimentation Manual, 2nd Edition.

LandFire 2010. LandFire Fact Sheet, http://www.landfire.gov/.

Lawrence, D. S. L. 1997. Macroscale surface roughness and frictional resistance in overland flow. Earth Surface Processes and Landforms 22: 365–382.

Limerinos J.T. 1970. Determination of the Manning coefficient from measured bed roughness in natural channels. U.S. Geological Survey Water Supply Paper 1898-B, 52 pages.

Litschert, S.E., D.M. Theobald, and T.C. Brown. 2014. Effects of climate change and wildfire on soil loss in Southern Rockies Ecoregion. Catena 118, 206–219.

Livingston, R.K., T.A. Earles, and K.R. Wright. 2005. Los Alamos post-fire watershed recovery: a curve-number-based evaluation. In Proceedings of the ASCE 2005 Watershed Management Conference, July 2005, Williamsburg, VA, pp. 471–481.

MacArthur, R., and J.J. DeVries. (1993) Introduction and application of kinematic wave routing techniques using HEC-1. U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, 68 pages.

MacDonald, L.H., R.N. Sampson, D. Brady, L. Juarros, and D. Martin. Predicting Post-Fire Erosion and Sedimentation Risk on a Landscape Scale: A Case Study from Colorado, pp. 57-87. Chapter 4 in Mapping Wildfire Hazards and Risks, edited by Sampson, R.N., Atkinson, R.D., and Lewis, J.W. Journal of Sustainable Forestry, Vol. 11, 1/2, 2000.

Maidment, D.R. 1992. Handbook of Hydrology McGraw-Hill, Inc.

McCuen, R.H. and T.R. Bondelid. 1983. Estimating Unit Hydrograph Peak Rate Factors. ASCE Journal of Irrigation and Drainage Engineering 109(2), 238–250.

Miller, J.D., and A.E. Thode. 2007. Quantifying burn severity in a heterogeneous landscape with a relative version of the delta Normalized Burn Ratio (dNBR). Remote Sensing of Environment 109, 66–80.

Moody, J.A., et al. 2013. Current research issues related to post-wildfire runoff and erosion processes. Earth Science Reviews, (in publication).

Moody, J.A., and D.A. Martin. 2009. Synthesis of sediment yields after wildfire in different rainfall regimes in the Western United States. International Journal of Wildland Fire, 18, 96–115.

Moody, J. A., and D.A. Kinner. 2006. Spatial structure of stream and hillslope drainage networks following gully erosion after wildfire. Earth Surface Processes and Landforms 31(3): 319–337.

Moody, J.A., and D.A. Martin. 2001. Hydrologic and sedimentologic response of two burned watersheds in Colorado, USGS Water-Resources Investigations Report 01-4122, 146 pages.

NASA 2012. NOAA National Aeronautics and Space Administration , Water and Energy Cycle Web site: http://science.nasa.gov/earth-science/oceanography/ocean-earth-system/ocean-water-cycle/

NWCG 2006. Glossary of wildland fire terminology. National Wildfire Coordinating Group, Incident Operations Standards Working Team.

O'Brien, J. S., P.T. Julien, and W.T. Fullerton. (1993). Two-dimensional water flood and mudflow simulation. ASCE Journal of Hydraulic Engineering 119(2): 244–261.

O'Brien, J.S., and W.T. Fullerton. 1989. Hydraulic and sediment transport study of Crown Pointe flood wall: Breckenridge, Colo., Lenzotti and Fullerton Consulting Engineers, Inc., 34 p.

Oreskes, N., K. Shrader-Frechette, and K. Belitz. (1994) Verification, validation, and confirmation of numerical models in the earth sciences. Science 263, 641–646.

Parsons, A., S.A. Lewis, C. Napper, and J.T. Clark. 2010. Field guide for mapping post-fire soil burn severity. USDA Forest Service General Technical Report RMRS-GTR-243, 49 pages.

Pierson, T.C. 2005. Distinguishing between debris flows and floods from field evidence in small watersheds. USGS factsheet 2004-3142.

Ponce, V.M. 1991. The kinematic wave controversy. ASCE Journal of Hydraulic Engineering 117(4): 511–525.

Ponce, V.M., and D.B. Simons. 1977. Shallow wave propogation in open channel flow. ASCE Journal of Hydraulic Engineering 103: 1461–1476.

Prochaska, A.B., P.M. Santi, J.D. Higgins, and S.H. Cannon. 2008. Debris-flow runout predictions based on the average channel slope (ACS). Engineering Geology, 98, 29–40.

Rallison, R.E. 1980. Origin and evolution of the SCS runoff equation. Proceedings of the Symposium on Watershed Management; American Society of Civil Engineers, Boise, ID.

Rallison, R.E., and N. Miller. 1982. Past, present, and future SCS runoff procedure. In Rainfall-Runoff Relationships, V.P. Singh, ed., Water Resources Publ., Littleton, CO, pp. 353–364.

Rawls, W.J., D.L. Brakensiek, and N. Miller. 1983. Green-Ampt infiltration parameters from soils data. ASCE Journal of Hydraulic Engineering. 109: 62–70.

Robichaud, P.R., S.A. Lewis, L.E. Ashmum. 2008. New procedure for sampling infiltration to assess post-fire soil water repellency. USDA Forest Service, Rocky Mountain Research Station, Research Note RMRS-RN-33.

Safford, H.D., et al. 2008. BAER Soil Burn Severity Maps Do Not Measure Fire Effects to Vegetation: A Comment on Odion and Hanson (2006). Ecosystems, 11:1, 1–11.

Santi, P. and L. Morandi. 2012. Comparison of debris-flow volumes from burned and un-burned areas. Landslides, 9, 1-13.

Santi, P. et al. 2006. Evaluation of post-wildfire debris flow mitigation methods and development of decision-support tools. Report to USGS and the Joint Fire Science Program, 78 pages.

Saxton, K.E., W.J. Rawls, J.S. Romberger, and R.I. Papendick. (1986) Estimating generalized soil-water characteristics from texture. Transactions of the American Society of Agricultural Engineers 50(4): 1031–1035.

Scott, D.F. 2000. Soil wettability in forested catchments of South Africa; as measured by different methods and as affected by vegetation cover and soil characteristics. Journal of Hydrology 231–232, 87–104.

Smith, R.E., D.C. Goodrich, D.A. Woolhiser, C.L. Unkrich. 2005. KINEROS – A kinematic runoff and erosion model. In: Computer Models of Watershed Hydrology, V.J. Singh (Editor). Water Resource Publications, Highland Ranch, CO, pp. 597–632.

Springer, E.P., R.H. Hawkins. 2005. Curve number and peakflow responses following the Cerro Grande Fire on a small watershed. In: Moglen, G.E., ed. Proceedings of Managing Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges, July 19–22, 2005, Williamsburg, VA, USA. American Society of Civil Engineers, Alexandria, VA.

Stoof, C.R., R.W. Vervoort, J. Iwema, E. van den Elsen, A.J.D. Ferreira, C.J. Ritsema. 2011. Hydrological response of a small catchment burned by an experimental fire. Hydrology and Earth System Sciences Discussions 8, 4053–4098.

Story, M. 2003. Cited by USDA Forest Service BAER Tools Web page.

Stuart, B. 2000. Maudlow Fire, Burned Area Emergency Rehabilitation (BAER) plan. Townend MT: USDA Forest Service, Northern Region, Helena National Forest.Cited by USDA Forest Service BAER Tools Web page.

Tedela, N.H., S.C. McCutcheon, T.C. Rasmussen, R.H. Hawkins, W.T. Swank, J.L. Campbell, M.B. Adams, C.R. Jackson, and E.W. Tollner. 2012. Runoff curve numbers for 10 small forested watersheds in the mountains of the Eastern United States. ASCE Journal of Hydrologic Engineering, 17, 1188–1198.

Theobald, D.M., D.M. Merritt, and J.B. Norman, III. 2010. Assessment of threats to riparian ecosystems in the Western U.S. A report presented to The Western Environmental Threats Assessment Center, Prineville, OR, by the USDA Stream Systems Technology Center and Colorado State University, Fort Collins, 61p.

Theurer, F.D., D.S. Moore, W.H. Merkel, Q.D. Quan, H.F. Moody, R.L. Bingner, J. Bonta, and D. Flanagan. 2010. Comparison of historical versus synthetic weather inputs to watershed models and their effect on pollutant loads. In Proceedings of the 2nd Joint Federal Interagency Conference, Las Vegas, NV, 12pp.

USACE-HEC (U.S. Army Corps of Engineers, Hydrologic Engineering Center), 2013. Hec-HMS.

USDA-ARS (U.S. Department of Agriculture-Agricultural Research Service), 2013a. AGNPS.

National Sedimentation Laboratory, ARS, USDA, Oxford, MS.

USDA-ARS (U.S. Department of Agriculture-Agricultural Research Service), 2013b. Soil and Water Assessment Tool: SWAT. Grassland Soil and Water Research Laboratory, ARS, USDA, Temple, TX.

USDA-ARS (U.S. Department of Agriculture-Agricultural Research Service), 2013c. The Soil Infiltration Model in KINEROS2. Southwest Watershed Research Center, Tucson, AZ.

USDA-ARS (U.S. Department of Agriculture-Agricultural Research Service), 2013d. Science Documentation Revised Universal Soil Loss Equation Version 2 (RUSLE2) ARS Washington, DC. 355pp.

USDA Forest Service (U.S. Department of Agriculture) 2015. Burned Area Emergency Response Tools Web page.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004a. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 9, Hydrologic soil cover complexes. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004b. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 10, Estimation of direct runoff from storm rainfall. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004c. WinTR-20 User Guide. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2009a. Small Watershed Hydrology WinTR-55 User Guide. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2009b. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 7, Hydrologic Soil Groups. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2010. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 15, Time of Concentration. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2007. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 16, Hydrographs. Accessed in April 2013.

USDA-SCS (U.S. Department of Agriculture-Soil Conservation Service), 1991. Engineering Field Handbook, Chapter 2, Estimating Runoff. Accessed in April 2013.

Woolhiser, D.A. 1992. Discussion of "The kinematic wave controversy" by Victor M. Ponce (April, 1991, Vol. 117, No. 4). ASCE Journal of Hydraulic Engineering 118(9): 1337–1339.

Yochum, S., B. Bledsoe. 2010. Flow resistance estimation in high-gradient streams. 2nd Joint Federal Interagency Conference, Las Vegas, NV, June 27– July 1.

Yochum, S.E., B.P. Bledsoe, G.C.L. David, E. Wohl. 2012. Velocity prediction in high-gradient channels. Journal of Hydrology. 424–425, 84–98, doi:10.1016/j.jhydrol.2011.12.031.

Yochum, S.E., F. Comiti, E. Wohl, G.C. L. David, L. Mao. 2014. Photographic guidance for selecting flow resistance coefficients in high-gradient channels. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, General Technical Report RMRS-GTR-323.

Zhang, X.C. and J.D. Garbrecht. 2003. Evaluation of CLIGEN precipitation parameters and their implication on WEPP runoff and erosion prediction. In Transactions of the American Society of Agricultural Engineers, 46, 311–320.

Appendix A: Case Study 1

High Park Fire, Colorado

References

BAER 2012. High Park Fire Burned Area Emergency Response Report. USDA USFS and NRCS, Larimer County, CO, Department of Transporation.

Capesius, J.P., and V.C. Stephens. 2009. Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado. U.S. Department of Interior, U.S. Geological Survey, Scientific Investigations Report 2009-5136.

Conedera, M., L. Peter, P. Marxer, F. Forster, D. Rickenmann, and L. Re. 2003. Consequences of forest fires on the hydrogeological response of mountain catchments: A case study of the Riale Buffaga, Ticino, Switzerland. Earth Surface Processes and Landforms 28, 117-129.

Garen, D.C., and D.S. Moore. 2005. Curve Number Hydrology in Water Quality Modeling: Uses, Abuses and Future Directions. Journal of the American Water Resources Association 42(2), 377-388.

Goodrich, D.C., H.E. Canfield, I.S. Burns, D.J. Semmens, S.N. Miller, M. Hernandez, L.R. Levick, D.P. Guertin, and W.G. Kepner. 2005. Rapid Post-Fire Hydrologic Watershed Assessment Using the AGWA GIS-Based Hydrologic Modeling Tool. In: Moglen, G.E., ed. Proceedings of Managing Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges, July 19-22, 2005, Williamsburg, VA, USA. American Society of Civil Engineers, Alexandria, VA.

Hawkins, R.H. 1993. Asymptotic Determination of Runoff Curve Numbers from Data. Journal of Irrigation and Drainage Engineering 119, 334-345.

Hawkins, R.H., R.J. Greenberg. 1990 WILDCAT4 Flow Model. School of Renewable Natural Resources, University of Arizona, Tucson, AZ. BLM contact: Dan Muller, Denver, CO.

Hudak, A.T., P.R. Robichaud, J.S. Evans, J. Clark, K. Lannom, P. Morgan, and C. Stone. 2004. Field Validation of Burned Area Reflectance Classification (BARC) Products for Post Fire Assessment. Remote Sensing for Field Users: Proceedings of the Tenth Forest Service Remote Sensing Applications Conference, Salt Lake City, Utah, April 5-9 2004.

Livingston, R.K., T.A. Earles, and K.R. Wright. 2005. Los Alamos Post-Fire Watershed Recovery: A Curve-Number-Based Evaluation. In: Moglen, G.E., ed. Proceedings of Managing Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges, July 19-22, 2005, Williamsburg, VA, USA. American Society of Civil Engineers, Alexandria, VA.

Maidment, D.R. 1992. Handbook of Hydrology McGraw-Hill, Inc.

Moody, J.A., and D.A. Martin. 2001. Post-Fire, Rainfall-Intensity-Peak Discharge Relations for Three Mountainous Watersheds in the Western USA. Hydrological Processes 15, 2981-2993.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-Frequency Atlas of the Western United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, NOAA Atlas 2, Vol 3, Silver Spring, MD.

Rallison, R.E. 1980. Origin and Evolution of the SCS Runoff Equation. Proceedings of the Symposium on Watershed Management; American Society of Civil Engineers, Boise, ID.

Springer, E.P., and R.H. Hawkins. 2005. Curve Number and Peakflow Responses Following the

Cerro Grande Fire on a Small Watershed. In: Moglen, G.E., ed. Proceedings of Managing

Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges, July 19-22, 2005, Williamsburg, VA, USA. American Society of Civil Engineers, Alexandria, VA.

Tedela, N.H., S.C. McCutcheon, T.C. Rasmussen, R.H. Hawkins, W.T. Swank, J.L. Campbell, M.B. Adams, C.R. Jackson, and E.W. Tollner. 2012. Runoff Curve Numbers for 10 Small Forested Watersheds in the Mountains of the Eastern United States. Journal of Hydrologic Engineering, 17(11), 1188-1198.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004a.

NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 9, Hydrologic Soil Cover Complexes.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004b. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 10, Estimation of Direct Runoff from Storm Rainfall.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2010. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 15, Time of Concentration.

Woodward, D. 2005. Personal Communications (email). Retired National Hydraulic Engineer, USDA Natural Resources Conservation Service, Washington, DC.

Wright, K.R., T.A. Earles, and E. Pemberton. 2005. Mesa Verde Bircher Fire Hydrological Impact. In: Moglen, G.E., ed. Proceedings of Managing Watersheds for Human and Natural Impacts: Engineering, Ecological, and Economic Challenges, July 19-22, 2005, Williamsburg, VA, USA. American Society of Civil Engineers, Alexandria, VA.

Yochum, S.E. 2012a. Poster: Increased Flood Potential of Steams Draining the High Park Fire, with Ratios of Predicted Post/Pre Fire Peak Flows for the 1-Hour, 25-Year Rain Event. U.S. Department of Agriculture, Natural Resources Conservation Service, Colorado State Office.

Yochum, S.E. 2012b. High Park Fire: Increased Flood Potential Analysis. U.S. Department of Agriculture, Natural Resources Conservation Service, Colorado State Office.

Yochum, S., and B. Bledsoe. 2010. Flow resistance in high-gradient streams. Proceedings of 4th Interagency Hydraulic Modeling Conference, June 21 – July 1st, 2010, Las Vegas, NV, USA.

Appendix B: Case Study 2:
Bitterroot Wildfires, Montana

References

Benavides-Solario, J.D., and L.H. MacDonald. 2001. Post-fire runoff and erosion from simulated rainfall on small plots, Colorado Front Range. Hydrological Processes, 15, 2931–2952.

Breiby, T. 2006. Assessment of soil erosion risk within a subwatershed using GIS and RUSLE with a comparative analysis of the use of STATSGO and SSURGO soil databases. Volume 8, Papers in Resource Analysis. Saint Mary's University of Minnesota Central Services Press. Winona, MN. 22 pages.

Capesius, J.P., and V.C. Stephens. 2009. Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado. U.S. Department of Interior, U.S. Geological Survey, Scientific Investigations Report 2009–5136.

Chen, L., M. Berli, C. Karletta. 2013. Examining modeling approaches for the rainfall-runoff process in wildfire-affected watersheds: using San Dimas Experimental Forest. Journal of the American Water Resources Association 1-16.

Conedera, M., L. Peter, P. Marxer, F. Forster, D. Rickenmann, and L. Re. 2003. Consequences of forest fires on the hydrogeological response of mountain catchments: A case study of the Riale Buffaga, Ticino, Switzerland. Earth Surface Processes and Landforms 28, 117–129.

Dawen, T., K. Shinjiro, O. Tailkan, K. Toshio, and M. Katumi. 2003. Global potential soil erosion with reference to land use and climate changes. Hydrologic Processes 17, 2913–2928.

Desmet, P.J.J., and G. Grovers. 1996. A GIS procedure for automatically calculating the USLE LS-factor on topographically complex landscape units. Journal of Soil and Water Conservation 51(5):427–433.

Elliot, W.J., A.V. Elliot, W. Qiong, and J.M. Laflen. 1991. Validation of the WEPP model with rill erosion plot data, paper presented at the 1991 ASAE International Winter Meeting, Am. Soc. Of Agric. Eng., Chicago, IL, Dec. 1991.

Guobin, T., C. Shulin, and M.K. Donald. 2006. Modeling the impacts of no-till practice on soil erosion and sediment yield with RUSLE, SEDD, and ArcView GIS. Soil & Tillage Research 85, 38–49.

Hudak, A.T., P.R. Robichaud, J.S. Evans, J. Clark, K. Lannom, P. Morgan, and C. Stone. 2004. Field Validation of Burned Area Reflectance Classification (BARC) Products for Post Fire Assessment. Remote Sensing for Field Users: Proceedings of the Tenth Forest Service Remote Sensing Applications Conference, Salt Lake City, UT, April 5–9 2004.

Huffman, E.L., L.H. MacDonald, and J.D. Stednick. 2001. Strength and persistence of fire-induced soil hydrophobicity under ponderosa and lodgepole pine, Colorado Front Range. Hydrologic Processes, 15, 2877–2892.

Larsen, I. J., and L.H. MacDonald . 2007. Predicting postfire sediment yields at the hillslope scale: Testing RUSLE and Disturbed WEPP, Water Resources Res., 43 (W11412): 1–18.

Litschert, S.E., D.M. Theobald, and T.C. Brown. 2014. Effects of climate change and wildfire on soil loss in Southern Rockies Ecoregion. Catena 118, 206–219.

References

BAER 2012. High Park Fire Burned Area Emergency Response Report. USDA USFS and NRCS, Larimer County, CO, Department of Transportation.

Cerrelli, G.A. 2005. FIRE HYDRO, a simplified method for predicting peak discharges to assist in the design of flood protection measures western wildfires. In Proceedings of the ASCE 2005 Watershed Management Conference, July 2005, Williamsburg, VA. pp. 935-941.

Mahlum, S.K., L.A. Eby, M.K. Young, C.G. Clancy, and M. Jakober, 2011. Effects of wildfire on stream temperatures in the Bitterroot River Basin, Montana. International Journal of Wildland Fire, 20, 240-247.

USDA-NRCS (U.S. Department of Agriculture Natural Resources Conservation Service), 2004a. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 9, Hydrologic Soil Cover Complexes.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004b. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 10, Estimation of Direct Runoff from Storm Rainfall.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004c. WinTR-20 User Guide. Available at http://go.usa.gov/KoZ/. Accessed in April 2013.

USDA-NRCS (U.S. Department of Agriculture-Natural Resources Conservation Service), 1984. NRCS National Engineering Handbook, Part 650 Engineering Field Handbook, Chapter 2, Estimating Runoff.

Appendix C: Case Study 3:
West Fork Complex Fire, Colorado

References

Benavides-Solario, J.D., and L.H. MacDonald. 2001. Post-fire runoff and erosion from simulated rainfall on small plots, Colorado Front Range. Hydrological Processes, 15, 2931–2952.

Breiby, T. 2006. Assessment of soil erosion risk within a subwatershed using GIS and RUSLE with a comparative analysis of the use of STATSGO and SSURGO soil databases. Volume 8, Papers in Resource Analysis. Saint Mary's University of Minnesota Central Services Press. Winona, MN. 22 pages.

Capesius, J.P., and V.C. Stephens. 2009. Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado. U.S. Department of Interior, U.S. Geological Survey, Scientific Investigations Report 2009–5136.

Chen, L., M. Berli, C. Karletta. 2013. Examining modeling approaches for the rainfall-runoff process in wildfire-affected watersheds: using San Dimas Experimental Forest. Journal of the American Water Resources Association 1-16.

Conedera, M., L. Peter, P. Marxer, F. Forster, D. Rickenmann, and L. Re. 2003. Consequences of forest fires on the hydrogeological response of mountain catchments: A case study of the Riale Buffaga, Ticino, Switzerland. Earth Surface Processes and Landforms 28, 117–129.

Dawen, T., K. Shinjiro, O. Tailkan, K. Toshio, and M. Katumi. 2003. Global potential soil erosion with reference to land use and climate changes. Hydrologic Processes 17, 2913–2928.

Desmet, P.J.J., and G. Grovers. 1996. A GIS procedure for automatically calculating the USLE LS-factor on topographically complex landscape units. Journal of Soil and Water Conservation 51(5):427–433.

Elliot, W.J., A.V. Elliot, W. Qiong, and J.M. Laflen. 1991. Validation of the WEPP model with rill erosion plot data, paper presented at the 1991 ASAE International Winter Meeting, Am. Soc. Of Agric. Eng., Chicago, IL, Dec. 1991.

Guobin, T., C. Shulin, and M.K. Donald. 2006. Modeling the impacts of no-till practice on soil erosion and sediment yield with RUSLE, SEDD, and ArcView GIS. Soil & Tillage Research 85, 38–49.

Hudak, A.T., P.R. Robichaud, J.S. Evans, J. Clark, K. Lannom, P. Morgan, and C. Stone. 2004. Field Validation of Burned Area Reflectance Classification (BARC) Products for Post Fire Assessment. Remote Sensing for Field Users: Proceedings of the Tenth Forest Service Remote Sensing Applications Conference, Salt Lake City, UT, April 5–9 2004.

Huffman, E.L., L.H. MacDonald, and J.D. Stednick. 2001. Strength and persistence of fire-induced soil hydrophobicity under ponderosa and lodgepole pine, Colorado Front Range. Hydrologic Processes, 15, 2877–2892.

Larsen, I. J., and L.H. MacDonald . 2007. Predicting postfire sediment yields at the hillslope scale: Testing RUSLE and Disturbed WEPP, Water Resources Res., 43 (W11412): 1–18.

Litschert, S.E., D.M. Theobald, and T.C. Brown. 2014. Effects of climate change and wildfire on soil loss in Southern Rockies Ecoregion. Catena 118, 206–219.

Maidment, D.R. 1992. Handbook of Hydrology McGraw-Hill, Inc.

McCuen, R.H. 1998. Hydrologic analysis and design. Second edition. Prentice-Hall, Inc., Upper Saddle River, NJ.

Miller, J.F., R.H. Frederick, and R.J. Tracey. 1973. Precipitation-Frequency Atlas of the Western United States. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Weather Service, NOAA Atlas 2, Vol 3, Silver Spring, MD.

Nearing, M.A. 1997. A single continuous function for slope steepness influence on soil loss. Soil Science Society of America 61(3): 917–919.

Perica, S., D. Martin, S. Pavlovic, I. Roy, M. St. Laurent, C. Trypaluk, D. Unruh, M. Yekta, G. Bonnin. 2013. NOAA Atlas 14 Volume 8 Version 2, Precipitation-Frequency Atlas of the United States, Midwestern States. NOAA, National Weather Service, Silver Spring, MD.

Rallison, R.E. 1980. Origin and Evolution of the SCS Runoff Equation. Proceedings of the Symposium on Watershed Management; American Society of Civil Engineers, Boise, ID.

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder. 1997. Predicting soil erosion by water: A guide to conservation planning with the revised universal soil loss equation (RUSLE), Agric. Handb. 703, 404 pp., USDA, Washington, DC.

Renschler, C.S. 2003. Designing geospatial interfaces to scale process models: The GeoWepp approach, Hydrol. Processes, 17, 1005–1017.

Robichaud, P.R. 2000. F ire effects on infiltration rates after prescribed fire in northern Rocky Mountain forests, USA, J. Hydrol., 231–232, 220–229.

Stoof, C.R., R.W. Vervoort, J. Iwema, E. van den Elsen, A.J.D. Ferreira, C.J. Ritsema. 2011. Hydrological response of a small catchment burned by an experimental fire. Hydrology and Earth System Sciences Discussions 8, 4053–4098.

Theobald, D.M., D.M. Merritt, and J.B. Norman, III. 2010. Assessment of threats to riparian ecosystems in the Western U.S. A report presented to The Western Environmental Threats Assessment Center, Prineville, OR, by the USDA Stream Systems Technology Center and Colorado State University, Fort Collins, 61p.

Toy, T.J, and G.R. Foster, co-editors. 1998. Guidelines for the use of the Revised Universal Soil Loss Equation (RUSLE) version 1.06 on mined lands, construction sites, and reclaimed lands. Office of Surface Mining and Reclamation (OSM). Western Regional Coordinating Center, Denver, CO.

USDA-NRCS (Department of Agriculture-Natural Resources Conservation Service), 2004a. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 9, Hydrologic Soil Cover Complexes.

USDA-NRCS (Department of Agriculture-Natural Resources Conservation Service), 2004b. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 10, Estimation of Direct Runoff from Storm Rainfall.

USDA-NRCS (Department of Agriculture-Natural Resources Conservation Service), 2010. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 15, Time of Concentration.

USGS (U.S. Geological Survey) National Gap Analysis Program. 2004. Provisional digital land cover map for the Southwestern United States. Version 1.0. RS/GIS Laboratory, College of Natural Resources, Utah State University.

Winchell, M.F., S.H. Jackson, A.M. Wadley, and R. Srinivasan. 2008. Extension and validation of a geographic information system-based method for calculating the Revised Universal Soil Loss Equation length-slope factor for erosion risk assessments in large watersheds. Journal of Soil and Water Conservation 63(3): 105–111.

Woodward, D., R. Hawkins, R. Jiang, A. Hjelmfelt, Jr., J. Van Mullem, and Q. Quan. 2003. Runoff Curve Number Method: Examination of the Initial Abstraction Ratio. World Water & Environmental Resources Congress 2003: pp. 1–10.

Yochum, S., and J. Norman. 2014. West Fork Complex Fire: Potential Increase in Flooding and Erosion. USDA Natural Resources Conservation Service, Colorado State Office, Denver, CO.

Appendix D: Case Study 4:
Whitewater Creek, Gila Wilderness, New Mexico

References

Bedient, P.B., W.C. Huber, and B.E. Vieux. 2012. Hydrology and Floodplain Analysis, Prentice Hall, NJ, 5th Edition, 801 pages.

Beven, K.J. 2001. How far can we go in distributed hydrologic modelling? Hydrology and Earth Systems Sciences 5, 1-12.

ESRI (Environmental Systems Resource Institute). 2010. ArcMap 10.0 ESRI, Redlands, CA.

MacArthur, R., and J.J. DeVries. (1993) Introduction and application of kinematic wave routing techniques using HEC-1. U.S. Army Corps of Engineers Hydrologic Engineering Center, Davis, CA, 68 pages.

Moody. T., M. Wirtanen, and S.N. Yard. (2003) Regional relationships for bankfull stage in natural channels of the arid Southwest. Report from Natural Channel Design, Inc., Flagstaff, AZ, 38 pages.

NOAA National Weather Service Precipitation Frequency Data Server 2013a. Available at http://dipper.nws.noaa.gov/hdsc/pfds/. Accessed Sep 2013.

NOAA National Weather Service, 2013b. Service Assessment, The Record Front Range and Eastern Colorado Floods of September 11-17, 2013b.

Oreskes, N., K. Shrader-Frechette, and K. Belitz. (1994) Verification, validation, and confirmation of numerical models in the earth sciences. Science 263, 641-646.

Osborn, H.B., L.J. Lane, and V.A. Myers. (1980) Rainfall/watershed relationships for Southwestern Thunderstorms. Transactions ASAE 23(1), 82-91.

Tillery, A.C., A.M. Matherne, and K.L. Verdin. (2012) Estimated probability of postwildfire debris flows in the 2012 Whitewater-Baldy fire burn area, Southwestern New Mexico. USGS Open File Report 2012-1188, 11 pages.

USACE-HEC (U.S. Army Corps of Engineers, Hydrologic Engineering Center), 2013. HEC-HMS Technical Reference Manual. Accessed in April, 2013.

USDA Forest Service (2012) Glenwood, Reserve and Wilderness Ranger Districts, BAER Report Executive Summary for the Whitewater Baldy Complex fire, including hydrology appendices.

USDA-NRCS. 2010. NRCS National Engineering Handbook, Part 630 Hydrology, Chapter 15, Time of Concentration.

USDA-SCS. 1985. Soil Survey of Catron County, New Mexico, Northern Part, 199 pp.

Appendix E: Case Study 5:
Saratoga Springs, Utah

Predicting and Comparing Measured Bulking and Peak Discharge Using Multiple Methods for Post-Fire Hydrologic and Sedimentation Analysis on the Dump Fire in Saratoga Springs

References

Arnold, J. G., D. N. Moriasi, P. W. Gassman, K. C. Abbaspour, M. J. White, R. Srinivasan, C. Santhi, R. D. Harmel, A. van Griensven, M. W. Van Liew, N. Kannan, M. K. Jha, SWAT: Model Use, Calibration and Validation. Transactions of the ASABE. 55(4): 1491-1508.

Bridges, B.L. 1973. Map: Estimated sediment yield for the State of Utah. Erosion and Sedimentation, Western U.S. Water Plan, prepared by SCS August 1973.

Cannon, S.H. and J.E. Gartner. 2005. Wildfire-related debris flow from a hazards perspective, in Jakob, M. and Hungr, O., Debris-flows hazards and related phenomena: Chichester, United Kingdom, Springer-Praxis Books, p. 362–385.

Fry, J., G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold, and J. Wickham, 2011. Completion of the 2006 National Land Cover Database for the Conterminous United States, PE&RS, Vol. 77(9):858-864.

Gartner, J.E., S.H. Cannon, P.M. Santi, and V.G. deWolfe. 2008. Empirical models to predict the volumes of debris flows generated by recently burned basins in the western U.S. Geomorphology, 96, 339-354.

Giraud, R.E., and J.J. Castleton. 2009. Estimation of Potential Debris-Flow volumes for Centerville Canyon, Davis County, Utah. Report of Investigation 267 Utah Geological Survey, Utah Department of Natural Resources, Salt Lake City, UT.

Goodrich, D.C., H. E. Canfield, I.S. Burns, D.J. Semmens, S.N. Miller, M. Hernandez, L.R. Levick, D.P. Guertin, and W.G. Kepner. 2005. Rapid Post-Fire Hydrologic Watershed Assessment using the AGWA GIS based Hydrologic Modeling Tool. Proc. ASCE Watershed Manage. Conf., July 19-22, Williamsburg, VA.

Kenney, T.A., C.D. Wilkowske, and S.J. Wright. 2007. Methods for estimating magnitude and frequency of peak flows for natural streams in Utah: U.S. Geological Survey Scientific Investigations Report 2007-5158, 28 p.

McLin, S. G., E.P. Springer, and L.J. Lane. 2001. Predicting floodplain boundary changes following the Cerro Grande wildfire. Hydrological Proc., 15(15): 2967-2980.

Smith, R.E., D.C. Goodrich, and J.N. Quinton. 1995. Dynamic, distributed simulation of watershed erosion: The KINEROS2 and EUROSEM models, Journal of Soil and Water Conservation, 50(5): 517-520.

USDA-ARS (U.S. Department of Agriculture-Agricultural Research Service). 2014. AGWA (Automated Geospatial Watershed Assessment Tool) Web site, through the ARS Southwest Watershed Research Center, Tuscon, AZ, http://www.tucson.ars.ag.gov/agwa/.

USDA-NRCS(a) (U.S. Department of Agriculture-Natural Resources Conservation Service), 2004. WinTR-20 User Guide. Available at http://go.usa.gov/KoZ/. Accessed in April 2013.

USDA-NRCS(b), 2004. National Engineering Handbook, Part 630 Hydrology, Chapter 9, Hydrologic Soil-Cover Complexes.

USDA-NRCS(c), 2012. Soil Survey Geographic (SSURGO) Database. Available online at http://sdmdataaccess.nrcs.usda.gov/. Accessed (2012).

Woolhiser, D.A., R.E. Smith, and D.C. Goodrich. 1990. KINEROS, A kinematic runoff and erosion model: Documentation and User Manual. U.S. Department of Agriculture, Agricultural Research Service, ARS-77, 130 pp.