KARST SINKHOLE BUFFERS: Effective Ground Water Protection Measures
by C. Nelson Hoy, Forester, Rancher and Conservationist

Editor's note: The following essay was originally published in "The River Runs", the flagship newsletter of the Cowpasture River Preservation Association and also published by the award-winning local newspaper, "The Recorder". The goal of the series is to create awareness among students, citizens and officials of the critical need to protect our surface and ground-water resources, and to stimulate interest in progressive stewardship.

WILLIAMSVILLE – Karst terrain is among the most fragile land forms in the world and it is a defining attribute of the Cowpasture River Valley of Virginia. Karst is a landscape that is formed by the dissolution of soluble rocks such as limestone and it is characterized by drainage systems with sinkholes; sinking, losing or negtive streams; and caves. During drougth and dry weather, the Cowpasture River flows beneath Berriedale Farms through crevices, channels and caves to resurge four miles further south as Coursey Springs.

Karst Sinkholes and Sinking Streams – Sinkholes are natural depressions in the surface of the land that are roughly shaped like a bowl. Rain that falls into a sinkhole and water that sheets along the surface or travels through soils and rock layers into a sinkhole then drains downward and recharges the underlying karst aquifer. Sinkholes are further characterized by either open or closed throats. Bullpasture Mountain, Jack Mountain, Tower Hill Mountain, Back Creek Mountain and Little Mountain, and the Burnsville Cove Area and Little Valley are all riddled with sinkholes varying in size from a few feet across to over a mile in length. The Cowpasture River in its northern reaches is a sinking stream as is Dry Run and in the Jackson River watershed Back Creek is a sinking stream.

Ground Water Contamination – Karst sinkholes and sinking streams are the primary conduites for contamination such as debris, sedimentation, bacteria, nutrients and industrial chemicals to enter our ground water aquifers. Ground water contamination in karst terrain is a huge problem because cracks, fissures, passageways and caves in limestone formations allow contaminated water to move long distances sometimes miles in short time spans like days and furthermore, without very much filtration or cleansing or none at all. Because there are no practical measures for cleaning up contaminated karst aquifers, the karst water resources can be lost for human and livestock consumption over a lifetime.

Ground Water Values – Homesteaders, farmers and businesses in the Cowpasture and Bullpasture Rivers Valley are 100% dependent upon cool, clear, water and use ground water for at least three purposes:

- Domestic and Public Water Wells – The water ecosystem services include water for drinking, cooking, bathing, gardening and washing.
- Farm Livestock Water Supplies – Services include water for draft horses, beef cattle, dairy cattle, sheep, goats, pigs, poultry and fish.
- Farm Irrigation Water Supplies – Agricultural uses includes operations such as commodity crop farms, landscape and horticulture businesses, and tree nurseries.

Protecting Ground Water Resources – Neither the Federal government in Washington nor the

Commonwealth of Virginia in Richmond effectively regulate human activity to guarantee the protection of ground water resources in rural communities like those of the Cowpasture and Jackson River valleys of Virginia. Both Bath and Highland Counties lack the subject matter expertise to either formulate or oversee ground water resource protection measures. So homesteaders, farmers, ranchers and businesses in the Cowpasture, Bullpasture and Jackson River valleys must establish for themselves the best in class measures necessary for ground water protection. The 12-step process outlined below is a rural community's gold standard for protecting the quality of ground waters with karst sinkhole buffers.

Step No. One – Desk-top Sinkhole Reconnaissance. All private, corporate, utility and government construction permits in karst terrain that involve earth movement and/or stormwater management should be preceeded with a desk-top reconnaissance for sinkholes and losing streams including; a review of topographic maps and the interpretation of aerial photography, side-looking radar and space platform imagery.

Step No. Two – On-the-ground Field Assessments. When sinkholes and/or sinking streams are found through reconnaissance within one quarter of a mile of a construction site, regulatory agencies should mandate that a karst-certified geologist conduct an on-the-ground assesment to locate both karst sinkholes and losing stream sinks and to record their GPS-coordinate locations within three feet.

Step No. Three – Identify Pollution Hot-spots. Pollution hot spots within the sinkhole basin including the Upland Water Source Capture Zone must be located and described in terms of the cumulative risks and exposures to the quality of ground water in karst aquifers including: gas transmission compressor stations; pipeline maintenance ports; horizontal directional drilling mud effluent discharge points; surface or ground water withdrawal points; hydrostatic testing water and waste disposal points; storage areas and dispensing facilities for gasoline, diesel fuel, oils and greases; blasting locations and the specific explosive chemicals used; temporary and permanent road crossings of rivers, runs and drafts; vehicle, truck and construction equipment storage, staging or parking areas; locations of dams, impoundments, ponds or catch-basins; Millboro (black) Shale rock and soil exposures; private or public septic fields; agricultural fertilizer storage or stockpiles.

Step No. Four – Delineation of Sinkhole Perimeter and Basin. Construction site plans must delineate the sinkhole throat or lowest point in a closed sinkhole, the sinkhole perimeter or parapet, the immediate surface water drainage area into the sinkhole, and the upland water supply basin for the sinkhole.

Step No. Five – Conduct Dye Tracing Studies. Dye tracing studies must be conducted of all sinkholes with open throats where a ground water pollution hot-spot is located within a karst sinkhole basin and determine the karst waters directional flow and resurgence. Dye tracing studies in the Cowpasture and Jackson River Valleys should investigate all domestic wells and resurging springs within a seven mile radius.

Step No. Six – Design and Construction of Three-zone Karst Sinkhole Buffers. Construction site plans must provide for the design, construction and maintenance of a three-zone karst sinkhole protection buffer that features: (a) a Critical Sanitary Protection Zone including the sinkhole and parapet with maximum protective measures such as no construction whatsoever, limited access and use, original and natural vegetation, and a perimeter fence; (b) a Contaminant and Microbiology Filtration Zone with the original and natural plant communities of trees, shrubs and grasses, and no earth movement; and (c) an Upland Water Source Capture Zone with strict stormwater discharge measures to keep stormwater out of the ground water recharge basin or divide.

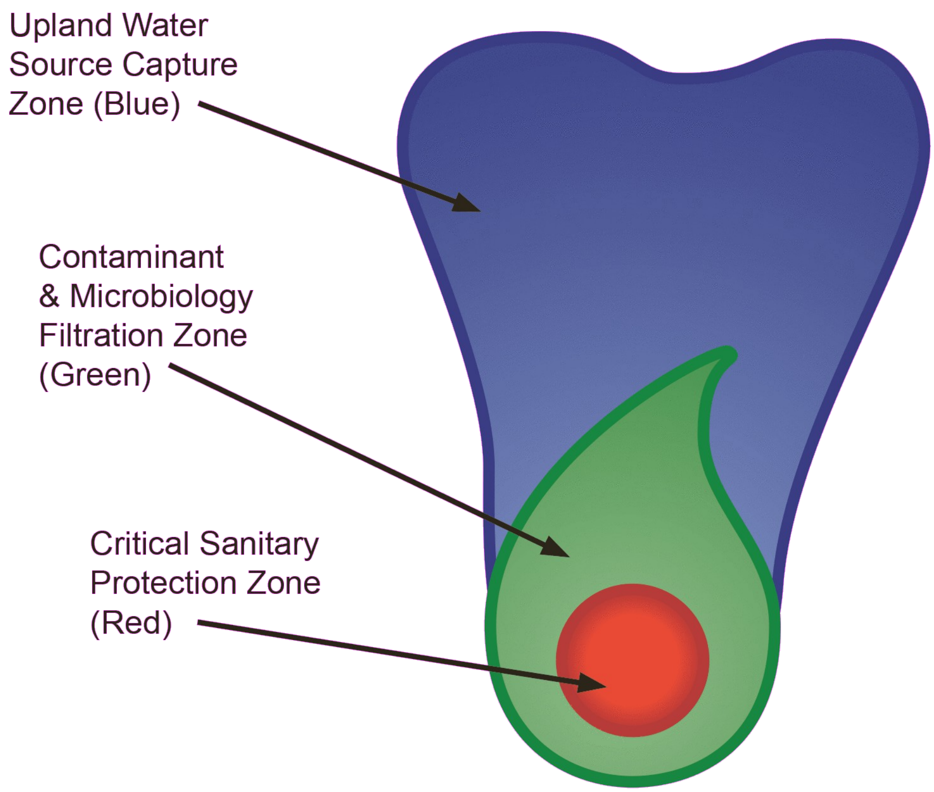

Figure No. 1 – A Three-zone Karst Sinkhole Buffer for the Best in Class Protection of Ground Water Resources in Rural Watersheds.

Step No. Seven – Preserve Natural Vegetation. Ensure that natural vegetation is preserved and particularly well-established and mature trees with deep roots that retain soil and loose rock.

Step No. Eight – Fence Sinkhole Perimeter. Protect the sinkhole at its perimeter or parapet with a livestock-poof fense that also discourages human activity in the sinkhole's Critical Sanitary Protection Zone.

Step No. Nine – Prohibit Construction Activity. Prohibit all earth movement, agricultural and construction activity within the karst sinkhole's Critical Sanitary Protection Zone.

Step No. Ten – Avoid Stormwater In-diversions. Avoid the diversion of stormwater from earth movement and construction activity into the karst sinkhole's Contaminant and Microbiology Filtration Zone.

Step No. Eleven – Deny Injection Well Permits. Deny any and all injection permits for wells that penetrate, intersect or terminate in karst formations.

Step No. Twelve – Establish riparian buffer areas along sinking, losing or negative streams for a sufficient distance upstream to ensure that the waterway naturally cleanses itself of debris, sedimentation, bacteria, nutrients and industrial contaminants. The width of effective riparian buffers varies depending upon both gradient and vegetative cover from 95' along slopes of 3-5% to 775' feet along slopes of 15% – **steeper slopes require even wider buffer areas**. The length of effective riparian buffers above or upstream from a sink reasonably may be a considerable distance and measured most likely in miles.

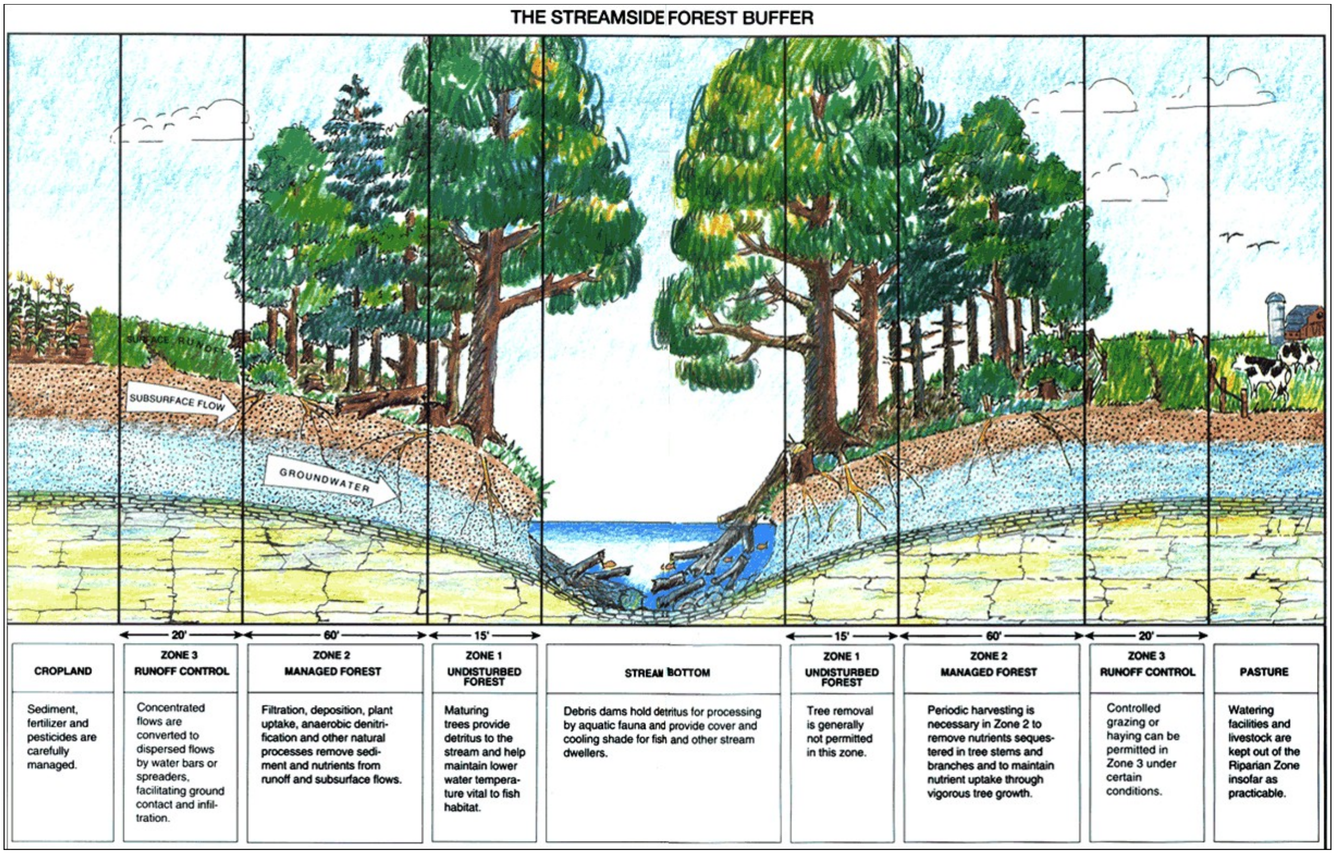

Figure No. 2 – A Riparian Buffer for Protecting a Karst Sinking Stream.

Call for Action – The Cowpasture and Jackson Rivers Preservation Associations should ask the Virginia Departmernt of Environmental Quality to implement this standard for best in class Karst sinkhole buffer protection and the Associations should ask the Federal Energy Regulatory Commission to mandate the same. Local planning commisions should be encouraged to establish “Karst Sinkhole Buffers” as local land use regulatory requirements. The National Environmental Policy Act of 1969 states, “The Congress recognizes...that each person has a responsibility to contribute to the preservation and enhancement of the environment.” So hold your political representatives accountable!!!

Technical References:

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- Natural Resources Conservation Service, Karst Sinkhole Treatment (Washington, DC: USDA Natural Resources Conservation Service, Conservation Practice Standard Code 527, September 2015), 3 Pages.

- USEPA Hotspot Site Investigation Worksheet.