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Using the Water Quality Index for Runoff from Agricultural Fields (WQIag)

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Introduction

Understanding and being able to estimate the fate and transport of nutrients in surface runoff from fields is a key component of agricultural and environmental sustainability. Runoff water containing residual fertilizers, as well as legacy nutrients in soil can enter adjacent waters and pose significant hazards to the health of aquatic ecosystems. To mitigate these environmental risks, producers may implement conservation practices, such as planting cover crops, installing grassed waterways, and creating riparian buffers. The U.S. Department of Agriculture's National Resource Conservation Service (NRCS) has created a web-based tool with which farmers and farm advisors can estimate the impacts of various land management strategies on water quality.

How to use WQIag

The WQIag uses a numerical and unit-less rating system based on a scale of one to 10, with one being associated with the lowest water quality and 10 the highest (see Fig. 1). The rating system includes several site specific factors that influence nutrient runoff such as physiochemical soil properties, fertility management, tillage regime, and irrigation strategy.

The web link, https://www.wcc.nrcs.usda.gov/ftpref/wntsc/WQI/RunoffWaterQualityIndex.pdf, provides access to WQIag, a rating worksheet (Fig. 2), and an online databases for soil information. To use WQIag, farm and land management information must be collected from farmer interviews and site visits prior to populating the following sections.

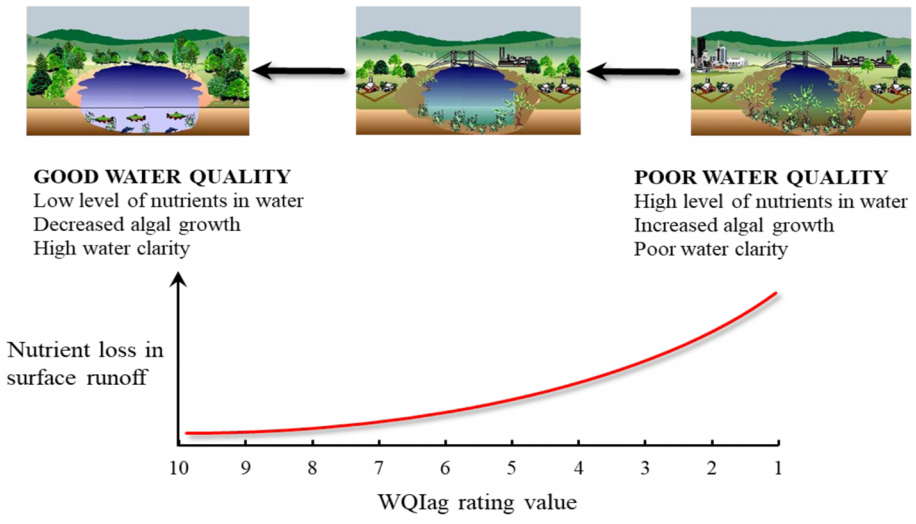

Figure 1. The WQIag rating value in relation to overall water quality.

Site Information

This section requires basic farm information such as state, county, and field acreage for the area analyzed. The hydrologic unit code can be accessed via county extension and state agricultural agencies.

The user is referred to the Arkansas Watershed Information System at http://watersheds.cast.uark.edu/find_your_watershed.html where suppling a street address provides 8, 10, and 12 digit Hydrologic Unit Codes (HUC; i.e., see https://water.usgs.gov/GIS/huc.html), numbers, and names.

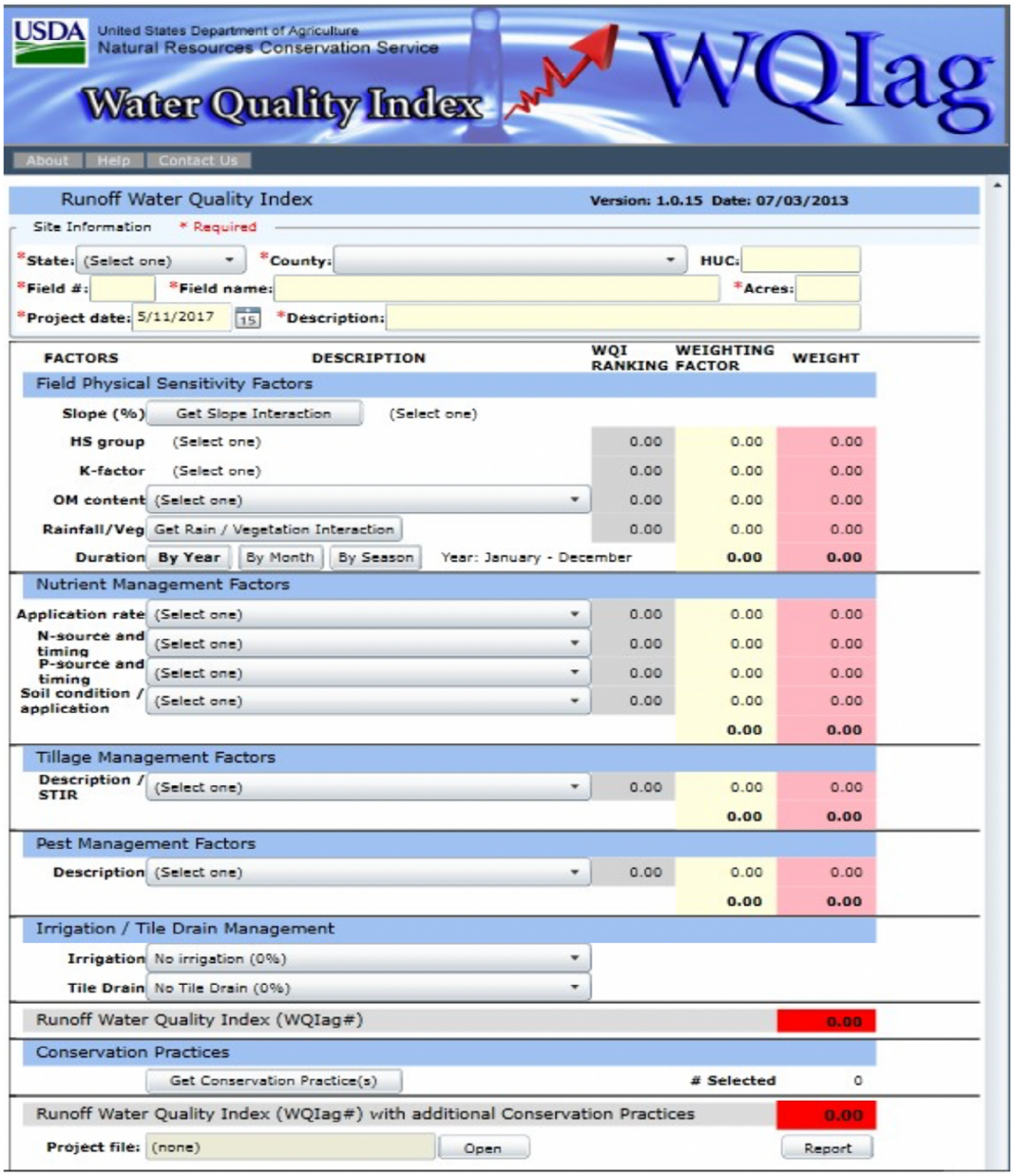

Figure 2. The WQIag rating worksheet.

Field Factors

This portion of the WQIag asks for site-specific factors such as slope, hydrologic soil group (HS), K-Factor for soil erosion potential, organic matter (OM) content of the soil, and the interaction between rainfall and vegetation. Higher WQIag ratings (i.e., better water quality) are given to fields with reduced slope percentage (<2% and 2-5%), HS groups A and B (low to moderately low runoff potential), K-Factors of very low to low soil erosion potential (<=0.10 and 0.11-0.20), higher percentages of soil OM content, and fields that have a high amount of vegetative cover throughout the year. Extensive field research has shown that these factors individually or in combination, reduce the risk of surface runoff (see https://sera17.org/publications/).

If these site-specific factors are not available from farm records or your local USDA Service Center, then they can be accessed via websites such as Web Soil Survey https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. In Web Soil Survey, the identification of an area of interest (AOI) is required. Once an AOI is defined, find the "Soil Data Explorer" tab and then select "Soil Reports." After selecting the "AOI Inventory," select "Water Quality Index (WQIag) Soil Factors," then click "View Soil Report." The resulting screen gives information needed to complete the majority of this section.

For the interaction between rainfall and vegetation, an estimation of monthly vegetative ground cover is required along with monthly rainfall totals. Monthly rainfall can be obtained through onsite collection equipment such as rain gauges, or regionally at www.usclimatedata.com.

Nutrient Management Factors

Nutrient management factors address the impact of fertilizer nitrogen (N) and phosphorus (P) application rate and soil condition during fertilizer application. For "application rate," a farmer can simply state they are following the Land Grant University (LGU) recommendations.

High WQIag rankings (i.e., better water quality) are given for zero to lower-than-LGU rates; split applications of N fertilizers during the growing season, along with having slow release technologies; split applications of P fertilizers during the growing season to no P applied; and dry/well-drained soil conditions with fertilizers injected or incorporated in to the soil.

Tillage Management Factors

The highest WQIag ratings assigned to this factor are for farm management practices such as no-till or tillage that has a "Soil Tillage Intensity Rating" (STIR) less than 30. For more information on the NRCS's STIR rating system and the calculations involved, go to https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1119754.pdf.

Pest Management Factors

Advanced Integrated Pest Management (IPM) is generally considered the most appropriate ranking option, or approach, for this set of factors. This is defined in WQIag as "primarily pest prevention/avoidance without suppression." However, the method that most farmers use and is recommended by the University of Arkansas is "Basic IPM," which is described as "threshold-based suppression with additional site-specific risk mitigation."

Irrigation Management

Highest WQIag rankings for irrigation management are given when the impact of runoff water leaving the field is significantly limited. These options include using no irrigation water; irrigation with a trickle/drip system; irrigation using a level basin with a blocked end; and center pivot irrigation with polyacrylamide (PAM).

The "Tile Drain Management" factor is based on the type of tile drain system used and weighted for "Nutrient Management Factors," "Tillage Management Factors" and "Pest Management Factors" (i.e., Nutrient, Tillage, Pest [NPT] factors). A particular tile drain selection could have an impact on the overall effect of the NTP. These impacts are expressed as percent increase or decrease of NTP and are factored into the ranking. The highest WQIag rankings are given when no tile drain is used along with standard density (+10% NTP) and high density (+5% NTP) tile drains, both having drainage water management included. As there is currently little tile drainage in production-agriculture systems in Arkansas, this factor is zero for State WQIag assessments.

Conservation Practices

The implementation and selection of conservation practices in any farming operation will greatly increase a WQIag rating. Although there are numerous conservation practices to choose from, such as contour buffer strips, riparian herbaceous covers, and sediment basins, the user is only allowed to choose up to three practices. Descriptions of these practices can be obtained from the NRCS at https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849.

The sum of all weighted inputs represents the final WQIag rating, which can be saved as a "project file" by WQIag or converted to other output-file formats, such as a PDF, Adobe's Portable Document file.

Benefits of using WQIag

One of the main benefits of using WQIag is that it provides an opportunity to comparing the risk outcomes different management strategies or scenarios. Another benefit is the ease of use via the user-friendly interface, where certain information can be accessed using Internet resources such as Web Soil Survey and NRCS's STIR rating system. These tools can be instructive and beneficial to farmers and producers, as well as enhancing their record keeping skills, as the STIR value requires preceding years of farm management data. The rainfall/vegetation interaction selection is useful through the locating and processing of data from nearby monitoring stations or customizing precipitation data according to an actual location.

Advanced Integrated Pest Management (IPM) is generally considered the most appropriate ranking option, or approach, for this set of factors. If farmers are confident that their applications are not above or below LGU recommendation, then this selection could serve as a valid point of reference. In addition, the "Soil Condition/Application" tab, along with the categories "Irrigation/Tile Drain Management" and "Con-

servation Practices," offer options for various situations that farmers may encounter or techniques they may choose to apply.

Future development of WQIag, linking yield or profit projections with nutrient loss risk, could inform management decisions and conservation/environmental protection versus production/profit tradeoffs.

Current limitations of using WQIag

A noteworthy limitation concerns the "Field Physical Sensitivity Factors" portion of WQIag. The percent slope, HS group, K-factor, and OM content values are ideal for mostly level soil surfaces and uniform soil composition as primarily observed in row crop agriculture. However, fields that have drastic fluctuations in slope and soil types, such as mountainous and hilly topography, will be subjected to selecting the most dominant map unit of that AOI and therefore, use of those values. This can overlook significant portions of a field that may have drastic impacts on soil and water runoff.

Another limitation of the current WQIag is that it was developed for national use and is still a general framework that will be further refined by individual States to better represent management practices. For example, some practices unique to Arkansas with respect to cotton and rice production or for irrigation techniques are not included at this time.

Currently, the Division of Agriculture is working with Arkansas NRCS to enhance WQIag to better represent locally important agricultural systems.

A further limitation at the moment, occurs with "Application Rate," where there is an option of "20% more than LGU recommendations." However, if a farmer applied more than 20 percent of the LGU recommendation, this would not be factored in the final WQIag ranking. Over-fertilizing and its potential water quality impact would not be accounted for.

A final limitation deals with "Pest Management Factors." Although all four pest management options are ideal for row crop settings, they are not appropriate for forage and livestock systems, where intensive and even basic pest management practices are rarely employed. The "Basic Pest Control" option results in the lowest WQI rating for this category and is the only one suitable for forage and livestock production. Penalizing farmers for choosing this selection seems inappropriate when pest control strategies are not typically a significant part of their operation management.

Conclusions

The WQIag tool concisely combines information from multiple water quality factors into a single, easy to interpret value. Most of the data can be found by accessing web-based services. In its current form, the tool is primarily geared for use in row crop settings, where soil characteristics and land magement strategies are generally uniform across fields. Soil characteristics in forage and livestock operations in mountainous or steeply sloped terrain, tend to lack uniformity, and accurate field information has a greater possibility of being omitted or skewed.

References

WQIag - Water Quality Index for Runoff Water from Agricultural Fields. 2017. NRCS Agronomy Technical Note No. 11. https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=40577.wba

Water Quality Index for Runoff from Agricultural Fields (WQIag): https://wqiag.sc.egov.usda.gov/

Web Soil Survey: https://websoilsurvey.nrcs.usda.gov

Soil Tillage Intensity Rating (STIR): https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1119754.pdf

Conservation Practices (NRCS): https://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_02 6849

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